Year book

2024

Blog Heart Surgery Today

Coordinator
José Manuel Martínez Comendador

Editors
Elio Martín Gutiérrez/José Manuel Martínez Comendador/ Bunty Ramchandani

SECCE
Sociedad Española de Cirugía Cardiovascular y Endovascular

Blog

Heart Surgery Today

Year book **2024**

Summarized comments of the main publications in cardiovascular and endovascular surgery

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Foreword

It is an honor to present, for the second consecutive year, the book *Heart Surgery Today*, this time with the English edition of the second volume compiling all the articles published during 2024.

Once again, we have selected the most outstanding scientific contributions in our specialty, organizing them chronologically to provide an in-depth and critical analysis. Our purpose remains clear: to extract the most relevant lessons and present this content in a clear, structured, and accessible manner, promoting rigorous and engaging dissemination of scientific knowledge. Additionally, this year we have introduced a new type of commentary called "expert opinion," featuring analyses of critical topics in our specialty by renowned professionals.

The extraordinary success of the first edition, now translated into English, has motivated us to maintain the same format for this new volume. The book is organized into six thematic sections covering key areas of our specialty: acropathies; ischemic heart disease; congenital heart diseases; heart failure and circulatory support devices; aortic, mitral, and tricuspid valve diseases; and finally, a miscellaneous section. This structure, designed based on the current relevance of each topic, ensures a coherent and chronological reading experience within each chapter.

In this second volume, we have compiled more than 130 carefully selected articles by 60 authors, establishing the *Heart Surgery Today* blog as one of the most appreciated resources among SECCE website users. Moreover, growing interest and demand from international scientific societies have led us to translate both this edition and the 2023 edition into English, further validating the quality and utility of its content.

I would like to express my deepest gratitude to all the authors whose contributions have made this work possible. Likewise, I extend an open invitation to all specialists in cardiac surgery, regardless of language or origin, to join this well-established and ever-growing project.

My gratitude also goes to the members of SECCE, especially former president Jorge Rodríguez-Roda Stuart and current president Juan José Legarra Calderón, whose support has been essential to the development of this project. Finally, I must highlight the invaluable work of the editorial team, composed of Dr. Elio Martín Gutiérrez and Dr. Bunty Ramchandani, whose dedication has been key to drafting and editing the critical commentaries included in this volume.

We hope this collection of articles will serve as a useful tool to inspire and deepen our knowledge and passion for cardiac surgery within the professional community.

Dr. José Manuel Martínez Comendador
Coordinator of *Cardiac Surgery Today* blog, 2024

Blog
Heart Surgery Today

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Section I:

Aortopathies

José Manuel Martínez Comendador

EACTS/STS 2024 Guidelines for the Aortic Organ: Innovations and Key Points

The consensus guidelines by EACTS and STS, published in 2024, address the diagnosis and treatment of acute and chronic aortic syndromes, now recognized as the "aortic organ."

Coinciding with thirty years since the first endovascular repair of the thoracic aorta (TEVAR), performed at Stanford and published in 1994 by Dake et al. for treating a descending thoracic aortic aneurysm, and a decade after the previous guidelines in 2014, the European Association of Cardio-Thoracic Surgery (EACTS), together with the American Society of Thoracic Surgeons (STS), have released new recommendations for diagnosing and treating aortic diseases in a joint guideline. A task force of professionals from both societies developed the document, which was then reviewed and approved by an external panel of global experts, allowing its simultaneous publication in the European Journal of Cardio-Thoracic Surgery and the Annals of Thoracic Surgery. A consensus of this magnitude between the two most influential societies in the field has never been achieved before. Therefore, these guidelines are the result of an extensive quorum, unprecedented to date.

The new guidelines represent a true *opus magnum* of clinical practice, presented in 195 pages spread over 19 chapters, covering all relevant aspects of aortic diseases and summarized in 36 recommendation tables and 33 figures. Out of 256 recommendations, less than 1% correspond to level A, 26% to level B, and 74% to level C. This reflects that the majority of recommendation classes, which indicate consensus on the effectiveness of a specific intervention, are based primarily on "level C" evidence. Therefore, despite the large number of references cited (983), the studies referred to are largely based on small cohorts, retrospective analyses, and expert opinions.

The document is very extensive and is designed to be consulted on multiple specific occasions. However, attempting to get a global view in one go can be overwhelming. The purpose of this article is to provide a summary of the structure of the guidelines, highlighting the most significant and novel changes compared to previous versions. Thus, readers can take away the key messages and, when they wish to delve deeper into the guidelines, do so in a simpler, more efficient, and enjoyable way.

Below, we break down the most important messages by sections:

The Aorta as an Organ (Nomenclature Change)

The guidelines begin with the phrase *The obvious is imperceptible until it is perceived*, attributed to the philosopher and psychologist William James, where he highlighted how the most obvious things can go unnoticed until someone consciously observes them.

For the first time, the aorta is recognized as an organ that should be interpreted and treated as an independent organ (class IC), becoming the twenty-fourth organ of the human body. The aorta is not simply a conduit for blood flow; it also has a complete functional unit that includes its embryonic origin, tissue structure, and essential function in blood circulation. This comprehensive perspective justifies its recognition as an organ in its own right, beyond its role as a blood vessel.

Specialized Centers and Infrastructure

The importance of aortic medicine has grown within health systems due to its economic impact and high complexity. Aortic diseases represent a considerable economic burden,

which has been increasing over the past 20 years. For example, the average hospital cost for patients treated for thoracic aortic dissections ($6,102 in medical treatment, $26,896 with endoprosthesis, and $30,372 in surgery) is 50% higher compared to patients hospitalized for other causes after appropriate propensity score analysis, as reflected in some economic studies. Given this context, the guidelines emphasize the importance of forming specialized teams for aortic diseases to effectively address this pathology. Therefore, it is recommended to make joint decisions with an aortic multidisciplinary team (class IC), refer patients with multisegmental or complex aortopathy to specialized centers (class IIa), and have a hybrid operating room available for endovascular procedures (class IC).

They also emphasize the importance of transferring patients with multisegmental aortic disease to "centers of excellence" that have a variety of specialists available with 24/7 coverage. This section is particularly useful for negotiating with and persuading administrations and policymakers about the need for these infrastructures, providing solid arguments.

Classifications, Scales, and Definitions

Establishing a common language is essential, so the guidelines have sought to standardize classifications across each segment. In terms of acute aortic dissection, the TEM classification, derived from the TNM system in oncology, has finally been recognized as the cornerstone of indications. Although widely commented on in other blog entries, it's worth a small reminder: T (type), according to the modified Stanford classification (A for ascending aorta, B for descending aorta, non-A non-B for involvement of the aortic arch with/without descending aorta affecting the ascending aorta). E (entry), according to the location of the entry site (0: undetermined, intramural hematoma; 1: ascending aorta; 2: aortic arch; 3: descending aorta). Lastly, M, presence of malperfusion and at what level: 0: absent; 1: coronary, 2: supra-aortic trunks, 3: visceral, medullary and/or limb; -: no clinical signs or +: with clinical signs). The GERAADA score (already commented on previously in the blog), the first tool to predict 30-day mortality using easily accessible clinical and radiographic data, is also highlighted. Moreover, the non-A, non-B type, affecting only the aortic arch or also the descending aorta, has been standardized as an accepted classification for acute aortic dissection. The extent of the disease and repair are now described using Ishimaru zones (from 0 to 11). As for the bicuspid aortic valve, it has been reclassified to describe it as fused, partially fused, or with two sinuses. The most relevant point is the importance attributed to the morphology of the aorta and the aortic root in patients with a bicuspid aortic valve (and also tricuspid). Depending on the aorta phenotype (type "root" or type "ascending"), the prognosis changes significantly. We recommend reviewing figure 7, which clearly illustrates how patients with a "root" phenotype (5-10% of cases) have a worse prognosis in terms of growth and complications, implying an earlier indication for surgery, more aggressive treatment, and stricter follow-up. Endoleaks: A clear and graphical review of the five types of endoleaks is presented, highlighting that types I and III remain the most important, as they are considered treatment failures and require reintervention. Aortic ulcers and traumatic injuries are clearly illustrated and classified. Additionally, a precise definition of Kommerell's diverticulum is provided, facilitating its proper management. Grading of hypothermia: A surprising and notable aspect is the effort of the drafting committee to unify the classification of hypothermia, eliminating the confusion existing in the literature about definitions and measurement locations. Four categories have been established: mild hypothermia (above 28 °C), moderate hypothermia subdivided into high moderate (24-28 °C) and low moderate (20-24 °C), and deep hypothermia (below 20 °C). It is important to note that these categories refer to the central body temperature, measured at locations such as the bladder or rectum.

Diagnosis and Indications

Diagnosis: A key aspect of the guidelines is how measurements should be performed. In angioCT, for example, it is emphasized that measurements should be made from outer diameter to outer diameter. Additionally, for the first time, the length of the aorta is incorporated as a criterion in decision-making, establishing a limit of 11 centimeters from the midline at the level of the aortic ring to the origin of the brachiocephalic trunk. Regarding the measurement of diameter, the approach continues to be to identify the maximum diameter, and it should be measured from sinus to sinus in the aortic root. The measurement of the true lumen, false lumen, and total aorta diameter has also been standardized, especially in postoperative contexts and for the formation of aneurysms.

Surgical Indications in Aortic Dilation

Diameter remains the most discussed component in the guidelines, with cut-off points generally between 5 and 5.5 cm, but with a clear trend towards lower thresholds than in the past. For example, if the surgical risk is low, in bicuspid and tricuspid aortic valves, elective surgery on the ascending aorta (excluding the root) is recommended with class IIa when the diameter reaches 52 mm or more, instead of the previous limit of 55 mm. Additionally, the length of the aorta (>11 cm) and the root phenotype have also been incorporated as variables to consider for surgical indication, suggesting surgery when these factors are present and the diameter exceeds 50 mm.

Management and Treatment

One of the great novelties is the inclusion of specific flowcharts for each subtype of acute aortic dissection, definitively clarifying what to do in each circumstance: In type A dissection, the TEM classification guides decisions. In most cases, the recommended surgery is replacement of the ascending aorta and hemiarch, except in specific cases of E2 (if the entry is on the greater curvature) and E3 (if the tear is in the first 10 centimeters from the left subclavian artery), where the frozen elephant trunk (FET) is suggested. In type B acute dissection, medical treatment remains the main option for uncomplicated cases. However, if there are "high-risk features" (already listed in previous blog entries), TEVAR is advised at three months if feasible, or FET if not. For complicated dissections, TEVAR is recommended as an emergency if viable, or FET if not. In other words, emergency intervention is not advised in uncomplicated dissections. In acute non-A non-B dissection, the approach depends on the location of the entry site. If it is in the aortic arch (E2), it generally involves the implantation of a FET, which can be delayed up to 48 hours if it is not a complicated dissection. In the case of an E3, if the dissection is uncomplicated, conservative treatment is the best option, but if it becomes complicated, TEVAR is the treatment of choice, resorting to FET if TEVAR is not viable. The manuscript also addresses in detail the surgical steps in acute dissection, the implantation of FET, the preservation of the root while preserving the valve, and combined vascular and endovascular operations. Additionally, there is an extensive chapter on open thoracoabdominal treatment, with a focus on protecting organs, the spinal cord, viscera, kidneys, and limbs.

Endovascular treatment is also positioned very clearly as a first or second choice in many cases:

TEVAR is the first-line intervention for almost all pathologies affecting the distal arch or descending thoracic aorta. It is especially recommended for the treatment of type B acute aortic dissection complicated and for those with "high-risk features," ulcers, and traumatic ruptures. It is also supported, with a class IIa recommendation, the stabilization of the membrane (PETTICOAT-type techniques or similar, like the recent AMDS® prosthesis)

in acute dissections in cases where adequate decompression of the distal lumen cannot be achieved with TEVAR alone. Endovascular repair of aneurysms with branches or fenestrations is considered equivalent to open surgery for treating thoracoabdominal pathologies (class IIa). As for open surgical treatment, FET becomes the treatment of choice for most diseases of the arch. A class IIa recommendation is offered for acute type A or non-A non-B aortic dissections, type B aortic dissections complicated not suitable for TEVAR, and chronic aortic diseases.

COMMENTARY:

One of the most notable features of these guidelines is the unification of classifications, scores, and definitions, such as the TEM classification, the GERAADA score, the non-A, non-B subtype of aortic dissection, the Ishimaru zones, the morphology of the aortic root, endovascular leaks, and a better understanding of Kommerell's diverticulum. This unification of language facilitates communication and understanding at a global level, a considerable achievement of these guidelines.

The better natural understanding of aortic diseases has been key to adjusting the surgical indications based on diameter, with a trend towards increasingly lower thresholds. Additionally, for the first time, the length of the aorta is incorporated as an additional criterion in decision-making. These new indications must be incorporated into our daily practice, and they will surely be the subject of repeated consultations by all of us in this new phase.

Another great novelty is the consensus reached on the classification of hypothermia, which will allow comparative studies at the global level with a common language in managing hypothermic circulatory arrest.

The recognition of the aorta as the 24th organ of the human body, along with a better understanding of the importance of effectively managing this high-cost pathology, has driven the creation of specialized centers for complex aortic pathology, equipped with the most advanced therapeutic resources and supported by clinical guidelines. In Spain, a successful example of this strategy is the aorta code in Madrid, whose goal has been to optimize the treatment of acute aortic syndrome in a network of five hospitals. This is achieved through early diagnosis, immediate transfer to the reference center, and treatment by an expert multidisciplinary team. We recently had the opportunity to analyze its results in a blog entry. This is a complex debate, with multiple factors at play, but it will undoubtedly generate a broad global debate, the outcome of which is yet to be seen.

It is necessary to highlight that the main weak point of these guidelines is the low level of evidence that supports many of the recommendations, which deserves constructive criticism. Some proposals from the committee lack solid data support, generating areas of controversy. Among them, the indication for prophylactic surgery in aortas of 45 mm or more in patients with Marfan syndrome, even without high-risk features; the measurement of aortic diameters from outer edge to outer edge instead of from inner edge to inner edge; and the use of moderate to high hypothermia in lower body circulatory arrest, as well as selective antegrade cerebral perfusion in complex arch procedures.

This low level of evidence should serve as an incentive for the aortic community to strive to generate more data through prospective randomized controlled trials. Additionally, it would be valuable to create networks of specialized hospitals that collaborate closely to advance knowledge and improve practices in this field.

In conclusion, we are faced with a highly useful clinical practice guideline for all professionals dedicated to aortic pathology. It stands out not only for its thoroughness

but also for its applicability in daily practice, providing great clarity in the new surgical indications for aortic aneurysms, as well as in the flowcharts for the treatment of aortic dissection, fundamentally the non-A non-B type, which until now remained in limbo.

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Frozen Elephant Trunk in Type A Aortic Dissection Deployed from Zone 0

A retrospective study examining the use of the "frozen elephant trunk" technique in patients with type A aortic dissection, implanted from zone 0, comparing outcomes and the distal positioning of the stent-grafts relative to their length.

Despite advances in surgery for acute type A aortic dissection (ATAAD) and its outcomes over the past four decades, the morbidity and mortality rate remain high, ranging from 10% to 26%, especially in patients with severe true lumen (TL) collapse and in cases of malperfusion syndrome.

The frozen elephant trunk (FET) technique for ATAAD, developed in the 1990s by Kato et al., has become increasingly popular due to its potential benefits, such as improving malperfusion syndrome through thrombosis of the false lumen (FL) and reducing the need for reoperations. It is believed that the FET technique allows adequate aortic remodeling by covering the initial portion of the descending aorta with a stent-graft. However, there is a possibility of causing spinal cord ischemia (SCI) when a stent longer than 150 mm is used or when the FET coverage extends below T8-10. On the other hand, insufficient coverage of the descending aorta is associated with a greater need for a second intervention. The optimal length of the FET stent and its distal position to achieve adequate aortic remodeling and improve distal malperfusion syndrome while avoiding SCI are still unclear in patients with ATAAD undergoing total arch repair. Recent studies, supported by good clinical outcomes, suggest a strategy of proximalizing the distal anastomosis as a promising approach.

At Akita University Hospital, Japan, since 2014, a strategy has been implemented that involves deploying the FET from the aortic zone 0 to the descending aorta, using stents of different lengths (60, 90, 120, or 150 mm). This approach has been characterized as easy and safe to apply and has yielded satisfactory postoperative outcomes. The purpose of this study was to investigate the optimal length of the stent and the distal location of the FET in patients with ATAAD undergoing total arch repair, where the FET is implanted from the aortic zone 0.

For this purpose, between October 2014 and April 2021, 191 patients (FET-150 group: 37 patients; stent length, 150 mm; age 66.3 years and FET-no-150 group: 154 patients; 60, 90, or 120 mm; age 64 years) underwent total arch repair with FET for ATAAD using the "zone 0 arch repair" strategy. In the FET-150 group, the proximal end of the stent was placed at the level of the origin of the innominate artery from the arch. In the FET-no-150 group, the distal end of the stent was positioned just proximal to the aortic valve level using transesophageal echocardiography (TEE). In both groups, the distal anastomosis was performed after trimming the unstented polyester prosthesis with four branches (for the individual reimplantation of the three supra-aortic trunks and another for the perfusion of the lower half of the body after the completion of the distal anastomosis) suturing it to the aortic wall 1 or 2 cm proximal to the origin of the innominate artery.

The distal ends of the stent were positioned as follows at the thoracic vertebral (T) levels: In T4-5 (0%), in T6-7 (32.4%), in T8-9 (67.6%), and in T10 (0%) in the FET-150 group, and in T4-5 (3.9%), in T6-7 (63.6%), in T8-9 (31.8%), and in T10 (0.7%) for the FET-no-150 group. No differences between groups in postoperative mortality were observed. The incidence of residual distal malperfusion syndrome and new-onset SCI in the FET-

150 versus FET-no-150 groups was 2.7% versus 6.5% ($p = 0.62$) and 0% versus 1.9% ($p = 1.00$), respectively.

The authors conclude that positioning the FET with the distal end around T8 may reduce residual distal malperfusion syndrome when a FET with a 150 mm stent is implanted from zone 0 aorta in patients with ATAAD undergoing total arch repair.

COMMENTARY:

In most centers, the conservative approach with hemiarch surgery remains the preferred technique for treating ATAAD, as the priority is to save the patient's life. However, this technique in most cases leaves a residual distal dissection. Therefore, under certain circumstances, a more aggressive strategy involving the complete replacement of the aortic arch is being promoted to prevent future complications, although this technique carries a significant risk, especially in centers with little experience. In this context, the use of the FET technique has become an alternative surgical option with indications for which there is consensus in most clinical guidelines, including: 1) rupture of the distal aortic arch and/or proximal descending thoracic aorta; 2) malperfusion syndrome; 3) patients under 70 years of age without significant comorbidities.

The FET improves blood flow to the TL by covering tears in the intima of the descending thoracic aorta and reduces pressure in the FL, improving malperfusion syndrome. In addition, it decreases the risk of dilatation in the distal FL, promoting adequate aortic remodeling and reducing late mortality and the need for additional surgeries to less than 20%. When a complete aortic arch replacement is considered to prevent long-term complications, the FET offers a more favorable postoperative recovery compared to the classic elephant trunk technique, in addition to reducing the need for subsequent procedures. Something very relevant, but rarely discussed, is that the distal anastomosis in the FET compared to the classic elephant trunk is safer and more hemostatic, as a consequence of the almost immediate thrombosis of the FL.

Takagi et al. present a highly relevant study that provides new valuable information, classifiable in four points of decreasing importance:

1. The deployment of the prosthesis using FET up to the level of T8 does not increase the risk of SCI and may improve distal malperfusion syndrome in patients with ATAAD. Until now, it had been suggested that positioning a FET approximately at the level of T8 might increase the likelihood of SCI. This is evidenced in the most current and robust meta-analysis, published by Preventza O et al. in 2020, which encompassed a total of 35 studies with more than 3,000 patients undergoing FET, and which revealed a significant association between FETs with stent-grafts longer than 15 cm or those reaching T8 or beyond, and SCI.

2. If a 15 cm prosthesis is released from the zone 0 at the level of the innominate artery, the distal part of the stent of the stent-graft is positioned at the level of T8-9, with very low probabilities of surpassing this level. This phenomenon seems to be valid in most patients of Japanese descent, who tend to have a not very tall stature. Therefore, it is very likely that this observation could be extrapolated to our own population. In other words, the 15 cm prosthesis released at the level of the innominate artery, even without precise measurements, is highly unlikely to be below T10, which would be dangerous.

3. Surgical technique novelties with the release of the prosthesis in the aortic arch and performing the distal anastomosis, always in zone 0. Unlike the more conventional technique in prostheses in our field, in which the release and anastomosis in zone 2 are recommended, between the left carotid artery and the left subclavian artery, which is generally ligated proximally in the aorta and reimplanted in isolation.

4. TEE presents itself as a valuable tool to avoid surpassing the limits that entail a greater risk of SCI, at least in the case of prostheses with lengths less than 15 cm. By releasing the prosthesis at the point where the distal position of the stent-graft does not exceed the proximal plane, right where the aortic valve is located, a positioning is ensured that rarely falls below T10. This practical and simple trick, although not completely accurate, can be very useful for adjusting the release zone of the prosthesis by a few centimeters.

The Frozenix® prosthesis (Japan Lifeline®) commercially unavailable in Spain, bears great similarity to the two devices most widely used in our country, the E-vita Open Plus® prosthesis (Jotec®) and Thoraflex Hybrid® (Vascutek Terumo®). The main difference lies in the absence of a collar for the anastomosis in the Frozenix® prosthesis, which implies the need to trim the prosthesis after releasing the stent of the stent-graft. In this way, after adjusting the length of the Dacron prosthesis, the distal anastomosis is performed. The rest of the steps of the procedure using the Frozenix® prosthesis are practically identical to those carried out in our hospitals.

It is crucial to highlight that SCI constitutes a devastating adverse event that, to some extent, could be prevented by using stent-grafts with a length less than 15 cm or by positioning them above T8. On the other hand, leaving a significant portion of dissected aorta uncovered, especially above T4-5, generally with short-length prostheses (60-90 mm), could be related to the lack of resolution of malperfusion syndrome. However, malperfusion does not only depend on the latter, but also on other factors, such as the time elapsed from the onset of the dissection until the restoration of blood flow in the affected organ. The release technique, which is always performed at the level of the innominate artery, and which has been developed in this hospital with 15 cm prostheses, seems to address both problems with a high degree of reliability, as it would cover a large part of the dissected aorta, resolving the malperfusion syndrome, without practically ever surpassing T8-9, thus avoiding SCI.

Although this study is extremely interesting from an educational and practical perspective, it is important to underline that it is a retrospective and single-center study. The lack of significance in the lower incidence of malperfusion syndrome observed with 15 cm prostheses (2.7% versus 6.5%) could be attributed to the limited statistical power of the research. However, it is risky to assert, as the authors do in their conclusions, that this prosthesis could be associated with a lower incidence of said syndrome based on a study of this nature. It is evident that more research is required before reaching a definitive conclusion on the ideal length of the stent-graft. To address this issue accurately, we must take into account the anatomical differences between patients, which can vary in terms of physical constitution, length, and shape of the aorta. Currently, with the widespread availability of highly precise imaging tests such as angioCT in our hospitals, it has become essential to perform an accurate and personalized calculation of the length and size of the aorta when considering the application of the FET technique. This ensures the selection of the most suitable prosthesis for each patient.

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José Manuel Martínez Comendador

Characteristics and Real Outcomes of All Acute Aortic Dissections in a Country

Retrospective study from the Danish national registry analyzing the characteristics and outcomes of all acute aortic dissections between 2006 and 2015.

Most studies on patient populations with acute aortic dissection (AAD) are based on data from large tertiary referral centers, such as the International Registry of Acute Aortic Dissection (IRAD), which reports considerably high hospital mortality rates for type A and type B AAD, at 22% and 14% respectively. However, many patients do not reach these tertiary centers (those performing aortic surgery or TEVAR procedures) due to acute complications, deaths, or a conservative treatment approach. Consequently, there is an unknown number of aortic dissection cases that may never be registered in large international registries, making it difficult to accurately assess the real prognosis of this disease. To address this issue, this group used the Danish national civil personal data registry as a source, which allows the inclusion of all registered AAD cases that had hospital contact (even in non-tertiary centers) across the population, allowing a more complete long-term follow-up and view of all patients with AAD. The goal of this study was to evaluate the short and long-term characteristics and outcomes of these patients.

Data from patients diagnosed with AAD for the first time between 2006 and 2015 were analyzed. Initially, 2671 were cataloged as some type of aortic dissection; after reviewing cases including their imaging tests, 280 patients were excluded for having had a previous aortic dissection, 213 for not having AAD, and 465 patients for having an unspecific diagnosis of dissection. Finally, of the 1713 patients included in the study, 68% had type A dissection and 32% had type B, with median ages of 66 years (range 57-74 years) and 70 years (range 61-79 years), respectively. 64% were men. The average follow-up was 8.9 years (range 6.8-11.5 years). In type A dissection, 74% were surgically treated, while in type B, 22% received surgery or endovascular treatment. Hospital mortality was 27% in type A (18% with surgery, 52% without surgery) and 16% in type B (13% with surgery/endovascular therapy, 17% with conservative treatment; $p<0.001$). Patients with type A dissection who were discharged had a better survival than those with type B ($p<0.001$). The unadjusted 1- and 3-year survival for patients with type A dissection who were discharged was 96% and 91% with surgery, and 88% and 78% without it, respectively. In type B, it was 89% and 83% with endovascular/surgical management, and 89% and 77% with conservative management, respectively.

The authors conclude that hospital mortality in both types of aortic dissection was higher than reported in referral center registries. Type A presented higher mortality in the acute phase, while, in patients discharged, mortality was higher in type B.

COMMENTARY:

The conclusions derived from the results obtained in this study are particularly significant. This is because it is based on an extensive national registry, which has a distinctive feature compared to previous similar research. In this study, AAD patients were included, both those admitted to referral hospitals, where there is the possibility of surgical intervention, and those diagnosed with AAD at any type of hospital.

In this study conducted by Pedersen M. et al., several key findings are highlighted:

1. The hospital mortality rate in AAD type A and type B cases exceeds that of other international referral registry rates.

2. A lower proportion of patients underwent surgery in the case of AAD type A compared to similar international registries.

3. The average age of patients with AAD type B is higher than that of those with AAD type A.

4. The hospital mortality of AAD type A is significantly higher than that of AAD type B.

5. The long-term mortality, age-adjusted, also shows an upward trend in the case of AAD type A.

6. As for the long-term survival of discharged patients, a better prognosis is recorded in the group of patients with AAD type A.

Once again, this study clearly highlights that AAD continues to be a condition with an extremely high hospital mortality rate. However, compared with previous studies based on tertiary referral center registries, some differences worthy of analysis are revealed.

Regarding AAD type A in this study, it is observed that hospital mortality follows the common pattern of being higher in patients who did not undergo intervention (52%) compared to those who underwent surgery (18%). However, it is important to highlight that overall hospital mortality is higher in this study compared to data reported in the IRAD (27% versus 20%-21%).

Recent reports from the IRAD have recorded an increase in the proportion of patients undergoing surgical treatment, reaching 90%. However, in the context of this study, only 75% of AAD type A cases underwent surgery. This discrepancy could be explained because international registries, like the IRAD, are based exclusively on data from large tertiary referral centers. This, in turn, may underestimate the real prognosis of AAD, as some patients might die before reaching a tertiary referral center due to the high mortality in the first hours of this disease or rejection in transfer given their comorbid condition, serious irreversible sequelae derived from the dissection and/or the predicted surgical risk being unassumable. In fact, in this particular study, it was identified that 10% of patients did not manage to access a tertiary referral center, and within this group, the hospital mortality rate was doubled, as evidenced in the subgroup analysis.

Regarding the hospital mortality rate of AAD type B in this study, a figure higher than that reported by the IRAD is also observed (16% compared to 11%). This discrepancy could be attributed to a possible selection bias in the IRAD, given that patients with AAD type B in that registry presented an average age six years younger than the patients included in this study.

When analyzing mortality during the follow-up in this study, it was observed that patients who survived until hospital discharge after a DA type A exhibited long-term survival rates higher compared to patients with DA type B, which is consistent with previous findings in the field. Additionally, during the follow-up, it was identified that mortality in both categories of diseases in this study was mainly attributable to non-cardiovascular causes. Something we already intuited from the results of the IRAD, where the hospital parameters that accurately predicted hospital mortality in aortic dissection type A did not seem to influence mortality during the follow-up.

The most significant limitation of this study, undoubtedly, lies in that 465 patients were not included due to a diagnosis of unspecified AAD, despite having employed a

reclassification process that involved evaluating computed tomographies and combining diagnoses with surgical procedure codes. Although not explained in full clarity, it is inferred that these patients with unspecified AAD could have had some type of acute aortic syndrome different from dissection or it was not possible to distinguish if it was a type A or B AAD. It is regrettable not to have information on the evolution of this group of patients, as this would have contributed to adding value to the overall analysis of these results. Secondly, it is important to consider that, as suggested by population studies, a substantial number of patients with AAD die before reaching the hospital for evaluation. With the design of this study, also excluded are the patients not admitted, and within those admitted, there is the risk that some patients die shortly after their arrival at the emergency department, where the DA is not registered or even not recognized as the cause of death. Therefore, the presence of a certain degree of selection bias cannot be dismissed. Thirdly, this study lacked information on the time elapsed between the onset of symptoms and hospital admission. This type of data would have been particularly valuable, given the high probability of serious complications during the acute phase, especially in the case of AAD type A.

As previously mentioned, evidence from population-based registries should ideally encompass the entire spectrum of AAD, which includes those unfortunate patients who die or are selected for conservative treatment and never reach a tertiary referral center. This study based on a national registry partly contributes to the inclusion of this group of patients. This approach provides valuable data on the essential aspects of early detection, decision-making, and timely referral, all of which are of vital importance to improve survival rates in patients with AAD.

Therefore, it would be highly advisable for current large-scale international AAD registries to broaden their scope to also include centers that are not tertiary referral centers. This would allow for a more complete and representative view of the disease and its outcomes, for the benefit of patient care and prognosis.

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José Manuel Martínez Comendador

Central Aortic Cannulation in Type A Aortic Dissection Surgery: An Effective and Safe Method?

This study assesses the impact of central versus peripheral aortic cannulation on the outcomes of surgical repair of acute type A aortic dissection.

Peripheral cannulation, whether femoral or axillary, remains the most commonly used method for establishing cardiopulmonary bypass (CPB) during surgery for acute type A aortic dissection (ATAAD) according to databases like STS. Antegrade arterial perfusion through the axillary artery offers advantages over the retrograde perfusion provided by the femoral artery, as it has proven more effective in preventing malperfusion syndrome and embolism, major contributors to the morbidity and mortality of this condition.

The infrequently used central cannulation of the ascending aorta appears to be gaining more followers due to its convenience and potential advantages over peripheral cannulation. These advantages include the simple and efficient establishment of CPB, avoiding a second incision, antegrade perfusion, and true lumen expansion. However, the widespread adoption of this technique is limited by the lack of solid studies on its outcomes, as only a few retrospective studies with small sample sizes have been conducted to date. Additionally, there remains uncertainty about the safety of this technique, without it leading to an increased risk of rupture or worsening of the dissection.

To address these questions, this observational study included all ATAAD repairs performed at a high-volume hospital in Pittsburgh from 2007 to 2021. Patients were stratified according to the type of aortic cannulation used, whether central, subclavian, or femoral. Survival estimates were made using the Kaplan-Meier method, and a multivariable Cox regression analysis was conducted.

The study population consisted of 577 patients who underwent ATAAD repair. Of these, central cannulation was used in 490 patients (84.9%), subclavian cannulation in 54 patients (9.4%), and femoral cannulation in 33 patients (5.7%). The rates of peripheral vascular disease, moderate or greater aortic insufficiency, and cerebral ischemia differed significantly among the groups, but the baseline characteristics were comparable in other respects. The times for CPB, aortic clamping, and circulatory arrest with antegrade or retrograde cerebral perfusion were significantly shorter in the central cannulation group. There were no differences among the groups in terms of the type of surgery performed on the distal aorta, whether hemiarch replacement, complete arch replacement, or elephant trunk procedure with or without freezing. There were also no differences in the type of proximal aorta reconstruction regarding aortic valve replacement, aortic valve resuspension, or David surgery. Only a higher proportion of Bentall procedures was found in the femoral cannulation group (33.3%) compared to 18% and 13% in the direct aortic and axillary cannulation groups, respectively. Operative mortality was lower in the central cannulation group (9.8%), but this did not significantly differ among the groups. Kaplan-Meier survival estimates were similar among the groups. In the multivariable Cox regression, cannulation strategy was not significantly associated with long-term survival.

The authors conclude that ATAAD repair can be safely performed via central aortic cannulation, with outcomes comparable to those achieved using other methods of peripheral cannulation.

COMMENTARY:

The findings of this study are of utmost importance, as they represent a milestone in comparative research on central aortic cannulation in patients with ATAAD. This study, conducted at a single center, has the largest patient cohort to date, with a total of 490 patients, up to five times the sample size of the next most significant study in this field. Among the most prominent messages and conclusions, we can highlight the following points:

In the majority of ATAAD cases, at least 85%, central aortic cannulation could be performed without difficulty. It emphatically confirms the viability, ease, simplicity, and effectiveness of this technique. It provides a detailed and practical description of the surgical technique, resulting from the extensive knowledge and experience of the research team in this field. The times for CPB, ischemia, and cerebral perfusion during circulatory arrest are significantly shorter with central cannulation than with peripheral. Short-term morbidity and mortality are at least comparable, if not lower, than those observed with peripheral cannulation. The comparison between central arterial and peripheral cannulation in ATAAD has been addressed in several retrospective studies, although all of them had small samples, and none had more than 100 patients in the central cannulation group. Most of these studies showed similar morbidity and mortality results, except for one that demonstrated lower short-term mortality with central cannulation, and another that highlighted the benefits of axillary cannulation. The study led by Kreibich et al., published 5 years ago, had the largest sample size to date. This study compared central with peripheral cannulation and obtained results consistent with the work we are analyzing at this moment, which significantly expands the cohort of patients with central aortic cannulation, nearly multiplying it by five.

Unlike most centers, where peripheral cannulation (axillary or femoral) is the preferred technique, at the Heart and Vascular Institute in Pittsburgh, central cannulation is the preferred option whenever feasible. The article provides useful tips for carrying out this technique. Mainly, cannulation was performed in the distal portion of the ascending aorta, with the caution of not performing it extremely distally to ensure sufficient aortic remnant after resection, necessary for subsequent arch reconstruction. The importance of coordination with the anesthesiologist, who by TEE, confirms the correct position of the guide in the true lumen after its insertion using the Seldinger technique, is highlighted. The cannulas used were of the femoral type, with a caliber of 18-20 Fr.

At the Complexo Hospitalario Universitario de A Coruña (CHUAC), we have experienced a change in our cannulation policy for treating ATAAD in recent years. Currently, direct aortic cannulation has become our preferred choice in most cases of ATAAD. The results obtained and our impressions in this regard have been very satisfactory. In relation to the technique, I would like to share some practical tips derived from our experience that can contribute to carrying out this cannulation with greater precision and safety. Firstly, it is crucial to perform a thorough evaluation of the angio-CT of the aorta. This not only allows us to determine the suitability and feasibility of the procedure but also provides us an understanding of the trajectory and location of the true lumen in the vicinity of the intended cannulation area. In most cases, the true lumen is found near the minor curvature of the aortic arch. Although occasionally its diameter may seem small and much smaller compared to the false lumen, it is important to note that the actual size is usually larger, as the angio-CT, being performed in the diastolic phase, always reduces its apparent size. This means that, when performing the cannulation in the distal ascending aorta, near the pulmonary artery, the depth at which we find the true lumen may vary depending on the case, but almost always we will find it there. To facilitate the puncture using the Seldinger technique, described in the article, we also use epiaortic

ultrasound. This provides us a clear depth at which the true lumen is located, allowing us to visualize in real-time the puncture and insertion of the guide. Once inside, we advance towards the descending aorta. At this stage, TEE comes into play, confirming precisely that the guide is inside the true lumen. At this point, we proceed to the cannulation with a cannula, in our case of the EOPA type from Medtronic® of 18-20Fr. However, instead of inserting just 2 cm, we advance it 3 to 5 cm and fix it to the skin or cloth to avoid unintentional decannulation during the cooling process in the CPB.

In their article, Yousef et al. describe that the only contraindications for carrying out central aortic cannulation, based on safety issues, were cases of rupture and tear (primary or secondary) in the arch, as well as circumferential dissection of the same. These situations represented only 15% of the dissections intervened. However, in our experience, even in these cases, it would be feasible to perform central cannulation.

Evidently, the main limitation of this study lies in its retrospective and observational design. Moreover, surgeons had the freedom to choose between central and peripheral cannulation, depending on their preferences and the patient's anatomy. Although confounding factors were controlled through multivariate analysis, patients undergoing peripheral cannulation, whether axillary or femoral, generally represented cohorts with higher surgical risk and underwent more complex procedures. The small sample size of the group of patients cannulated peripherally is a limitation in itself due to its lower statistical power and the impossibility of conducting a propensity analysis. Lastly, the fact that the study was conducted at a single high-volume center, with extensive experience in central cannulation, raises questions about the generalizability of these results to other institutions.

As Henry Ford once said: "if you always do what you've always done, you'll always get what you've always got." Counterintuitively, some surgical techniques in cardiac surgery, such as transcatheter aortic valve replacement through a transcarotid approach, are proving to be equally valid or even superior options to those traditionally considered of choice. Similarly, in the case of ATAAD, central aortic cannulation, at first glance and without knowledge of these studies, might not seem the most logical option due to the risk of a definitive rupture of an already compromised aorta. However, studies like the one conducted by Yousef et al., which demonstrate that central aortic cannulation offers results at least comparable and can be performed safely, support the idea of adopting it as the technique of choice in most cases of ATAAD, or at least considering it as an available option if necessary.

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Elio Martín Gutiérrez

Malperfusion in Type A Aortic Dissection: Solve it…, and solve it quickly.

Single-center study of the experience at the University of Pittsburgh Medical Center describing their approach to Type A aortic dissection focused on minimizing complications of cerebral and peripheral malperfusion.

Organic malperfusion is a condition associated with acute Type A aortic syndrome that greatly complicates survival. Given that this pathology is dynamic and time is crucial for survival, we must address it comprehensively from the preoperative to the first hours/days of the immediate postoperative period. In fact, malperfusion can persist even after achieving successful repair of the aortic entry site. And, what may be even more concerning, it can be caused by redirecting the flow to the true lumen when some structures depended on their perfusion through the false lumen. Although this scenario is less common, it is not impossible.

The TEM classification, which has already been discussed in detail in previous blog entries, refers to the presence of malperfusion systematizing it with values for the M element (malperfusion) at 0: absent, 1: coronary, 2: of supra-aortic trunks, and 3: spinal, visceral and/or lower limbs. This classification adds nuances (+) or (-) depending on the presence of compatible clinical signs or that, during the exploration/anamnesis, the patient does not show them. It is a dynamic entity so we must always keep in mind that, what we have assessed in the tomographic study is not necessarily the exact situation we will face during the intervention minutes or even hours later.

The mechanisms by which malperfusion occurs are classified into static and dynamic. The former arise from an occlusion of the true lumen of the vessel by progression of the dissection in it and pressurization of the false lumen, generally in a cul-de-sac, which obliterates the flow in it. The dynamic form has two variants: the first understands a mechanism analogous to the previous one, but without complete obliteration of the flow, rather causing a critical or variable stenosis depending on the pressurization of the false lumen and the demands of the tributary territory; the second consists of a gate mechanism where the middle-intimal flap occludes the ostium of a collateral branch at its origin, like a cap, which can be reversible with a new balance of pressures between both lumens. Vessel thrombosis due to low flow and/or progression of native disease, generally atherosclerotic, will lead to a situation of fixed malperfusion, which can evolve from a previously dynamic one.

Coronary malperfusion must be corrected at the time of the intervention. To this effect, there is a little-used classification that systematizes it into A: ostial dissection without affecting the proximal vessel path of the right and/or left coronary, B: ostial dissection that extends through the proximal vessel, and C: rupture of the continuity of the middle-intimal membrane that separates the lumens of the affected coronary vessel. Situation C usually occurs at the level of the ostium and is necessarily corrected by coronary bypass. In the case of form A, mere obliteration of the false lumen with the reconstruction of the root (use of sealants, commissural resuspension of the aortic valve, and proximal anastomosis of the supracoronary conduit) are usually sufficient. Form B is the most doubtful and may be a candidate for repair by bypass, an attitude that can be taken from the outset or if the patient presents early ischemic changes from the emancipation of the extracorporeal circulation until the immediate postoperative period.

Cerebral malperfusion can present clinically from early stages of the dissection in the form of syncope or neurological deficits. Depending on the time elapsed and the degree of involvement, they can compromise the patient's viability given the low tolerance of the

nervous system to ischemia, making them irreversible and even worsening (hemorrhagic transformation e.g.) after correcting the dissection. On the other hand, it can be caused after redirecting the flow to the true lumen or, more frequently, by the creation of new entry points and, therefore, pressure balances in the manipulation of the supra-aortic trunks for its control, cerebral perfusion, etc.

Finally, M3 perfusion encompasses all that which may affect being tributary of the descending aorta. This is usually the most larval appearance, especially the spinal and, above all, the mesenteric forms. That of the limbs usually presents a better solution, through the performance of derivations. It is common for the affectation to predominantly involve one limb by extension of the dissection to the iliac or femoral vessels, being the best solution the performance of a femoro-femoral bypass from the contralateral donor territory. However, the main value of the affectation of the lower limbs lies in that it acts as a strong predictor of future malperfusion problems at the mesenteric level that have not yet manifested clinical signs.

The authors of the work describe their experience (University of Pittsburgh Medical Center) in the treatment of Type A aortic dissection. Regarding the surgical technique, the authors propose a quite particular approach. First, they prefer the initial perfusion by direct cannulation with Seldiger technique of the true lumen in the ascending aorta (technique recently analyzed in our blog). Criteria for exclusion from this approach are those described by other authors who carry out the same procedure with circumferential dissection, complex entry points in the aortic arch, and/or the presence of rupture or threatening signs of the same. Cerebral monitoring was carried out using INVOS and BIS systematically, performing cerebral protection by retrograde. This form of perfusion, in general more in disuse than antegrade perfusion in the last decade, has been revisited by different groups for its benefits in the prevention of embolism and by the absence of manipulation of the supra-aortic trunks as a source of embolism or creation of new reentries, which agree with the previously argued. The technique of choice was the replacement of the suprasinus ascending aorta and hemiarch. They only proposed the need to perform a complete replacement of the aortic arch in the presence of entry points in the aortic arch at its greater curvature, the presence of previous aneurysmatic pathology of the aortic arch, the circumferential dissection of the aortic arch or the presence of carotid dissection as a cause of cerebral malperfusion, with or without the presence of carotid thrombosis. In the case of procedures for complete replacement of the aortic arch, antegrade cerebral protection was carried out in order to achieve a situation closer to physiological in procedures with longer circulatory arrest times. The anastomosis of the trunks would be carried out extra-anatomically to a trifurcated prosthesis, sequentially and interrupting the perfusion intermittently.

The authors' experience is summarized in the period between 2010 and 2018. During the same, 467 patients were operated on, 332 of whom (71.1%) did not present malperfusion syndrome and 135 (28.9%) did. Of those who presented malperfusion, 71.9% presented only one affected territory, while 17.8% presented two and 10.4% 3 or more territories. The most frequent form was iliofemoral involvement (n = 63), followed by cerebral (n = 51), coronary (n = 29), renal (n = 26), visceral (n = 13), and spinal (n = 6). Regarding the clinical situation, they use another, also little widespread, classification of the University of Pennsylvania consisting of class a: hemodynamic stability without signs of malperfusion (48.8% in the study), class b: hemodynamic stability with signs of local malperfusion (19.7%), class c: hemodynamic instability with tamponade, rupture or shock (24.4%). This classification makes sense since none takes into account the hemodynamic situation with which the patient is intervened, with marked prognostic sense and that, in the presence of hemodynamic compromise, it is more likely that they will worsen or that situations of malperfusion that would be detected in non-gravity

contexts pass unnoticed. Indeed, 7.1% of the patients were classified in class b and transitioned to c during the evolution.

With all this, hospital mortality was 10.3%. However, this presented significant differences between patients who presented with malperfusion and those who did not (21.5% vs. 5.7%, $p < 0.001$), with the corresponding results of greater morbidity and hospital stays associated with a worse initial clinical condition. Indeed, the presence of malperfusion in any of its forms was identified as an independent risk factor for hospital mortality (HR 2.43, $p < 0.001$). Likewise, the number of territories affected by malperfusion correlated with a worse prognosis.

The authors conclude that the malperfusion syndrome is associated with higher mortality of patients operated on for acute Type A aortic syndrome and that this risk is proportional to the number of vascular territories involved.

COMMENTARY:

The acute Type A aortic syndrome, particularly in its form of dissection, is a devastating pathology that threatens the life of the patient. The correction constitutes nothing more than a palliation where the correction of the flows between the lumens seeks, at the proximal level, to prevent progression to the root that would cause the patient's death by cardiac failure due to aortic insufficiency, coronary malperfusion, and/or cardiac tamponade. At the distal level, it aims to rebalance the pressures between the lumens and protect from the malperfusion that there is, is, or is going to take place.

The results exposed in this study are absolutely enviable, describing just over 5% mortality in patients without the presence of malperfusion syndrome. They can be explained by a remarkable mastery in the treatment of this involvement, which translates into an average of almost 60 cases per year and a greater aggressiveness in the indications for approaching the aortic arch. Precisely, this is the key aspect of the work, the results of more aggressive criteria than usual, to preferably consider surgery for replacement of the aortic arch over the hemiarch. And it is that, the presence of an entry point at the greater curvature of the arch has traditionally been the main indication, but the other three have been reason for a more conservative attitude, considering the hemiarch procedure sufficient to save the patient's life. With this approach, the authors try to minimize in the surgical act the two problems of malperfusion that, either are present, or can present in the immediate postoperative: coronary and cerebral ischemia. This greater technical aggressiveness did not translate into an increase in postoperative morbidity and mortality, as traditionally considered. In this way, they leave the M3 type malperfusion, of a more larval presentation and with possibilities of short-term treatment, for a deferred approach if necessary, generally by endovascular procedures that, probably due to the low frequency of the same, do not provide details of their frequency. However, due to their aggressiveness with the approach to the aortic arch, they perform a significantly higher number of substitutions of the same in patients with malperfusion (28.6 vs. 48.9%, $p < 0.001$), with no differences in the techniques of "lax" or "frozen" elephant trunk that ranged between 6-8% and 7-10%, respectively. They also performed up to 20-23% of the cases, procedures for reimplantation of the aortic root.

In short, Type A aortic dissection teaches us that it is a dynamic pathology, so, "what we operate is not necessarily what we thought and what happens is not necessarily what we expected to leave". Around all this uncertainty is the malperfusion, one of the main causes of morbidity-mortality of the patients intervened, even with a theoretical successful repair of the entry point in the ascending aorta. Considering extending the procedures to the aortic arch seems, along with the new trends in cannulation already commented, a new approach as to address this pathology and that contravene classical

principles previously taken for granted. Yes, a greater surgical complexity may be accompanied by morbidity-mortality that could counteract the expected results, especially if the necessary experience and volume are not available, as we are discussing in this analysis. Intermediate solutions can be the application of devices like the AMDS prosthesis, which allows a more conservative approach (replacement of the ascending aorta without hemiarch in the absence of an entry point in it) and which is specially designed for the correction of cerebral and distal malperfusion by means of obliterating the false light with the implantation of an open-cell stent. Until then, we only have prudence and good practice, without losing sight of the silent killer that is malperfusion.

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Elio Martín Gutiérrez

Surgical Risk Assessment in Aortic Dissection: The New German Tool

Validation of the perioperative risk prediction system for patients undergoing type A aortic dissection repair derived from the GERAADA German registry.

Surgical risk prediction tools are a useful tool in the stratification of clinical management of patients as well as providing a benchmark for adjusting the outcomes reflected in a registry or in the experience of a center. Typically, the EuroSCORE II and STS-score have been the reference systems, but the representation of different types of pathology or population subgroups in them has limited their validity in other contexts. Thus, the representation of women with coronary pathology, the treatment of isolated tricuspid insufficiency, patients with chronic liver disease, among others, did not demonstrate adequate representation in these databases, having derived initiatives such as the TRI-SCORE or the application of the MELD score, which had already been previously analyzed in the blog, as better predictors of surgical risk and outcomes.

It is worth noting that these types of risk scales are indicative, distribute patients in a graduation of low, moderate, or high risk, but the value they offer should not be considered to the letter for each particular case, where a risk range should be taken into account when informing the patient, once estimated based on their clinical condition and particular characteristics of each case. And what we consider low, intermediate, or high also varies from one pathology to another, with different degrees of definition. We know that for revascularization surgery a risk of 4% would be high, while for aortic valve replacement, as is widely known, it would be the limit to start considering a moderate risk.

Type A dissection also constitutes a special context where EuroSCORE II shows notable gaps. It is an entity that involves systematically marking emergency items and aortic surgery, two of the ones that have the greatest impact on surgical mortality. However, the weight that has been given to them in EuroSCORE II comes from the aggregation of cases included in its development in which, the presence of these variables, was not necessarily due to cases of type A aortic dissection. In addition, the interaction that these variables present in the model, with each other and with others such as age, renal dysfunction, need for multiple surgical procedures, or critical perioperative situation, probably is not specific to the context of type A aortic dissection but derived from the entire spectrum of cardiovascular surgery. Finally, there are peculiarities such as the location of the entry door, the extension of the dissection, or the presence of territories with poor perfusion that are important determinants of the patient's prognosis and that are not considered.

Czerny et al., based on the powerful database of the German registry GERAADA, developed a predictive model that today, the authors of the work try to validate in the experience of their institution, in a context with similarities and differences with the original, such as the American system (Pennsylvania). Between 2010 and 2021, they included the retrospective experience with 689 patients operated on for type A aortic dissection. The overall mortality of the series was 12% at 30 days, involving 80% type I dissections, with 27% of patients hemodynamically unstable, with poor perfusion of at least one territory in 41% and with significant aortic insufficiency in 23%.

The GERAADA scoring system comprises a stratification into low risk <15%, intermediate 15-30%, or high risk >30%. It is assumed that the skill of the Pennsylvania group is enviable, since it is impossible to believe that the average mortality is entrenched in a profile of low risk due to the characteristics of the operated patients. Although the

American system is more selective than the European environment in the choice of candidates for surgery, it is more likely that the data is due to the good results that are well below the predicted risk. This is proof of the low utility of these risk assessment systems in predicting specific risks (adjustment), which has nothing to do with the true function, the stratification of patients.

And in this aspect is where he demonstrated good discrimination capacity, with an area under the ROC curve of 0.76. The authors conducted subanalyses determining the discrimination capacity in different risk subgroups within type A aortic dissection. Thus, the GERAADA score demonstrated the best discrimination for the presence of the primary entry in the aortic arch (area under the ROC curve of 0.86) and for the presence of significant aortic insufficiency (area under the ROC curve of 0.82). The worst discrimination occurred in cases of reoperation due to the presence of previous surgery (area under the ROC curve of 0.69) and the need for resuscitation prior to surgery (area under the ROC curve of 0.67). As for the age groups, the best discrimination occurred for patients between 50 and 59 years old (area under the ROC curve of 0.81), being poorer in patients with extreme ages >80 years old (area under the ROC curve of 0.64).

The authors conclude that the GERAADA scoring system is a practical and easily accessible tool to reliably estimate the 30-day mortality risk of patients undergoing surgery for acute type A aortic dissection.

COMMENTARY:

The existence of surgical risk estimation scales is, for the generations that we currently find ourselves in active, inherent to the surgery we perform. Probably, derived from the high standardization of most procedures, it is possible to apply this type of methodologies that, in other fields of surgery, would be unthinkable. Also, in the DNA of those generations is the work with databases and records, which is a desire to compare ourselves with others and, now more than ever, with the interventional competitor.

The GERAADA score (https://web.imbi.uni-heidelberg.de/geraada-score/) is a logistic model analogous to EuroSCORE II that contemplates the following variables: age, sex, need for resuscitation prior to surgery, previous cardiac surgery, intubation and mechanical ventilation upon patient reception, preoperative catecholaminergic support, presence of aortic insufficiency, presence of poor perfusion (with the same criteria as the TEM classification), presence of preoperative neurological deficit (hemiparesis/plegia), extension of type A dissection and location of the entry door (again compatible with the TEM classification).

Naturally, models like that of GERAADA have been developed in environments and with the experience of centers that, probably, exceed those of many others, including our country. However, it seems realistic since it may overestimate the risk in patients undergoing surgery in experienced centers in aortic pathology with results well below the predicted risk. And, I repeat, in calibration the important thing is not the prediction but the stratification when making decisions with individual patients. For this reason, a context of similar gravity as type A aortic dissection and surgery of such complexity as that required, involves too many details that can "make you go from joy to tears" in a matter of seconds, and mark the prognosis of the patient. In this way, it is necessary to incorporate them, as far as possible, into these models in the form of those clinical conditions in which such complications or adverse events can occur more frequently. In fact, it can be seen how the predictive capacity of the score changes in the subanalyses when considering variables that condition the technical complexity or the variability of the clinical context such as the presence of an entry door in the aortic arch, the age of the patient or hemodynamic instability.

German tools remain reliable. Czerny and the GERAADA registry provide us with a useful tool in decision-making in a context as adverse as aortic dissection. The authors of this work have validated it in the experience of a high-level American center. It would be very good to replicate similar experiences in our environment, for example, combining it with the data of the Spanish Registry of Cardiac Surgery (RECC)… who dares?

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Lourdes Montero Cruces

Implementation of a Multidisciplinary Network for Acute Aortic Syndrome: The Aorta Code

Description of the Aorta Code, a program aimed at improving outcomes in the treatment of acute aortic syndrome across a network of 5 hospitals through early diagnosis, immediate transfer to the reference center, and treatment by an expert multidisciplinary team.

Acute aortic syndrome type A is a pathology with high morbidity and mortality due to the natural history of the disease, the frequent delays in diagnosis, and the complexity of its treatment. Emergency surgery is the treatment of choice, though hospital mortality in major series is around 17-25%. Various studies have shown significant improvement in outcomes by concentrating experience in high-volume centers with specialized multidisciplinary teams. The Aorta Code was implemented in 2019 within a cardiovascular network comprising 5 hospitals in the Community of Madrid, with Hospital Clínico San Carlos as the reference center, covering a population of 1.3 million people. It was based on three key aspects: early diagnosis, immediate transfer to the reference center, and treatment by an expert multidisciplinary team.

To increase diagnosed cases and ensure as early a diagnosis as possible, a simple diagnostic algorithm was designed, and initial training sessions were held in Emergency Services, which were repeated every six months. Regarding the protocol, once a diagnosis was established, the Hospital Emergency Services communicated with the Extrahospital Emergency Service (SUMMA 112) who activated the Aorta Code and performed the immediate transfer of the patient to the Acute Cardiovascular Care Unit of the reference center. An experienced multidisciplinary team was created there, composed of 3 Cardiologists, 2 Cardiac Surgeons, 2 Vascular Surgeons, and 3 Anesthesiologists, providing 24/7 coverage throughout the year. Upon admission, the team jointly evaluates the patient and decides the timing and type of procedure to be performed. Protocols for preoperative medical and anesthetic management were defined, and surgical techniques standardized according to anatomical and clinical features.

With the recent publication of this program's results, the purpose of today's study was to retrospectively compare all patients with type A acute aortic syndrome before the implementation of the Aorta Code (2005-2018) and after its implementation (2019-2023). Baseline characteristics, intraoperative details, and 30-day morbidity and mortality were analyzed.

Between January 2005 and February 2023, a total of 172 patients were operated on (102 in the pre-Aorta Code period and 70 post-Aorta Code implementation). During the Aorta Code period, there was an increase in the number of patients operated on per year (from 7.3 to 16.8), with an increase in the number of patients transferred from other hospitals. The median time to diagnosis (6.5 hours vs. 4.2 hours), transfer to the center (4 hours vs. 2.2 hours), and transfer to the operating room (2.7 hours vs. 1.8 hours) was significantly shorter ($p < 0.05$). Regarding surgical technique, aortic valve preservation and total arch replacement were more frequent after the Aorta Code was established, with shorter times for cardiopulmonary bypass and ischemia. There was also a significant decrease in the incidence of prolonged mechanical ventilation (53.9% vs. 36.9%), stroke (17.7% vs. 7.1%), and 30-day mortality (27.5% vs. 7.1%; $p = 0.001$).

The study concluded that the Aorta Code can be successfully implemented using a standardized protocol within a hospital network. This increases the number of cases

operated per year, shortens the times to diagnosis, transfer, and arrival at the operating room, and significantly reduces 30-day mortality.

COMMENTARY:

The goal of implementing the Aorta Code was to improve outcomes in acute aortic syndrome by optimizing resource use and reducing variability in healthcare delivery. An organizational and process change was implemented by establishing simplified and standardized diagnosis and treatment protocols, continuous medical education through training sessions at the involved centers, early transfer to the reference center, and optimal medical and surgical management by an experienced multidisciplinary team.

Some key aspects of the program's success include:

1. Having a coordinated transportation system through a single phone call to reduce pre-surgical times.

2. Having a multidisciplinary team managed by professionals from different specialties allowing 24-hour coverage every day of the week.

3. Diagnosing patients with acute aortic syndrome requires a high index of suspicion and can often be confused with other entities. Although treatment is centralized at H. Clínico San Carlos, it is crucial that other involved hospitals recognize it and activate the code promptly. The diagnostic algorithm implemented is based on three fundamental steps: initial clinical suspicion, basic evaluation with complementary tests, and confirmation or exclusion of the pathology through diagnostic imaging. The average time to diagnosis according to the International Registry of Aortic Dissection (IRAD) was 4.3h, whereas after the implementation of the Aorta Code, the average time of diagnosis was reduced from 6.5 hours to 4.2 hours, thus meeting international standards.

4. Once the diagnosis is made, medical management until intervention is crucial to reduce the risk of complications and keep the patient stable. Among the measures aimed at this are strict control of blood pressure and heart rate, as well as pain management.

5. Close collaboration between the Cardiac Surgery and Vascular Surgery teams allows for joint planning of procedures to define the most appropriate surgical strategy based on the clinical and anatomical profile of the patient, reducing the risk of developing certain complications, including malperfusion syndrome.

6. Regarding surgical technique, after the implementation of the Aorta Code, surgery was of greater complexity and quality, with a higher number of complete arch replacements (20.6% vs. 40.0%) and most performed using the frozen elephant trunk technique. Various studies demonstrate the association between experienced surgical teams and improved outcomes in type A acute aortic syndrome. In the pre-Aorta Code era, interventions were performed by 8 different surgeons, while after the implementation of the Aorta Code, 94% of the interventions were performed by two surgeons members of the multidisciplinary team.

7. Finally, the implementation of a standardized protocol for patient management during the intervention, with strict intraoperative monitoring, and adequate myocardial and cerebral protection during cardiopulmonary bypass is important. Considering all the previously mentioned measures, the Aorta Code has had a significant impact on the short-term morbidity and mortality of patients operated on for type A acute aortic syndrome. The effect of these measures on long-term terms of reintervention and survival currently requires further follow-up.

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Bunty Ramchandani

Conservative Management of Type A Aortic Dissection Remains an Option

Contemporary Data on Conservative Management of Type A Aortic Dissection in Non-Surgical Patients from the University of Michigan.

"Life's tragedies are fundamentally arterial," this is a phrase by William Osler referring to aneurysms and aortic dissections, which remains valid to this day. Aortic dissection is a rare pathology affecting 2-4 patients per 100,000 person-years, with two-thirds being type A, and more frequently affecting males than females. The associated risk factors include hypertension, atherosclerosis, aortic aneurysms, connective tissue diseases, and a history of cardiac surgery. In contrast, a bicuspid aortic valve is a risk factor for aortic aneurysms but not for dissections. Historical cohorts, prior to the 1990s, show a survival of type A aortic dissections managed medically of 43% in the first month and 39% in the first year (Masuda Y et al.). Indeed, the mortality from type A aortic dissections is 1-2% per hour that passes before intervention, which is the benchmark for standard treatment. In the 1990s and 2000s, surgical techniques have been refined with antegrade cerebral perfusion, neuromonitoring, and minimizing, even avoiding, cardiocirculatory arrest. However, despite advances, there remains a portion of the population who are not, and will not be, candidates for surgical treatment due to high surgical risk either from clinical situation, comorbidities, and to a lesser extent, patient's own will.

Today's article aims to evaluate the outcomes of patients who were not operated on with type A aortic dissection. For this purpose, they collected data from all dissections operated on at the Ann Arbor Cardiovascular Center, Michigan, from 1996 to 2021. A total of 999 patients came to the center with type A aortic dissection, of which 839 received surgical treatment, 148 were managed with medical treatment and 14 received endovascular treatment. The patients assigned to be medically treated were due to severe comorbidities, organ failure or malperfusion syndrome that increased the surgical risk prohibitively, as well as some cases were by the patient's will. The data was taken from the STS database and crossed with national and state of Michigan mortality databases, so the patient follow-up was 100%.

Hospital and 30-day mortality in the medically managed cohort was 9 times higher than the surgical cohort (70% vs. 7.9%). The results of this cohort improved over time and when analyzed by decades (1996-2021 vs. 2011-2021), mortality improved (87% vs. 58%; $p < 0.001$), the risk of aortic rupture decreased (21% vs. 8%; $p = 0.008$) and 3-year survival improved (13% vs. 29%; $p = 0.005$). Analyzing the non-surgical cohort more deeply, patients with malperfusion syndrome had similar in-hospital and 30-day survival to those who did not present this syndrome. However, the risk of aortic rupture was four times higher (OR = 4.1; $p = 0.03$). On the other hand, the intramural hematoma turned out to be a protective factor of mortality (OR = 0.36; $p = 0.02$).

The authors concluded that surgery in the context of type A aortic dissection remains the standard of treatment. However, alternative treatments such as medical and/or endovascular are a real option in comorbid patients or with malperfusion syndrome, especially in the case of intramural hematoma.

COMMENTARY:

The IRAD registry (International Registry of Acute Aortic Dissections) has reported in a recent study a survival of 62.3% in patients treated medically, data that the present study corroborates. These data are relevant because they allow us to have a cut-off point of surgical risk after which it is better to manage patients medically. Indeed, Centofanti et

al. developed a mathematical model to calculate the risk of these patients taking into account age, renal failure, cardiogenic shock, presence of coma, and need for reintervention.

As for medical management, it consists of aggressive blood pressure control aiming to keep systolic pressure below 100 mmHg. Aggressive pain control and absolute rest during the first two weeks are also important. Patients with multi-organ failure or shock will also require pertinent management of complications. Globally, the treatment will be very similar as for a surgical candidate only prolonged. The benefits of this strategy have already been analyzed for intramural hematoma in previous blog entries. Extending it now to more complex forms of presentation of type A aortic syndrome, it is necessary to repeat the imaging test after the first week to determine the dissection situation. At the Ann Arbor cardiovascular center, they were very aggressive with malperfusion syndrome and all non-surgical patients who presented this complication were treated using endovascular procedures. Not without reason, because the risk of aortic rupture in patients with this complication was OR = 4.1. Because of this, mortality in their non-surgical cohort stratified by malperfusion was similar.

Coming to the part of the limitations, we must remember that this article is a single-center retrospective study. The sample size of the cohort studied was small to be able to draw solid conclusions and not fall into type II error. Also, being a center specialized in aortic pathology, the results are hardly extrapolable to our daily practice. Not everywhere is so aggressive in treating malperfusion syndrome.

In conclusion, there is no doubt that surgery is the treatment for type A aortic dissection. However, in certain cases, the patient we are evaluating will not be operable and in such a scenario medical management can provide a solution, if not real, at least pragmatic. As long as, aggressive blood pressure control is maintained, if the patient survives up to 30 days they will probably have overcome the aortic dissection... a benefit that may be greater than what a surgery could offer, which, if performed, might condition that to be their last day of life. Let us remember the old surgical aphorism, "do not operate on a patient on the day of their death."

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José Manuel Martínez Comendador

FET Procedure and Paraplegia in Acute Dissections: Is the Key the Degree of Involvement of the Posterior False Lumen?

A retrospective study investigating the association of involvement of the posterior false lumen in the descending aorta and post-surgical paraplegia after a frozen elephant trunk intervention in acute type A aortic dissection.

The total aortic arch replacement using the frozen elephant trunk (FET) procedure has shown to promote beneficial aortic remodeling and facilitate future interventions on the descending aorta, as previously discussed in our blog.

Spinal cord ischemia (SCI), especially paraplegia, represents a devastating complication after aortic repair for acute type A aortic dissection (ATAAD). Specifically, one of the major challenges associated with the FET procedure is the observation of an increased incidence of postoperative paraplegia in patients with ATAAD. However, these previous studies have been limited by the small size of patient cohorts, and the risk factors for paraplegia remain unclear due to the limited application of the FET procedure in this population.

A large extension of the false lumen (FL) after ATAAD has been previously associated with an increased risk of late aortic reintervention and distal aortic dilation, as has been discussed in recent publications also addressed in our blog. What had not yet been studied was whether the location of the FL within the descending aorta could significantly affect the blood supply to the spinal cord in ATAAD. When the FL is located in the most posterior position closest to the spinal column, it is reasonable to assume that the bilateral segmental arteries (SAs) will be compromised by the dissection, increasing the risk of paraplegia. This study aimed to investigate the association between the number of segments of the posterior false lumen (PFL) and paraplegia after an FET procedure in patients with ATAAD.

From January 2013 to December 2018, this study included 544 patients with ATAAD who underwent FET procedures at Fuwai Hospital (China). The number of PFL segments between T9 and L2 levels was calculated. Hospital outcomes and long-term survival were analyzed based on the number of PFLs.

The average age was 46.5 ± 9.9 years and 19.5% of the patients were women in this cohort. The incidence of postoperative paraplegia significantly increased when PFL was present in 3 or more segments. Patients were divided into a high PFL group (3-6 segments; n = 124) and a low PFL group (0-2 segments; n = 420). Demographic characteristics were similar between both groups. The involvement of the celiac artery and the superior mesenteric artery was significantly lower in the high PFL group (p < 0.05). Other baseline characteristics and variables were statistically balanced. The incidence of postoperative paraplegia was significantly higher in the high PFL group (7.3% vs 1.9%; p = 0.006). Multivariable logistic regression analysis revealed that high PFL was independently associated with postoperative paraplegia after an FET procedure (odds ratio, 3.812; 95% CI, 1.378-10.550; p = 0.010). Additionally, a moderate nasopharyngeal temperature during hypothermic circulatory arrest (>23.0 °C) was identified as a protective factor for paraplegia (odds ratio, 0.112; 95% CI, 0.023-0.535; p = 0.006).

Patients with ATAAD who present a high PFL between T9 and L2 levels have a significantly elevated risk of postoperative paraplegia if they undergo an FET procedure.

COMMENTARY:

The FET procedure has been increasingly used in ATAAD to extend the repair distally, especially in patients with intimal tears in the aortic arch and distal malperfusion syndrome, almost invariably in patients with DeBakey type I dissections (as was the case for all patients included in this study). The expectation is that the FET procedure will improve long-term aortic remodeling and reduce the need for reintervention.

However, the incidence of SCI associated with the FET (approximately 5%) seems to be consistently higher than the incidence observed with DAA intervention without FET. A hypothesis related to this association is the use of an excessively long endoprosthesis (>15 cm) or extended coverage of the descending aorta beyond T8, as demonstrated in the meta-analysis conducted by Preventza and colleagues. The study by Yamamoto et al., recently discussed in detail in this blog, showed a reduction in malperfusion syndrome and SCI, provided the distal end of the FET does not exceed T8-9, even when using long prostheses with a 150 mm stent, implanted from the aortic zone 0. On the other hand, besides the length of the endoprosthesis, another possible cause of SCI could be thrombosis of the PFL in its posterior part, in the area corresponding to the SAs. Indeed, a single-center observational study in Germany showed that extensive thrombosis of the PFL is associated with SCI.

In the study by Wei et al. that we discuss today, they go a step further and try to analyze the association between the degree of involvement of the PFL in patients undergoing the FET procedure for ATAAD and the incidence of SCI. Their hypothesis is that, since the SAs originate in the posterior part, the FET procedure will promote thrombosis of a greater number of these arteries if a greater proportion of the FL is located in a posterior position. The implication is that, because the FET procedure promotes FL thrombosis, patients with a greater number of segmental arteries originating from the FL will experience more SCI.

One of the study's limitations to highlight is the youth of the operated patients and that they were operated on by experienced surgeons. Although this was a retrospective study conducted at a single center, it has great merit, as they were able to collect image data from a cohort of 544 patients undergoing ATAAD repair. Wei et al. found a significantly higher incidence of postoperative SCI (7.3%) among patients with PFL in more than 3 spinal segments, compared with the cohort with PFL in 2 segments or less (1.9%). This very explicit association has been demonstrated for the first time. Furthermore, they discovered that moderate hypothermia is protective against postoperative paraplegia.

The relevance of this study lies in that its results validate for the first time the idea that acute thrombosis of a significant number of SAs after the FET procedure can trigger SCI. This conclusion suggests that the risk of SCI could be assessed by a detailed review of preoperative computed tomography (CT). The surgical planning of ATAAD through a thorough review of CT is crucial; however, this study provides us with another variable of utmost importance to consider in surgical decision-making. If an increase in the presence of PFL is observed, avoiding the FET procedure, opting for revascularization of the left subclavian artery, or adopting a more aggressive approach in spinal cord protection strategies during the procedure and in the Intensive Care Unit might be considered. On the other hand, if the presence of PFL is minimal, proceeding with the FET operation in patients with marginal indications for extended aortic arch repair might be justified, given its presumed long-term benefits. The upcoming randomized controlled trial, Hemiarch vs Extended Arch in Type 1 Aortic Dissection (HEADSTART; NCT03885635), which will compare standard hemiarch surgery with extended aortic arch surgery in patients with ATAAD type I from DeBakey, will surely shed light on many of

the uncertainties related to the FET procedure. Meanwhile, we will continue applying common sense based on the available evidence.

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Audelio Guevara Bonilla

Is Right Axillary Artery Cannulation Safe in Dissected Right Axillary Arteries in Acute Type A Aortic Dissections?

Observational, single-center, retrospective study analyzing the safety, in terms of hospital mortality and stroke, of cannulation over a dissected right axillary artery.

The indication for emergency surgery in a type A dissection, according to the Stanford classification, is clearly established. Likewise, it is considered that the cannulation of the right axillary artery (RAA) is the first option to initiate antegrade perfusion with cardiopulmonary bypass (CPB), being an indication IIa according to current clinical guidelines. Several studies emphasize the benefits of this type of cannulation, including that of Rosinski et al., carried out at the Cleveland Clinic, where it was observed that this cannulation route was safe and offered good results for reestablishing adequate systemic perfusion. However, although the indication is clear, it is not well established what to do in the presence of a dissected axillary artery. This scenario could pose aborting the use of this route for the initiation of systemic perfusion. This study seeks to clarify whether the use of a dissected right axillary artery (DRAA) is safe and if there are repercussions on the evolution of these patients, with the primary objective being hospital mortality and stroke with sequelae.

The paper we will review is an observational retrospective cohort study. The records of all patients who underwent type A aortic dissection surgery from January 2016 to November 2020 were reviewed. The strategy for perfusion in this center was normally direct right axillary artery cannulation unless anatomical problems (depth for the approach, small diameters, arterial calcification) or technical problems made it impossible, in which case alternative femoral cannulation was performed (in some cases double axillary and femoral cannulation), over the brachiocephalic trunk or central cannulation by the Seldinger technique. The primary endpoints were hospital mortality and established stroke. Secondary objectives included complications related to RAA cannulation.

From a purely statistical point of view, an initial univariate analysis of all variables involved in the study was carried out, followed by a bivariate analysis of each predictor variable with the response, after which the most important variables were selected to perform a multivariate analysis using a propensity score adjustment. Finally, a multivariable logistic regression was performed to define the specific contribution of each predictor.

A total of 931 type A aortic dissections were urgently intervened at the Guandong Provincial Hospital, of which only 835 patients would have an adequate study with CT. Of the 835 patients, 124 (14.9%) presented right axillary artery dissection; the rest, 711 (85.1%) did not. The majority of the patients were male in both branches. There was a greater presence of moderate-severe aortic insufficiency and poor cerebral perfusion in those patients with a DRAA.

The rate of failed cannulation was higher in patients with DRAA, but not statistically significant (2.4% vs. 0.7%, $p = 0.102$). Five patients presented vascular complications related to cannulation, however, all of them belonged to the group of non-dissected right axillary artery. No case of upper limb ischemia was observed after cannulation.

With a propensity analysis, the percentages of in-hospital mortality (13.4% vs. 12.5%, $p = 0.842$) and stroke (9.8% vs. 7.1%, $p = 0.472$) did not show statistically significant differences. Through a multivariable logistic regression analysis, it was concluded that

age (p = 0.045), circulatory collapse (p = 0.010), coronary disease (p = 0.046), the need for coronary bypass (p = 0.012) and time on CPB (p = 0.001) were independent predictive factors for in-hospital mortality. With the same analysis, the presence of DRAA was not considered a predictive factor for hospital mortality (p = 0.431) or stroke (p= 0.276).

The conclusion reached after the analyses performed was that cannulation over a dissected right axillary artery is possible and safe at least in experienced centers.

COMMENTARY:

Despite the accumulated experience on the surgical approach in type A aortic dissections, there may be some controversy about the arterial cannulation route to reestablish systemic perfusion through true lumen, especially given the heterogeneity of cases and the variability of findings that we can encounter in imaging tests. This article by Tong et al. addresses a topic of great clinical impact, as it is part of our attitude in managing a type A dissection and specifically in how to act in the face of a dissection that progresses towards the right axillary artery, considering that it is the most commonly used arterial cannulation route.

Several experts advise not to perform a cannulation over a dissected artery due to its fragility and susceptibility to new ruptures which could produce a new reentry and an alteration of the flow with the risk of expanding the false lumen, so they would opt for an approach of a femoral artery even when it does not follow a physiological flow as it is retrograde flow. Given the absence of a consensus in this problem, there are those who mention that cannulation over a dissected right axillary artery is possible, without presenting vascular or systemic perfusion complications in CPB, which represents the hypothesis that is studied in this article.

Although the conclusions and results observed in this article, in terms of hospital mortality, established stroke or vascular complications, encourage cannulation over a dissected right axillary artery, it would be correct to clarify certain points:

First, it is a single-center study which clearly limits its external validity. Second, the statistical techniques selected for this study are correct, although a sufficient number of events is not available so that the estimates of the coefficients of each predictor variable are sufficiently precise. We assume that the absence of collinearity or autocorrelation between an excessive number of predictor variables has been tested, although the article does not comment on it, since this could be a cause of unstable estimates (wide confidence intervals of the odds ratio) of the coefficients of the predictor variables. It is noteworthy within the analysis of Tong et al., that once the adjustment by propensity analysis was made, the most appropriate thing to know the causal effect of the dissection of the right axillary artery against the non-dissection on the primary and secondary objectives, would have been necessary to carry out directly a bivariate analysis between the matched variable (DRAA vs. RAA) and the result, since the two branches (DRAA vs. RAA) are already comparable in terms of causality. Certain events such as cannulation failure and vascular complications probably should not be used as secondary outcomes due to their low incidence. In summary, a greater number of events is needed to reach statistical power and precision in the estimates. Third, the extent of the dissection on the right axillary artery is not clearly defined, so it could be that the cannulation was performed only in cases of proximal dissection from the subclavian origin. Considering that a dissected artery is very fragile and susceptible to intimal ruptures, it would draw attention to the realization of a direct cannulation and the almost null vascular complications. The work also does not specify the technique used, whether semi-Seldinger with open vessel exposure, pure percutaneous Seldinger or with the interposition of an 8 mm Dacron conduit anastomosed end-to-side. In case of extensive

dissection of the axillary artery, it could be suggested the opening and intimal inspection of the artery and subsequent performance of an 8 mm Dacron conduit anastomosis, which would offer greater safety of remaining in true lumen and of avoiding intimal ruptures posterior to the cannulation point produced by a direct cannulation by Seldinger techniques. In conclusion, this is a very interesting article that encourages cannulation over a dissected right axillary artery, but it must be interpreted with caution given the limitations of the study. Finally, the technique used for the initiation of perfusion in CPB will continue to depend on the individual characteristics of each patient and even on the way of working of each center.

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Elio Martín Gutiérrez

Residual aortic growth after type A dissection repair in bicuspid and tricuspid aortic valves: which fares worse?

This study examines the evolution of the residual aorta post-type A dissection repair, distinguishing patients with bicuspid (BAV) versus tricuspid (TAV) aortic valves.

We have consistently observed that the ascending aorta in patients with bicuspid aortic valve (BAV) seems to be of inferior quality compared to those with tricuspid aortic valve (TAV). Microscopically, BAV patients exhibit more advanced degenerative changes (disruption of elastic laminae, enhanced metalloproteinase activity, cystic medial degeneration), yet it remains unclear whether this is due to a genetic predisposition or hemodynamic stress. The lack of a well-defined genetic profile for aortopathy likely suggests a complex polygenic background, beyond the simple autosomal dominant/recessive or X-linked inheritance, with contributions from environmental factors and hemodynamic stress further complicating its clinical presentation.

Building on this premise, the survival of a patient post-repair of an aortic dissection raises the question of whether the distal aorta will exhibit behavior distinct from that of the proximal, now replaced by a prosthetic graft. This study, from a Michigan-based group, addresses this question by analyzing data from the STS registry for 655 TAV and 60 BAV patients who underwent type A dissection repair at their institution between 1996 and 2021.

Preoperative differences between groups were minimal, with BAV patients being younger (54 vs. 61 years; $p < .001$) and a higher rate of hypertension in the TAV group (67% vs. 78%; $p = .05$). BAV patients underwent aortic root replacement more frequently (70% vs. 26%; $p < .001$) and had more aortic valve replacements, often associated with Bentall-De Bono procedures, while valve-sparing root replacements were more common in the TAV group (20% vs. 65%; $p < .001$). Distal extension typically involved hemiarch replacement (67% vs. 60%, $p = .26$), with minimal full or partial arch replacements without differences between groups. Only 6.7% and 4.7% of BAV and TAV patients, respectively, had isolated ascending aorta replacement. Surgical times were comparable to typical practice (circulatory arrest 29-33 minutes, cross-clamp 141-184 minutes, and cardiopulmonary bypass 214-233 minutes). Cerebral protection varied, with deep hypothermia to 17-18°C as standard; isolated antegrade perfusion was used in only 40-46% of cases, while retrograde, combined, or no perfusion accounted for the remainder (4-6%). The group achieved satisfactory outcomes, with an operative mortality of 6.7-8.2% and in-hospital mortality of 5-7.9%. Stroke rates were 6.7-6.9%, with other complications aligning with expectations for a pathology of this severity.

During follow-up, the primary objective of this study, initial mean diameters of the residual aortic arch showed no differences between groups (34-35 mm; $p = .12$), although differences were noted in the thoracic descending aorta (BAV 32.2 mm vs. TAV 37 mm; $p = .003$) and abdominal aorta (BAV 27.9 mm vs. TAV 31 mm; $p = .01$). Arch growth rates over time were not significantly different within the BAV group (mean 0.23 mm/year; $p = .13$) but were within the TAV group (mean 0.39 mm/year; $p < .001$). When comparing BAV to TAV, no statistically significant difference was observed. However, BAV patients maintained a mean offset of -1.08 mm, consistently presenting with smaller residual arch diameters ($p = .21$). For the thoracic descending aorta, growth rates were 0.61 mm/year for BAV and 0.79 mm/year for TAV, both showing significant intragroup differences. Intergroup comparison was not statistically significant, though BAV patients maintained a -4.07 mm mean diameter difference relative to TAV patients ($p < .004$). In the abdominal aorta, intragroup differences remained significant, with mean growth rates

of 0.51 mm/year for BAV and 0.68 mm/year for TAV. Intergroup mean growth rate differences were statistically significant (p = .03), with the BAV group showing a -2.94 mm smaller diameter than the TAV group (p = .005).

Only 12% of patients required interventions over the follow-up period due to progression of residual aortopathy. Among BAV patients, 8.3% required intervention on the descending aorta, and 5% on the thoracoabdominal aorta. In TAV patients, only 0.8% needed intervention on the aortic arch, 9.7% on the descending aorta (5.2% with TEVAR and 4.3% with surgery), and 1.8% required thoracoabdominal surgery. At the 10-year mark, no differences in reintervention rates were noted between BAV and TAV groups (BAV 9.7% vs. TAV 16%; p = .77). Cox regression analysis did not identify independent risk predictors for reoperation during follow-up, aside from female gender, excluding a statistically relevant role for BAV or TAV presence.

The authors conclude that BAV patients, in the absence of known collagenopathies, may be managed similarly to TAV patients regarding the evolution of the residual aorta following type A dissection repair.

COMMENTARY:

This study answers our original question: in terms of degeneration, the residual aorta after type A dissection repair does not have a worse prognosis in BAV patients compared to TAV. In fact, BAV patients show a more favorable evolution with lower growth rates at all levels and smaller mean diameters at the time of ascending aorta and/or aortic root repair. Another key contribution is data on mean growth rates, providing insights into residual aortic degeneration and highlighting the low rates of reintervention necessary for this patient cohort, which constitutes a significant portion of outpatient activity in our specialty.

Additionally, this work offers insights into the importance of acquired and hemodynamic factors in the varied presentations of aortic pathology. While every pathological manifestation has a complex genetic backdrop influencing susceptibility, it is external factors that shape the presentation and explain the wide clinical spectrum. Thus, excluding genetic collagenopathies, hemodynamic factors primarily drive ascending aorta dilation in BAV (which does not occur in the arch or descending aorta) and likely contribute to descending aorta pathology in TAV patients with a higher age and hypertension rates.

Despite its originality, this study should not be interpreted as a typical comparative study due to significant group size disparities and the absence of matching. Preprocedural characteristics were relatively similar, making this more of a descriptive study of two independent groups, with intragroup comparisons more informative than intergroup ones. In fact, these comparisons suggest that the TAV group, given the larger sample size and greater significant differences, is more heterogeneous. Follow-up was exemplary in survivors (100%), reflecting data quality from both the institution and the STS database. Lastly, like all studies examining disease progression by intervention rates, this study has an inherent bias as it omits patients who declined intervention or were deemed too high-risk, thus systematically underestimating progression rates.

Ultimately, this study debunks the myth of poor aortic prognosis associated with BAV, at least for the arch and ascending aorta, even in the challenging context of post-aortic dissection. Such studies allow us to shift focus and achieve a 21st-century understanding, far removed from the initial impressions. This approach supports continuous learning, placing science at the service of curiosity, originality, rigor, and clinical care.

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Ramón Aranda

Reentries after type A dissection repair: the problems grow

A retrospective bicentric study using propensity score matching on over 1000 Japanese patients, analyzing the impact of primary entry tears in the descending thoracic aorta following urgent surgery for type A aortic dissection.

The extent of repair in type A aortic dissection is highlighted as a knowledge gap in this year's exceptional clinical guidelines on aortic disease, which have been previously discussed on this blog.

Resection of the primary entry tear is a procedural principle, yet this can be challenging in patients with entry tears located in the descending thoracic aorta. This article focuses on analyzing a pertinent question: What is the significance of residual primary entry tears in the descending thoracic aorta following surgery? Are there age-related differences?

This year, Kawaito et al. published in *Annals of Thoracic Surgery* an analysis on the impact of primary entry tears in the descending thoracic aorta in over 1000 patients who underwent type A aortic dissection repair in two high-volume Japanese centers, with a median follow-up of 16 years.

The authors reviewed patients over a 28-year period, dividing them into two age groups (older or younger than 70 years), further categorized based on the presence of a primary entry tear in the descending thoracic aorta.

The surgical intervention generally followed the tear-oriented approach recommended by guidelines:

- Hemiarch replacement if the entry tear was located in the ascending aorta (E1), lesser curvature (E2, lesser curvature), or if no entry tear was observed in the root, ascending aorta, or arch (E0 or E3).

- Total arch replacement (TAR) if the entry tear was found in the arch or supraaortic vessels (E2, greater curvature).

Myocardial protection was achieved with cold blood cardioplegia, applied retrograde or antegrade. For perfusion and organ protection, deep hypothermia at 20ºC was used until 2008, and subsequently either deep or moderate hypothermia (20-28ºC) with selective cerebral perfusion (either unilateral or bilateral) was applied. The patient group distribution for each method was not reported in the article.

In the younger group, there were 191 patients with a residual entry tear in the descending thoracic aorta (E3, 28%) and 490 patients without a residual entry tear (72%), compared to 74 patients (E3, 18%) and 348 patients (82%) in the older group under the same categories. Propensity score matching using the nearest neighbor method without replacement resulted in 179 and 71 pairs, respectively, in each age and entry presence category.

The primary outcome was a composite event termed "DAE" (distal aortic events), encompassing malperfusion, recurrence of new distal dissection, rupture, reintervention, or death due to an aortic event.

Short-term outcomes reported an overall in-hospital mortality of 7.4%, with no differences between age groups. Hospital morbidity was also similar across groups.

Regarding the type of surgery, TAR was more frequent in patients without residual entry tears across both age groups. Among those with residual entry tears in the descending thoracic aorta, 89% of younger patients and 96% of older patients underwent hemiarch or ascending aorta replacement. Root surgery was uncommon, with no cases in patients over 70 years and less than 5% in younger patients.

Patients with residual entry tears had shorter cardiopulmonary bypass (CPB) times (139 vs. 207 min in patients under 70 years), likely due to the reduced surgical extent. No differences were observed in morbidity or mortality between groups.

Long-term follow-up, with a median of 16.8 years and an exceptional follow-up rate of 98.7%, showed similar 10-year survival rates between groups with and without residual entry in those under 70 (72% vs. 74%) and those over 70 (53% vs. 52%). Deaths at 10 years from non-aortic causes were more frequent in patients over 70 years (37.3% vs. 14.2%; $p < .001$).

Distal aortic events (DAEs) were more frequent in younger patients (80 vs. 13 cases). Younger patients with residual entry tears had more frequent DAEs at 10 years compared to those without (35% vs. 22%; $p < .001$). However, no differences were observed in the older group at 10 years (11% vs. 9%).

COMMENTARY:

This is not the first time that Kawahito et al.'s group has published on this topic; however, this analysis focuses on primary entry tears in the descending thoracic aorta. Importantly, we are not referring to reentries in the descending thoracic aorta, but to patients without observable entry tears in the arch or ascending aorta in type A dissections or whose entry tear is in the descending thoracic aorta. This phenomenon, termed by some as non-iatrogenic retrograde aortic dissection, may lead to persistent pressurization of the residual false lumen, potentially resulting in an increase in late aortic events.

Although rare, type A dissections originating from an entry tear in the descending thoracic aorta (A,E3) may account for approximately 7% of all type A dissections, as indicated by the International Registry of Acute Aortic Dissection (IRAD).

This study compares patients with primary entry tears in the ascending aorta or arch against those with entry tears in the descending thoracic aorta, categorized by age.

The study's main conclusion is clear: residual primary entry tears in the descending thoracic aorta do not affect 10-year mortality but do increase the frequency of distal aortic events in patients under 70.

Various factors should be considered:

Definitions: The terminology used may cause confusion as patients are classified based on preoperative CT scans and intraoperative findings, comparing classic type A dissections (A, E1-2) with retrograde dissections (A, E3). Thirty patients in the residual entry group underwent arch surgery, but details on the false lumen patency and whether the elephant trunk technique was applied remain unknown.

Age: An arbitrary cutoff of 70 years was used, yet younger patients with aortic dissection may have a genetic predisposition. Detailed descriptions of patients experiencing late aortic events, including age and associated pathology, are missing.

Repair Extent: The tear-oriented approach to ascending aorta and arch is recommended in the 2024 guidelines. Most patients with residual entry tears underwent ascending aorta

replacement or hemiarch, with no information on the frozen elephant trunk technique. This study may prompt age-based stratification for frozen elephant trunk technique.

Postoperative Structural Changes: This study lacks information on false lumen status, residual aorta diameters, and new distal reentries, all factors associated with late aortic events.

Survival and Follow-up Duration: Survival appears unaffected by descending aorta entry tears. The low DAE frequency in older patients (under 10%) supports a conservative approach in this group.

Mortality: Type A dissection mortality in Asian studies is typically low, with this study reporting only 7%, whereas registries like German (16%), British (17%), and international (18%) report higher rates. The study's results may not be broadly applicable to clinical practice.

In summary, recent data prompt us to reconsider management for retrograde type A dissections (entry in descending thoracic aorta or E3), especially in patients over 70. Aggressive treatment and close follow-up for those under 70 may be justified based on these findings.

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José Manuel Martínez Comendador

Frozen Elephant Trunk with Thromboembolic Complications: Are There Peculiarities in the Rate and Pattern of Complications?

This retrospective study evaluates the frequency and clinical impact of thromboembolic complications following aortic arch repair utilizing the Frozen Elephant Trunk (FET) with the Thoraflex® device (Terumo Aortic®).

The management of aortic pathology in the aortic arch and its proximal segments remains a technical challenge for cardiovascular and vascular surgeons, carrying a high risk of stroke, mortality, and other postoperative complications. Currently, the surgical approach is not limited solely to the aortic arch and ascending aorta but also extends to the descending section. The FET technique involves a hybrid device that integrates a traditional graft with a vascular stent graft, allowing treatment of pathological descending thoracic aorta. This approach is increasingly used in both acute aortic syndromes and complex aortic aneurysms affecting the arch and descending aorta as discussed in other blog entries. Among the potential benefits of the FET technique are favorable remodeling of the distal aorta in the short and long term in cases of acute Type 1 DeBakey dissections and improvement or resolution of the distal malperfusion syndrome.

The Thoraflex® hybrid is one of five globally approved devices for FET repair. Since its approval in 2012, satisfactory clinical outcomes have been observed in the short and medium term, with acceptable rates of perioperative mortality, spinal cord ischemia (SCI), and stroke (CV). However, thrombosis in the stented portion of the hybrid graft remains a particular complication, with little knowledge regarding its incidence, clinical impact, and predisposing factors. This study aimed to assess the frequency and clinical impact of thromboembolic (TE) complications post-FET repair using the Thoraflex® hybrid. The study included 128 consecutive patients (average age 67.9 years; 31.0% females) who underwent aortic arch repair with FET using the Thoraflex® from September 2014 to May 2021 across four Canadian centers. Patient characteristics, intraoperative details, and thromboembolic complications were retrospectively collected and analyzed.

Fifteen patients (11.7%) presented thrombi within the Thoraflex® stent graft on imaging studies (n = 8; 53.3%) or experienced a thromboembolic event (n = 9; 60.0%) prior to hospital discharge. The incidence of embolism was: mesenteric (n = 8; 88.9%), renal (n = 4; 44.4%), and iliofemoral (n = 1; 11.1%). Patients with thromboembolic complications were more likely to have a history of autoimmune disease (n = 3; 20.0% vs. n = 2; 1.8%; p = 0.01) and implantation of a longer Thoraflex® stent graft (150 mm vs. 100 mm) (n = 13; 86.7% vs. n = 45; 39.8%; p < 0.001). All patients with thromboembolic complications received therapeutic anticoagulation, and some required surgical (n = 5; 33.3%) or endovascular intervention (n = 2; 13.3%). Radiographic resolution was observed in 86.7% of patients (n = 13). In-hospital mortality occurred in one patient, a stroke in another, and SCI in one.

The authors concluded that thromboembolic complications occur more frequently than previously recognized following aortic arch repair with FET using Thoraflex®, and are associated with increased rates of surgical and endovascular reintervention.

COMMENTARY:

The results from this study of patients treated with FET are notable for several reasons:

Firstly, the series shows excellent outcomes considering 20% had acute aortic dissections, 24% concurrent surgeries, 23% aortic root surgeries, and nearly 40% emergency or urgent surgeries. With a mortality rate of 4.6%, stroke rate of 6.2%, and SCI rate of 5.4%, these complication rates are lower than most published series analyzing FET outcomes. Additionally, comparing groups with or without thromboembolic complications revealed no significant differences in mortality, stroke, or SCI rates. Secondly, it provides invaluable and previously scarce information on the behavior of thrombi and/or distal thromboembolic events related to FET. 12% of all patients in the series met these criteria. Of these, 5% presented a thrombus within the FET alone (without clinical manifestations), another 5% experienced isolated distal thromboembolic events, and 2% had both a thrombus within the FET and a distal thromboembolic event. Notably, most cases were asymptomatic (60%), though all exhibited embolic events confirmed on imaging studies and received systemic anticoagulation therapy. Lastly, in this series, 40% of these patients required surgical or endovascular treatment for their thromboembolic complications. The 12% rate of thromboembolic complications found in this study, higher than expected, might be due to the specific search for this complication in all study patients through systematic computed tomography (CT), unlike previously published studies. This might explain why this complication may have been underestimated in earlier studies with similar surgeries involving the aortic arch and FET.

The distal endoprosthesis of the Thoraflex® prosthesis is made of polyester and nitinol, materials widely used in endovascular implants due to their biocompatibility. However, when in contact with blood, their surface can activate the coagulation cascade and platelets, which can lead to blood clot formation and serious thrombotic events depending on the patient's predisposition to clotting. This study identified autoimmune disease as a predisposing factor for thromboembolic complications, a finding previously described in clinical cases. Additionally, the association with a longer endoprosthesis (150 mm) is not entirely surprising, as larger prostheses increase the blood-surface interface, which is prone to clot formation. However, no relationship was found between thrombus formation and the appearance or more or less rectified aspect of the Thoraflex® stent graft. Likely, future research in computational fluid dynamics may help better clarify if there are anatomical configurations that predispose to clot formation in FETs.

Recent publications over the last 10 years analyzing the clinical outcomes of the Thoraflex® hybrid prosthesis for FET repair are generally very satisfactory. The perioperative mortality rate varies from 0% to 12%, the SCI rate ranges from 0% to 7%, and the stroke rate can reach up to 18%. These results may be even better today, as suggested by the outcomes analyzed in this study or those derived from the ongoing U.S. Investigational Device Exemption trial for the Thoraflex® device, which is expected to publish one-year clinical outcomes soon. According to this trial, which describes the experience of 74 patients undergoing repair across 12 centers, thromboembolic events were infrequent; they occurred in only 2 (3%) patients, and none of the events resulted in death.

However, until now, we had little information about the rate of thrombosis in the endoprosthesis of this type of device because it has not been a specifically studied complication in most published series. Comparing the ischemic complication rate in TEVAR, which is around 9%, with the one found in this study, we observe similarities. However, the ischemia associated with TEVAR is not exclusively related to arterial thrombosis or embolism, as it can often be secondary to arterial dissection or even arterial obstruction that may occur as a result of endoprosthesis malpositioning. The rates vary depending on the organ under study or the scenario in which the endoprosthesis is implanted, with an SCI incidence of 1-3% or a CV incidence of 4-8%.

Therefore, these are relatively high figures for a procedure that is theoretically of lower risk than an FET procedure. Other complications are almost exclusive to TEVAR; the acute thrombotic (almost complete) occlusion of TEVAR, although very rare and described in less than 10 clinical cases in the literature, usually affects young, male patients treated with TEVAR for blunt traumatic injury of the descending aorta, with small aortic diameters, and in whom the oversizing of the prosthesis could reach up to 33%. In this study, there is no occurrence of this complication with the Thoraflex®, as it is logical, since 90% of the patients undergoing FET had aortic aneurysms. Additionally, it was confirmed that 93% of the stent grafts of the prosthesis were well expanded and none were pleated.

The main limitation of this study is its retrospective nature. It concludes that the rates of thromboembolic complications are significantly higher after total aortic arch repair using the Thoraflex® device, but this conclusion is based on the use of a single FET device and lacks a comparative device. No information was collected on the impact of the use of preoperative antiplatelet or anticoagulant agents before FET implantation, which could have influenced the incidence of postoperative thrombus formation in the stent graft. Additionally, the timing of postoperative imaging tests was not protocolized, which prevented precisely determining the exact moment of thrombus formation. Also, there was no standardized treatment algorithm to manage postoperative thromboembolic complications, although all patients with these complications received anticoagulation. Lastly, the observation period was limited to short-term results, and further studies will be necessary to assess the optimal duration of therapeutic anticoagulation and antiplatelet therapy.

Given the 5% mortality rate among 128 patients undergoing total aortic arch replacement, this study supports the excellent results of FET, particularly with the Thoraflex® prosthesis. However, the incidence of thromboembolic complications turned out to be higher than expected (12%), although no significant clinical repercussions were observed after anticoagulation (administered to all patients) or the performance of additional endovascular or surgical procedures (necessary in 40% of patients).

In light of these findings, it is important to consider the possibility of complications after the use of this prosthesis, especially in cases of patients with possible predisposing factors, such as the need for long endoprostheses, autoimmune disorders, or diseases that increase the risk of thrombosis. Prophylactic anticoagulation could be considered as early as possible and/or more stringent monitoring using standardized imaging tests in the immediate postoperative period. In any case, before sounding the alarm about the Thoraflex® prosthesis, these findings should be corroborated in future prospective studies.

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Consuelo Sisinni Ganly

Innovations in the surgical treatment of aortic arch pathology: increasingly endovascular?

A study published by an Austrian group presents the surgical outcomes following the hybrid implantation of a custom-made aortic prosthesis for the treatment of aortic arch pathology during their initial experience at their center.

The frozen elephant trunk (FET) technique, introduced in 1996 as an evolution of the classical elephant trunk approach, is a therapeutic alternative for complex aortic arch pathology. This intricate surgical method involves replacing the aortic arch and reimplanting the supra-aortic branches into the FET prosthesis. Continuous improvements in both the prosthesis design and surgical technique have led to widespread use and favorable postoperative outcomes. Nevertheless, one of the many challenges surgeons face during the implantation of these hybrid prostheses is the anastomosis of the left subclavian artery (LSA). Depending on its origin from the aortic arch and patient anatomy, this reimplantation can be technically demanding and may increase the risk of neurological complications due to prolonged cardiopulmonary bypass and selective cerebral perfusion times. This preliminary report highlights their experience with a novel prosthesis (E-vita Open NEO-LSA®, Jotec®) designed to enable fully endovascular LSA management alongside FET implantation, aiming to address this challenge.

This prospective observational study, conducted from 2020 to 2021, included four patients diagnosed with aortic arch and proximal descending aorta aneurysms or dissections, with a mean follow-up of 35 months. Exclusion criteria encompassed LSA anomalies (aneurysms, dissections, and kinking), separate vertebral artery origin from the arch, hemodynamic instability, and cardiac or renal dysfunction. Outcomes assessed included hospital mortality, stroke, paraplegia, paraparesis, and the need for permanent dialysis (<90 days).

All four patients (two women) underwent implantation of the custom-made hybrid prosthesis. Diagnoses included one case of penetrating aortic ulcer, one case of subacute non-A non-B dissection, and two cases of aortic arch and proximal descending aorta aneurysms. Two patients required coronary artery bypass grafting to the left anterior descending artery. Mean cardiopulmonary bypass and antegrade cerebral perfusion times were 195.75 ± 24 minutes and 111 ± 10 minutes, respectively. All patients were extubated within 48 hours, had a mean ICU stay of 4.8 days, and were discharged without major complications after an average of 25.6 days. Despite the prosthesis customization, all cases required endovascular extension of the LSA branch due to endoleaks. The main procedural complication was a brachial artery pseudoaneurysm in one patient, secondary to percutaneous LSA access for endoleak resolution using telescopic stent grafting. Over a mean follow-up of 35 months, patients maintained good health, with significant aneurysm reduction in two cases and false lumen occlusion in the dissection case.

COMMENTARY:

The FET technique for total aortic arch replacement is a widely accepted alternative recommended in clinical guidelines for acute and chronic aortic conditions. However, it has faced criticism for prolonged cardiopulmonary bypass and circulatory arrest times, as well as higher rates of neurological complications. Continuous innovations aim to optimize this technique. This initial study seeks to demonstrate the feasibility of a novel prosthesis for the FET technique, potentially simplifying total aortic arch replacement by proximalizing the distal anastomosis to zone 2 and enabling endovascular LSA

management through a lateral stented branch tailored to the patient. By reducing the number of anastomoses—particularly the LSA, one of the most complex—the technique could shorten hypothermic circulatory arrest times, avoiding open LSA anastomosis, which can be challenging when located distally or posteriorly.

In this small cohort, all patients were discharged in good clinical condition without immediate complications and demonstrated favorable postoperative recovery. Additionally, over a 35-month mean follow-up, patients maintained good clinical outcomes with positive aortic remodeling results. However, the high frequency of LSA branch endoleaks and the need for additional procedures underscore a prosthesis design limitation in its early clinical use, requiring further refinement.

The custom-made E-vita Open NEO-LSA® prosthesis appears to be a safe and viable option for selected indications. Nevertheless, the high rate of endoleaks and the necessity for reinterventions highlight the importance of larger studies to evaluate long-term clinical outcomes and potential design modifications. Comparative studies with other techniques would also be valuable to assess whether it offers additional clinical benefits over the conventional FET approach. The results are encouraging regarding short- and medium-term clinical outcomes with this device. However, the high rate of reinterventions for endoleaks and the small sample size necessitate further research before considering it a standard treatment or replacing devices with more established clinical experience.

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Bunty Ramchandani

Rapid Growth in Thoracic Aortic Aneurysms: A Reliable Surgical Criterion?

A retrospective study conducted by Yale University over three decades scrutinizes the data from its Aortic Institute to assess the validity of surgical indications for rapid growth exceeding 3 mm/year.

The 2010 American Society for Thoracic Surgery guidelines suggest prophylactic surgery for thoracic aortic aneurysms upon confirmation of rapid growth. However, the aortic experience at Yale New Haven highlights that many cases labeled as rapid growth stem from measurement inaccuracies, thus questioning the legitimacy of this criterion for surgical intervention.

For this purpose, they analyzed a cohort of 2.781 patients with thoracic aortic disease over a 30-year span. They selected 811 patients who had at least two spaced aortic imaging studies over a minimum of two years. Rapid growth was defined as an aortic enlargement exceeding 3 mm per year. Thus, 42 cases of potential surgical indication for rapid growth in ascending aortic aneurysms and 27 in descending aortic aneurysms were identified. All clinical, surgical, and imaging data were re-evaluated by a panel of experts to confirm their accuracy.

Among the 42 patients with ascending aortic aneurysm growth, 12 were confirmed, 11 were rejected (19 imaging tests were inaccessible). Out of the 27 patients with descending aortic growth, 6 were confirmed, and 4 were rejected (with 17 imaging tests inaccessible). Based on available data and adjusting for the unavailable studies, three likelihoods for rapid growth rates were calculated: low probability, considering only the confirmed cases; high probability, considering the confirmed cases and assuming unanalyzed studies as positive; and medium probability, taking into account the confirmed cases and prorating the rates of positive findings in the unanalyzed imaging studies. This resulted in 2.7%, 4.7%, and 6.9% rates for ascending aortic rapid growth and 1.6%, 4.3%, and 7.3% for descending aortic rapid growth, respectively. The medium rate was deemed most reflective of real-life scenarios. Among the confirmed rapid growth cases, 4 patients were deemed inoperable, of which 3 succumbed to their aortopathy. Of the remaining 23 who underwent surgery, only one patient died.

The authors conclude that while rapid aortic growth does occur, it is exceedingly rare for both ascending and descending aortas. Up to half of the cases might have been due to measurement errors, suggesting such surgeries might not have been necessary. They urge a reevaluation of patients presenting with rapid growth of thoracic aortic aneurysms and insist on reassessing radiological measurements to rule out potential measurement errors.

COMMENTARY:

The 2010 American Society for Thoracic Surgery guidelines recommend prophylactic surgery when the growth rate exceeds 5 mm per year for aortas under 55 mm. Indeed, applying a 5 mm growth threshold only yielded one case of rapid ascending aortic growth and two descending cases that met the 2010 guideline criteria within the study cohort. Variations between 3–5 mm could be due to intra- and interobserver variability, thus negating the rationale for an aggressive 3 mm/year criterion. There are five reasons for such variability: comparing non-matching segments, oblique measurements, systolic-diastolic variations of the aorta, measurements taken with versus without contrast, and measurements performed with different imaging systems, even when the same imaging technique is used, and lastly, measurements that include the arterial wall versus those

that do not. Fortunately, the use of digital imaging, vascular lumen-centered techniques, and cardiac synchronization through electrocardiography during imaging can significantly reduce the variability previously mentioned. Therefore, the central message of today's article is the rarity of rapid aortic growth, and should we encounter a similar case in our practice, the first step should be to verify that growth to rule out a measurement error.

As for the limitations of this study, its single-center and retrospective nature encompasses 30 years. Despite a large patient database, only a third were eligible for the study. The restrictive criterion of selecting patients with at least two imaging tests spaced at least two years apart led to a significant loss of potential candidates. This criterion is purely artificial and arbitrary, since consulting for dimensional changes in the aorta from one year to the next is common. Additionally, over half of the selected cases could not verify the images because they were conducted in the pre-digital era. Finally, only genomic sequencing was performed on patients from the last decade, so we do not have data to assert that malignant degeneration of some aneurysms may have a solid genetic basis.

In conclusion, today's study shows that up to 5% of thoracic aortic aneurysms may exhibit rapid growth. Whenever we face this entity, we must ensure that measurements are accurate, because in up to half of the cases, we will be pleasantly surprised.

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Adrián Muinelo Paúl

Comparing Valve-Sparing Root Replacement vs. Composite Valve Graft Replacement

Comparison of valve-sparing versus valved conduit root replacement techniques in a high-volume American center over the past 24 years.

The Bentall procedure and valve-sparing root replacement are established surgical techniques for treating aortic root pathologies. The Bentall procedure is considered the standard approach, offering the possibility of replacing the aortic valve with either a mechanical or biological prosthesis, each with advantages and limitations regarding anticoagulation requirements or structural deterioration over time. Conversely, valve-sparing techniques are technically demanding, with a potential risk for early aortic insufficiency if the repair is unsuccessful.

This article presents a comparative analysis of mid- and long-term outcomes in aortic root replacement surgeries using valve-sparing techniques versus the Bentall-De Bono valved conduit replacement, conducted by the Weill Cornell Medicine team in New York.

The authors analyzed data from 1,635 patients who underwent aortic root replacement between 1997 and 2022. Among them, 473 patients received valve-sparing root replacement (VSRR) with a reimplantation technique, and 1,162 underwent composite valve graft (CVG) replacement. Cases with aortic dissection were excluded. To mitigate selection bias, the comparison utilized a propensity score-matched analysis.

The CVG group presented with more comorbidities and included a higher proportion of patients with bicuspid native valves. Intraoperative mortality was 0.4% for CVG and 0% for VSRR. The incidence of major postoperative complications was 2.9% (3.6% vs. 1.1%; $p = 0.009$). Ten-year survival was 93.1% with no significant differences. Aortic valve reinterventions were comparable between groups. However, differences were observed in the recurrence of moderate-severe aortic insufficiency, which was less prevalent in the CVG group (6.1% vs. 11.1%).

In conclusion, the article finds that with careful patient selection, both techniques offer excellent short- and mid-term outcomes.

COMMENTARY:

The authors undertake the challenging task of comparing two techniques for addressing a rare pathology by conducting a retrospective observational study in a high-volume center. However, these two interventions, while targeting the same pathology, are not typically intended for the same patient profiles. This distinction is acknowledged in the study, and to minimize selection bias, a propensity score-matched analysis was performed. This approach, combined with a large sample size, allowed the authors to achieve statistically significant results. Nevertheless, the conclusions should be interpreted cautiously.

Aortic root replacement with a valved conduit and coronary ostia reimplantation was initially described by Bentall and De Bono in 1968. Since then, this technique has undergone minor modifications to become the standard for treating aortic root aneurysms. As the native aortic valve is replaced, neither the native anatomy nor the level of valvular and annular calcification pose an obstacle, making this technique suitable for older patients with comorbidities, including renal insufficiency, bicuspid valves, and/or stenotic components, as reflected in this study's findings.

Regarding prosthesis choice in CVG, there is a trend toward using biological prostheses in younger patients, paralleling the trend observed in isolated aortic valve replacement in our setting. The option for TAVI valve-in-valve offers the possibility of CVG with biological prostheses in younger patients.

Cardiac surgeons, driven by the goal to preserve anatomically healthy native aortic valves in cases of aortic root aneurysms, have developed valve-sparing root replacement techniques. Native valve preservation provides benefits, such as no anticoagulation requirements and improved resistance to infection. However, while any patient suitable for a valve-sparing procedure could undergo a Bentall procedure, not all Bentall candidates are eligible for valve-sparing surgery. Several valve-sparing root replacement techniques are in constant evolution.

Aortic remodeling, also known as the Yacoub procedure, involves attaching a festooned Dacron graft to the remaining sinus tissue around the aortic valve. The reimplantation technique, or David surgery, involves attaching a cylindrical graft to the aortic annulus and then securing the sinus remnants within the graft.

Miller and colleagues classified these techniques as follows:

- David-I: The original reimplantation using a cylindrical tubular graft.
- David-II: The classic Yacoub remodeling.
- David-III: A remodeling technique combined with synthetic annuloplasty to prevent annular dilation.
- David-IV: Reimplantation using a circumferentially pleated graft at the sinotubular junction (STJ), with the graft diameter sized to be 4 mm larger than the theoretical STJ diameter (based on subcommissural triangle height and native annular features), creating a more anatomically correct configuration at the STJ level.
- David-V: An even larger graft (6-8 mm) with narrowing at both ends to create pseudo-sinuses of Valsalva, which are crucial for restoring the hemodynamic function of the native valve.

Additionally, the less commonly performed Urbanski technique involves resecting each pathologic sinus and replacing it with a teardrop-shaped patch, while the "Florida sleeve" approach developed by Hess and colleagues allows a less invasive approach by placing an aortic graft over the root, suturing the native valve and coronary ostia, thus overcoming some technical challenges of aortic repair.

The reimplantation technique using a Valsalva graft preserves aortic root geometry, theoretically reducing recurrent aortic insufficiency. This is achieved as the aortic annulus is anchored by the Dacron graft, preventing further annular dilation. This technique is considered the most reliable among valve-sparing root replacement procedures and is the one used by the authors in this study. However, the specific technique subtype (David I, IV, or V) is not detailed, leaving open the question of whether one subtype may offer superior durability in terms of recurrent aortic insufficiency compared to CVG.

In this study, patients with bicuspid aortic valves were predominantly included in the CVG group (521 [44%] vs. 114 [24.1%]). In recent years, VSRR techniques have been applied to bicuspid valves. Future decision-making may benefit from standardizing criteria, as

proposed by Brussels and Hamburg teams, based on cusp asymmetry classifications (e.g., symmetric with commissural angles of 160º-180º, asymmetric with angles of 140º-159º, and highly asymmetric with angles of 120º-139º) or other alterations that may influence the choice between techniques.

In summary, based on the results provided, both procedures yield excellent short- and long-term outcomes with follow-ups extending up to 10 years. VSRR is associated with a higher risk of recurrent aortic insufficiency, but no difference was found in reinterventions compared to CVG. This leads us to conclude that similar outcomes can be achieved with both techniques. Thus, individualized patient assessment should guide the choice of the best therapy. Nonetheless, further evidence on VSRR's natural history beyond 10 years and how to manage cases involving bicuspid valves would further inform decision-making.

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Adrián Muinelo Paúl

Valve-Sparing Aortic Root Replacement with Reimplantation vs. Remodeling: A Meta-analysis

This meta-analysis compares reimplantation and remodeling techniques for valve-sparing aortic root replacement (VSARR) in patients with a dilated aortic root. It includes data from comparative studies on reimplantation and remodeling techniques for VSARR published up to December 31st, 2022.

Fifteen articles met eligibility criteria, covering a total of 3,044 patients (1,991 in the reimplantation group and 2,018 in the remodeling group). All studies were nonrandomized and observational.

For overall survival, the median follow-up was 5 years (interquartile range: IQR = 2.2–8.6 years). Patients who underwent VSARR with remodeling demonstrated a higher risk of all-cause mortality (hazard ratio [HR] = 1.54; 95% confidence interval [CI] = 1.16–2.03; $p = 0.002$, log-rank test $p < 0.001$). This mortality risk was significantly elevated (HR > 1) in the postoperative period up to 4 years, after which the risk became non-significant. At the 4-year benchmark, survival was lower in patients undergoing VSARR with remodeling (HR = 2.15; 95% CI = 1.43–3.24; $p < 0.001$), with no survival differences observed beyond 4 years (HR = 1.04; 95% CI = 0.72–1.50; $p = 0.822$).

The median follow-up in the reintervention rate analysis was 3.4 years (IQR = 0.9–7.3 years). The risk of requiring reintervention on the aortic valve and/or root was higher in patients who underwent VSARR with remodeling (HR = 1.49; 95% CI = 1.07–2.07; $p = 0.019$, log-rank test $p < 0.001$). No statistically significant differences were identified in age, female sex, connective tissue disorders, bicuspid aortic valve, aortic dissection, coronary artery bypass, total arch replacement, or annular stabilization, indicating that these variables did not influence the results in the pooled analysis.

Authors conclude that VSARR with reimplantation is associated with improved overall survival and a reduced risk of reintervention compared to VSARR with remodeling. For overall survival, a favorable temporal effect was noted with the reimplantation technique up to 4 years of follow-up, though not beyond.

COMMENTARY:

This meta-analysis provides valuable data for the literature, mostly from single-center studies, many of which failed to detect significant differences between techniques.

These findings likely reflect the prevalence of observational series (mostly single-center) that carry a high risk of bias, along with pathology heterogeneity represented, including sporadic aneurysms, type A dissections, bicuspid aortic valves, and genetic aortopathies.

The reimplantation technique was associated with improved overall survival and a lower risk of reintervention over time. However, after 4 years, this benefit was not clearly evident. Furthermore, no modulating factors were identified in these observed effects.

The long-term stability of the remodeling technique compared to reimplantation may be compromised due to the lack of aortic ring stabilization, particularly when no additional subvalvular stabilization suture or concomitant annuloplasty rings are used. David et al. emphasized that restoring the normal geometry of the aortic cusps is critical for the long-term success of VSARR. Cusp coaptation should occur a few millimeters above the nadir

of the aortic annulus, and the coaptation length should be at least 4 mm in the central portion.

The primary advantage of the remodeling technique is argued to be the restoration of aortic sinuses for more physiologic aortic valve function. However, while aortic root remodeling is a physiologically superior procedure compared to aortic valve reimplantation, it does not address aortic annulus dilation, a significant issue in younger patients. Progressive annular dilation post-remodeling has been the main cause of procedural failure, particularly in patients with Marfan syndrome.

When annular dilation is present, or when the annulus is at risk of future dilation, the remodeling procedure is now commonly combined with annuloplasty, which can be performed using an external ring, a Dacron band, or a heavy Gore-Tex suture.

A recent substudy from the Aortic Valve Insufficiency and Ascending Aorta Aneurysm International Registry (AVIATOR) indicated that VSARR is a safe and durable procedure for patients with hereditary aortic disorders. However, root remodeling alone was associated with late annular dilation. In AVIATOR, grade 2 or higher aortic insufficiency rates were high in both groups and comparable between reimplantation and remodeling with annuloplasty, prompting consideration of valved conduit replacement (De Bono-Bentall procedure) in cases with suboptimal outcomes. The comparison between valve-sparing root replacement vs. valved conduits has already been discussed in previous blog entries.

In this meta-analysis, only 3 studies clearly described the type of reimplantation technique (whether David I or David V or a combination), limiting the ability to evaluate this as a confounding or modulating variable. Additionally, it would have been beneficial if studies had described annular and aortic root sizes to analyze the extent to which these factors modulate our findings.

In concluding this discussion, it is important to note that in technically demanding surgeries such as those described by David and Yacoub, surgeon experience creates a significant confounding factor. Therefore, surgeons should avoid generalizing results with both strategies and should prioritize individualized decisions for each patient and operating surgeon.

The surgical treatment of the aortic root presents contrasting alternatives with ongoing questions. When should the aortic valve be replaced or preserved? Is remodeling or reimplantation better? Should annuloplasty be routinely added to remodeling, and if so, which is preferable? Scientific evidence, to which this meta-analysis now contributes, gradually helps answer these questions. Nevertheless, while this debate continues, the cardiac surgeon must decide on the best therapeutic option for each patient with a dilated aortic root.

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María Rey Bascuas

Type I Thoracoabdominal Aneurysms Associated with Heritable Aortic Disease: Does Open Repair Remain the Preferred Approach for This Patient Group?

This retrospective study included 992 patients with Crawford type I thoracoabdominal aortic aneurysms who underwent open repair, focusing on outcomes for those with heritable thoracic aortic disease (HTAD).

Genetic disorders are a key factor in aortic aneurysms, especially in younger patients, encompassing well-defined syndromic conditions that increase the risk of acute aortic events and often necessitate invasive treatment at an earlier age.

Despite the high-risk nature of open repair in this population, clinical guidelines continue to recommend open repair as the primary choice over endovascular approaches, which are reserved for emergencies or as bridge procedures to definitive surgical repair.

In this retrospective analysis, we assessed 992 patients who underwent open repair of type I thoracoabdominal aortic aneurysms from 1990 to 2022. Patients were stratified by the presence of HTAD (HTAD; n = 177, including 72 with Marfan syndrome) versus non-HTAD (n = 815). Binary logistic regression models were developed to identify predictors of operative death and adverse events. Median follow-up was 6.7 years.

At 10 years, both groups demonstrated similar repair failure rates ($p = 0.4$). However, the HTAD group showed significantly greater repair-free survival ($p < 0.001$) and lower mortality ($p < 0.001$). Furthermore, HTAD patients experienced markedly lower rates of operative mortality and adverse events but required more frequent reinterventions, particularly those with aortic dissection.

The authors emphasize the benefits of open repair for HTAD patients, given the low intraoperative mortality and subsequent adverse event rates, crucial in a younger patient group with long life expectancy. However, the increased likelihood of aortic reintervention, especially in those with dissection, remains an essential consideration.

COMMENTARY:

The advancement and growth of endovascular techniques have undoubtedly limited the role of open repair for distal aortic disease. However, in patients with aortic disease associated with genetic conditions, clinical guidelines continue to favor open repair.

This study provides a substantial sample of patients who underwent surgical repair of type I thoracoabdominal aneurysms, analyzing predictors of adverse events and operative mortality, with a particular focus on the HTAD group. This focus is noteworthy, given the young age of these patients and the frequent need for subsequent interventions. The study's relevance lies in both the large sample size collected over three decades and the nearly seven years of follow-up for each patient, in addition to the specific patient population it examines.

Although the HTAD group had higher rates of aortic reintervention, as expected given their longer life expectancy, it is noteworthy that they also had extended repair-free intervals. Additionally, they achieved excellent outcomes in terms of operative mortality (1.7%) and adverse events (2.8%), which were significantly lower than in the non-HTAD group. The article's authors conclude by noting that, although published series report a substantial risk of late reintervention in patients with chronic dissections managed endovascularly, even definitive open repair, despite achieving a lower proportion of reinterventions, remains challenging and is not without the need for future procedures.

No previous series have reported on type I aneurysm repairs in HTAD patients, making this study valuable in supporting what guidelines already recommend, with a IIaC evidence level, that open repair is the choice in an elective clinical setting. Thus, we conclude that open surgery in patients with type I thoracoabdominal aneurysms and heritable aortic disease continues to be the preferred approach over endovascular therapy.

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Bunty Ramchandani

Aortic Graft Infection: transposition of the greater omentum

This single-center retrospective study examines outcomes with omental transposition in the mediastinum for treating infected aortic grafts.

Aortic graft infection (AGI) is a lethal, complex complication affecting 1–3% of patients, likely higher due to underreporting among those deemed unsuitable for surgical treatment. Historically, AGI treatment outcomes have been poor, with mortality ranging from 25–75%, and little improvement has been achieved to date. Surgical treatment typically involves resecting and debriding all infected material, followed by reconstructing affected areas. However, the aggressive nature of these techniques limits patient eligibility.

This study reports their experience using the omentum as a vascularized flap for AGI treatment. From 2005 to 2023, 31 AGI patients were retrospectively analyzed following omental transposition. Included cases involved infections of the aortic root graft, ascending aorta, and aortic arch, as well as hybrid prostheses or full arch replacements with frozen elephant trunks, excluding infected endovascular prostheses. Two patient groups were analyzed: curative intent (n = 9), where aggressive treatment involved graft replacement and mediastinal debridement followed by omental transposition; and palliative intent (n = 22), where the AGI could not be replaced, and only mediastinal cleaning with omental interposition was performed.

With a median follow-up of nearly 2 years, in-hospital and one-year mortality was 0% in the curative cohort, whereas the palliative cohort saw mortality rates of 23% (n = 5) and 41% (n = 9), respectively. No reinfections occurred within 3 years in the curative group. In the palliative group, 3-year survival was 52%, with a 59% infection-free rate (n = 13).

The authors conclude that omental transposition for AGI may be a viable palliative option for high-risk patients who are unsuitable for aggressive surgery. However, mortality remains elevated. For patients with curative intent, this procedure could serve as an effective adjunct treatment and should be considered in conjunction with extensive debridement.

COMMENTARY:

The omentum has been utilized in various surgical contexts for over 130 years. It is a voluminous, highly vascular, and pedicled tissue capable of absorbing fluids, resisting infection, sealing inflammation, and covering tissue defects. Deriving from the mesogastrium as a double layer of peritoneum, its vascular network supports lymph-rich in macrophages, thus earning it the title of the ideal biological drain. Experimental studies in the 1960s with canine models demonstrated its utility, where infected aortic grafts covered with omentum showed a remarkable survival rate. In cardiac surgery, its use has been limited to case series, with this study of 31 patients representing the largest published series. The potential advantages of the omentum over other vascularized pedicles include its reach to any intrathoracic region, the volume and flexibility to cover irregular spaces, and as a source of endothelial growth factors promoting angiogenesis in ischemic territories.

Omental use may require assistance from an experienced general surgeon for extraction and handling. The objective is to achieve contact across the graft's entire surface, covering suture and fibrous areas. Complications include pedicle necrosis due to

vascular torsion, diaphragmatic hernia, gastrointestinal issues, or infection spread to the peritoneal cavity.

Concerning limitations, this is a single-center, retrospective study, and while it is the largest series to date, it still involves a limited patient sample. No control group without omental transposition was available for comparison in either the curative or palliative cohort, complicating outcome assessment. Individualized treatment and technical variability further challenge comparability.

In conclusion, while the need to “make a heart of stone” may not always be necessary, knowledge of such techniques and the willingness to apply them can make a crucial difference in returning our patients from the brink of the Styx. After all, as Voltaire reminded us, we are not only responsible for what we do, but also for what we fail to do.

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Section II:

Ischemic heart disease

Marina Combarro Eiriz

Perioperative Myocardial Infarction: Are We Diagnosing It Correctly?

The European Association for Cardio-Thoracic Surgery's consensus document on perioperative myocardial infarction (PMI) reviews current diagnostic criteria and gaps in evidence, presenting a straightforward diagnostic algorithm with prognostic impact.

Cardiac surgery is an excellent tool for treating a wide range of heart diseases, whether congenital or acquired. Due to this diversity of pathologies, the available surgical techniques are also varied. Over the evolution of the specialty, these techniques have been refined, making them today procedures with low rates of serious complications. However, inevitably, all cardiac surgeries result in secondary myocardial injury.

This postoperative myocardial injury generally arises from various insults to the heart during surgery: direct manipulation, including cannulation and access; ablation and defibrillation techniques; inflammation; cardioplegic arrest, leading to hypoxia-reperfusion injury; metabolic damage, etc. The most common form of PMI occurs in the perioperative period of coronary bypass surgery, often related to graft occlusion, accounting for approximately two-thirds of PMIs. Other frequent causes include the appearance of new coronary lesions in native beds due to coronary damage during surgery or distortion of existing plaques/stents, as well as coronary spasm.

One of the immediate, and likely most utilized, methods for diagnosing PMI is determining biochemical markers of myocardial injury (troponinemia or serum creatine kinase levels) in the initial hours or days post-surgery. These parameters are highly sensitive but not very specific, as they may be markedly elevated in any cardiac insult, not solely ischemic in nature. Until now, no consensus has existed regarding the cut-off point for these biomarkers to be considered diagnostic of PMI. Consequently, significant disparities arise in results and their interpretation across different workgroups evaluating PMI. In this review, the authors explore the current evidence, comparing PMI definitions and prognoses across patient groups based on the definition used.

The task force included experts in the field (cardiac surgeons, clinical and interventional cardiologists, anesthesiologists, epidemiologists, and biostatisticians), all free from conflicts of interest. A systematic literature review was conducted, focusing on recent and highly impactful studies (mainly randomized or prospective studies). Only English-language publications were included. Data from each study were compiled in detailed tables, summarizing the study year, sample size, PMI definition criteria, and outcomes, among other factors.

Typically, the threshold for troponinemia used in PMI diagnosis ranges between 10 and 35 times the upper limit of normal (ULN). Complementary tests support myocardial ischemia detection, such as new electrocardiogram alterations, new segmental ventricular dysfunction in echocardiography, and/or pathological findings in coronary angiography. However, a large proportion of patients with biomarker elevations above these cut-offs show no signs of hypoperfusion or necrosis on magnetic resonance imaging, nor increased mortality compared to control patients. Therefore, this review proposes a higher biomarker threshold for PMI diagnosis.

The consensus concludes that biomarker elevation only has prognostic impact for PMI diagnosis when associated with additional ischemia signs or when the elevation is pronounced, regardless of accompanying findings. Thus, a user-friendly algorithm was developed, based on postoperative biomarker determinations at immediate postoperative and 24-hour intervals. PMI is defined only when troponin values exceed

35 times the ULN with additional ischemia signs or in cases where troponinemia exceeds 500 times the ULN without additional tests. The remaining scenarios (troponinemia <35xULN and troponinemia 35-500xULN, without other ischemia signs) are defined as perioperative biomarker elevation and perioperative myocardial damage, respectively. This algorithm also applies to serum creatine kinase levels, with cut-offs at 10xULN and 20xULN.

COMMENTARY:

Accurately defining perioperative myocardial infarction is complex, and establishing firm diagnostic criteria even more so. The fourth and latest international definition of myocardial infarction defined cardiac surgery-related myocardial infarction (type 5) as having troponinemia >10xULN persisting 48 hours post-surgery, accompanied by electrocardiographic or echocardiographic changes or angiographic evidence of flow-limiting lesions. This study revisits the concept, introducing two new terms for perioperative biomarker elevation and myocardial injury, previously undefined.

In cardiac surgery's inherently injurious context, a "normal" degree of myocardial injury is expected. Besides direct damage mechanisms, various confounding factors (brady- or tachyarrhythmias, anemia, respiratory failure, hemodynamic instability) may contribute to myocardial oxygen supply-demand imbalance, causing type 2 infarctions. Additionally, renal clearance should be considered when assessing troponinemia levels.

Given the above, it is logical that the biomarker elevation threshold for diagnosing infarction in post-cardiac surgery patients should be higher than in non-surgical patients. Until now, no standard threshold existed, with arbitrary levels set at x10 or x35 ULN based on consulted documents. Reviewing available evidence shows that this threshold is highly sensitive but not specific for PMI diagnosis and lacks clear prognostic relevance.

Thus, this consensus document seeks to standardize PMI definitions by establishing significantly higher biomarker cut-offs and distinguishing myocardial infarction from perioperative injury. This aims to reclassify truly at-risk patients who may benefit from additional medical or surgical intervention.

The document's main strength lies in its exhaustive review of numerous high-sample studies, enabling robust result extraction and comparison. These findings have guided the establishment of prognostic cut-offs for PMI, relying on biomarker plasma levels and additional findings.

As a primary limitation, this document presents an algorithm applicable to all cardiac surgery patients. However, biomarker elevation and PMI risk vary significantly by surgical technique, urgency, clinical status, and patient comorbidities. Therefore, a single algorithm may struggle to adequately differentiate PMI across scenarios. Ideally, patient- and technique-specific algorithms would be developed, though impractical in clinical settings.

The document also addresses the controversy over whether PMI should be included among adverse events in revascularization study outcomes. Logically, it should be included, as it is an inherent procedural complication with prognostic implications for surgical patients. Excluding it risks overestimating procedural benefits, particularly in studies comparing cardiac surgery with less invasive methods. The lack of evidence and a robust PMI definition has led to wide variability in reported PMI incidence across studies, resulting in weak conclusions about its actual risk. Hence, this study's most critical conclusion is the universal validation of a single PMI definition and the prognostic

impact of new intermediate biomarker elevation categories and perioperative myocardial injury.

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Elio Martín Gutiérrez

Multiplying Arterial Graft Anastomoses: The Role of Composite and Sequential Grafts

This study evaluates the patency of the internal mammary artery (IMA) graft to the left anterior descending artery (LAD) based on different IMA graft configurations: standalone, composite, and sequential.

Significant attention has been given to the advantages of complete revascularization and maximizing arterial graft anastomoses in the treatment of multivessel disease. However, graft harvesting itself can be a surgical trauma, potentially involving up to three or four surgical fields on the patient's skin. Not all patients have a complete theoretical graft pool available, or their usage may be contraindicated, leading to a need to balance graft availability with morbidity.

In this context, myocardial revascularization surgery offers a range of graft configurations. Two major technical variants multiply the number of anastomoses dependent on a donor graft: composite and sequential grafts.

In the first approach, composite grafts utilize Y or inverted T configurations, where one branch serves as the donor and another as the recipient from a side-to-end anastomosis toward another coronary vessel. The common trunk of the graft should not be restrictive, enabling sufficient flow to two territories. This configuration has been suggested for T-configured mammary arteries (the so-called "tector"). While this setup is commonly used with both internal mammary arteries, other configurations are also possible, including using saphenous vein grafts or a free arterial graft (either the mammary or radial artery), where the donor anastomosis is performed on another graft (typically the proximal saphenous vein) instead of the aorta due to length or fragility concerns. This configuration allows for anastomosis between right and left coronary territories, as the composite graft arms are independent yet connected by the common trunk. The distal anastomoses are often side-to-side longitudinal, enabling greater graft length. An exotic variation extends a graft using a saphenous vein or radial artery with a mammary artery donor, allowing for an "no-touch" strategy on the ascending aorta. Sequential anastomoses are then possible with the recipient graft, gaining protection from endothelial factors downstream from the IMA donor graft.

In the second approach, sequential grafting covers multiple epicardial vessels with a single graft, incorporating at least two anastomoses. The final distal anastomosis is side-to-end, while intermediate ones are side-to-side. To maximize graft length and match graft trajectory with epicardial vessels, these may be performed as longitudinal or 90º "diamond" anastomoses. The latter, despite initial permeability, result in higher shear forces due to perpendicular inflow, which may impact patency. This configuration uses graft length most efficiently, though its construction poses a higher technical risk in length measurement and anastomotic geometry. Connecting right and left coronary territories is generally less recommended due to differing physiology, and the progressive drop in flow exposes distal anastomoses to greater native bed competition, necessitating severely diseased vessels, particularly for the right coronary artery. Many studies highlight the benefits of sequential grafts in covering parallel resistances, as the resulting resistance is lower than that of individual grafts.

These configurations are not mutually exclusive, as the first is a proximal anastomosis variant and the second is a distal one. They can coexist in the same revascularization procedure, even as a composite proximal graft with sequential branches.

Despite all these doses of creativity, most of the available evidence, particularly that which relies on clinical trials, barely considers these types of configurations. The majority of grafts used are direct, single grafts, and the composite configuration of both mammary arteries is only considered in a few studies focused on the use of multiple arterial grafts. As we mentioned, there are more than a dozen ways to achieve complete revascularization in multivessel disease. If we add these technical variants, the possibilities approach a hundred, which, aside from being poorly standardized, logically should not yield the same results in all patients.

To this end, this Australian group analyzed the patency of the internal mammary artery (IMA) graft anastomosed to the left anterior descending (LAD) artery in different configurations. It is well known that the proper functionality of this anastomosis is the main prognostic marker for the revascularization of multivessel disease. For this purpose, they conducted a retrospective study of angiographic records from 2002 to 2020 of patients who had previously undergone revascularization surgery. A total of 84% of the patients were referred due to angina symptoms, although only 5.7% showed signs compatible with anterior ischemia. They selected 570 direct internal mammary artery grafts, 100 sequential, and 129 composite grafts. They excluded angiograms where no internal mammary artery graft was anastomosed to the LAD, those that combined both composite and sequential configurations simultaneously, and those composite grafts covering vessels from both the left and right coronary arteries simultaneously. This thorough case selection for analysis led to a reduction from the initial 1,256 angiograms to a final 799.

For direct grafts, 90.7% showed a proximal LAD lesion >70%, and this was <1.5 mm in 3.3%. The failure rate for these grafts was only 3.7%. For sequential grafts, 89% had a >70% proximal lesion in the LAD, with a caliber <1.5 mm in 8%. In 93% of the cases, the initially bypassed vessel was a diagonal branch, with a >70% lesion in 86% of the cases and a caliber <1.5 mm in 10%. The failure rate for the LAD bypass was 9%. For composite Y grafts, the LAD had a stenosis >70% in 92.9% of cases and a caliber <1.5 mm in 3.1%. In 45.7% of cases, the other arm of the anastomosis was used to bypass a diagonal branch, and in 54.3%, it was used for an obtuse marginal branch. Failure of the internal mammary artery anastomosis to the LAD occurred in 6.2% of cases.

The authors performed a logistic regression analysis, concluding that female sex and the presence of a non-significant proximal lesion in the LAD led to worse graft patency. Regarding the configuration, they concluded that direct grafts have better patency and that the failure rate, although not reaching statistical significance, is higher for sequential configurations compared to composite ones. Failure in the sequential configuration occurred distally, prior to the LAD anastomosis, while in the composite configuration, it tended to occur at the level of the Y-branch anastomosis. Therefore, the authors recommend, whenever possible, the use of simple grafts, and if alternative configurations are required—as a compromise between graft availability and revascularization needs—composite configurations should be preferred over sequential ones.

COMENTARY:

The analyzed study stands out for its originality, addressing a previously unexamined assumption: that different graft configurations, as long as they are permeable and function normally intraoperatively, are equivalent. Although this is a retrospective experience with most patients studied due to angina recurrence, it is known that a significant proportion of grafts fail without clinical repercussion, which inherently biases the study's design. Nevertheless, the "one bridge, one graft" principle is validated, allowing for a standardized revascularization pattern with coronary grafts that are direct

and individual, as previously discussed. From this model, other potential variants may yield similar or inferior results, which may be accepted based on graft availability and the reasonable morbidity associated with their harvesting. Consequently, revascularization remains a custom-fit strategy... but now with a framework to tailor adjustments to each patient's needs. Although occasionally complex, this technique may provide the best solution for complete revascularization. Alternative configurations also present greater risks of anastomotic error, particularly when not frequently practiced.

This study brings us closer to enhancing knowledge in revascularization techniques. The outcomes provided for IMA grafts might not replicate with saphenous vein or radial artery grafts or different combinations. Ideally, future studies will resolve some of these doubts. For now, we understand that we have a one-size-fits-all framework adaptable to a procedure that remains bespoke. Should alternative graft configurations be needed, it is advisable that the IMA-LAD graft remains intact.

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Laura Varela Barca

Right Mammary or Radial Artery as a Second Arterial Graft: Do You Prefer Mom or Dad?

A systematic review and meta-analysis comparing the use of double internal mammary artery versus internal mammary and radial artery on long-term survival following myocardial revascularization.

The selection of grafts used in myocardial revascularization surgery has become a recurrent topic of debate among cardiac surgeons. This is reflected in recent recommendations on graft utilization, previously addressed in another entry in this blog. However, recent studies and the lack of clear evidence leave us questioning which grafts to employ.

The use of the internal mammary artery (IMA) to revascularize the left anterior descending artery (LAD) is the cornerstone of any credible coronary surgery today. Complete arterial revascularization of the left territory has extended as a long-term patency guarantee, thus increasing survival. However, the addition of a second mammary graft remains controversial.

Notably, the use of the right internal mammary artery (RIMA) is recommended as a Class IIa indication in myocardial revascularization guidelines, while the radial artery (RA) is a Class I recommendation when coronary stenosis is severe. These recommendations are primarily based on two clinical trials. On one side, the RAPCO study compared the radial artery to both saphenous vein and mammary artery. In the branch comparing mammary and radial arteries (RAPCO-RITA), the radial artery showed excellent patency and increased 10-year survival, though certain methodological limitations existed due to the small patient number.

On the other hand, the ART study analyzed 5- and 10-year survival in revascularization with one or two mammary arteries, finding no differences between groups. Despite the high expectations generated, some methodological limitations, such as the use of RA in 20% of the patients in the single-mammary group, left the question of RIMA as a second arterial graft unresolved.

In light of whether to endorse these findings and favor the radial artery over RIMA, various meta-analyses have been published pointing in the opposite direction. Among these is the study by Benedetto et al., which aggregates results from numerous observational studies (over 15000 patients) and concludes that the RIMA is superior to the RA in terms of long-term survival. Thus, today, the question of RIMA versus RA remains very much alive.

Urso et al.'s present meta-analysis attempts once again to clarify this age-old dilemma, this time through significant nuances. The authors conduct a systematic review, including only articles with propensity-matched or matched-pair analysis. Of the 51 initially found publications, they select only 12 observational studies including 6450 patients in the double-mammary group versus 9428 in the left mammary and radial artery group. Notably, in 8 of the included studies, mean follow-up exceeded 7 years, and propensity score matching was applied in nearly all. The primary endpoint was long-term survival. For statistical analysis, the authors introduce a novel approach to what has been published thus far: they conduct a global meta-analysis using the inverse-variance method, but also include a Kaplan-Meier meta-analysis with individual patient data.

The initial results using the inverse-variance method favored the use of RIMA as a second arterial graft (HR: 0.84; 95% CI: 0.74-0.95; *p*=0.04), with no asymmetry or publication bias observed.

The Kaplan-Meier meta-analysis with individual data reflected similar long-term survival in both groups (*p*=0.31). One-, five-, ten-, and fifteen-year survival was 97.3%, 91.5%, 79.9%, and 63.9% in the RA group versus 97.0%, 91.3%, 80.0%, and 68.0% in the RIMA group. However, Schoenfeld residual analysis indicated a violation of the proportional hazards assumption. To address this, the authors repeated the analysis by dividing the curves into two time intervals: 0-10 years and over 10 years. In this segmented analysis, the proportional hazards assumption held, showing similar survival between the two groups in the first 10 years (HR: 0.99; 95% CI: 0.91-1.09; *p*=0.93), but increased survival in the double-mammary group after 10 years (HR: 0.77; 95% CI: 0.63-0.94; *p*=0.01).

The authors suggest that the use of RIMA as a second arterial graft in myocardial revascularization is associated with increased survival after 10 years.

COMMENTARY:

This is an intriguing meta-analysis favoring the use of RIMA over RA starting 10 years post-surgery. The authors employ meticulous methodology and statistical analysis, which introduces time-based survival assessment, a novelty in the literature to date.

Urso et al. have extensive experience in this area, having published numerous meta-analyses in the field of myocardial revascularization, evaluating arterial revascularization strategies, IMA harvesting technique, and revascularization strategy in left main coronary artery disease, among others. In 2019, the authors conducted a first meta-analysis of propensity-matched studies comparing single versus double IMA, finding no benefit in the double-mammary subgroup. After four years of publications on this topic, the population size has increased sufficiently to yield different outcomes in the present study.

As for potential limitations, while the study's methodology and statistical analysis are robust, we must remember that including observational studies, despite propensity matching, introduces the inherent limitations of such designs. Additionally, the exclusion of methodologically different studies regarding adjustment may introduce other sources of bias.

Given these results, the authors reflect on the possible explanation for higher survival in the double-mammary group only after 10 years. Anatomically, the RA has poorer characteristics than the IMA, which would lead us to expect survival differences across both time intervals; however, no differences are seen in the first 10 years. The authors speculate that early mortality in the double-mammary group due to wound infection complications may dilute its benefits in terms of survival during the initial period.

Despite this, this is an important meta-analysis on a complex and recurring topic in cardiac surgery and represents additional evidence supporting arterial revascularization. While, based on these results, survival following RIMA or RA use is similar in the early years post-intervention; in the long term, double-mammary use reduces mortality. In clinical practice, this may prompt us to reconsider the surgical strategy in younger patients with long life expectancy.

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Elio Martín Gutiérrez

The Ten Commandments of Saphenous Vein Grafts

This review examines applicable measures and available evidence aimed at enhancing long-term patency of saphenous vein grafts.

The foremost commandment for successful myocardial revascularization surgery is complete revascularization. However, following simple Socratic logic, if we only have four theoretical arterial grafts (considering both radial arteries), and if certain patients present contraindications for their use, achieving quality surgery without saphenous vein grafts becomes challenging. In my opinion, an average of over three grafts per procedure is typical in a revascularization service, with four or more grafts often required for multi-vessel disease, warranting systematic treatment of the right territory if its caliber and development are favorable, even in the presence of chronic occlusion.

Except in rare cases, these axioms make the use of saphenous vein grafts predominant in daily practice, originally popularized by Favaloro, who standardized the procedure with this graft. Indeed, some teams still consider more conservative approaches, using a single arterial graft per procedure, which further increases reliance on saphenous vein grafts.

This review evaluates aspects related to maintaining the quality and patency of saphenous vein grafts. It is essential to consider that, despite intraoperative hemodynamic results, various technical factors dependent on the graft itself may affect mid- and long-term patency, regardless of anastomotic quality or the condition of the target vessel.

COMMANDMENTS:

- Verify Function of All Grafts: This applies to all grafts used in revascularization surgery, as it is an essential quality standard today. A graft's future function cannot be guaranteed if intraoperative failure occurs, defined as a flow of <15-20 cc/min and/or a pulsatility index >3-3.5 (>5 for the right coronary territory). Multiple measurements should be taken after constructing the anastomoses, during extracorporeal circulation, and before reversing heparinization. However, the definitive measurement should be considered the one taken with protamine administered, prior to sternal closure, and with a mean arterial pressure >70 mmHg (systolic >100 mmHg). The characteristics of the measurement should be contextualized according to the vessel, territory, and graft used, even if showing signs of apparent normal function. A reverse flow value of <3% should be considered acceptable; if exceeded, competitive flow may be suspected, either due to a lack of significance in the proximal lesion of the grafted vessel or because of the supply of that territory from other grafts or vessels, grafted or not. This phenomenon can occur even with parameters of normal graft function but may also have implications for patency. In arterial grafts, this can manifest as a "string phenomenon" due to vasospasm, and in venous grafts, it can lead to intimal hyperplasia and accelerated atherosclerosis. If graft dysfunction or an unexpected result is evident, the entire course of the graft should be reviewed, ensuring proper geometry, verifying the quality of the anastomosis performed, and ultimately, using additional tools like epiaortic/epicardial ultrasound if necessary. With adequate training, patterns of graft injury and issues at anastomosis sites can be identified that might explain the observed

results. The combination of both systems can result in a change in strategy or the need for a revision in 10-25% of cases.

- Removing Perivascular Tissue Results in an Incomplete Graft: This is one of the aspects that the selected study emphasizes the most. Using skeletonized grafts has been proposed as a technique that facilitates their use, primarily by preventing technical errors due to interference from the adventitia during branch control or anastomosis construction. Favaloro already advised, "care should be taken to dissect only the vein, avoiding the adventitia surrounding it as much as possible." However, handling skeletonized grafts (both venous and arterial) also prevents damage during extraction and maintains autoregulation, partly through nervous/paracrine pathways (due to endothelium-independent factors such as nitric oxide and prostaglandins), and above all, nutritional supply via the vasa vasorum. It has been noted that using skeletonized arterial grafts may provide more length and limit spastic tendencies by having a larger caliber. However, the biology of venous grafts differs; as spasticity and limited caliber are not common issues, losing a structure that maintains the graft's integrity and contains the forces from its arterialization could lead to poorer long-term results. The study refers to "the sixth layer" of the graft, and consequently, using it without perivascular fat is like using an incomplete graft. Studies have shown that graft atherosclerosis accelerates if the vasa vasorum are lost, reducing the graft to a mere conduit without a nourishing capillary network. Moreover, interesting aspects studied by the group behind the study highlight reduced meta-inflammatory or chronic inflammation phenomena in the perigraft fat (of both mammary artery and saphenous vein) compared to the epicardium of coronary vessels. This favors the graft's biology and the release of intraluminal factors that counteract the progression of disease in the native bed. Like any technical variation, there are trade-offs. In the case of venous grafts, extraction with adipose tissue can lead to more anastomotic errors due to adventitia interference, as well as higher degrees of injury to the saphenous nerve. For the mammary artery, there is a known increased frequency of mediastinitis, which is why bilateral pedicled use is not recommended. Pedicling provides a shorter graft length, particularly for arterial grafts, but also protects against kinking along the course.

- Graft Extraction, Minimal Handling: The group responsible for the study, as well as clinical guidelines, advocate for a "no-touch" strategy, which includes several aspects: the aforementioned pedicling, performing anastomoses without touching the coronary or graft endothelium with instruments, and minimizing contact during needle steps. This also involves minimizing the size of the suture and needle used, as well as branch control with minimal vessel interference. In fact, branch control should be executed with proximal and distal clips or ligatures, followed by cold cutting. Practices involving electrocautery only transmit current into the vessel, creating thermal injury that could potentially lead to degeneration in the future.

- Prohibit Graft Distension: A common practice is venous graft distension to check the watertightness of branch control and to increase the caliber. Although this might provide a more manageable graft and even a potentially better immediate hemodynamic outcome, it causes significant wall damage by disrupting the vein's layers and creating gaps in the tunica media and elastic layers, promoting inflammatory cell infiltration, intimal hyperplasia, and

the atherosclerotic process. The graft should be verified using an intraluminal flush without distal occlusion, as it will already experience pressurization when connected to the arterial territory, though this pressure will still be more controlled compared to what we can impose manually.

- Patency Over Aesthetics: In this regard, the authors of the study are highly critical of endoscopic graft extraction. They acknowledge a higher rate of wound complications with open extraction; however, the current techniques and systems used subject the graft to trauma that will affect its future patency. Branch control by direct coagulation has already been argued against, as has excessive skeletonization or pulling that even leads to endothelial disruption. They describe experiences with prototypes and modifications to the technique using currently marketed systems to preserve periadventitial fat or perform branch control with bipolar electrocautery (which causes much more localized damage). However, a recommendation cannot be offered that supports the one currently in clinical guidelines, which are clearly influenced by economic interests and where the quality of the obtained grafts should be valued, even if it means a more conspicuous wound that affects the patient's prognosis.

- Exostents Delay Intimal Hyperplasia: In this section, the authors provide a brief review of the role of exostents, particularly VEST, as supports for saphenous vein grafts. Their use is intended for skeletonized grafts. They describe experiences from the five published studies (VEST I-IV and CTSN VEST), although there are other analogous experiences published by other authors, with even identical clinical trial methodologies. In this regard, our group recently published a meta-analysis that aggregates the evidence, finding no differences in clinical events or patency, but significant differences in terms of saphenous vein graft degeneration, specifically luminal irregularity due to intimal hyperplasia. This phenomenon is the main factor in adverse remodeling of grafts, beginning a few months after anastomosis construction and being the primary factor in long-term failure. It is caused by shear forces that lead to subendothelial proliferation of fibro-inflammatory tissue, similar to atherosclerosis. Counteracting these forces with external support, either through periadventitial tissue or synthetic mesh, could help minimize them and prolong graft durability. However, one of the main limitations is that the VEST studies have follow-ups that are still insufficient to determine long-term benefits in terms of patency from this better luminal regularity.

- Graft Geometry Is as Important as Anastomosis Quality: Graft construction does not end with extraction and good anastomosis quality. Often, graft failure occurs due to kinking along the course, a phenomenon known as geometry. This must take into account the graft's route along the surface of the heart and its relation to the grafted vessel, since non-laminar flows, like side-to-side "diamond" anastomosis configurations, can lead to focal intimal hyperplasia and ultimately revascularization failure. Moreover, it is essential to consider that graft configuration changes with the sternal retractor versus during the working opening, making it advisable to perform measurements with the retractor closed. This is a common personal practice to ensure there is no modification of graft configuration. However, the results obtained should be similar to the "official" measurement previously described, which should be taken as close to the distal anastomosis as possible. Another factor to consider is that grafts must have sufficient length since, in the short

term, they undergo another remodeling phenomenon: dilation. This affects arterial grafts, but especially saphenous vein grafts, and in this case is due to transmural forces. Dilation, like with stents, leads to longitudinal shortening, and graft geometry that was initially adequate may later result in anastomosis distortion or altered relations with epicardial structures. This effect may be more pronounced in sequential anastomoses, particularly at the distal level. The major issue with this aspect is the inability to predict this phenomenon's occurrence, which can only be mitigated by ensuring adequate graft length and preventing kinks along the route.

- Endothelial Protection: Flushing and Storage: When avoiding graft distension, we mentioned intraluminal flushing, but with what? Heparinized saline is commonly used; however, this product is highly toxic to the endothelium, causing damage and denudation, effectively turning the graft into a "zombie conduit." Using blood for intraluminal flushing has been proposed as a solution, under the assumption that blood contains buffering factors and would be physiologically more suitable. The only advantage of blood is its color, which makes it easier to verify branch or anastomosis integrity. However, stagnant blood, especially in contact with plastic or metal surfaces, exhibits high levels of platelet and leukocyte activation, which affect the graft if stored until use. The most appropriate approach seems to be using non-blood buffered solutions with osmotic characteristics similar to plasma. Various products have been suggested, such as classic papaverine (too acidic, which is why it was not recommended for intraluminal use, usually mixed with whole blood, despite its drawbacks) or the Hong-Kong or He solution (verapamil + nitroglycerin buffered at pH 7.4). The big promise lies in Duragraft®, which, although still lacking solid clinical evidence, has demonstrated excellent results in vitro as an excellent endothelial preservative, both for flushing (with blood staining) and for storage.

- Four Spans of Graft, Not All Can Be the Same: A common practice is using the saphenous vein "as it comes," obtaining sufficient length depending on the number of grafts planned. The presence of visible varicosities should lead to excluding the graft, but it's not uncommon to tolerate irregularities or even varicose nodes in graft configuration. While repair techniques are described, these should be limited to scenarios with no other alternatives; it is far preferable to select suitable graft segments, as they will be the ones that help avoid ischemic events for the patient in the future. Preoperative graft evaluation is also an uncommon practice that can be conducted via ultrasound, giving a clearer idea of the surgical strategy. This practice reduces wound morbidity from unnecessary open approaches or helps predict the presence of significant branches in cutaneous bridge or endoscopic approaches.

- One Vessel, One Graft Standard: Despite the versatility of saphenous vein grafts and their almost infinite use possibilities, each more creative than the last—sequential grafts, composite grafts, extension of internal mammary artery grafts—it should be emphasized that "fun" does not align with science: available evidence encompasses only saphenous vein grafts used as single grafts with two anastomoses, one proximal to the aorta and one distal to the native vessel. This is quite different from arterial grafts, for which clinical trials themselves accept more varied configurations. Therefore, if the patency of these grafts is inferior in their best configurations, these kinds of "exotic"

approaches should be minimized except in scenarios where the limitation of graft availability prevents offering complete revascularization.

COMMENTARY:

The saphenous vein graft, though often disparaged and underestimated, remains relevant 60 years later. Its versatility and easy availability have led to both mistreatment and inconsiderate use in equal measure. While the internal mammary arteries have been considered the Holy Grail and the radial artery the perpetual candidate as a secondary graft, it seemed that almost anything was acceptable for the poor saphenous vein. New concepts and the dismissal of outdated ones seem necessary as we continue to refine one of the oldest techniques in both general surgical treatments and, specifically, cardiac surgery. We must stop thinking of the saphenous vein as mere "spaghetti" and give it the respect it deserves: that of a coronary revascularization graft, with its own biology, indications, and "instructions" for use.

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Gregorio Cuerpo Caballero

Angioplasty or Surgery for Left Main Coronary Artery Disease: The Expert Commentary

Expert commentary by Dr. Gregorio Cuerpo, analyzing the available evidence and the particular context in our country regarding revascularization of left main coronary artery disease.

The evolution in recommendations concerning the treatment of left main coronary artery disease (LMCAD) undoubtedly reflects the current state of cardiac surgery over recent years. Despite excellent results, the surgical community has been compelled to "defend" itself against publications of questionable evidence and hasty interpretations of certain studies.

Historically, for stable angina, LMCAD has predominantly been treated surgically. Given the high mortality associated with this pathology, classical studies from the early '90s recommended surgery to address the ischemic myocardium at risk. For decades, myocardial revascularization was primarily surgical. However, advancements in percutaneous treatment have prompted various studies to reconsider the suitability of surgical (CABG) versus percutaneous (PCI) treatment.

Without evaluating the number of CABG procedures, which are undoubtedly below those observed in other countries, it is essential to understand the outcomes of myocardial revascularization surgery in Spain. According to consistent data from the national registry, coronary surgery mortality rates are around 2% (2.24% for CABG with extracorporeal circulation (ECC) in 2022, 1.59% for CABG without ECC in 2022). Although the registry data do not provide specific outcomes for LMCAD, preliminary data from the Spanish Cardiac Surgery Registry (RECC) confirm these figures, placing the mortality rate for myocardial revascularization surgery in Spain between 2-3%, despite an increase in patient risk and the percentage of PCI prior to surgery in recent years.

Changes in treatment guidelines began with the publication of coronary revascularization guidelines. In the United States, the guidelines were released in 2021, stating that surgical revascularization is a Class I recommendation for LMCAD in patients with stable angina to improve survival. For certain patients, PCI is deemed reasonable. Earlier, in 2018, European guidelines took a significant step by equating the recommendation level between CABG and PCI for patients with LMCAD and a Syntax score between 0-22 points (low Syntax score). For patients with intermediate or high Syntax scores, the PCI recommendation drops to IIa and III, respectively. This change in European guidelines was prompted by the development of several clinical trials, most notably the EXCEL study, which will be discussed later.

The first of these notable studies was the SYNTAX study, which analyzed 705 patients with LMCAD. After 5 years, the benefit of surgery was observed only in high-risk Syntax scores (46.5% of major cardiovascular events in PCI vs. 29.7% in surgery). However, the 10-year follow-up showed no surgical advantage over percutaneous treatment. This study reinforced the superiority of surgical treatment for multivessel disease, but not for LMCAD. Various studies conducted in this field sought differences through "new" statistical tools, focusing on combined outcome objectives and non-inferiority studies.

Among these, the NOBLE study, which analyzed 1200 patients, explored differences between both treatment modalities, with a primary outcome that included mortality, need for revascularization, stroke, and non-procedural myocardial infarction. The result showed 28.4% of events in PCI compared to 19% in surgery. The interpretation of this study suggested that CABG "appears superior to PCI for LMCAD treatment." From this

study, the predictable conclusion was that adding up events, non-procedural myocardial infarction and the need for revascularization penalized percutaneous treatment.

The EXCEL study learned from previous "errors" and identified the need for certain improvements to continue analyzing the “problem.” Consequently, it considered that the need for revascularization did not require analysis, and by modifying the protocol, it changed the definition of infarction to include procedural infarctions based solely on enzymatic criteria. Following the third universal definition of infarction, in the Excel study, periprocedural infarctions (PPI) were observed at 2.2%, increasing to 6.1% in the surgical branch following the protocol change. Despite a 40% discrepancy from the initial protocol, mortality differences favoring surgery (13.0% in PCI vs. 9.9% in CABG), many unpublished data, and a non-inferiority obtained based on the expected enzymatic increase after surgical revascularization, the EXCEL study results were published in the New England Journal of Medicine. This likely influenced the clinical guidelines change and contributed to the perception within the cardiological community that surgery and angioplasty were now equivalent for LMCAD treatment.

All these events had a dual impact within the surgical community. The first was the public reaction, with rejection statements covered by non-scientific media. For the first time, “opinion differences” between surgery and cardiology were broadcast to the public. The second impact was the development of new studies and reinterpretations of previous studies that could shed more light on the ideal treatment for LMCAD.

Regarding the reinterpretation of previous data, we highlight, on one hand, the Bayesian approach to the EXCEL study conducted by Gaudino in 2020, and on the other, the creation of a working group between the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS) in 2022. The Bayesian approach uses existing study data and modifies the order of data analysis. By focusing on the event itself, the goal is to determine whether the cause was PCI or CABG, an original and distinct approach compared to traditional methods. This allows for analyzing the magnitude of each effect. Without delving into details, as a detailed analysis of this study has already been published, the major shift involved moving away from the frequentist (often simplistic) approach centered on finding a “p.” A more comprehensive interpretation of the results was achieved, highlighting the magnitude of differences between events.

Fortunately, this controversy sparked a reflection that materialized into a return to common sense. Consequently, the ESC and EACTS worked to analyze the therapeutic recommendations for LMCAD in 2022. The results were reviewed by 12 members from both societies, taking into account four major clinical trials (NOBLE, SYNTAX, EXCEL, and PRECOMBAT) and a meta-analysis published by Sabatine (*The Lancet*, 2021). Overall, 4,394 patients with five-year follow-up data were analyzed. The primary endpoint was mortality, while secondary endpoints included myocardial infarction, stroke, the need for repeat revascularization (NRR), and a composite of death-stroke-myocardial infarction.

In summary, according to a Bayesian analysis, PCI was associated with an 85.7% higher likelihood of increased mortality. However, the impact on early mortality was less pronounced. Regarding secondary outcomes, there were more spontaneous myocardial infarctions in the PCI group (NNT = 29 CABG procedures would prevent one spontaneous myocardial infarction during follow-up), with no significant differences observed in periprocedural infarctions under the third universal definition of infarction. There were no significant differences in stroke (2.7% for PCI, 3.1% for CABG). PCI was associated with a higher need for repeat revascularization (NNT = 14 CABG procedures would prevent one repeat revascularization during follow-up). The combined endpoint of

death-stroke-myocardial infarction showed 19.7% of events in the PCI group compared to 15.5% in the CABG group at five years. Approximately 20 events occurred in the PCI group over five years versus 16 in the surgery group.

In summary, the working group concluded that out of 100 patients undergoing PCI for LMCAD, 89 would be alive at five years, and 80 of these would remain event-free. In the surgical branch, out of 100 patients, 90 would be alive and 84 event-free. Based on these results, it was recommended to modify the guidelines. For the low-to-moderate Syntax score group, PCI's recommendation was downgraded to IIa, while maintaining Class I for surgery.

This appeared to close (for now) an era in LMCAD research characterized by statistical ambiguity. Studies with leading titles, questionable influence from "scientific" sponsors, repeated losses to follow-up, protocol deviations, composite endpoints, non-inferiority with absolute rather than relative margins—all simplified the problem of treating LMCAD and led to flawed conclusions. The interpretation and extrapolation of these studies is undoubtedly the most critical point. For instance, it would be unreasonable to interpret Holger Thiele's study on ECMO use in cardiogenic shock to mean it should be entirely dismissed from treatment. Among other reasons, studies sometimes seem disconnected from daily clinical practice.

Reflecting on daily clinical practice, we highlight two recent studies to conclude this commentary. The first is a propensity-matched analysis of 1,128 patients with LMCAD undergoing surgery or PCI in Canada. After seven years, the study demonstrated increased mortality with PCI (54%) compared to surgery (35%), as well as more myocardial infarctions in the PCI group (19% versus 11%) and a higher need for repeat revascularization (18% versus 6%). On the other hand, the surgical branch showed more strokes (5.3% in PCI versus 7.6% in CABG). The second study, previously analyzed in this blog, is the SWEDEHEART registry, which examined 11,137 patients over a 10-year period. Mortality and major cardiovascular events were favorable to the surgical branch. However, one of the study's most interesting findings was the analysis of median survival. Moving beyond the simplification of Kaplan-Meier survival curves and incorporating recommendations to analyze the area under the curve for true survival impact, the Swedish study revealed a median survival difference of 2.58 years. In this study, patients with LMCAD undergoing surgery lived nearly three years longer than those undergoing PCI.

LMCAD can be treated surgically or percutaneously. PCI results make this treatment option feasible in cases that are technically uncomplicated or when surgery is considered high-risk. Generally, for operable patients with a life expectancy of more than five years, current scientific evidence supports the suitability of surgical treatment. In retrospect, the studies on LMCAD treatment have had clear benefits, even for the surgical community. Not only through the scientific knowledge gained, which has required the development of additional statistical skills, but also by motivating the surgical community to continue achieving optimal surgical outcomes and improving techniques and approaches. Just as the "TAVI phenomenon" has prompted surgeons to perform less invasive surgeries with excellent results in terms of mortality and hemodynamics, excellence is essential in coronary disease treatment. Whether prevention or medical treatment calls for a more aggressive option, the boundaries between surgical and percutaneous approaches must disappear, with one ultimate beneficiary always at the center of our actions: the patient.

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Begoña Bernal Gallego

PCI versus Surgery for Left Main Coronary Artery Disease According to Age: The Last Surgical Frontier at Risk?

A meta-analysis including 4 randomized controlled trials and 10 observational studies comparing percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) in left main coronary artery (LMCA) disease according to patient age.

Obstructive unprotected left main coronary artery (ULMCA) disease is a high-risk condition with potentially poor clinical outcomes if not treated promptly. Coronary artery bypass grafting (CABG) has been the first-line treatment for several decades, relegating PCI to cases of high surgical risk. However, advances in PCI outcomes, coupled with technological and pharmacological progress, including new-generation drug-eluting stents, intracoronary imaging, and antithrombotic therapy, have progressively positioned PCI as a safe alternative to CABG in certain patient subgroups. Recent studies indicate CABG may be more favorable in younger patients, whereas PCI could be an equivalent option in older patients. Thus, this meta-analysis aimed to evaluate outcomes of PCI versus CABG in ULMCA disease based on patient age at presentation.

Fourteen studies (4 randomized controlled trials and 10 adjusted observational studies) involving a total of 24767 patients (7952 treated with PCI and 16779 with CABG) were included. The primary endpoint was all-cause mortality, with major adverse cardiovascular events (MACE), myocardial infarction, and repeat revascularization as secondary endpoints. The median follow-up was 4.6 years. For younger patients, CABG was associated with lower mortality and fewer repeat revascularizations compared to PCI. In older patients, no significant differences were observed in overall mortality, myocardial infarction, or repeat revascularization between the two approaches; however, a higher risk of MACE was noted after PCI. This is attributed by the authors to the use of a lower age threshold in most analyzed studies, leaving the elderly population underrepresented.

The study concludes that while myocardial revascularization remains the preferred treatment for ULMCA disease in younger patients, PCI can be a safe and effective alternative for older patients, highlighting the need for further studies focused on this age subgroup.

COMMENTARY:

This meta-analysis, which includes 14 studies, evaluates percutaneous versus surgical revascularization for LMCA disease stratified by age. However, most studies in the meta-analysis were not specifically designed to examine age effects, with insufficient representation of elderly patients. Additionally, the authors acknowledge data heterogeneity and lack of detailed procedural information, affecting the ability to draw definitive conclusions applicable to the elderly population. The inherent limitations of meta-analyses, including data heterogeneity and inadequate elderly representation, create uncertainty and emphasize the need for more targeted studies to make more precise clinical decisions in this subpopulation.

Left main coronary artery disease has historically resisted PCI as the last frontier. Until recently, major clinical trials and guidelines almost exclusively endorsed surgical revascularization for this condition. However, in the past 10 to 15 years, the rapid and significant advances with drug-eluting stents have spurred change. Randomized trials comparing both revascularization methods aim to elevate PCI to a level comparable to surgery across various patient groups (elderly, comorbidities, favorable PCI anatomy, etc.), as shown in this meta-analysis. European myocardial revascularization guidelines

recommend both techniques with similar evidence levels (IA) when the SYNTAX score is low (≤ 22 points). For intermediate scores (22-32 points), the evidence level for PCI drops to IIaA, and it is not recommended at all (IIIB) for high SYNTAX scores (> 32 points). Nevertheless, following findings from the EXCEL study, EACTS withdrew support for these recommendations.

The growing interest among interventionalists in percutaneous approaches for LMCA is evident, and with the recent technological advances and the "TAVI phenomenon" as precedent, there are new challenges ahead. The results thus far endorse the effectiveness and superiority of the surgical approach. Studies like this should encourage surgeons to adopt less invasive procedures and pursue excellence in treating coronary artery disease. PCI also plays a key role in LMCA treatment, especially for favorable anatomies or when surgery poses high risk. Therefore, revascularization strategies should be individually tailored, guided by a multidisciplinary team to provide the best-suited option for each patient.

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Stefano Urso

Coronary Surgery Remains the Treatment of Choice for Left Main Coronary Artery Disease and Multivessel Coronary Disease: A Review of the 2024 European Guidelines

Review article on coronary disease management as proposed by the 2024 clinical practice guidelines from the European Society of Cardiology (ESC) for chronic coronary syndrome management.

The 2022 review of left main coronary artery disease (LM CAD) management in the myocardial revascularization guidelines from the European Association for Cardio-Thoracic Surgery (EACTS) and the ESC (originally issued in 2018) downgraded percutaneous coronary intervention (PCI) for patients with LM CAD and low-to-intermediate SYNTAX score (0-32 points) to class IIa, while maintaining coronary surgery as class I.

The 2024 clinical guidelines by the ESC, endorsed by the EACTS, propose several adjustments that do not alter the established clinical superiority of coronary artery bypass grafting (CABG) over PCI or medical treatment for LM CAD:

Recommendations for Myocardial Revascularization in Chronic Coronary Syndrome Based on Anatomy and Clinical Presentation (ESC 2024 Clinical Practice Guidelines)

Condition	Recommendation	Class
Left Main Coronary Artery Disease (LM CAD)		
In patients with chronic coronary syndrome (CCS) and low surgical risk (e.g., no previous cardiac surgery, severe comorbidities, frailty, or immobility that would impede CABG) with LM CAD, coronary revascularization is recommended over medical treatment alone to improve survival.	I	A
Coronary artery bypass grafting is recommended as the preferred revascularization method over PCI, due to lower risk of spontaneous myocardial infarction and repeat revascularization.	I	A
In patients with CCS and LM CAD of low complexity (SYNTAX score ≤22) where PCI can provide complete revascularization equivalent to CABG, PCI is recommended as an alternative due to lower invasiveness and comparable survival.	I	A
In patients with CCS and LM CAD of intermediate complexity (SYNTAX score 23-32) where PCI can provide complete revascularization equivalent to CABG, PCI should be considered as an alternative due to lower invasiveness and comparable survival.	IIa	A
Left Main Coronary Artery Disease with Multivessel Disease (MVD)		

Condition	Recommendation	Class
In CCS patients with low surgical risk and suitable anatomy, CABG is recommended over medical treatment alone to improve survival.	I	A
In CCS patients with high surgical risk, PCI may be considered as an alternative to medical therapy alone.	IIb	B

The 2024 ESC guidelines allocate significant attention to multivessel disease, proposing various treatment approaches based on the number of affected coronary arteries and the presence of diabetes:

Myocardial Revascularization Recommendations for Multivessel Disease and Diabetes

Condition	Recommendation	Class
Multivessel Disease and Diabetes		
In CCS patients with significant multivessel disease and diabetes who respond inadequately to guideline-recommended medical therapy, CABG is recommended over both medical therapy alone and PCI to improve symptoms and outcomes.	I	A
In CCS patients with extremely high surgical risk, PCI should be considered over medical therapy alone to alleviate symptoms and adverse outcomes.	IIa	B
Triple Vessel Disease without Diabetes		
In CCS patients with significant triple vessel disease, preserved left ventricular ejection fraction (LVEF), and no diabetes who do not respond to guideline-recommended medical therapy, CABG is recommended over medical therapy alone to improve symptoms, survival, and other outcomes.	I	A
In CCS patients with preserved LVEF, no diabetes, and significant triple vessel disease of low-to-intermediate anatomical complexity where PCI can provide complete revascularization comparable to CABG, PCI is recommended due to its less invasive nature and generally non-inferior survival.	I	A
Single or Double Vessel Disease Involving the Proximal Left Anterior Descending (LAD) Artery		
In CCS patients with significant single or double vessel disease involving the proximal LAD and inadequate response to guideline-recommended medical therapy, CABG or PCI is recommended over medical therapy alone to improve symptoms and outcomes.	I	A
In CCS patients with significant complex single or double vessel disease involving the proximal LAD, less amenable to PCI, and an inadequate response to medical therapy, CABG is recommended to alleviate symptoms and reduce revascularization rates.	I	B

Condition	Recommendation	Class
Single or Double Vessel Disease Not Involving the Proximal LAD		
In symptomatic CCS patients with significant single or double vessel disease not involving the proximal LAD and insufficient response to medical therapy, PCI is recommended to relieve symptoms.	I	B
In symptomatic CCS patients with significant single or double vessel disease not involving the proximal LAD, non-amenable to revascularization with PCI, CABG may be considered to improve symptoms.	IIb	C

The 2024 ESC guidelines also detail revascularization recommendations for patients with left ventricular ejection fraction (LVEF) ≤35%:

Recommendations for Improving Outcomes in CCS Patients with LVEF ≤35%

Condition	Recommendation	Class
In CCS patients with LVEF ≤35%, choosing between myocardial revascularization and medical treatment should follow careful assessment, ideally by the Heart Team, of coronary anatomy, the correlation between coronary disease and LV dysfunction, comorbidities, life expectancy, individual risk-benefit ratio, and patient perspectives.	I	C
In surgical candidates with multivessel coronary disease and LVEF ≤35%, CABG is recommended over medical therapy alone to improve long-term survival.	I	B
In selected CCS patients with multivessel coronary disease and LVEF ≤35% who have high surgical risk or are inoperable, PCI may be considered as an alternative to surgery.	IIb	B

COMMENTARY:

The 2024 ESC clinical guidelines uphold CABG as a class I indication for LM CAD patients with acceptable surgical risk, given its survival benefits compared to medical therapy and its superior outcomes compared to PCI in terms of reducing spontaneous myocardial infarction and repeat revascularization.

PCI remains a class I indication for LM CAD patients of low complexity (SYNTAX score ≤22), while retaining class IIa status for intermediate complexity (SYNTAX score 23-32), provided that complete revascularization equivalent to CABG is achieved. In 2018, the ESC and EACTS guidelines classified high-complexity LM CAD (SYNTAX score ≥33) as class I for CABG and class III (not recommended) for PCI. However, the 2024 ESC guidelines do not include a class III indication for any treatment modality in chronic coronary syndrome.

For these guidelines, ESC authors drew primarily on the individual patient data meta-analysis by Sabatine et al. (2021), which analyzed data from four randomized clinical trials (RCTs): SYNTAX, PRECOMBAT, EXCEL, and NOBLE. This meta-analysis,

covering 4,394 patients randomly assigned to either PCI with drug-eluting stents (n=2,197) or CABG (n=2,197), documented CABG's superiority in 5-year risk reduction for spontaneous myocardial infarction (hazard ratio [HR]=2.35; 95% confidence interval [CI] 1.71-3.23; *p*<.0001) and repeat revascularization (HR=1.78; 95% CI 1.51-2.10; *p*<.0001), without a significant survival difference over 5 years (HR=1.10; 95% CI 0.91-1.32; *p*=.33).

The Sabatine et al. meta-analysis also provided results from a Bayesian analysis of overall mortality, suggesting a possible survival benefit for CABG over PCI, estimated at less than 0.2% per year. However, this finding was not considered robust enough by the 2024 ESC guideline authors to confirm a survival advantage for CABG over PCI.

As documented, the current ESC guidelines dedicate a specific section to patients with LM CAD associated with multivessel disease. This issue is critical, as the majority (53%) of patients with LM CAD in the previously mentioned RCTs (SYNTAX, PRECOMBAT, EXCEL, and NOBLE) also had multivessel disease. In fact, only 16% of the populations treated in these four RCTs had isolated LM CAD. This distribution is not surprising. The 2023 SWEDEHEART study, commented on in the guidelines, corroborates the survival and outcome benefits of CABG over PCI in a representative cohort from Sweden's healthcare system, analyzing 11,137 patients with LM CAD treated with either CABG (n=9,364) or PCI (n=1,773) over an 11-year period. In the majority of this population (81%), LM CAD was associated with multivessel disease.

According to the 2024 ESC guidelines, for patients with LM CAD and multivessel disease, CABG retains a class I recommendation, while PCI holds a class IIb recommendation.

In general, recommendations for treating multivessel coronary artery disease without associated LM CAD continue to demonstrate the clinical superiority of surgical treatment. This superiority is most pronounced in patients with diabetes (CABG: class I; PCI: class IIa) and in patients with LVEF ≤35% (CABG: class I; PCI: class IIb). Notably, CABG maintains a class I recommendation (equivalent to PCI, provided it achieves complete revascularization) even in patients without diabetes. This contrasts with the 2021 American Heart Association (AHA)/American College of Cardiology (ACC) guidelines, where the controversial interpretation of the ISCHEMIA trial downgraded CABG to a class IIb recommendation for multivessel disease treatment. The core evidence supporting CABG in multivessel disease patients is the 2018 individual patient data meta-analysis by Head et al., which analyzed outcomes across 11 RCTs. This study documented that in a 5-year mortality analysis for patients with multivessel disease treated surgically (n=3,520) or percutaneously (n=3,520), PCI was associated with a significantly higher mortality risk (mortality in the PCI group: 11.5%; mortality in the CABG group: 8.9%; HR=1.28; 95% CI 1.09–1.49; *p*=.0019).

The central role of CABG in patients with multivessel disease, particularly those with diabetes and left ventricular dysfunction, is further supported by the FREEDOM and STITCH trials, respectively.

In conclusion, the current ESC guidelines on chronic coronary syndrome management represent a major advancement toward sustained collaboration between European cardiology and cardiothoracic surgery societies. This collaboration enhances the balance observed in the recommendations formulated for various clinical entities. These guidelines reaffirm the superiority of CABG over both medical treatment and PCI for isolated LM CAD, LM CAD with multivessel disease, and isolated multivessel

coronary artery disease, especially in patients with diabetes or LVEF ≤35%. Local Heart Teams' failure to adhere to the evidence presented in these guidelines not only contradicts the cooperative approach promoted by the ESC and EACTS but also risks exposing CCS patients to unacceptably high rates of adverse cardiovascular events.

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Elio Martín Gutiérrez

Early Extubation After Coronary Artery Bypass Surgery: It's Not the Destination, It's the Journey

A single-center study evaluated the outcomes of early extubation in the operating room (OR) compared to intensive care unit (ICU) extubation in patients undergoing myocardial revascularization surgery.

Enhanced recovery in cardiac surgery (ERCS) should be the standard postoperative management for most patients. This approach should be seen as multimodal and multidisciplinary, where each participant can contribute minor benefits that cumulatively reduce morbidity and shorten postoperative stays. One of the key factors is patient extubation, marking hemodynamic stability, neurological integrity, respiratory sufficiency, and hemostatic control, essentially signaling the patient's awakening—a crucial milestone in recovery.

Intubation duration varies depending on patient complexity, institutional practices, and the surgical procedure, resulting in notable differences across studies. Prolonged ventilation solely for monitoring, when extubation criteria are met, is highly detrimental and should be avoided. However, to what extent could intubation be prolonged without adversely affecting the postoperative course? Some authors advocate for OR extubation, with times trending toward zero, while others define early extubation within 2-4 hours post-surgery.

This study examined postoperative outcomes from 2017 to 2022 in myocardial revascularization patients extubated in either the OR or ICU based on protocol. Among 1397 patients, 506 were extubated in the OR and 891 in the ICU. Over 95% of surgeries used cardiopulmonary bypass (CPB), with an average graft count exceeding 3.5. This retrospective, non-randomized study selected patients for extubation based on anesthetist and surgeon consensus, with mandatory criteria: elective surgery, stable intraoperative hemodynamics, no inotropic or mechanical circulatory support, and adequate hemostatic control. Perioperative variables allowed for 414 matched pairs through propensity analysis.

This group's outcomes were remarkably favorable, with zero mortality and reintubation rates of 1.7% in both groups. Other morbidity rates were similarly low, including stroke (0.5% in both), reoperation for bleeding (0.7% vs. 1.7%, $p = 0.2$), and postoperative renal failure (0.2%-0.5%). Patient selection yielded a low-risk cohort: average age of 64-65 years, BMI of 27-28 kg/m², STS risk score of 0.8%, and left ventricular ejection fraction of 60%. Surgical times were within normal standards, with an average ischemic time of 90 minutes and CPB time of 110 minutes.

OR extubation was associated with shorter ICU stays (14 vs. 20 hours, $p < 0.0001$) and postoperative hospital stays (3 vs. 5 days, $p < 0.0001$), as well as a higher discharge-to-home rate (97.3% vs. 89.9%, $p < 0.0001$). Prolonged mechanical ventilation, defined as exceeding 24 hours postoperatively, occurred in 1% of OR-extubated versus 3.6% of ICU-extubated patients ($p = 0.0106$).

The authors conclude that routine OR extubation is feasible and safe for myocardial revascularization surgery patients, without increased morbidity or mortality.

COMMENTARY:

The results presented by this group for myocardial revascularization, one of the most frequently performed and lowest-morbidity cardiac surgeries, are nearly optimal in terms of postoperative morbidity and mortality. However, the profile of this highly selected

cohort, typical of the American healthcare system, may not align with public, universal systems like ours. Furthermore, the authors' generalization of their conclusions is overly optimistic, asserting systematic OR extubation feasibility. The study reflects a retrospective experience over five years, with OR extubation increasing from 6.2% to 83.3%, lacking procedural uniformity. The group's growing familiarity with this practice introduces bias, alongside the non-randomized design. The selected OR-extubated patients likely had favorable characteristics, leading to superior outcomes. Although propensity adjustments were made, some confounding factors remain challenging to balance adequately.

Despite these considerations, this study offers valuable insights. The described postoperative rehabilitation protocol, including transition through care levels on a timed basis, is exemplary: mobilizing patients within three hours of ICU admission, ambulation within 3-6 hours, and prompt removal of intravenous lines and thoracic drains. Following criteria fulfillment, patients transfer from ICU to intermediate care, resulting in ICU stays averaging less than one day—aligned with the definition of early extubation (within six hours). Postoperative stay differences could stem from a higher postoperative atrial fibrillation rate in the ICU-extubated group (15% vs. 5.1%, $p < 0.0001$), likely due to uncontrolled confounders rather than direct causation by earlier extubation.

Ultimately, OR extubation is indeed feasible, but with the caveat that candidate selection is likely more restrictive than suggested by the study. Systematizing this approach faces two obstacles: extubation should not substitute appropriate ICU protocols to prevent unnecessary prolonged ventilation, and patient comfort and management should not be compromised by premature extubation without prior postoperative assessment. Thus, the most suitable strategy may be early extubation within a 2-4-hour window post-surgery. While early awakening is pivotal, reaching home discharge remains the ultimate goal, requiring an intensified rehabilitation and daily care protocol to yield substantial benefit.

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Elio Martín Gutiérrez

Ventricular Restoration Surgery: Reviving the STICH Hypothesis

Experience from the San Donato Group on Ventricular Restoration Surgery and Comparison with the Classic STICH Study Cohort

Ventricular restoration surgery has been one of the most overlooked techniques in the past decade. This was largely due to the limited studies addressing the challenges posed by the STICH study, a key reference for this procedure. The primary objective of ventricular restoration is to recover a functional left ventricle after ischemic damage, by excluding areas with transmural akinetic and/or dyskinetic necrosis (ventricular aneurysm). However, this procedure often includes myocardial revascularization, correction of functional mitral regurgitation, and ablation of ventricular arrhythmias. Thus, the technique aims to restore the heart as closely as possible to its pre-ischemic state, as discussed in previous entries of this blog.

The STICH study was the first large-scale effort to test a technique previously suggested by observational studies and a small trial by Ribeiro et al. at the beginning of the century. Other techniques, such as Batista's ventricular reduction, latissimus dorsi cardiomyoplasty, or even “pacopexia” in honor of the late Francisco Torrent Guasp, are now considered historical. The technique followed in the STICH study, and later popularized for ventricular restoration surgery, was primarily described by Vincent Dor. In summary, this technique involved a ventriculotomy through akinetic/dyskinetic areas to the left of the left anterior descending artery, with identification of viable adjacent myocardium using complementary echocardiographic and MRI studies. Following this identification, a circular suture was applied with or without a pericardial patch, avoiding interference with the subvalvular mitral apparatus. The ventriculotomy was then closed longitudinally to achieve adequate seal, although overlap techniques were also described to prevent potential distortion of ventricular architecture (overlap technique). The goal was to reduce the size of the dilated ventricular cavity, mechanically excluding non-viable akinetic or dyskinetic myocardial areas and thereby partially correcting the tenting forces restricting mitral valve systolic motion. This exclusion, combined with scar resection, also serves as a ventricular arrhythmia correction measure, although ablation lines can be created from the infarcted area to an electrically neutral region, such as the mitral annulus. The remaining viable myocardium would be restored by complete revascularization, with mitral valve repair or replacement performed via ventriculotomy or conventional transatrial approach.

The STICH study was designed as a multicenter, randomized study, initially enrolling 2136 patients with a left ventricular ejection fraction <35%. Patients were randomized to undergo revascularization surgery and ventricular restoration versus isolated revascularization. Recruitment encountered challenges, including slow enrollment due to the rarity of the procedure, ultimately resulting in a highly heterogeneous population. Moreover, the fundamental limitation and primary cause for the study's results was that the ventricular volume reduction, the technique's main objective, averaged only 19%, compared to the stipulated protocol criterion of over 30%. This limited reduction led to a lack of significant differences between the ventricular restoration surgery group and the isolated revascularization group in terms of mortality or rehospitalization rates at 5 years. Additionally, with the inclusion of a cohort receiving only optimal medical treatment, the study extended follow-up (STICHES study) and provided valuable insights into the role of myocardial viability in decision-making for ischemic dilated cardiomyopathy revascularization, as also previously discussed. By the time reanalyses were conducted

focusing on subgroups of the cohort with proper surgical restoration, which showed clinical benefits, ventricular restoration had already started losing popularity.

The San Donato group was involved in the initial STICH cohort and has continued the technique to the present day. In the current work, they present the largest series with the longest follow-up of ventricular restoration surgery to date, including patients operated on between 2001 and 2019. Their surgical technique was particularly systematic, performing aneurysmectomy and using a reference balloon to adjust the residual ventricular cavity to the appropriate size (50 cc/m2). This method ensured significant ventricular size reductions, a crucial factor for differential benefits over simple revascularization. They ultimately included 725 patients and compared them with the STICH cohort of 501 patients who underwent ventricular restoration surgery. The San Donato cohort patients were older (66 vs. 61.9 years; $p < 0.01$), required more mitral valve surgery, had lower diabetes rates, and a lower mean indexed end-systolic volume (77 vs. 80.8 cc/m2; $p = 0.02$). The mortality rate for the San Donato cohort was 7.4%. The propensity-matched analysis of the two populations determined that:

1. At a mean follow-up of 9.9 years, matching the STICHES study follow-up, the survival rate for the San Donato cohort was superior to that of the optimal medical therapy arm (HR = 0.45; $p < 0.001$).

2. At the same mean follow-up, the San Donato cohort also showed lower mortality than the isolated myocardial revascularization arm of the STICHES study (HR = 0.63; $p < 0.001$).

3. At a mean follow-up of 4 years, as published for the STICH study, the San Donato cohort had lower mortality than the STICH study cohort (HR = 0.71; $p = 0.001$).

4. Furthermore, they demonstrated a greater reduction in left ventricular size compared to the STICH restoration group (LVESVI reduction: -39.6% vs. -10.7%; $p < 0.001$). In a similar subanalysis, as conducted in previous post-hoc analyses of the STICH study, they found that greater reductions in left ventricular size were associated with lower mortality in both cohorts.

The authors conclude that post-infarction patients with left ventricular remodeling who underwent ventricular restoration surgery in a high-experience center showed better long-term outcomes than those reported by the STICH/STICHES trial. This suggests that the technique should be revisited through new clinical trials to test its clinical utility hypothesis.

COMMENTARY:

The San Donato group's impressive results in ventricular restoration surgery are beyond question. They hold the most published experience on this topic and have demonstrated that their series may hold superior value over the STICH study. They can certainly be considered a reference center and should lead initiatives, as proposed in their conclusions, to create new evidence to overcome the limitations associated with ventricular restoration surgery.

The study addresses the inherent limitations of an observational analysis, as the San Donato cohort is retrospective, and the STICH cohort was not collected explicitly for this work. As with all studies addressing heart failure with reduced ejection fraction, having wide temporal series can introduce bias due to significant pharmacological

advancements in recent times. Nonetheless, both cohorts are contemporaneous for the most part, so it can be expected that the medical treatment protocols were updated simultaneously.

To add one more fact, the San Donato series also shows excellent survival, reaching 74.7% at 5 years and 54.9% at 10 years, higher than the typical 5-year 50% survival for patients with severe ventricular dysfunction. The main predictors of this long-term mortality were identified as age, diabetes, and uncorrected mitral regurgitation. These positive outcomes are likely related to careful patient selection (lower LVESVI) and improved surgical technique (higher target reductions in left ventricular cavity size, with a cut-off at 60 cc/m2, and mitral valve correction).

Once again, a clinical trial dogma is questioned. The San Donato group demonstrates that when done well, surgery often yields positive results. It is increasingly important to evaluate the methodology of these so-called class A evidence sources and continue generating high-quality evidence before findings, such as those for ventricular restoration surgery, irreversibly impact clinical guidelines.

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Elio Martín Gutiérrez

Men, Women, and Myocardial Revascularization

This review article provides an update on the benefits of multiple arterial grafting strategies and delves into gender-based differences in outcomes due to sex-related variations in coronary artery disease and its distinct presentation.

Recently, I read in a national newspaper that arterial disease, including ischemic heart disease, was described as a "man's disease that kills women." The headline's sensationalism was somewhat tempered by the article's clarification, which acknowledged that atherosclerotic arterial disease affects both genders equally and is the leading cause of morbidity and mortality in both sexes.

However, the unique physiological and hormonal differences between men and women cause the disease to manifest differently, which may result in a clinical recognition and therapeutic algorithms that are skewed towards the male profile due to its higher prevalence. Just as "a child is not a small adult," perhaps we should not equate arterial disease in women to that in men.

The protective vascular effect during a woman's fertile years results in a lower overall incidence and prevalence compared to men. Nevertheless, when coronary artery disease occurs in women, it presents more aggressively and poses a greater therapeutic challenge. These factors impact various arterial disease presentations, including ischemic heart disease, with distinct sex-based outcome variations:

Current diagnostic and therapeutic algorithms have been developed based on the male population. They are predicated on the male pathology profile, whereas women more frequently present with a broader spectrum of symptoms, such as atypical chest pain, dyspnea as an angina equivalent, or silent angina without chest pain. At times, this symptomatology can be mistaken for anxiety or respiratory or rheumatological conditions, leading to delays in diagnosis and appropriate therapeutic intervention.

Additionally, diagnostic and therapeutic delays are inherent to a woman's life course, with post-menopausal disease acceleration causing the condition to manifest up to 10 years later than in men. This delay means that women present for revascularization with higher morbidity due to age and an accumulation of cardiovascular risk factors, such as hypertension, diabetes, and dyslipidemia. This scenario leads to an increased likelihood of requiring revascularization under higher-risk conditions, such as heart failure or in emergency/urgent settings, including cardiogenic shock or acute myocardial infarction. These circumstances often compromise revascularization quality (fewer arterial grafts), increase early complication risks, and adversely affect long-term outcomes.

Physiologically, women's vessels are narrower, including both coronary arteries and arterial grafts, which adds technical difficulty to revascularization, increasing the risk of technical errors that may impair graft patency. Moreover, whereas ischemia in men mainly results from epicardial disease, in women, endothelial dysfunction, microvascular dysfunction, hyperreactivity, vasospasm, and microembolization are more prevalent, which are not entirely addressed by revascularization surgery.

Finally, after revascularization, women tend to report lower quality of life, which may reflect the differences in disease presentation, symptomatology, and pathophysiology.

In summary, coronary artery bypass surgery in women is characterized by a compromised quality if we define quality as maximum revascularization coverage with the highest number of arterial grafts and minimal complication rates. For various reasons, including older age, higher diabetes mellitus rates, and increased risk of mediastinitis

with bilateral internal mammary artery grafts (particularly in diabetic and obese women), arterial graft utilization is lower. Radial artery use is also limited in women due to underdevelopment or contraindications, such as carpal tunnel syndrome, graft underdevelopment, or vasospastic disorders. Regarding coronary vessels, certain territories are deemed non-amenable for grafting due to their naturally smaller caliber, which is characteristic of the female population in regions like Spain.

Following this review, the authors offer various data on the evidence available regarding revascularization outcomes in women, which we will discuss below.

COMMENTARY:

The existing evidence on revascularization, both surgical and percutaneous, has consistently shown poorer outcomes in women compared to men. These findings parallel a limited data pool based on recruitment that reflects disease incidence and procedural frequency. Indeed, the EuroSCORE II penalizes female sex due to the poorer outcomes observed in women undergoing revascularization surgery.

The physiopathology differences in ischemic heart disease among women, coupled with the smaller luminal areas following stent implantation (often oversized for smaller vessels), may influence these outcomes. Additionally, women might experience a distinct inflammatory and intimal hyperplasia response compared to men. Thus, despite poorer outcomes observed in men, certain patient profiles may benefit more from surgery based on sex, alongside established coronary anatomy and diabetes mellitus indications.

In the United States, coronary bypass procedures involve women in only 20% of cases, although this percentage might be higher in Europe. However, this low representation still results in limited female inclusion in clinical trials, reducing their representativeness. Trials investigating the benefits of multiple arterial revascularization have shown minimal female enrollment. For example, the ART trial included only 14% women, while RAPCO included 19%. However, studies such as RADIAL and RAPCO demonstrated greater benefits of multiple arterial grafts, specifically radial artery usage, in women relative to men. Women may benefit more from using arterial grafts due to their vasodilatory agent release, which mitigates endothelial dysfunction and vasospasm, as well as better rheology due to proportionate calibers in native vessels.

Finally, the ROMA:woman study recruitment is now underway. This extension of the ROMA (Randomized Comparison of the Outcome of Single Versus Multiple Arterial Grafts trial) has already enrolled 690 women, with plans to include 1310 more. With the same design and inclusion criteria, it aims to provide definitive evidence on the benefits of multiple arterial grafting in women. Similar initiatives in percutaneous interventions would be desirable, although until then, we rely on meta-evidence from existing cohort studies. Beyond racial considerations that likely impact outcomes in an Anglo-Saxon evidence base, we must continue providing optimal care across both sexes. Indeed, revascularization outcomes might be a gender issue that remains overlooked.

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Elio Martín Gutiérrez

When More is Better: Surgical Ablation and Left Atrial Appendage Closure in Conjunction with Myocardial Revascularization

This multicenter American study compares clinical follow-up outcomes in patients with atrial fibrillation (AF) undergoing coronary artery bypass grafting (CABG), categorizing patients into those with no concomitant procedures, those who underwent left atrial appendage closure (LAAC) only, and those who received both LAAC and surgical ablation of arrhythmia.

Current recommendations for concomitant surgical ablation in atrial fibrillation (AF) suggest a class IIb indication for asymptomatic cases and class IIa for those with symptomatic, clinically significant AF. Conversely, left atrial appendage closure (LAAC) has gained traction since the publication of the LAAOS III trial, achieving a class IIa recommendation. While a synergistic effect from combining LAAC with ablation is conceivable, various factors lead to a selective approach for LAAC alone in patients undergoing CABG, and even then, not universally applied:

Firstly, the fact that discontinuation of oral anticoagulation is generally not recommended makes invasive AF treatment less appealing. However, performing LAAC in this patient group, most of whom have non-valvular AF and are managed with antiplatelet therapy, may allow for anticoagulation discontinuation in those experiencing bleeding complications or other contraindications, especially in younger patients with a CHA2DS2VAsc score < 2.

Secondly, many surgical teams prefer off-pump CABG. This, combined with the complexity and suboptimal outcomes of epicardial-only ablation, can lead to abstaining from AF treatment altogether or limiting it to epicardial approaches, such as the clip devices (AtriClip®) that have recently become more widely adopted. Some teams report complications with graft geometry on the lateral wall due to interference from these larger clips, recommending excision-suture techniques preferable in cardiopulmonary bypass (CPB) settings. When CPB is employed, intracavitary ablation increases complexity, duration, and procedural risk, making it less comparable to isolated CABG outcomes in the short term.

Thirdly, the long-term benefit of concomitant ablation remains uncertain due to high recurrence rates. Indeed, some argue that LAAC is included as part of ablation protocols due to its potential benefit, making it a preferred intervention among ischemic heart disease patients with AF. However, patients in this population, mostly without underlying valvular disease, may show outcomes closer to those undergoing isolated AF ablation. Notably, 89% of patients in this study had paroxysmal AF.

To address these questions, the authors analyzed data from Medicare®-affiliated American centers involving patients aged 65 or older who underwent CABG for AF between 2018 and 2020. A total of 19524 patients were distributed into three groups: 11508 (58.9%) underwent isolated CABG, 4541 (23.3%) underwent CABG + LAAC, and 3475 (17.8%) received CABG + LAAC + ablation. After robust adjustment using double risk analysis with a multivariate Cox model and Fine-Gray time-to-event analysis, both perioperative and three-year survival outcomes were evaluated.

At 30 days, isolated LAAC was associated with a significantly lower rate of stroke readmission compared to no AF procedure (HR = 0.65; p = 0.10). However, isolated LAAC was linked to higher readmission rates for heart failure (previously reported in other studies, likely associated with impaired natriuresis driven by natriuretic peptides) compared to the LAAC + ablation and isolated CABG groups. Other perioperative

complications such as mortality, renal failure, or perioperative bleeding showed no significant differences between groups or attributable etiological explanations.

At follow-up, LAAC + ablation and isolated LAAC with CABG reduced stroke readmission rates compared to no concomitant AF treatment (HR = 0.74, p = 0.49; HR = 0.75, p = 0.03, respectively). However, only LAAC + ablation, and not isolated LAAC (HR = 0.86, p = 0.16 vs. HR = 0.97, p = 0.57, respectively), was associated with improved survival over isolated CABG.

The authors conclude that, in candidates for CABG and AF, concomitant LAAC + ablation reduces stroke risk and improves survival compared to no concomitant procedure or LAAC alone.

COMMENTARY:

The findings of this study are particularly novel and, despite limitations, illustrate the clear benefits of offering a comprehensive treatment for the underlying cardiac pathology in patients undergoing surgery. For those of us who have long believed in the benefits of ablation, these results are encouraging, affirming our choice to continue with the procedure despite skepticism, which may take forms such as “You know what we do with AF patients here?... Just give them warfarin!”

It is unfortunate that, being a registry-based study, there is no available data on the type of ablation performed (epicardial/intracavitary, lesion pattern, energy source, etc.), AF recurrence rates (and measurement method), or the exact LAAC procedure. Nonetheless, the large patient volume lends the study statistical power, and hard outcomes such as survival and stroke rates make the conclusions credible, potentially prompting a shift in surgical practice for those still hesitant or newly skeptical after the surge a decade ago. In fact, this study answers three key questions:

Firstly, LAAC reduces stroke rates, making it essential to seize the opportunity to perform it on any patient with AF, regardless of future anticoagulation needs, even with agents of superior efficacy and safety profiles like direct oral anticoagulants, which will likely become standard in this patient group.

Secondly, the synergy between both procedures is clear, with only the combination of ablation and LAAC improving survival, likely by reducing heart failure rates and preventing or limiting the progression of functional mitral and/or tricuspid valve disease. If off-pump CABG is preferred, these findings open the door to exploring hybrid approaches, such as pulmonary vein isolation or box lesions performed during surgery and completed later with percutaneous techniques, as they yield the best results for isolated AF patients. Beyond devices like the bipolar radiofrequency clamp (e.g., AtriCure® Isolator®) or band ablation systems (e.g., Stetch Cobra®), the EPi-Sense® system performs left atrial posterior wall ablation via pericardioscopy and can be integrated into the surgical field, whether by median sternotomy or minimally invasive CABG approaches.

Thirdly, this study shows that the profile of patients suitable for concomitant ablation with CABG is favorable, with most having paroxysmal AF, where the benefits of complete AF treatment (ablation + LAAC) surpass those of mere LAAC, clarifying previous uncertainties.

In conclusion, careful, well-executed work highlights the consequences of leaving cardiac disease untreated, even in the absence of apparent structural substrates. Properly designed studies allow us to maintain faith in these techniques and to revive procedures where patient selection is key to achieving successful outcomes. Reducing our craft to cutting and stitching—short of performing the classical Cox maze—may have

led to the current situation, where retooling, adopting new technology, and finding ways to demonstrate the extensive potential of our therapeutic capabilities could well be the future.

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Carolina Mayor Deniz

One Million for Optimal Myocardial Revascularization

This multicenter, observational, and retrospective study evaluates the 10-year survival outcomes of one million patients undergoing myocardial revascularization with a multiarterial versus single-arterial grafting approach.

Different myocardial revascularization models exist for multivessel coronary disease, with ongoing debate as to whether a multiarterial graft (MAG) strategy using the internal mammary artery (IMA) and/or radial artery (RA) provides a survival benefit over a single-arterial graft (SAG) combined with a saphenous vein. Previous single-center observational studies have associated MAG with improved survival, but recent clinical trials have not demonstrated statistically significant differences. This study aims to analyze long-term survival in a large population from the Society of Thoracic Surgeons (STS) database to help clarify this controversy.

Sabik et al. designed this multicenter, observational, retrospective study, including all U.S. patients who underwent elective, isolated myocardial revascularization with at least two grafts, one being arterial, between January 2008 and March 2019. Data were sourced from the STS Adult Cardiac Surgery Database and combined with data from the Centers for Disease Control and the National Death Index. Survival outcomes were estimated using Kaplan-Meier methodology, with the hazard ratio (HR) assessed at a 95% confidence interval (95% CI). To adjust results for baseline patient differences between MAG and SAG groups, inverse probability weighting (based on propensity scores), multivariable analysis, time-to-event analysis, and multiple sensitivity analyses were employed. Subgroup analyses (e.g., demographics, patient risk, surgical center volume) further identified potential variability in the effect of multiarterial grafting.

A total of 1021632 patients from 1108 cardiac surgery centers in the U.S. were included. Among them, 100419 patients (9.83%) received multiarterial grafts (47% double IMA, 45.5% IMA and RA), while 920943 patients (90.17%) received a single arterial graft with saphenous vein. Patients in the MAG group were generally younger males with lower incidences of heart failure, hypertension, chronic obstructive pulmonary disease, cerebrovascular disease, or peripheral artery disease, and with better ejection fraction and estimated glomerular filtration rate. However, coronary disease severity, number of grafts, and incomplete revascularization rates were similar in both groups. The median follow-up was 5.3 years (range 0–12 years). Long-term survival was higher in the MAG group at centers performing >10 procedures annually, with an unadjusted HR of 0.59 (95% CI 0.58–0.61) and an adjusted HR of 0.86 (95% CI 0.85–0.88; $p = 0.0001$), with comparable impact across all subgroups and time-to-event intervals. The observed difference was most significant among younger male patients and less marked in those with comorbidities or without cardiopulmonary bypass. MAG was equivalent to SAG in patients aged >80 years, those with NYHA class IV, severe pulmonary disease, or estimated glomerular filtration rate <45 mL/min, and inferior in patients with morbid obesity (BMI >40 kg/m^2).

COMMENTARY:

This study provides an updated, real-world analysis of long-term survival in over a million cases, representing more than 97% of all CABG procedures in the U.S. While the observed benefits of a multiarterial grafting (MAG) strategy are promising, some key points require commentary.

First, patient characteristics across groups were unevenly distributed. The MAG group comprised predominantly younger males with fewer comorbidities, representing a “better

patient" cohort. This factor may influence results, as the benefits of MAG were also more pronounced in younger, healthier males. Despite propensity score adjustments, key preoperative and intraoperative conditions (frailty, graft quality, and revascularizable targets) were not evaluated. Multiarterial grafting is sometimes a rescue choice in CABG when a fully arterial revascularization plan is unfeasible. In such cases, saphenous vein grafting becomes an alternative option if arterial graft length or quality, underdeveloped internal mammary arteries, hemodynamic instability, or bleeding risk necessitate adjustments during surgery.

Additionally, the study registry shows that over half (53.6%) of U.S. centers perform multiarterial revascularization in <5% of cases annually, likely to reduce the potential risk of wound complications. Furthermore, choice of arterial graft varies, with approximately 47% using double IMAs and 45.5% IMA with RA, and only a residual 7.5% using both double IMA and RA. Although similar long-term outcomes have been reported with different arterial grafts, no specific subanalyses were done based on graft type or use of cardiopulmonary bypass.

The threshold for benefit was set at 10 cases annually. A threshold this low raises questions about whether greater experience might yield different outcomes in specific patient profiles, especially those with comorbidities like obesity, small-caliber mammary or coronary arteries, and bleeding risk. Analysis by higher-volume centers with expertise in multiarterial grafting and off-pump revascularization could further elucidate potential benefits. The ART trial demonstrated MAG benefit when stratified by surgeon experience.

Despite retrospective limitations, the survival outcomes align with the recent Spanish meta-analysis by Urso et al. (previously discussed) and PRIORITY, a multicenter cohort study. Nonetheless, the ROMA trial (Randomized comparison of the clinical Outcome of single vs Multiple Arterial grafts, also reviewed here) is anticipated to provide further evidence in this debate.

In conclusion, pending the results of the ROMA trial, this extensive observational study supports MAG as associated with improved long-term survival for most patients undergoing CABG.

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Elio Martín Gutiérrez

The Awakening of Hibernating Myocardium: Shockwave Therapy

The CAST-HF clinical trial results on shockwave therapy for the recovery of hibernating myocardium concurrently with revascularization surgery.

A few months ago, we delved into the management of akinetic/dyskinetic regions in patients with ischemic left ventricular dysfunction. Today, the focus shifts to hibernating myocardium, the component with the greatest recovery potential within the context of revascularization surgery.

Surgical revascularization has proven to be the optimal therapeutic option to restore ventricular function and enhance survival in patients with ischemic ventricular dysfunction associated with multivessel disease. Among its refined advancements, reaching high-quality standards, are the selection, care, and use of multiple arterial grafts, preoperative functional-guided revascularization, optimization of myocardial protection and perfusion techniques using minicircuits, among others. Nonetheless, the study presented today introduces a completely disruptive concept—a new approach to the pathology and the application of an adjunctive therapy, shockwave therapy.

For some, such therapies may evoke memories of unsuccessful revascularization techniques based on energy sources, such as LASER use. For those unfamiliar with this phase in the “archaeology of cardiac surgery,” it is worth mentioning that this therapy sought to create sinusoids in the thickness of the left ventricular wall via a LASER-induced lesion, through which intracavitary blood could improve myocardial thickness perfusion. Although the concept was innovative, LASER failed in clinical results and was soon relegated to the anecdotal within the specialty.

Shockwaves have demonstrated regenerative effects in various fields, such as the recovery of tendinopathies, healing disorders, bone fractures, chronic cutaneous ulcers, post-stroke spasticity, and even aesthetic medicine treatments. Thus, based on numerous preclinical studies by the Austrian author group, the application of these shockwaves on the myocardium is described in the study we are analyzing today, being pioneers in human application.

In this study, 63 patients with ischemic left ventricular dysfunction (left ventricular ejection fraction <40%), coronary artery disease candidates for surgical revascularization, and regional wall motion abnormalities were recruited, excluding those with extensive scarring by magnetic resonance imaging. Patients were randomized to receive complete revascularization with concurrent shockwave therapy (33 patients) versus controls who underwent only revascularization with application of a shockwave device but without active treatment (30 cases). Revascularization was performed using extracorporeal circulation, a single aortic clamp, and grafting of all vessels >1.5 mm and stenoses >50% (SYNTAX criteria). Shockwave therapy was applied during cardioplegia and after revascularization, delivering 300 pulses per coronary territory with an intensity of 0.38 mJ/mm² and a frequency of 3 Hz. These parameters were defined in prior preclinical studies.

The study does not present peri-procedural results but focuses on the one-year follow-up comparison. Patients receiving concurrent shockwave therapy showed a greater increase in left ventricular ejection fraction from preoperative baseline (+11.3% vs. +6.3%; $p = 0.14$), improved functional capacity in the 6-minute walk test (127.5 m vs. 43.6 m; $p = 0.28$), and an enhancement in the Minnesota Living with Heart Failure quality of life questionnaire (11 points vs. 17.3 points; $p = 0.15$).

The authors conclude that shockwave application on hibernating myocardium concurrently enhances left ventricular ejection fraction and functional capacity in surgically revascularized patients with ischemic ventricular dysfunction.

COMMENTARY:

This study is both intriguing and attractive, featuring a clinical trial design that proposes, for the first time, a clinical application of shockwaves on the myocardium. This energy source consists of electrohydraulic shockwaves. By applying a high potential difference between two points with high water content, a mechanical wave propagates through the tissue, with a pressure peak variation of 120 MPa and a trough of 10 MPa. According to previous preclinical literature by the Austrian group, the therapy stimulates neoangiogenesis and hibernating cardiomyocytes.

While promising, some procedural details that could have been requested of the authors are missing. They meticulously describe minor follow-up losses and two non-cardiac deaths. However, perioperative details would have been beneficial, particularly considering revascularization quality, the primary confounder of results. Aspects such as graft type and number, incomplete revascularization rates (per SYNTAX criteria), and intraoperative non-functional graft rates remain undeclared. Notably, they excluded the impact of shockwave therapy application duration on extracorporeal circulation, as well as the consequences of transducer contact on the heart surface post-revascularization (potentially causing damage to anastomoses or grafts). Finally, the authors acknowledge that the shockwave protocol was developed in humans through unpublished preclinical experiences, with prior data being exclusively derived from animal experiments. While this approach might reflect an effort to safeguard the concept from espionage or plagiarism, there are established methods to protect intellectual property, such as the publication of results, which could have also addressed some of the ethical aspects of the study.

In conclusion, the CAST-HF study introduces a new concept for addressing hibernating myocardium and a novel form of therapy, based on an energy source and employing new technology. A single study is not sufficient to make broad recommendations on this approach, but it will be interesting to follow the development of this therapy to determine its potential for widespread application. Until then, the only shock we will continue to deliver is defibrillation during weaning from extracorporeal circulation, when necessary.

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Elio Martín Gutiérrez

Mixing Water and Oil: Consensus on Hybrid Revascularization

Critical analysis of two position papers addressing indications, technical aspects, and clinical management of patients eligible for hybrid myocardial revascularization.

When we discussed the article on hybrid myocardial revascularization (HMR) on the blog months ago, I never imagined that this topic would generate such interest to warrant the publication of two consensus documents on either side of the Atlantic. The European one, authored by the Cardiovascular Surgery Working Group of the European Society of Cardiology and the Association of Percutaneous Cardiovascular Interventions, is more comprehensive and predominantly cardiology-focused, resembling the methodology used for clinical guidelines development. In contrast, the American document, a more modest initiative by representatives of the Society of Thoracic Surgeons, serves as a review of the current evidence to update the state of the art.

The methodologies of these two works differ significantly. The European document reflects a broader perspective derived from meetings and guideline-style methodologies. The American paper relies on a literature search and evidence aggregation. Despite these differences, they complement each other well. Below, we provide an organized and critical summary of their main messages.

The growing interest in HMR emphasizes its potential to combine the benefits of both treatment strategies: the long-term patency and prognostic impact of internal mammary artery (IMA) to left anterior descending artery (LAD) anastomosis, and the reduced invasiveness of percutaneous treatment for other territories using new drug-eluting stents, which have demonstrated failure rates below 5% within a year compared to 20% for saphenous vein grafts. While this rationale is valid, it tells only part of the story. Despite saphenous vein grafts being the most frequently used conduits, excluding comparisons with other arterial grafts in the evaluation of new stents creates an unfair competition. Indeed, as cited in the European document to confirm this observation, "the benefit of surgery over intervention in non-LAD vessel revascularization is ambiguous." Fortunately, the tone of the American paper is more moderate and cautious.

Indications for HMR

The American document defines the ideal candidate as someone who would benefit from the advantages of both procedures. Such a candidate would present:

- Tolerance for single-lung ventilation.
- No history of prior thoracic surgery or radiation.
- Left ventricular ejection fraction >30% and tolerance for CO_2 insufflation in the surgical field.
- No contraindication for dual antiplatelet therapy.
- Multivessel coronary disease with a complex LAD lesion and focal, low-complexity lesions in other vessels.
- LAD anastomosis site free from significant calcification or intramyocardial course.

- Well-preserved IMA graft suitability.

The European document provides a detailed list of indications, including the following:

- Patients with two-vessel disease and an LAD lesion unsuitable for intervention: Although multivessel disease often equates to three-vessel disease, the term "multi" includes more than one vessel, and assumptions made for three-vessel disease should apply equally to two-vessel disease, particularly in non-acute contexts. Pathophysiologically, multivessel disease differs significantly from single-lesion disease due to its potential to involve multiple coronary tree vessels.

- Patients with multivessel disease requiring surgery but with contraindications to median sternotomy or limited graft availability: This approach offers a less invasive alternative to achieve complete revascularization. Such "rescue" from surgical contraindications is particularly relevant, as these patients are often referred for complete percutaneous treatment, especially in our setting.

- Patients with multivessel disease and a complex LAD lesion but poor distal beds for surgical treatment in other territories suitable for percutaneous intervention: This indication seems overly forced, as vessels unsuitable for surgery are often unsuitable for intervention. Conversely, the opposite is less frequent. Percutaneous treatment in such cases may increase event rates, ultimately resulting in incomplete revascularization regardless of the therapeutic option chosen. However, this approach maximizes options for attempting complete revascularization and avoids morbidity from harvesting dysfunctional grafts.

- Patients with multivessel disease undergoing primary angioplasty for the culprit lesion, with deferred revascularization of the remaining territories due to surgical anatomy (residual three-vessel disease, left main disease, or equivalent): This may be the most common scenario in our setting, where HMR has often been performed out of practicality rather than purpose.

- Patients with multivessel disease and surgical candidacy but extensive aortic disease precluding complete revascularization using no-touch techniques: This indication is highly limited to cases where complete revascularization is unachievable, considering the high versatility of surgical revascularization.

Both documents advocate for a consensus-based Heart-Team approach to decision-making regarding vessel strategy, timing, and method. The European guidelines expand the concept of hybrid revascularization to include minimally invasive surgical approaches (e.g., MIDCAB, mini-thoracotomy, inferior mini-sternotomy, robotic techniques, with or without cardiopulmonary bypass) for two vessels, leaving a third vessel or even left main disease—once protected—for percutaneous intervention. This opens the door to the use of multiple arterial grafts, maximizing benefits. Some groups routinely revascularize the left-sided coronary tree, often using multiple arterial grafts, leaving the right-sided tree for subsequent percutaneous intervention. By adhering to this philosophy, they essentially follow HMR principles. The American consensus document adopts a

narrower definition, almost equating HMR to MIDCAB (or robotic surgery) combined with stents.

Sequential or Simultaneous Treatment

This is one of the most controversial topics, with each document offering a distinct approach. The European document simplifies the matter by defining four scenarios:

1. Non-LAD or unprotected left main (LM) as the most significant lesion: Intervention first, followed by surgery.

2. Unprotected left main disease: Surgery first or simultaneous treatment.

3. LAD and/or LM culprit lesion in the context of non-ST-elevation acute coronary syndrome (NSTE-ACS):Surgery first or simultaneous treatment.

4. NSTE-ACS where the culprit lesion is not in LM or LAD: Intervention first.

The American document includes a more detailed algorithm that integrates both indications and treatment sequence. Notably, it excludes patients with a SYNTAX score >28–30, severe diabetes, youth, or severe left ventricular dysfunction from HMR or intervention, aligning with the European document's earlier criticism. Subsequently, its recommendations for sequential treatment are similar to those in the European consensus but omit simultaneous treatment during the same procedure. The American guidelines also make an intriguing assumption for cases of LAD disease as the primary or most severe lesion in the context of NSTE-ACS or unstable angina:

- If non-LAD lesions are critical, intervention is recommended within 48–72 hours after MIDCAB to prevent new ischemic events.

- If non-LAD lesions are not critical, intervention may be deferred for 4–6 weeks post-surgery to minimize complications from dual antiplatelet therapy (DAPT).

The sequencing of treatments has profound implications for the need for DAPT and its associated hemorrhagic risks. The European document is more flexible, advocating for consensus in decision-making. However, it specifies that if intervention precedes surgery, a 4-week waiting period is recommended—a common practice when surgery completes revascularization after primary angioplasty. Additionally, extending DAPT for the first year is suggested for standard ischemic risk scenarios.

The European document, reflecting its cardiological perspective, reviews functional implications of initiating treatment with one approach versus the other. For intermediate lesions, surgery-first strategies reduce lesion significance, providing potential stability until intervention. Conversely, if intervention precedes surgery, formulas used for fractional flow reserve (FFR) calculations increase residual LAD lesion significance, placing the patient at risk until the surgical stage. These considerations, derived from studies like FAME III, align with the timing recommendations discussed earlier for achieving complete revascularization.

Technical Aspects

The European document places limited emphasis on technical aspects, focusing primarily on the hemodynamic implications outlined earlier. It opens the door to diverse

surgical approaches, emphasizing that these should stem from team practice and Heart-Team consensus. The American document delves deeper into the technical specifics of MIDCAB, promoting complete dissection of the internal mammary artery through thoracoscopy to avoid first intercostal branch steal—one of the classical technique's Achilles' heels. It also briefly mentions robotic-assisted approaches, which are less common, particularly in our setting.

COMMENTARY:

The growing interest in this therapeutic option, previously considered marginal, is striking, especially when viewed as a strategy designed for stable coronary artery disease. Currently, HMR holds a Class IIb recommendation in the revascularization guidelines. It would be imprudent to endorse a strategy without robust evidence, especially as we await results from the Hybrid Coronary Revascularization trial to draw meaningful conclusions or issue stronger recommendations. However, there is a notable push to promote innovation and challenge established practices.

I hesitate to think that the promotion of HMR is a strategy to boost stent implantation by leveraging "our" mammary arteries. In other words, if surgical patients typically receive poor-quality vein grafts yet have lower revascularization needs, these new stents would seemingly perform better when paired with an IMA-LAD anastomosis. Once again, we face a scenario where PCI may not involve sutures but still operates with precision.

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José Manuel Martínez Comendador

Revascularization in Left Ventricular Dysfunction: A Review of Indications and Surgical Strategies

This scoping review examines indications and surgical strategies for revascularization in patients with severe ventricular dysfunction through an analysis of the most recent evidence.

Ischemic cardiomyopathy (ICM), characterized by significant left ventricular dysfunction with an ejection fraction (LVEF) ≤40% due to coronary artery disease (CAD), accounts for more than 60% of congestive heart failure cases and is associated with high morbidity and mortality rates. Treatment for ICM aims to extend survival, improve quality of life, and reduce both cardiac and non-cardiac complications. Although ventricular dysfunction in these patients is not necessarily irreversible, coronary artery bypass grafting (CABG) may enhance ventricular function by restoring blood flow to ischemic segments, thereby improving clinical outcomes. In fact, revascularization has been shown to significantly increase LVEF in up to 60% of patients with hibernating myocardium, a topic previously discussed in the blog.

Despite its significance, ICM patients have been systematically excluded from most clinical trials, leading to uncertainty about the applicability of existing results to this population. The 2021 ACC/AHA guidelines recommend surgical revascularization for patients with ICM and an LVEF <35% to improve survival. However, no specific recommendations exist regarding the optimal revascularization strategy for these patients. On the other hand, the ESC/EACTS guidelines recommend surgical revascularization as the first line of treatment in this specific population when an acceptable surgical risk is present.

In this review article, based on the latest evidence, readers will find a comprehensive analysis of studies comparing optimal medical therapy (OMT), percutaneous coronary intervention (PCI), and CABG in the search for the best option for patients with ICM. Additionally, it explores various revascularization strategies in depth, focusing on the benefits and limitations of techniques such as on-pump CABG (ONCABG), off-pump CABG (OPCAB), and hybrid revascularization. Throughout the study, coronary graft options are examined, with particular emphasis on the use of arterial grafts such as the left internal thoracic artery (LITA), right internal thoracic artery (RITA), and radial artery (RA), as well as special considerations required to maximize outcomes in high-risk patients.

Understanding the methodology used in this study is important, as it follows the Arksey and O'Malley framework, designed to conduct a "scoping review." This methodology is ideal when a broad overview on a specific topic is desired, in this case, myocardial revascularization in patients with ischemic left ventricular dysfunction. Unlike other types of reviews that may focus solely on high-quality studies or specific designs, this type of review seeks to include all relevant literature, regardless of study design. This approach allows for identifying both what is known and unknown about a topic, providing a broad map of available research. Following this methodology, the study was able to narrow an initial set of 358 references to 134 relevant studies, ensuring that the selection of studies was carried out with precision and consistency.

Evidence on Optimal Strategy in Patients with LVEF ≤35%

- Clinical Guidelines:

Although European guidelines recommend CABG as a Class I indication for patients with multivessel or left main coronary artery disease presenting with angina or heart failure and with an acceptable surgical risk, the optimal strategy for these patients with severe left ventricular dysfunction remains unclear. PCI is recommended as a Class IIa indication in patients with single or double-vessel disease and could also be considered for those with three-vessel disease with a low SYNTAX score, taking into account patient expectations for complete revascularization, diabetic status, and comorbidities. The AHA guidelines consider CABG for patients with moderate to severe left ventricular dysfunction (LVEF 35-50%) as Class IIa, and it may also be considered for those with severe left ventricular dysfunction (LVEF <35%) with significant left main coronary artery disease. PCI is preferred as an alternative to CABG in selected, stable patients with significant left main coronary artery disease, favorable anatomical conditions, or clinical characteristics predicting a significantly greater risk of adverse outcomes with surgery. Therefore, despite recommendations from European and AHA guidelines, the current understanding of myocardial revascularization in patients with severe left ventricular dysfunction (LVEF ≤35%) remains uncertain. While CABG is recommended as the first-line treatment in patients with multivessel or left main coronary artery disease, PCI is seen as a valid alternative in certain scenarios. However, the optimal revascularization strategy for these patients is still not clearly defined.

- Most Relevant Studies:

The STICH trial, which evaluated the efficacy of CABG compared to OMT in patients with LVEF <35%, found no significant differences in overall mortality in the mid-term follow-up. However, in a later analysis with a median follow-up of 9.8 years (STICH Extended), a reduction in mortality was observed in the CABG group (16% reduction in all-cause mortality). Subgroup analyses indicated that patients with three-vessel disease ($p = 0.04$) or severely remodeled left ventricles (end-systolic left ventricular volume index >78 mL/m² or LVEF <27%; $p = 0.03$) appeared to gain the most benefit from revascularization. Despite these findings, the methodological limitations of the study, such as the substantial crossover rate of 17%, the lack of objective ischemia evaluation, and the inclusion of patients without considering myocardial viability (with a low proportion of patients showing viability), raise questions about the trial's ability to accurately identify patients who would benefit most from revascularization.

The SYNTAX trial, with a five-year follow-up, showed that CABG provided a significant advantage for patients with complex lesions in three vessels or left main coronary artery disease. However, it is noteworthy that patients with ICM and an initial LVEF ≤30% constituted a minority within the CABG group, representing only 2.5% compared to a mere 1.3% in the PCI group, which could limit the generalizability of these findings to this specific population.

The HEART trial was designed to evaluate the feasibility of different revascularization strategies in patients with ICM and LVEF <35% with residual myocardial viability based on conventional imaging tests, such as dobutamine stress echocardiography, angiography, and positron emission tomography (PET). Although the initial plan was to include 800 patients, only 138 were randomized, and no significant differences were found between OMT and invasive revascularization in the five-year follow-up.

A recent meta-analysis comparing various revascularization strategies in patients with CAD and depressed LVEF demonstrated that CABG provides significant advantages over PCI and OMT, particularly in terms of survival and reductions in repeated

revascularizations or reinfarctions. However, this benefit is more clearly observed in the long term. An important limitation to consider in most of these studies is that medical therapies did not include modern medications, such as angiotensin receptor-neprilysin inhibitors (ARNIs) or sodium-glucose cotransporter 2 inhibitors (SGLT2 inhibitors), which have shown to improve cardiovascular outcomes.

Patients with left ventricular dysfunction pose significant challenges in coronary surgery due to their increased risk of complications and early mortality. However, these are precisely the patients who could benefit most from CABG.

Despite the evidence supporting CABG as the preferred revascularization strategy, most data come from observational studies, highlighting the need for more ad hoc randomized controlled trials (RCTs) to identify the most beneficial strategy and optimize treatment for these complex patients.

Surgical Revascularization Strategies and Indications

- Off-Pump Coronary Artery Bypass (OPCABG) vs. On-Pump Coronary Artery Bypass (ONCABG):

OPCABG can provide significant advantages, particularly in high-risk patients, by reducing global myocardial ischemia and limiting the systemic inflammatory response, which may result in improved postoperative outcomes. Compared to ONCABG, OPCABG has shown benefits in some studies, including lower hospital mortality, reduced postoperative neurological events, and decreased need for prolonged ventilation. However, the debate is ongoing, and studies have shown mixed results when comparing both techniques:

The ROOBY trial indicated that although short-term outcomes did not significantly differ between ONCABG and OPCABG, long-term mortality was higher with OPCABG. However, this conclusion has been questioned due to limitations in the study's design, such as the selection of surgeons and the limited representation of patients with left ventricular dysfunction. The ROOBY follow-up study, which assessed the long-term outcomes of these techniques, found no significant advantage of OPCABG in terms of outcomes or costs, concluding that both techniques are complementary and that neither should be preferred over the other in patients who are candidates for both. However, in patients with extremely low left ventricular function (LVEF 10-20%), OPCABG proved to be a viable option, with a reasonable mortality rate (11%) and a significant improvement in average LVEF to 35% at one-year follow-up.

Recent data, such as those from the STS registry, suggest that OPCABG may be a favorable option for patients with left ventricular dysfunction, particularly those with comorbidities and high preoperative risk. Despite performing fewer distal anastomoses, OPCABG does not appear to increase long-term mortality in older patients, highlighting its potential as a viable revascularization strategy in high-risk patients with left ventricular dysfunction.

The CORONARY trial compared OPCABG and ONCABG techniques in a large cohort (4,752 patients), including those with left ventricular dysfunction (23%). Results showed that in low-risk patients, off-pump surgery might be associated with higher one-year mortality, whereas in high-risk patients, OPCABG yielded better outcomes. This difference may be explained by the lower incidence of complications related to cardiopulmonary bypass in low-risk patients, suggesting that OPCABG could be more beneficial in medium- to high-risk patients.

Additionally, OPCABG stands out as a particularly beneficial technique for patients with significant comorbidities, such as those undergoing hemodialysis or those with diabetes and advanced vascular disease, who are at high risk for cerebrovascular complications. In these cases, the “no-touch” technique associated with OPCABG can significantly reduce postoperative complications, reinforcing its utility in high-risk populations.

In OPCABG, the use of a preoperative intra-aortic balloon pump (IABP) in patients with left ventricular dysfunction has shown benefits in high-risk patients. This device enhances cardiac performance and facilitates access to target vessels during surgery, maintaining hemodynamic stability. Known benefits of IABP include reducing ventricular afterload, improving diastolic coronary perfusion and subendocardial perfusion, and redirecting blood flow to ischemic myocardial areas. Additionally, a reduction in ventricular arrhythmias and a lower incidence of postoperative low cardiac output syndrome has been observed, helping to prevent organ dysfunction. However, the IABP is not without risks, as it can cause vascular complications, especially in certain patient groups. These complications may be mitigated by evaluating the status of the thoracic and abdominal aorta with angiography or CT scans beforehand, maintaining activated coagulation times above 150 seconds with unfractionated heparin, and shortening the IABP duration by removing it immediately after the procedure whenever possible.

Besides the use of IABP, the OPCABG technique also benefits from intracoronary shunts and CO2 blowers. Intracoronary shunts are useful for maintaining blood flow during coronary anastomosis construction, which helps prevent surgical errors. The humidified CO2 blower, on the other hand, improves the visualization of the arteriotomy, allowing for greater precision in anastomosis.

- Hybrid Revascularization

Hybrid coronary revascularization (HCR) combines the benefits of CABG and PCI in patients with multivessel disease. This approach is based on the proven efficacy of the LITA graft to the left anterior descending (LAD) artery via CABG, and the advantages of PCI for completing revascularization of other affected arteries in a minimally invasive manner. There are multiple approaches to HCR, but two main strategies exist: simultaneous revascularization in a hybrid operating room and staged procedures, a topic we recently discussed in previous blog posts.

Despite its potential, HCR has limitations, especially when compared to conventional CABG. Several multicenter studies and a meta-analysis indicate that, although there are no significant differences in short-term mortality between HCR and CABG, HCR may be associated with higher rates of repeat revascularization. Furthermore, long-term evidence suggests that HCR may be related to higher mortality, which could limit its utility in patients with multivessel disease over the long term.

In summary, while HCR may be a viable short-term alternative (1 year), especially when performed simultaneously, long-term results favor conventional CABG in terms of mortality and the need for reinterventions.

- Graft Options for Patients with ICM

CABG is the preferred option for patients with ICM, yet there is no consensus in international guidelines on the optimal graft to maximize outcomes in these patients.

The LITA graft has proven superior to PCI in patients with severe coronary artery disease due to its better long-term patency and higher survival rates compared to saphenous vein grafts (SVGs), which are more prone to failure due to intimal fibrosis and accelerated atherosclerosis.
The use of multiple arterial grafts, such as bilateral internal thoracic artery (BITA), has

shown significant survival benefits, particularly when RITA is used as a second conduit. Although BITA is not commonly used in patients with left ventricular dysfunction due to the increased technical complexity and associated risk, it offers significant benefits in reducing mortality and recurrence of cardiovascular events. Despite these advantages, observational studies have shown contradictory results on the long-term advantage of BITA over LITA with SVG grafts. Although the ART trial found no significant differences in mortality between groups treated with BITA and LITA + SVG, potential confounding factors, such as the use of RA as a second conduit in the SITA group, high adherence to guideline-directed medical therapy, and the short follow-up period, suggest that more research is needed to determine the true value of BITA in different patient subgroups, particularly those with left ventricular dysfunction.

The use of BITA in CABG presents significant long-term benefits, but its adoption has not been universal due to the higher risk of sternal complications, such as deep wound infections and healing issues, especially in high-risk patients like the elderly, women, diabetics, and morbidly obese individuals. To mitigate these risks, the BITA skeletonization technique has been developed to preserve sternal perfusion, and strict perioperative glycemic control through intraoperative insulin infusions has been promoted.

Although CABG with BITA is generally reserved for patients under 75 years, the technique remains viable for some older patients, especially when no-touch aorta and off-pump techniques are used to reduce the risk of postoperative complications. Advanced age, diabetes, and the risk of osteoporosis and stroke are factors limiting the use of BITA, although studies have not shown significant differences in long-term survival up to 79 years.

Additionally, the use of the RA as an additional conduit in completely arterial revascularization strategies has been explored. This option is generally well tolerated, although there are contraindications for patients with upper extremity vascular disease or a history of forearm trauma. In patients with chronic kidney disease, it is important to weigh the potential benefits of using the RA against the need for future hemodialysis, as limited evidence is available on this topic.

The RA has proven to be an effective alternative to SVGs in CABG, with a lower incidence of adverse cardiac events and occlusions, as well as better patency at five years. While the RA offers an option to reduce the risk of severe sternal complications associated with BITA use, its application in patients with left ventricular dysfunction remains limited, with low representation in clinical studies. This complicates the application of findings from studies such as RAPCO and RAPS in this specific population.

Despite these limitations, the RA remains a valuable option in completely arterial revascularization strategies, with studies suggesting significant benefits in long-term survival and reduced major cardiovascular events when three arterial conduits are used instead of one or two.

Heart Failure with Improved Ejection Fraction (HFimpEF)

HFimpEF is a newly defined category recently established by the Heart Failure Society of America (HFSA), the Heart Failure Association of the European Society of Cardiology (HFA/ESC), and the Japanese Heart Failure Society (JHFS). This entity describes patients who initially presented with an LVEF ≤40% and, after treatment, achieved an LVEF greater than 40% with an increase of at least 10% from their baseline value. This improvement in LVEF has been associated in some studies with a better prognosis and a significant enhancement in health-related quality of life.

However, research on HFimpEF shows mixed results. While some studies found no significant differences in mortality between patients with HFimpEF and those with heart failure with reduced ejection fraction (HFrEF), other studies, such as a recent meta-analysis, suggest that patients with HFimpEF have a significantly lower risk of all-cause mortality, cardiac hospitalization, and composite events compared to patients with HFrEF.

Recent studies have highlighted the connection between improved LVEF and enhanced quality of life in heart failure patients. According to Wohlfart et al., each 10% increase in LVEF translates into a significant improvement in quality of life, as measured by the Kansas City Cardiomyopathy Questionnaire. Similarly, DeVore et al. found that patients achieving an LVEF increase of ≥10% experienced a greater quality of life improvement compared to those who did not achieve this increase.

The study by Zamora et al. suggested that HFimpEF patients who showed a recovery of ventricular function tend to have a shorter duration of heart failure and belong to lower NYHA functional classes, contributing to an improved quality of life. However, quality of life is a subjective measure influenced by various factors, including comorbidities and previous hospitalizations, which should be considered when assessing patient well-being.

COMMENTARY:

Although this scoping review synthesizes the available evidence, the study acknowledges several limitations, primarily the systematic exclusion of ICM patients from most randomized controlled trials (RCTs), leading to a reliance on observational studies that may underrepresent these patients and introduce potential biases. Additionally, the lack of a universal definition for left ventricular dysfunction and the heterogeneity of reported outcomes in existing literature complicated a comprehensive evaluation of this topic.

There is an urgent need for more RCTs to properly evaluate the potential benefits of various surgical techniques and graft options in ICM patients. It is also crucial to conduct additional randomized studies exploring the clinical significance of LVEF improvements and their impact on patient-centered outcomes. An ongoing study, the MASS VI VF, is investigating this issue by comparing myocardial revascularization surgery with medical treatment in patients with multivessel coronary artery disease, angina, and severe left ventricular dysfunction, potentially providing valuable insights into optimal management for these patients.

In summary, some key conclusions from this review by section include:

- Benefits of Surgical Revascularization: Surgical revascularization has proven to be a beneficial intervention in patients with left ventricular dysfunction and an LVEF ≤35%. This intervention not only improves LVEF but is also associated with enhancements in quality of life and reductions in mortality rates, possibly linked to lower rates of repeat revascularization. These benefits are more evident in patients with demonstrated myocardial ischemia and/or angina.

- Choice of Surgical Technique: ONCABG is recommended for patients with multivessel disease, especially utilizing LITA grafts to the LAD. For older or high-risk patients, OPCABG with the “no-touch aorta” technique is a viable option that reduces the risk of cerebrovascular events.

- Considerations for Graft Selection: The risk of SVG graft occlusion suggests the need to consider a second arterial graft or even complete arterial revascularization. RITA and RA provide viable options, with techniques like skeletonization and strict perioperative glycemic control, which can mitigate risks, especially in diabetic patients.

- Need for Further Research: Despite positive findings, there is a critical need for more RCTs that include patients with left ventricular dysfunction, as most current studies are observational and present certain limitations. Additional research is also needed to explore the long-term impact of myocardial revascularization on cardiac function and clinical outcomes.

- Hybrid Revascularization: Hybrid revascularization, combining surgical grafts with percutaneous interventions, remains an option for certain patients, although clear guidelines are lacking. However, this technique could offer benefits, such as shorter hospital stays and lower costs when determined through a multidisciplinary approach.

To illustrate how some of these measures are implemented in our department at CHUAC (A Coruña), here is an overview of our general policy regarding myocardial revascularization surgery:

- OPCABG: All team members adhere to a policy of performing the majority of coronary surgeries using the OPCABG technique, achieving a rate >95% of cases and maintaining mortality below 2% over the past three years. During this technique, we perform proximal occlusion whenever possible and use shunts only when strictly necessary. The policy of consistently using OPCABG aims to train the team to handle any circumstance, not just "easy" cases. In this way, when we encounter more complex situations, such as patients with severe ventricular dysfunction, we can more likely ensure a successful surgery.

- Use of Bilateral Internal Thoracic Arteries: In more than 98% of surgeries, regardless of the patient's age, we employ the skeletonized technique with the in situ left internal mammary artery, using the Tector technique. Routine use and constant training in this technique ensure good results, even in technically challenging cases.

- Hybrid Revascularization: Primarily applied in two specific circumstances:

    1. When there is a poor posterior descending artery bed or a proximal lesion under 90%: after surgery and if ischemia is detected during hospitalization.

    2. When revascularization of a relevant vessel cannot be achieved during surgery: performed during hospitalization prior to discharge following a Heart-Team meeting with the interventional cardiology team.

- Patients with Severe Dysfunction: We perform OPCABG and complete arterial revascularization with double mammary artery whenever the patient

tolerates it. In exceptional cases, hybrid revascularization is chosen if necessary, postoperatively.

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Carmen García Meré

Will the fate of right coronary revascularization improve with Y-anastomosis?

This retrospective study evaluates the prevalence of competitive flow and the 1-year patency in terminal Y-anastomoses on the right coronary artery (RCA).

Composite revascularization with sequential and Y-anastomoses using in situ left internal thoracic artery (LITA) is primarily beneficial for patients with limited graft options and those requiring avoidance of aortic manipulation. Although patency and unidirectional flow have been demonstrated in left coronary territory revascularization, Kang et al. innovatively assess the prevalence and outcomes of these anastomoses in the RCA distal segment.

The study included 642 patients who underwent off-pump coronary artery bypass grafting (OPCAB) using Y-composite grafts, with one terminal arm directed to revascularize the RCA. Mean age was 67.1 years, with 77% male. The saphenous vein (SV) served as the secondary conduit, except in 30 patients. Competitive flow in the RCA graft was defined when the flow towards the anastomosis originated not from the donor LITA but instead reversed from the native RCA. Initial patency was assessed by angiography within 24 hours postoperatively, and follow-up angiography was performed at one year. Subgroup analyses evaluated risk factors associated with competitive flow presence at the one-year follow-up.

A total of 1,507 distal anastomoses were performed with secondary conduits, with an average of 2.3 anastomoses per conduit. Mean stenosis in target coronary vessels was 81.7%. Early occlusion and competitive flow in the RCA distal anastomosis were observed in 4.4% and 10.7% of cases, respectively. Univariate and multivariable analyses identified that target vessel stenosis ($p < .001$) and the most severely diseased non-LAD vessel ($p < .001$) were significantly associated with competitive flow in RCA grafts. Diabetes mellitus was protective against competitive flow ($p = .029$). Competitive flow prevalence was significantly higher in terminal anastomoses to vessels with less than 90% stenosis ($p < .001$). At the one-year follow-up, 81% of patients underwent angiography. Of the 55 patients with competitive flow observed on initial angiography, 14 (24.5%) exhibited occlusion, and 17 (30.9%) experienced graft failure. Both univariate and multivariable analyses found early competitive flow to be the sole factor significantly associated with one-year RCA anastomosis occlusion ($p = .015$).

COMMENTARY:

In recent years, several studies have analyzed the patency of grafts in myocardial revascularization using composite grafts. Nakajima et al. conducted a similar study with the radial artery as a secondary conduit, emphasizing the importance of selecting the target vessel to enhance long-term patency. The IMPAG study analyzed preoperative FFR to improve patency at six months post-surgery, yielding values of 0.71 in the right system and 0.78 in the left system. These findings align with those of Kang et al. and also relate to the distance from the subclavian artery origin and the distal RCA anastomosis. Greater graft length results in a pressure drop, increasing the risk of competitive flow. Additionally, a drop in pressure across sequential anastomoses, particularly in the distal anastomosis, may restrict flow, especially when supplying a different territory from the left coronary system.

For cases requiring aortic non-manipulation, using an in situ right internal thoracic artery (RITA) or extending it with a secondary graft (utilizing the remaining graft with the LITA for left coronary revascularization) could shorten the distance to the RCA, thereby minimizing the risk of competitive flow.

The success of RCA revascularization depends on comprehensive analysis and strategic selection, considering the degree of terminal lesion, graft type, and patient characteristics for optimal surgical planning.

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Section III:

Congenital heart disease

Marta Gambra Arzoz

Disproportion in weight during neonatal transplantation: infants can handle almost anything

This retrospective study reviews data from the United States Organ Procurement and Transplant Network, comparing waitlist times, complication rates, and survival outcomes in infants under one year of age transplanted with a donor-to-recipient weight ratio (DRWR) >2 versus others.

In recent years, mortality among pediatric heart transplant candidates has progressively declined. However, this improvement has not extended to infants, where waitlist mortality remains approximately 20%. This discrepancy is primarily attributed to donor shortages, leading to prolonged waitlist times. One proposed solution involves expanding donor availability by reconsidering size discrepancy criteria for donor-recipient matching.

The International Society for Heart and Lung Transplantation (ISHLT), in its December 2022 guidelines, recommended evaluating graft size based on weight, setting a DRWR limit of 0.8–2. More recently, the ISHLT consensus has debated these guidelines, suggesting that a DRWR of 0.6–3 is not associated with worse outcomes.

The authors hypothesize that expanding donor weight limits reduces waitlist duration and associated morbidity and mortality without increasing post-transplant complications.

This study retrospectively analyzed data from the US Organ Procurement and Transplant Network. It included infants under one year transplanted between 2007 and 2020, categorizing them into three groups by DRWR: <1 (group A), 1–2 (group B), and >2 (group C).

Between 2007 and 2020, 1,392 infants under one year of age received transplants with DRWR ranging from 0.5 to 4.1. Patient characteristics—including gender, race, cardiac pathology (congenital vs. dilated cardiomyopathy), renal function, and need for ECMO or long-term ventricular support before transplantation—were similar across groups. However, patients in group C were more likely to require mechanical ventilation during the waitlist period, receive ABO-incompatible transplants, and experience longer ischemic times.

Waitlist times were significantly shorter in group C. Post-transplant complications (e.g., primary graft dysfunction, renal failure, or stroke) and 30-day mortality were comparable across groups. Multivariable analysis, adjusting for type of cardiac pathology, showed similar 30-day survival rates across groups, although pre-transplant ECMO was a significant risk factor for hospital mortality (OR 4.4).

Survival at 1, 3, and 5 years post-transplant was also statistically similar among the groups.

COMMENTARY:

Currently, the donor shortage necessitates rethinking strategies to balance supply and demand, especially in the pediatric population. Without such measures, the consequences include prolonged waitlist times and higher mortality rates among infant heart transplant candidates. Expanding donor size acceptance criteria could maximize organ utilization.

As noted, ISHLT guidelines initially recommended a DRWR of 0.8–2 but have since considered a broader range (0.6–3), as evidence suggests no adverse outcomes.

Efforts to identify prognostically significant donor-recipient size parameters have included predictive models using MRI or CT imaging to estimate size in terms of mass or volume. These models incorporate variables such as sex, age, weight, and height, with recent findings favoring total cardiac volume (TCV) as the best measure for survival impact. However, these findings, such as those by Plasencia et al., are derived from limited cohorts and warrant cautious interpretation.

A key strength of this study is its focus on a large cohort of over 1,300 infants, a high-risk group often excluded from prior studies. Group C (DRWR >2) included sicker infants with higher rates of mechanical ventilation, ABO-incompatible transplants, and longer ischemic times. Despite these challenges, waitlist times were significantly shorter without increased complications or reduced survival at 30 days, 1 year, 3 years, or 5 years.

At La Paz Hospital, 22 transplants in infants under one year of age with DRWRs of 0.8–3 were performed over the last 20 years. Eight of these patients fell into group C. The mean ischemic time for group C was 239.5 minutes compared to 221.21 minutes ($p > .05$). Post-transplant ECMO was required in 4 patients, none of whom had a DRWR >2. Among the 22 transplants, 3 involved ABO-incompatible protocols (2 with DRWR = 2 and 1 with DRWR >2). Five-year survival was higher in group C (75% vs. 66%).

One limitation of this study is the lack of investigation into other morbidities potentially associated with donor-recipient size mismatch, such as delayed sternal closure and related complications.

Nevertheless, this study's relevance lies in its focus on infants, a critical risk group where strategies to mitigate donor scarcity are crucial. At La Paz Hospital, adopting donor-recipient size mismatch strategies, along with ABO-incompatible and circulatory death donation protocols, has achieved a 5-year survival rate of 80% in infants under one year. Based on these results, future efforts may prioritize broader acceptance of DRWR (2–3), alongside other strategies like circulatory death donation and expanded ABO-incompatible protocols.

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Alejandra Peña

Long-term use of ventricular assist devices in children: Is it feasible and safe?

This study, conducted at a tertiary pediatric cardiology center, evaluates the long-term use of ventricular assist devices (VADs).

Heart failure in pediatric patients is one of the leading causes of mortality in this population. Its management includes medical treatment, circulatory support with VADs, surgical intervention, and heart transplantation. While VADs are a management option for these patients, their use in the pediatric population only increased significantly after the year 2000. Since then, both the technique and the devices have improved considerably, not only altering heart failure management strategies but also significantly enhancing survival rates in these patients. However, their application remains limited due to challenges such as the availability of suitable devices, medium- and long-term complications, and other factors.

This was a descriptive, retrospective study conducted at Texas Children's Hospital between May 2008 and September 2022. The authors evaluated the number of VAD implantations rather than the number of patients. The indications for VAD placement included: bridge-to-transplant (for patients already listed for transplantation at the time of device implantation), bridge-to-transplant candidacy (for patients with potentially reversible contraindications to transplantation), bridge-to-decision (as a rescue therapy), bridge-to-recovery, and, occasionally, destination therapy. As part of the hospital's routine practice, all patients who received a VAD were kept inactive on the heart transplant waitlist for at least three months. During this period, their physical and psychological progress was monitored. If patients showed improvement in left ventricular function or a reduction in the left ventricular end-diastolic volume z-score, they were classified as responders and remained under prolonged surveillance to achieve greater recovery, always with family consent. If the potential for cardiac recovery was deemed minimal, the patient was reactivated on the heart transplant waitlist.

The overall outcomes of the study were categorized into four groups: heart transplant, device explantation due to myocardial recovery, ongoing support (or destination therapy), and death. Long-term survival rates were calculated using the Kaplan-Meier method, and follow-up data were censored at the time of death, loss to follow-up, or the end of December 2022.

A total of 100 events were included. The devices used were HeartWare® in 67% of cases, HeartMate II® in 17%, and HeartMate 3® in 16%. The median age at implantation was 14 years, with a mean weight of 50 kg and a mean body surface area of 1.6 m^2. The primary diagnosis was cardiomyopathy, which accounted for 58% of cases, followed by congenital heart disease (CHD) in 37% (including single ventricle physiology).

At six months, 94% of cases showed favorable outcomes: 64 patients underwent heart transplantation, 15 required ongoing support, and 7 were in the recovery phase. A total of 82% of cases were discharged home with VAD support, showing a decrease in bleeding, infection, and cerebrovascular events. At three months, 51% of the cases met the responder criteria. By the end of six months, 88% had successfully completed this period, and only 10 patients required early heart transplantation or died. Survival rates at one, two, and five years were 90%, 86%, and 77%, respectively. Among the 14 deaths, half occurred in-hospital before discharge following VAD implantation, with the main causes being infections and cerebrovascular events.

Regarding hospital readmissions, 46% of cases required rehospitalization. Among the 82 cases discharged, more than half returned to school or work. One patient married and had a daughter, while six others graduated from high school with VAD support. One of these patients is currently in college and holds the record for the longest follow-up, which spans 11 years.

The study concluded that the use of VADs is feasible for ambulatory patients in a tertiary pediatric institution. The capacity of implantable devices provides not only a bridge to heart transplantation but also excellent support for other types of bridges or even as destination therapy.

COMMENTARY:

This is a single-center study evaluating the prolonged use of VADs in pediatric patients. However, it is not free of limitations, as it presents a retrospective analysis that carries the potential for biases and limitations in data collection. The study does not specify whether delaying the patients' activation on the heart transplant waitlist for three months had any negative impact. Furthermore, it does not detail the clinical conditions considered for deciding which patients (particularly critically ill ones) should receive circulatory support, nor whether any demographic or social factors were taken into account for device implantation. Additionally, the study fails to define long-term complications associated with the use of these devices and does not specify the causes or costs of readmissions.

This study involves a substantial series of pediatric patients with VADs and clearly demonstrates that these patients can be safely discharged home and return to their activities. One of the main consequences of progress in diagnosing and managing congenital heart diseases, including patients with single-ventricle physiology, is a significant increase in survival, with many requiring heart transplantation as the definitive treatment for end-stage heart failure.

Currently, the use of VADs is primarily oriented as a bridge to heart transplantation. However, the scarcity of donor availability is a common problem that necessitates alternative strategies, which come with additional costs and psychological impacts not only on patients but also on their families, which must be taken into consideration.

For this reason, the use of VADs is becoming increasingly common, and one of the main challenges lies in deciding whether to refer a patient for heart transplantation or instead opt for long-term circulatory support, which could potentially become destination therapy. While it is true that these devices have evolved, becoming safer and easier to manage, adverse effects are not uncommon. These include bleeding (mainly gastrointestinal), infections, thrombus formation, neurological complications, and others. Furthermore, when considering sociodemographic factors related to healthcare access or adherence to prescribed measures, it becomes evident that this decision is not straightforward.

Access to adequate medical care, convenience, and the cost of follow-up depend heavily on the distribution of qualified centers and the availability of VADs. Consequently, in pediatric populations, this type of therapy is only accessible in developed countries.

There is no doubt that advances in the diagnosis and management of pediatric cardiology have significantly improved survival rates in these patients. However, the use of VADs in the pediatric population remains far from being widely implemented. Institutional development imbalances and disparities in healthcare resources on an international level greatly restrict access to medical care and overall survival in this population.

In conclusion, VADs play a crucial role in managing end-stage heart failure, even in pediatric patients. Significant progress has been made in recent years, but the application of these devices in pediatric patients lags behind that of adult patients in many respects. To overcome these challenges, more registries should be established, including the largest possible number of patients, to guide clinical decisions, improve knowledge, and enhance efficiency.

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Bunty Ramchandani

Berlin Heart® as a bridge to recovery

A systematic review analyzing nearly 1000 pediatric Berlin Heart® implants to describe the characteristics of patients who achieved successful explantation.

Heart transplantation is the treatment of choice for advanced heart failure in the pediatric population. The universal shortage of organs has driven the use of ventricular assist devices (VADs) as a bridge to transplantation. Over the last decade, the use of VADs has increased to the extent that they are employed in up to half of transplanted patients. Currently, the Berlin Heart EXCOR® (BHE) is one of the few paracorporeal VADs specifically approved for the pediatric population. Its use is indicated in INTERMACS 1 and 2 patients and allows for transplantation rates of up to 70%. However, a significant proportion of children experience cardiac function recovery after receiving this therapy.

Successful explantation implies cardiac function recovery, avoiding the use of immunosuppressive medications and the uncertainties surrounding graft durability. The benefits extend beyond the individual patient, positively impacting the collective of patients awaiting a heart by reducing demand, increasing organ availability, and shortening waiting times. So, which patients might be expected to recover?

Today's article is a systematic review that aims to answer this question. A systematic search was conducted in five databases: PubMed, Medline, OVID, Web of Science, Cochrane Central, and CINAHL Complete, for articles about successful BHE VAD explantation in pediatric patients. Articles mixing pediatric and adult patient outcomes, studies with fewer than 10 patients, and those with no successful BHE explants were excluded. Successful explantation was defined as withdrawal of VAD support without mortality or severe neurological complications. The primary objective was to identify the characteristics of patients who achieved successful explantation, with a secondary aim to analyze the different published weaning protocols.

Out of 42,000 potential studies, 14 were analyzed, including data from 58 hospitals across four continents during the 1990–2020 period. A total of 984 patients with BHE were analyzed. The most common primary diagnosis was dilated cardiomyopathy (33% of patients), followed by congenital heart disease (25%). Successful explantation of BHE was achieved in 85 children (8.6%). The primary diagnosis was identified in half of these cases (n=44): 14 of 166 cardiomyopathies (8.4%), 17 of 35 myocarditis cases (48.6%), and 12 of 72 congenital heart disease cases (16.7%). Most patients with successful explantation had left VADs, while successful explantation in biventricular VAD patients was exceedingly rare.

The authors concluded that successful explantation of a BHE is not an uncommon milestone, occurring in up to 8% of cases with this type of VAD. Patients diagnosed with myocarditis and those with left VADs are more likely to achieve successful explantation. The authors emphasize the need to standardize BHE-related publications and initiate prospective registries to better identify such patients and unify weaning protocols.

COMMENTARY:

There is a myriad of publications on the BHE, but this is the first article focused on identifying patients in whom this therapy served as a bridge to recovery. Typically, a BHE is implanted as a bridge to transplantation, but this review shows that cardiac recovery in this patient profile can occur in up to 8% of cases—a surprisingly high figure to consider

it anecdotal. In fact, according to the authors, nearly half of myocarditis cases and 17% of congenital heart disease cases might achieve successful explantation. Unsurprisingly, patients with left VADs had higher weaning rates compared to biventricular ones, given the severity of cardiac dysfunction. Curiously, more successful BHE explantations have been reported in Europe and Asia compared to the United States and Australia. Another notable observation is that the U.S. transplants more congenital heart disease patients, while Europe transplants more dilated cardiomyopathy cases.

Unfortunately, very little has been published on weaning protocols, and among the studies that do mention them, few define the clinical parameters they use. Some cases involve cardiac catheterization with the device turned off to obtain baseline hemodynamic measurements, followed by a volume test to assess tolerance. Others, after observing clinical, echocardiographic, and laboratory recovery, perform weaning trials in the operating room. Some studies mention stress echocardiograms, while others refer to specific explant protocols without providing a citation for reference. In short, each institution has its own approach to BHE weaning and explantation, making it difficult for readers to benefit from this information.

We must not overlook the limitations of such studies. They rely on single-center studies, show significant heterogeneity in diagnoses, and differ in how data is presented. Duplicate publications from the same hospital were excluded, potentially leading to the loss of relevant information. Additionally, this study's selection criteria—including only studies with more than 10 pediatric patients and at least one successful BHE explant—may overestimate explantation rates. There is also no follow-up data on these patients, so we do not know if those with successful explantation eventually required a transplant or continued living with their recovered heart.

In conclusion, despite the important limitations of this study, we cannot ignore the possibility of cardiac recovery after BHE implantation. We still don't know exactly who the possible candidates could be. To do this, we would have to strive to collaborate on a common prospective multicenter registry of all BBB patients. In the end, with pathologies so rare, unity is strength.

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Diana Salas Mera

More challenging yet: outcomes of heart transplantation in children with heterotaxy syndrome

This retrospective study utilized data from the United Network for Organ Sharing (UNOS) and the Pediatric Health Information System (PHIS) to evaluate the outcomes of heart transplantation in children with heterotaxy syndrome. These were compared with outcomes in patients with other congenital heart diseases (CHD) and cardiomyopathies, focusing on survival, rejection, and additional complications.

Heterotaxy syndrome, also known as isomerism, encompasses a heterogeneous group of laterality disorders involving thoracoabdominal visceral organs. It is frequently associated with complex cardiac defects and anomalies in venous return. Although rare, comprising 2-3% of all CHDs, these conditions often necessitate heart transplantation due to the anatomical complexity that hinders successful univentricular palliations or reparations. Previous studies and blog entries have highlighted these patients as a high-risk group for cardiac surgery, with poorer morbidity and mortality outcomes compared to other CHDs. However, data specifically on transplantation are scarce.

The article under review analyzed outcomes of heart transplantation in children with heterotaxy syndrome using cross-referenced data from the UNOS and PHIS registries. It included patients under 18 years of age who underwent heart transplantation between 2016 and 2019, excluding those with genetic anomalies. The cohort was divided into three groups: heterotaxy, other CHDs, and cardiomyopathies. Data were collected on demographics, clinical variables (such as dialysis, mechanical ventilation, ECMO, or ventricular assistance), waiting list and ischemia times, and post-transplant outcomes (mortality, hospital stay duration, primary graft dysfunction, stroke, rejection, pacemaker or dialysis requirements). Non-parametric methods were used for univariate analysis, while Kaplan-Meier survival curves and log-rank tests evaluated survival. A Cox regression model was developed for the heterotaxy group, incorporating previously identified risk factors for worse post-transplant survival.

A total of 1,122 patients were analyzed: 143 in the heterotaxy group, 428 in the other CHDs group, and 551 in the cardiomyopathy group. The baseline characteristics of the heterotaxy and other CHDs groups were similar, with both groups having younger and lighter patients compared to the cardiomyopathy group. Patients with heterotaxy and other CHDs required more inotropic support and mechanical ventilation but were less likely to receive ventricular assist devices at the time of transplantation. ECMO use was low and comparable across all groups. The waiting list duration was longer for the heterotaxy group (91 days vs. 63 days for other CHDs vs. 56 days for cardiomyopathies; $p < .001$). Ischemia time was comparable between the heterotaxy and other CHD groups and longer than for cardiomyopathies (3.8 h vs. 3.4 h; $p < .001$). Operative mortality was 1% for cardiomyopathies and 4% for the other two groups ($p < .001$). There were no significant differences in other post-transplant complications. Hospital stays were shorter in the cardiomyopathy group (57 days vs. 99 days for other CHDs vs. 89 days for heterotaxy; $p < .001$). Rejection rates during hospitalization were similar across groups; however, at one year post-transplant, rejection rates were higher for heterotaxy (22% vs. 19% for other CHDs vs. 13% for cardiomyopathies; $p < .001$). Five-year survival was highest in the cardiomyopathy group (87%), followed by other CHDs (78%) and heterotaxy (69%), primarily due to lower early mortality in the cardiomyopathy group. A more pronounced survival decline was observed in the heterotaxy group around the three-year mark, although this difference did not reach statistical significance. No risk

factors significantly affecting survival were identified in the multivariable analysis for the heterotaxy group.

COMMENTARY:

As previously noted, cardiac surgery in patients with heterotaxy syndrome carries higher morbidity and mortality compared to other CHDs. Despite the expectation that similar factors might adversely impact transplantation outcomes (e.g., venous return anomalies, prior univentricular palliations necessitating complex vascular reconstructions, challenging re-sternotomies, and extracardiac conditions like primary ciliary dyskinesia, immunodeficiency, and gastrointestinal anomalies), this study found no significant differences in procedural mortality, ischemia times, hospital stays, or postoperative complications between heterotaxy and other CHD groups. The authors attribute this to improved case selection for the transplantation waiting list, the more recent cohort analyzed, and greater surgical experience. Consistent with previous findings, global mortality remained higher for CHD patients (with and without heterotaxy) compared to cardiomyopathy patients, who exhibited better pre-transplant clinical stability due to higher rates of ventricular assistance.

The greater heterogeneity of heterotaxy patients presents challenges for study and classification. Improved coding systems, such as ICD-10, have enabled better identification, but the limited follow-up period (three years) restricts long-term outcome evaluation. Additionally, the lack of differentiation between subgroups (e.g., left vs. right atrial isomerism or biventricular vs. univentricular defects) limits the granularity of the data. The absence of pre-transplant evolution metrics, such as waiting list mortality, introduces potential survival bias.

The slightly elevated one-year rejection rate in the heterotaxy group could reflect heightened sensitization from prior surgeries. However, data on pre-transplant procedural history and anti-HLA antibodies were insufficient. Similarly, immune suppression adjustments for infection risks in heterotaxy-associated immunodeficiencies were not addressed, highlighting areas for further research.

Despite its limitations, this study provides valuable insights into an under-researched population. The findings suggest that transplantation outcomes for children with heterotaxy are comparable to other CHDs, supporting their inclusion in transplant lists before clinical deterioration compromises prognosis. Future research should aim to confirm these findings and explore the specific characteristics of this group in greater depth.

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Juan-Miguel Gil-Jaurena

Transplantation in Fontan: an expert's perspective

A review commentary on the complex topic of heart transplantation in patients with Fontan circulation physiology, authored by expert Dr. Juan-Miguel Gil-Jaurena.

The mortality rate for transplantation in patients with prior Fontan surgery was double that reported by the International Society for Heart and Lung Transplantation (ISHLT) 20 years ago, reaching 30%. A multicenter study from a decade ago estimated this rate at 20-25%. More recently, outcomes have improved, with survival rates reaching 80% and even 90%.

Why is transplantation mortality higher in Fontan patients? Perhaps comparisons should be made not with dilated cardiomyopathy in a virgin chest but with congenital heart disease (CHD) transplants in general. Single-ventricle physiology is inherently more precarious and may fail due to either dysfunction of the single (systemic) ventricle or venous congestion caused by the absence of a sub-pulmonary ventricle (hepatic fibrosis, protein-losing enteropathy). In this regard, circulatory support as a bridge to transplantation presents technical challenges and inferior outcomes compared with biventricular physiology.

Several authors emphasize similarities with “conventional” transplantation, while highlighting strategy and technical differences in the anticipated anastomoses. Identifying the type of cavo-pulmonary connection (atrio-pulmonary, lateral tunnel, extracardiac conduit, etc.) is crucial due to their many variants. This necessitates the “deconstruction” of venous and arterial connections before graft implantation. Key considerations include:

- Previous Interventions: These patients often face a fourth sternotomy following Norwood, Glenn, and Fontan procedures. The risk of antigenic sensitization is elevated. Adhesions and tissue fragility increase the likelihood of requiring cardiopulmonary bypass during dissection. However, peripheral cannulation (e.g., femoral) is frequently unfeasible due to vessel occlusion from repeated catheterizations, necessitating alternative cannulation strategies (axillary, carotid, jugular, etc.).

- Collateral Circulation: The presence of abundant collateral circulation warrants low flows due to excessive return to the common atrium. Hypothermia, sometimes profound, with one or more periods of circulatory arrest, is often required.

- Foreign Materials: External materials such as Dacron or PTFE patches, often adhered to tissues, are commonly encountered. Stents, predominantly in pulmonary branches and venae cavae, are increasingly prevalent. Their partial or complete removal depends on vessel fragility and suture line integrity.

- Anatomical Variants: Situs abnormalities (solitus, inversus, ambiguus), apex orientation (levo-, meso-, dextrocardia), number and position of venae cavae (right or left-sided axis; one or two superior), and the relative position of the aorta and pulmonary artery (e.g., prior LeCompte) require preoperative planning. Sequential analysis of five suture lines in bi-caval procedures is

imperative. Tissue harvesting from the donor (aorta, arch, superior vena cava with innominate vein, pericardial patch) is essential for anastomotic adaptations.

Special attention is required for cases with initial Norwood surgery due to the need for aortic and pulmonary branch reconstructions.

- Neo-aorta Challenges: The neo-aorta's wide, short, and fragile structure complicates clamping and reconstruction. Extensive removal of prior material, hemi-arch anastomosis, or conduit interposition often necessitates alternative cannulation (e.g., innominate trunk) or brief circulatory arrest.

- Pulmonary Branch Reconstruction: After Glenn disassembly, pulmonary branches (especially with left-sided stents) often require reconstruction. My preference is donor pericardial patch augmentation (or alternative materials) to expand these branches from hilum to hilum. Low flows or circulatory arrest in hypothermia are necessary.

These complex surgeries often extend to 12 hours, with factors such as adhesions, hypothermia, extensive dissection, bleeding, and suspected pulmonary hypertension contributing to increased morbidity. Delayed chest closure and ECMO support during the first 48 hours are common.

Our group published a series of 20 Fontan transplants in 2021 (including one heart-liver transplant), with 90% survival, comparable to 52 non-Fontan congenital transplants. From 2013 to 2023, we performed 112 congenital transplants, 32 of which were Fontan cases (13 adults). While demanding, preoperative strategies for cannulation, hypothermia, and reconstruction contribute to outcomes approaching those of other transplant cohorts.

Significant challenges remain, such as combined heart-kidney and heart-liver transplants. For failed Fontan patients once deemed ineligible due to hepatopathy, heart-liver transplantation now offers a viable option, albeit with logistical and organ allocation complexities. Some authors advocate for a "special treatment" of Fontan patients, suggesting new risk stratification models and reconsideration of waitlist prioritization (e.g., young patients, poor candidates for mechanical support, right-sided support, prior sensitizations).

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María Luz Polo López

Pediatric Ventricular Assist Devices in Europe: 4th Paedi-EUROMACS Registry

The fourth report of the European registry of long-term ventricular assist devices (VADs) in pediatric patients covers the period 2001–2022, analyzing observed data and trends over time.

This article reviews the fourth report of pediatric patients included in the European registry of long-term VADs (Paedi-EUROMACS). The study encompasses 590 primary long-term VAD implants (uni- or biventricular) in patients under 19 years of age during a 21-year period (2001–2022). A total of 29 hospitals across 15 countries, primarily European, participated in this registry. The primary endpoints analyzed were VAD explantation due to death, heart transplantation, or recovery of cardiac function. Secondary endpoints included thromboembolic, infectious, and cerebrovascular complications, as well as right ventricular failure, respiratory failure, and renal dysfunction in VAD recipients.

The predominant initial diagnosis was cardiomyopathy in 68% (mainly dilated), congenital heart disease (CHD) in 17%, and acute myocarditis in 15%. Patients with CHD were significantly younger, clinically more compromised, had higher rates of prior surgeries, and were more often implanted with pulsatile-flow devices compared to patients with cardiomyopathy.

The primary indication for VAD implantation was bridge to transplant (63%), potential bridge to transplant (26%), with destination therapy being anecdotal in children (0.5%). Regarding the type of VAD implanted, 62% were paracorporeal devices (predominantly Berlin Heart EXCOR®), and 36% were intracorporeal devices (primarily HeartWare®). Most VADs provided univentricular support (85%), including 10 patients with a single ventricle. In 15% of cases, biventricular support was utilized. The median duration of support was 3.9 months.

Observed outcomes at two years in the overall cohort for primary endpoints showed that 59.7% underwent transplantation, 22% died, and 10% recovered. Patients with CHD had higher mortality and lower transplantation rates compared to those with cardiomyopathy. The leading causes of death were stroke and multiorgan failure. Multivariate analysis identified INTERMACS profile I and the need for prior extracorporeal membrane oxygenation (ECMO) as risk factors for mortality. However, CHD was not a risk factor for mortality in this study. Among adverse events associated with VADs, pump thrombosis was the most frequent complication, followed by infections and strokes. Multivariate analysis of pump thrombosis risk factors associated this complication with smaller body surface area and pulsatile-flow devices. Patients with CHD exhibited higher rates of pump thrombosis, malfunction, and infection, while those with cardiomyopathy experienced more arrhythmias. Smaller body surface area was also a risk factor for stroke, and postoperative bleeding was linked to INTERMACS I profile and prior ECMO use.

COMMENTARY:

As in adults, the use of long-term VADs in children as a treatment for end-stage heart failure is steadily increasing. Due to the relatively small number of pediatric VAD implants compared to adults, collaborative studies among hospitals are essential to identify trends, evaluate outcomes, and draw conclusions about this therapy in the pediatric

population. This fourth Paedi-EUROMACS report includes 590 primary long-term VAD implants (uni- or biventricular) in patients under 19 years of age over a 21-year period.

The primary diagnosis of children requiring VADs remains cardiomyopathy, although the proportion of CHD patients has increased compared to the previous European report, albeit still lower than in the American registry (17% in Paedi-EUROMACS vs. 25% in PEDIMACS).

In this pediatric cohort, VADs were primarily implanted as a bridge to transplant. These devices have reduced waiting list mortality and enabled a higher percentage of children to reach transplantation.

Among the implanted devices, 62% were pulsatile-flow devices (primarily Berlin Heart EXCOR®). In the 36% intracorporeal group, HeartWare® was predominant, though its market withdrawal in 2021 is expected to lead to increased use of Berlin Heart EXCOR® and HeartMate3®.

Univentricular VADs were generally implanted (85%), while 15% received biventricular support. Ten patients with single ventricles and univentricular VADs were not separately analyzed, likely due to their small numbers, though these cases may increase in the future as terminal heart failure is a common manifestation in this population over time.

The two-year outcomes observed in the overall cohort were promising, with nearly 60% undergoing transplantation, 22% dying, and 10% recovering. Despite modifications to anticoagulant and antiplatelet protocols, pump thrombosis remains the most frequent adverse event, associated with pulsatile-flow devices and smaller body surface area.

This study compared CHD and cardiomyopathy populations, revealing that the former were significantly younger, had worse clinical conditions, more prior surgeries, and more pulsatile-flow devices. CHD patients also had higher mortality and lower transplantation rates compared to cardiomyopathy patients.

Multivariate analysis identified INTERMACS I profile and prior ECMO use as risk factors for mortality and postoperative bleeding. These factors have also been associated with poorer outcomes in adult VAD patients.

In conclusion, the use of long-term VADs in pediatric patients is increasing and serves as an effective tool to achieve transplantation or VAD explantation due to cardiac recovery in up to 70% of cases. While nonmodifiable factors such as weight or cardiac diagnosis exist, preimplant clinical condition can be optimized. Timing of VAD implantation should consider these factors to avoid excessively early or delayed interventions, aiming for the best possible outcomes.

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Bunty Ramchandani

Congenital supravalvular aortic stenosis: what does the future hold?

A systematic review, meta-analysis, and microsimulation study investigating short- and long-term outcomes of congenital supravalvular aortic stenosis.

Elastin arteriopathies are the primary causes of congenital supravalvular aortic stenosis. The most notable example of this condition is Williams-Beuren syndrome, also known as Williams syndrome. Elastin dysfunction leads to reduced arterial elasticity, increasing stiffness. This triggers smooth muscle cell migration and proliferation, resulting in hypertension and vascular stenosis. There are two forms of presentation: discrete and diffuse. The discrete form occurs in 75% of cases and involves the sinotubular junction, which acquires a "hourglass" morphology. Diffuse forms are more severe, potentially affecting a significant portion of the arterial tree, including coronary arteries, in extreme cases. Pulmonary artery involvement is present in approximately half of the patients, though it is usually well tolerated and rarely prompts surgical intervention. Surgical indication is typically determined by left-sided stenosis at the level of the ascending aorta, mid-aortic syndrome, aortic valve, coronary, renal, or visceral arteries. Once diagnosed, prompt action is advised, as the risk of sudden death is increased by 25–100 times compared to the general population.

The aim of the study was to evaluate surgical outcomes in this rare condition. A systematic review was conducted, including observational studies with over 2 years of follow-up and cohorts exceeding 20 patients. Both pediatric and adult populations were analyzed. Risk factors, event rates, and survival curves were examined to perform a 30-year microsimulation study, predicting life expectancy.

A total of 23 publications involving 1,472 patients and 13,125 patient-years with a median follow-up of 6.3 years were included. The mean age at initial repair was 4.7 years. Nearly half of the cases utilized the McGoon technique, involving the implantation of a single enlargement patch. Early mortality was 4.2%, and late mortality was 0.61% per patient-year. Based on the microsimulation, a patient undergoing surgery at 4.7 years of age was estimated to have a life expectancy of 90% compared to the general population. At 30 years, these patients faced an 8% risk of myocardial infarction and a 30% risk of reintervention, with one-third attributable to repair dysfunction.

The authors concluded that, at 30 years, patients operated on for congenital supravalvular aortic stenosis exhibit lower survival compared to the general population, with a significant reintervention risk. Therefore, they recommend continued cardiovascular monitoring in these patients, emphasizing the diagnosis and treatment of residual stenosis and coronary obstruction.

COMMENTARY:

It is a mistake to group all supravalvular aortic stenosis under the same category, as each condition involves distinct obstruction patterns of varying severity. First, it is essential to distinguish whether the underlying pathology is an elastin dysfunction arteriopathy (with Williams syndrome being the classical etiology), Shone complex (which may involve multilevel left heart obstruction), or iatrogenic, resulting from an overly ambitious closure following an aortotomy. In Williams syndrome, the severity and association of systemic arterial lesions determine the patient's short-term survival and potential long-term complications. This condition demands perioperative and intraoperative decisions that can drastically alter the planned surgical course. It is crucial

to judiciously enlarge clinically significant stenotic areas while minimizing ischemic time. Consequently, various surgical techniques exist, with no clear consensus on the superior method. Options include single-patch repair (McGoon technique), two-patch repair (Doty technique), three-patch repair (Brom technique), and the Myers interdigitating aortoplasty, which avoids patch use.

One of the most challenging decisions is whether to enlarge the coronaries, as no diagnostic test definitively clarifies coronary flow compromise in these patients. This explains the high rates of perioperative myocardial infarction reported in the literature. Following stenotic relief, it may be assumed that coronary flow would improve. However, coronary insufficiency in these patients is counterintuitive: elevated aortic root pressure distends the lumens of thickened coronaries, preventing collapse. Treating the supravalvular stenosis alone reduces aortic root pressure, potentially collapsing coronary lumens. A high index of suspicion for coronary involvement and a comprehensive evaluation are necessary. Aggressive and diffuse disease presentation likely indicates coronary involvement as well. Reaching and executing this decision is far from straightforward.

Another limitation worth mentioning is the quality of the studies underpinning the meta-analysis and microsimulation. Due to the rarity of this disease, most literature comprises small-sample retrospective observational studies. This diminishes statistical power, which is further weakened by combining heterogeneous pathologies and pooling pediatric and adult populations.

In conclusion, any study on rare conditions requires tremendous effort, which must be acknowledged and appreciated. However, making 30-year predictions is akin to building a house of cards.

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María Luz Polo López

Mitral valve replacement in pediatrics: size matters greatly. The expert's perspective

Update on the status of mitral valve replacement in pediatric patients, by expert Dr. María Luz Polo.

In pediatric patients, valvular diseases are mainly secondary to congenital defects or rheumatic fever, constituting a significant source of global morbidity and mortality. Congenital mitral valve disease is rare compared to acquired conditions secondary to rheumatic fever, ischemic heart disease, or degenerative mitral disease in the elderly.

Congenital mitral valve disease may occur in isolation, be associated with other anomalies such as atrioventricular septal defects or dilated cardiomyopathy, or form part of Shone's syndrome. In neonates and infants, stenosis predominates, often presenting with hammock-like valves with rigid leaflets and anomalies of the subvalvular apparatus, such as a parachute valve with a single papillary muscle. In older children, mitral regurgitation due to leaflet prolapse or chordal rupture is more common.

When mitral valve disease requires surgery, an initial repair is preferred, which in children shows good results, minimal hospital mortality, and favorable long-term outcomes, with acceptable reintervention rates during follow-up. Neonates and infants, however, present worse outcomes in terms of mortality and morbidity compared to older children, as they represent the most severe end of the mitral valve disease spectrum. Nonetheless, if a mitral repair in infants is successful and no reintervention is needed within the first two postoperative years, long-term prognosis is excellent and comparable to repairs performed in older children.

Mitral valve repair in pediatrics allows for time to be gained, acknowledging the likelihood of future reintervention during the patient's lifetime. When repair is no longer feasible, valve replacement becomes necessary, ideally when the patient reaches adulthood, as this allows for more technical options and improved outcomes. With current advancements, many children with congenital valvular disease will reach adulthood, making it likely that the need for valve replacement will increase as these patients transition from adolescence.

The mitral valve, located posteriorly within the heart, consists of the annulus, leaflets, and a subvalvular apparatus comprising chordae and papillary muscles. This anatomy makes its surgical access more challenging compared to other cardiac valves. In children, alternative approaches such as transseptal or superior septal access are often required to achieve adequate visualization of the valve. Pediatric cases pose additional challenges, considering factors such as the size of the patient, the left atrium, and the mitral annulus, future growth, physical activity levels, and in females, menstruation and potential future pregnancies.

When mitral valve repair is not feasible or fails, the valve must be explanted and replaced with a prosthetic substitute, which is more complex in pediatric patients compared to adults. Implanting a mitral prosthesis should avoid an intra-annular position to prevent circumflex artery damage, posterior atrioventricular groove rupture, subaortic stenosis due to prosthesis protrusion into the left ventricular outflow tract, or conduction system damage causing complete atrioventricular block. Retaining parts of the subvalvular apparatus with papillary muscles is essential to ensure it does not interfere with prosthesis function. If the entire subvalvular apparatus is removed to fit the prosthesis,

the left ventricular geometry is altered, increasing the likelihood of dysfunction. The only effective method for annular enlargement is the mitro-aortic David procedure, which involves sacrificing the aortic valve as collateral damage.

The greatest surgical challenge lies in the smallest patients, weighing less than 10 kg, who often present with complex mitral valve disease and significant preoperative comorbidities, including pulmonary hypertension and failure to thrive, leading to worse postoperative outcomes and higher mortality compared to older children. These patients frequently have small mitral annuli and left atria, significantly limiting technical options. In this age group, surgery is always palliative, as any valve substitute will have a limited lifespan and require replacement in the future due to the child's growth, while the implanted prosthesis remains fixed in size. Hospital mortality rates for mitral valve replacement in infants range from 5–30%, with poorer outcomes in those younger than two years with small prosthetic sizes.

Mechanical prostheses are currently the best option for mitral annuli larger than 15 mm due to their durability and resistance to degeneration. However, over time, pannus growth may cause stenosis or interfere with proper function. These prostheses require lifelong anticoagulation, which is more challenging in small patients, with increased difficulty achieving a therapeutic range and greater risk of thromboembolic complications. The smallest available prosthesis on the market is currently 15 mm. These prostheses can be placed in an intra-annular, partial, or fully supra-annular position or mounted on a Gore-Tex or Dacron conduit using the "chimney" technique, ensuring the pulmonary vein return to the left atrium is not obstructed.

Bioprostheses with stents have a higher profile than mechanical prostheses, with the smallest size being 19 mm. Their implantation requires confirmation that prosthetic commissures do not obstruct the outflow tract or damage the free wall of the left ventricle. While they do not require prolonged anticoagulation, their disadvantage in pediatric patients is accelerated calcification, contributing to early deterioration.

Melody® bioprostheses, constructed from bovine jugular veins and supported by a stent, were initially designed for percutaneous pulmonary valve replacement. These prostheses have been hybrid-implanted in the operating room by pediatric cardiac surgeons and interventional cardiologists on a compassionate basis as mitral substitutes when the annulus is smaller than 15 mm, yielding good initial and mid-term results. This approach is safe, effective, reproducible, and allows for redilation during follow-up to accommodate the child's growth, without requiring lifelong anticoagulation. The stent is bent to shorten the prosthesis's profile to 20 mm, ensuring it does not obstruct pulmonary vein drainage or cause left ventricular outflow tract stenosis.

Alternative surgical techniques to avoid long-term anticoagulation remain limited in use and experience among small children. The inverted pulmonary autograft placed in the mitral position (Ross II procedure) is technically complex and may necessitate future reinterventions at both the pulmonary and mitral sites. Homograft interposition in children is associated with higher degeneration rates due to accelerated calcification and immune responses, potentially leading to hypersensitization that contraindicates future transplantation.

Tissue engineering studies aim to create living valves tailored to each patient's anatomy and needs, with the capacity for growth, repair, and remodeling. Initial results in animal models show promise but reveal early degeneration within six months, highlighting the need for further research before advancing to human clinical trials.

A recent publication discussed on this blog involving partial semilunar valve transplants in pediatric patients offers promising possibilities. While the long-term durability of these transplants remains to be evaluated, initial results show adequate valve function with low doses of immunosuppressants during follow-up.

There is still no ideal valve substitute: one that offers good hemodynamics, availability, biocompatibility, and properties akin to the native mitral valve's flexibility, durability, and strength, free from degeneration, calcification, or infection, requiring no anticoagulation, capable of growth and remodeling, and cost-effective for widespread use. Current evidence strongly supports mechanical prostheses for annuli larger than 15 mm and Melody® prostheses for annuli smaller than 15 mm as the best available options.

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Bunty Ramchandani

Inspiris Resilia in pulmonary position: a warning

A retrospective single-center study comparing outcomes of the Inspiris Resilia bioprostheses versus Mosaic.

Pulmonary valve replacement using a bioprosthesis is among the most common strategies to address right ventricular outflow tract (RVOT) problems in adults with congenital heart disease, particularly in patients with repaired Fallot's tetralogy during childhood. However, the use of these bioprostheses in the RVOT is an off-label indication. Currently, there remains debate about the most suitable bioprosthesis for this context, as the surgical community continues the relentless search for a valve with enhanced durability to minimize the frequency of complex reinterventions.

Today's article aims to evaluate the outcomes of the new Inspiris Resilia (Edwards Lifescience Inc) compared with the Mosaic (Medtronic Inc), the bioprosthesis previously used at Sandford University Hospital (California). The study reviewed all pulmonary valve replacements with either Mosaic or Inspiris bioprostheses, ranging from 19 mm to 29 mm in size. Freedom from moderate or greater prosthetic regurgitation, stenosis with a Doppler gradient >36 mm Hg, or reintervention were analyzed.

A total of 225 patients were included, 163 with the Mosaic valve and 62 with the Inspiris valve. No significant differences in baseline characteristics were found between cohorts. Postoperative transprosthetic gradients were low in both groups, albeit slightly higher in Mosaic recipients. No patient was discharged with moderate or severe prosthetic regurgitation. Median follow-up was 7 years for Mosaic recipients and 1.7 years for Inspiris recipients. At three years, moderate or greater regurgitation occurred in 10 Mosaic patients and 9 Inspiris patients. Freedom from moderate or severe regurgitation was 93% in the Mosaic cohort and 69% in the Inspiris cohort. Rates of stenosis with a maximum gradient of 36 mm Hg were similar between cohorts. Regarding reinterventions, two Inspiris prostheses were reintervened within 14 months due to thrombosis: one for endocarditis and another following a percutaneous valve implantation. In the Mosaic cohort, only one patient underwent reintervention within the first two years, electively replacing the valve during pulmonary branch expansion. In multivariate analysis, Inspiris valve implantation and prosthesis size were risk factors for prosthetic regurgitation.

The authors concluded that the Inspiris valve shows a higher rate of moderate or severe regurgitation compared to Mosaic valves. This finding suggests that the durability of this new prosthesis in the pulmonary position may not surpass that of other commonly used bioprostheses.

COMMENTARY:

The Inspiris Resilia bioprosthesis, developed in 2004 and marketed in 2017, is constructed from bovine pericardium incorporating innovative leaflet preservation technology. Its processing achieves a stable reduction of free aldehydes, preventing the calcification-glycerolization cycle that exposes more aldehydes, thereby accelerating calcification. The positive outcomes of Resilia technology were demonstrated in the 2017 COMMENCE Aortic Trial, which reported low transprosthetic gradients, minimal regurgitation, and no structural valve deterioration at 5 years. Additionally, this valve is designed for future percutaneous valve-in-valve procedures via radiopaque markers and an expandable zone (Vfit technology). These features, along with dry storage and

excellent clinical outcomes, position it as a worthy successor to the Perimount Magna Ease.

Essentially, the Inspiris Resilia is a prosthesis designed and validated for the left heart, specifically the aortic position, where it performs exceptionally. However, the hemodynamics and requirements of a bioprosthesis in the right heart differ significantly. Just as one type of nut does not fit all bolts, not all bioprostheses suit every position. Such oversimplifications disregard the intricacies of cardiac physiology and hemodynamics. Early experiences with the Inspiris Resilia bioprosthesis (discussed in a previous blog entry) suggest failures may result from several mechanisms. On the one hand, bovine leaflets may require higher pressure to move freely, and pulmonary pressures may be insufficient to achieve optimal leaflet excursion, potentially leading to the recorded regurgitations. Porcine leaflets, being thinner, might function better in lower-pressure circulations. However, bovine leaflets in Perimount Magna Ease bioprostheses have not shown similar behavior in the pulmonary position. Another hypothesis involves Vfit technology, which may allow prosthetic ring expansion in a distensible RVOT. It's important to note that while the aortic root is anchored within the fibrous cardiac skeleton, the pulmonary valve rests on a muscular infundibulum and lacks fibrous support. This lack of rigidity and systolic expansion might hinder adequate leaflet coaptation when supported on a malleable frame.

Despite being a single-center, retrospective study with a limited sample size, this research successfully demonstrated a statistically significant higher incidence of prosthetic regurgitation in Inspiris Resilia recipients in the pulmonary position.

In conclusion, the hypotheses surrounding Inspiris Resilia's failure in the pulmonary position are numerous and likely multifactorial. What is clear is that its performance in the pulmonary position differs significantly from its success in the aortic position. In war and love, anything goes, but the Inspiris valve in the pulmonary position appears not to.

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Marta Gambra Arzoz

Mitral valve replacement in children: five-year outcomes from the HALO trial

This prospective, multicenter, single-arm clinical trial evaluates the efficacy and safety of the 15-mm St. Jude Medical Masters HP® mechanical mitral valve over five years in pediatric patients under five years of age.

In pediatric patients with mitral valve disease requiring surgery, repair is the preferred treatment. This approach allows time to delay valve replacement, a procedure associated with higher complexity, complication rates, and mortality in this age group compared to adults. The size of the mitral annulus remains a significant limitation. However, not all cases are suitable for repair.

This article reports the outcomes of the HALO trial conducted in children under five years of age using the 15-mm St. Jude Medical Masters HP® mechanical prosthesis from Abbott®.

A total of 23 patients from 15 healthcare centers in the United States underwent mitral valve replacement (MVR) between May 2015 and March 2017. Clinical, surgical, echocardiographic, and postoperative variables were analyzed.

The mean age was 7.8 months (range: 2 weeks to 27.4 months), and the mean weight was 5.5 kg (range: 1.9 to 10.9 kg). Diagnoses included mitral stenosis (n=10), mitral regurgitation (n=6), and combined lesions (n=7). Underlying cardiac conditions included atrioventricular septal defects in 10 patients (7 complete, 1 partial, and 2 transitional) and congenital mitral valve disease in 13 patients.

Six patients (30%) underwent correction of cardiac anomalies unrelated to mitral valve disease during the same procedure, including pulmonary vein stenosis surgery, pacemaker implantation in one patient with preoperative second-degree atrioventricular (AV) block, ventricular septal defect closure in three patients, and aortic arch repair in two patients. The mean durations of cardiopulmonary bypass and aortic cross-clamping were 154.7 (range: 65.0-273.0) and 90.0 (range: 42.0-190.0) minutes, respectively.

Mitral valve replacement was performed in all patients: 43.5% (n=10) in the annular position and 56.5% (n=13) in the supra-annular position. Three patients required ECMO support upon weaning from cardiopulmonary bypass; all were successfully decannulated, though one died 45 days later due to severe biventricular dysfunction.

Six patients died during follow-up. Survival rates were 91.3% at 30 days, and 71.0% at 12 months and 5 years. Procedure-related mortality was 0%. Four patients required pacemaker implantation due to postoperative AV block (two with annular prostheses and two with supra-annular prostheses).

Adverse events during the five-year follow-up included endocarditis (n=1), anticoagulant-related bleeding (n=5), thromboembolic events (n=1), prosthetic dysfunction (n=1), prosthetic thrombosis (n=4), and prosthetic valve replacement (n=13). All events occurred within 12 months of surgery.

For mitral prosthetic thrombosis, three of four affected patients required surgical valve replacement. Two received low-molecular-weight heparin (LMWH) anticoagulation, and one had a factor V Leiden deficiency.

Freedom from bleeding was 85.4% at 30 days and 74.1% at 5 years. None of the patients experienced severe hemorrhage. Thirteen patients underwent valve replacement surgery (9 for patient-prosthesis mismatch, 3 for thrombosis, and 1 for prosthetic stenosis). The median time to replacement for mismatch was 31 months compared to 21 days for thrombosis-related replacement.

The mean transvalvular gradient was 7.3 mmHg at one year, 10.4 mmHg at two years, and 14.6 mmHg at three years. Echocardiographic analysis at five years in four patients showed no or mild regurgitation in all cases.

COMMENTARY:

Mitral valve disease poses a significant surgical challenge in pediatric patients, particularly those of younger age and smaller weight. Whenever possible, repair should be the first-line approach, though this is not feasible for all patients.

Three critical considerations emerge in pediatric MVR:

- High procedural mortality: Mortality rates for MVR in this age group range from 10-36% in published series. In the study by Ibezim et al., which included 441 pediatric patients, mortality was 11.1%, with age under two years being the main prognostic factor. In the HALO trial, which included younger patients, 31-day and 5-year survival rates were 91.3% and 71.0%, respectively, with no procedure-related mortality.

- Chronic anticoagulation: Freedom from bleeding in the HALO trial was 74.1% at five years, a higher incidence compared to other series, likely due to the younger patient population. Regarding prosthetic thrombosis, three of four cases required surgical replacement. Two patients were on LMWH, and one had a factor V Leiden deficiency. A notable limitation highlighted by the authors is the absence of standardized anticoagulation guidelines for pediatric patients.

- Prosthesis replacement due to growth: Prostheses have fixed diameters, necessitating reoperation as children grow. In this study, nine patients required replacement for patient-prosthesis mismatch (median: 35 months post-surgery).

The study validates the 15-mm St. Jude Medical Masters HP® prosthesis as an effective option for children under five years ineligible for mitral valve repair, offering context to surgeons, cardiologists, and families confronting this situation.

The authors advocate avoiding LMWH based on outcomes and emphasize the need for standardized anticoagulation guidelines. Despite the study's limitations, such as small sample size and absence of a control group, the low rate of severe hemorrhagic events and prosthetic thrombosis emphasizes the prosthesis's utility. Further, the authors note the need for more extensive long-term studies to refine management in this demographic.

Alternative options like the Melody® jugular vein prosthesis offer advantages such as potential expansion through percutaneous dilation and no anticoagulation requirement. However, issues like left ventricular outflow tract obstruction and perivalvular leaks remain concerns.

One innovative technique, the “chimney technique,” developed at Hospital Infantil La Paz, uses a Dacron conduit segment for supra-annular mitral valve positioning and enlarges the left atrium with a heterologous pericardial patch to prevent pulmonary vein return issues.

At our center, we consider the Melody® prosthesis as the second-line option for small mitral annuli. Our series includes six patients, with satisfactory initial outcomes. However, limited durability (median: 3 years) remains a significant limitation. In two cases with a 13-mm annulus, the chimney technique achieved a prosthesis duration of two years.

Regarding experience with the 15-mm St. Jude Medical Masters HP® mechanical prosthesis, we implanted it in one patient who experienced two episodes of thrombosis. The first resolved with fibrinolysis; after the second, the valve was replaced with a Melody® prosthesis.

In summary, significant challenges persist in the management of pediatric patients ineligible for mitral valve repair. The ideal valvular substitute remains elusive for this age group, with all options linked to high morbidity, mortality, and limited durability. More studies are needed to evaluate long-term outcomes and refine treatment strategies.

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Hugo Auquilla Luzuriaga

Melody prosthesis: Is it an effective alternative as a bridge to mechanical valve replacement in young children?

Updated results on the Melody bovine jugular vein bioprosthesis as a strategy to gain time before definitive prosthetic valve replacement in pediatric patients with non-repairable mitral regurgitation.

Mitral valve disease in children poses a significant challenge due to its high morbidity and postoperative mortality. Even when repair is feasible, the associated mortality and reoperation rates remain substantial, reflecting the imperfect nature of available treatments for a valve that must continue to grow under abnormal physiological and anatomical conditions. When repair is not possible or unsuccessful, mitral valve replacement becomes inevitable. However, mitral valve replacement in children, especially those under 2 years of age, carries a short- and medium-term mortality rate of 20–30%. This raises the question: is the implantation of the Melody prosthesis a viable alternative as a bridge to mechanical valve replacement?

To address this question, the present study retrospectively analyzed all biventricular circulation patients who underwent Melody prosthesis implantation in the mitral position between 2013 and 2023. This single-center study evaluated survival, durability, and complications of the procedure. Survival analysis was performed using Kaplan–Meier curves, and the Fine and Gray subdistribution method was applied to quantify the cumulative incidence of mechanical prosthesis implantation, reoperation, and length of hospital stay. Surgical decisions, including indications, timing, and type of replacement, were made during multidisciplinary meetings. In the first year of the center's experience, the Melody prosthesis was reserved as a rescue procedure for failed conventional strategies. However, from the second year onward, it became the standard intervention for all children under 1.5–2 years of age.

A total of 25 patients underwent Melody prosthesis implantation, with a median age of 6.3 months. Congenital mitral valve disease was the primary indication for surgery in 60% of cases. The majority of patients (84%) had a history of prior valve surgery, either repair or replacement. Mortality at 6 months, 1 year, and 5 years was 8.3%, 12.5%, and 17.6%, respectively. Two patients required early replacement of the Melody prosthesis without subsequent morbidity or mortality. Fifty percent of patients underwent mechanical valve replacement 3.5 years after Melody implantation.

The authors concluded that Melody prosthesis implantation offers reasonable short-, medium-, and long-term survival with minimal complications, achieving a high success rate in delaying eventual mechanical valve replacement.

COMMENTARY:

Mitral valve disease in young children presents a unique challenge, particularly when valve repair fails, making replacement the only solution. This necessitates inevitable reoperations as the child grows, with significant associated morbidity and mortality. These challenges have driven the evolution of surgical strategies, including the use of the Melody prosthesis. This approach allows serial balloon dilations as the child grows, enabling the annulus to accommodate a sufficiently sized mechanical prosthesis in the future. Today, it appears to be the preferred option for patients with annular diameters less than 12 mm and those younger than 1–2 years.

Another major advantage is the ability to delay anticoagulation, thus avoiding related complications. This cohort demonstrated that no patients experienced thrombotic or bleeding episodes after hospital discharge. In comparison, up to 25% of patients undergoing mechanical valve replacement encounter such complications. Moreover, maintaining therapeutic INR levels in infants is exceedingly difficult. In this study's cohort, enoxaparin was sufficient during the first 3 months, followed by acetylsalicylic acid until prosthesis explantation.

Studies described in the literature, both single- and multicenter, report promising survival outcomes. This cohort represents one of the largest single-center experiences with the best-reported survival results to date. It is noteworthy that during the first year, Melody prosthesis implantation was reserved as a rescue procedure for failed conventional treatments in critically ill patients, initially yielding unfavorable results—two patients died early. This prompted a reevaluation of therapeutic strategies, including surgical techniques and decision-making. Subsequently, as indications shifted to exclude decompensated patients and surgical experience improved, the survival curve steadily increased.

How does this mortality compare? Several studies report high mortality rates (20–25%) in patients under 2 years of age undergoing mechanical mitral valve replacement, primarily due to early and late mortality. This study highlights the survival benefit of Melody prosthesis implantation, achieving a 5-year survival rate of approximately 83%, the best result reported so far.

In terms of durability, the Melody prosthesis does not offer significant advantages. This study demonstrated rapid valve deterioration in most cases, necessitating early replacement within 2–3 years. This aligns with findings from other studies showing long-term freedom from reoperation in only 30% of cases. Thus, this valve replacement strategy primarily serves to delay anticoagulation initiation and facilitate implantation of a larger, definitive prosthesis.

In summary, the Melody prosthesis serves as a bridge to accommodate growth, enabling subsequent mechanical valve replacement and reducing associated complications. While it does not eliminate the need for reoperation, it mitigates complications linked to mechanical prostheses in neonates. Despite encouraging results, this study's limitations include a small sample size and its retrospective, single-center nature. Therefore, caution is warranted, and further randomized studies with larger cohorts and longer follow-ups are needed.

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Jorge Luís Cervantes

The Ebstein anomaly and the difficulty in drawing conclusions for decision-making

Results from the experience of six centers in Australia and New Zealand in the management of Ebstein anomaly over 34 years.

When a condition such as the Ebstein anomaly displays significant heterogeneity in its presentation (ranging from manifestations in the neonatal period to those in adulthood) and its low prevalence limits surgical groups' experience with these patients, multicenter studies become essential. However, while these studies help improve decision-making for managing these patients, they are not always easy to interpret or apply in clinical practice.

Various surgical techniques have been described for correcting this condition, which extends beyond a mere tricuspid valve anomaly. As highlighted in the article under review, this anomaly is considered a right ventricular myopathy, of which tricuspid regurgitation is just one manifestation. Therefore, this anomaly must be studied and conceptualized from this perspective. Essentially, Ebstein anomaly is a myopathy caused by the variable delamination failure of the tricuspid valve leaflets. Myocytes in these patients have a reduced number of myofibrils compared to healthy individuals, a feature that shares genetic abnormalities with noncompaction cardiomyopathy.

The combination of varying degrees of tricuspid valve delamination failure and the underlying myopathy creates a broad spectrum of clinical presentations. This heterogeneity, together with the condition's low prevalence, makes it difficult to draw robust conclusions about its management. Personally, I believe that neonatal presentations of the anomaly should be analyzed separately from those presenting during school-age or later. A large proportion of neonatal patients require univentricular repair due to the severity of the lesion during this period.

The article discussed in this commentary examines the outcomes of surgical management for Ebstein anomaly patients treated at six hospitals in Australia and New Zealand over 34 years, from 1985 to 2019.

A total of 125 patients aged over 15 years were analyzed, with a mean patient age of 35 years. The number of cases managed varied by center, ranging from nine in the center with the lowest volume to 40 in the one with the highest. Most patients presented in NYHA functional class I-II, while 30% were in class III-IV.

More than half of the patients underwent tricuspid valve repair using different techniques, while 40% required tricuspid valve replacement. Among the latter, 19% required permanent pacemaker implantation due to post-surgical heart block, with a higher prevalence in the replacement group.

The 30-day mortality rate was 2%, with an average follow-up period of nine years (range: 3.4–20 years). Notably, only eight patients completed the 10-year follow-up. Total mortality was 6%, and the need for reoperation during follow-up was 17%. After 10 years of follow-up, there were no significant differences in reoperation rates between repair and replacement patients.

COMMENTARY:

As seen, despite the long timeframe of the study (34 years) and the inclusion of data from six centers across two countries, only 125 patients older than 15 years were analyzed due to the low prevalence of the condition. Consequently, most centers manage fewer than one case per year on average.

There is limited clarity regarding the specific repair techniques used in patients who underwent tricuspid valve preservation. Only a small percentage underwent the repair described by Da Silva, while the techniques applied to the remaining patients are not specified. It is reasonable to assume that repair techniques evolved as their efficacy became better understood. Likely, various surgical techniques were employed throughout the study period, beginning with Danielson's method described in 1979, which was later refined by Carpentier in 1988 with anterior leaflet mobilization and reorientation of the plication. Subsequently, Da Silva perfected this approach in 2007 by mobilizing all leaflets and reorienting them clockwise. Additionally, simple but effective maneuvers such as those by Wu, Hetzer, and the Sebening stitch provided solutions in challenging cases.

Similarly, a subgroup of patients (13% of the total sample) underwent a bidirectional cavopulmonary shunt (BCPS). The authors noted that this procedure was added in cases of right ventricular dysfunction, cyanosis, anticipated tricuspid stenosis after repair, or difficulty separating the patient from cardiopulmonary bypass. Based on the authors' data, it is challenging for readers to establish clear criteria for selecting patients eligible for BCPS. Nearly all patients exhibited right ventricular dysfunction, and the authors did not provide objective data or cutoff points for deciding on this intervention.

Most patients also presented atrial septal defects which, combined with severe tricuspid regurgitation, suggest that cyanosis is not attributable to a single factor. Furthermore, the decision to perform BCPS due to challenges in separating patients from cardiopulmonary bypass reflects a lack of preoperative planning and clear criteria, leading to intraoperative decisions under critical conditions. Unfortunately, even the most experienced surgeons in Ebstein anomaly cannot definitively determine when BCPS should be initially performed or if the azygos vein should always be ligated in these cases, nor when to close the atrial septal defect.

Although mortality and reoperation outcomes are similar to those reported in other studies, it is worth noting the limited follow-up, as only a small percentage of patients completed the full follow-up period. Interestingly, the long-term outcomes were comparable between patients undergoing repair versus replacement. This observation must be considered alongside the average age of the patients in this series (35 years). When patients present at this age, it is likely that repair and replacement yield similar outcomes. However, the scenario may differ for younger patients, especially school-aged children, in whom the accelerated degeneration of bioprostheses requires that repair be prioritized whenever possible.

Finally, I would like to add that although repair or replacement should ideally be pursued in these patients, there is a subgroup with severe ventricular dysfunction—not only of the right ventricle but also the left—caused by significant displacement and dilation of the right chambers. For this subgroup, where treatment success is unlikely, heart transplantation should be considered as a definitive therapeutic option.

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Bunty Ramchandani

Consensus document from the AATS on the management of neonatal and infantile Ebstein anomaly

Consensus document on the management of Ebstein anomaly by the Clinical Practice Standards Committee of the American Association for Thoracic Surgery (AATS).

Neonatal and infantile Ebstein anomaly (EA) represents a rare and heterogeneous condition characterized by significant clinical instability in affected patients. Overall mortality is approximately 27%, with primary repair-related mortality reaching 40% and one-year survival at 37%. Neonates and infants exhibit worse outcomes, with mortality rates approaching 50%.

The Clinical Practice Standards Committee of the American Association for Thoracic Surgery (AATS)—comprising 12 pediatric cardiac surgeons and 2 pediatric cardiologists—reviewed over 400 articles on EA published since 2000. Among them, 71 focused on EA in neonates and infants. These articles, combined with the committee's collective experience, formed the basis of the following recommendations:

1. Prenatal Diagnosis

In cases of suspected severe EA, prenatal evaluation and monitoring should occur in a center with a multidisciplinary team including pediatric cardiac surgeons, pediatric cardiologists, and pediatric cardiac intensive care specialists. The team should be prepared to assess the high-risk neonate at delivery.

2. Preoperative Assessment and Risk Stratification

"High-risk cases for intrauterine death and postnatal morbidity/mortality should be identified by fetal echocardiography findings of early cardiomegaly, bidirectional shunting at the ductus arteriosus, anatomic or functional pulmonary valve atresia, circular shunting, left ventricular (LV) dysfunction, low right ventricular systolic pressure (RVSP <20-25 mm Hg), or fetal hydrops (I-B)."

EA presents a wide spectrum of clinical manifestations. Depending on the severity and degree of delamination of the septal and posterior leaflets, presentations may range from silent to massive tricuspid regurgitation (TR). All fetuses with EA are at risk of developing fetal hydrops and heart failure, with intrauterine death occurring in approximately 20% of cases. One-third of live-born neonates with severe pathology die in the neonatal period. These neonates often exhibit severe cardiomegaly caused by significant volume overload due to severe TR, leading to marked dilation of the right atrium (RA) and atrialized right ventricle (RV), which may occupy the entire thoracic cavity. This expansion restricts pulmonary growth, often resulting in hypoplasia. Severe dilation of the right chambers compromises LV function due to impaired circumferential contractility and diastolic filling caused by ventricular-ventricular interaction. Consequently, cardiovascular compromise exacerbates low cardiac output, affecting cerebral oxygen delivery. Additionally, RA dilation is frequently associated with supraventricular arrhythmias, further destabilizing an already fragile circulation.

"Fetal echocardiographic evaluation should occur every 2-4 weeks until the 32nd week, after which it should increase to every 1-2 weeks, as high-risk features typically manifest later in gestation (I-B)."

Fetuses face risks of hydrops and maternal mirror syndrome (triple edema involving the fetus, placenta, and mother), with associated complications. Identifying risk factors enables coordination of delivery timing and the decision to administer corticosteroids to enhance fetal lung maturity.

"High-risk fetuses should be delivered in centers with expertise in ECMO and cardiac surgery (I-C)."

3. Management of an Unstable Neonate

"Unstable neonates with a circular shunt require emergent intervention to interrupt the shunt (I-B)."

A circular shunt occurs when pulmonary regurgitation (PR) permits blood flow from the aorta to the pulmonary artery via the ductus arteriosus, which then passes through the RV and RA via severe TR. Blood is subsequently shunted to the left heart via an atrial communication and re-enters the aorta, perpetuating the cycle. This condition often develops within hours after birth, leading to cardiogenic shock.

"Neonates in refractory cardiogenic shock, despite inotropic support, mechanical ventilation, and prostaglandin therapy for ductal-dependent pulmonary blood flow, should undergo palliative Starnes procedure (I-C)."

The Starnes procedure creates a single-ventricle physiology by excluding the RV with a fenestrated patch, often combined with RA reduction. This approach improves LV contractility by reducing right-sided volumes. Alternative strategies include biventricular repair, such as the Knott-Craig technique, in cases without anatomic pulmonary atresia. While the Starnes procedure offers consistent outcomes, it does not preclude future biventricular repair.

"In neonates with hemodynamic instability, circular shunt, and low RVSP (<25 mm Hg), the main pulmonary artery should be ligated/occluded, and the Starnes procedure performed (I-C)."

When anatomic pulmonary atresia is present, immediate surgical intervention is warranted. Approximately 20% of patients develop postoperative heart block, which can be mitigated by securing the patch over Todaro's ligament. The goal of intervention is RV decompression.

"Comfort measures may be considered for neonates with severe associated comorbidities, including prematurity, genetic syndromes, or significant medical complications."

4. Management of a Stable Neonate

"In neonates with functional pulmonary atresia and normal RVSP (>25 mm Hg), a medical trial of ductal closure should be performed. If the first attempt fails, additional attempts can be made within the first two weeks of life (I-C)."

In neonates with severe EA, normal RVSP may suffice to maintain adequate pulmonary blood flow once the ductus arteriosus closes. Prolonged ductal patency exposes the RV to systemic pressure, potentially impeding ejection. After ductal closure, pulmonary vasodilators may help reduce pulmonary resistance, facilitating RV ejection.

"Hemodynamically stable neonates with EA, normal RVSP (>25 mm Hg), and PR at risk of developing a circular shunt should undergo medical closure of the ductus arteriosus (I-C)."

In neonates with adequate RV pressure but insufficient antegrade pulmonary blood flow, interventions such as ductal stenting or a Blalock-Taussig (BT) shunt may be necessary as initial palliation before biventricular repair. In symptomatic neonates with stable hemodynamics but dependence on prostaglandins or respiratory support, these palliative strategies can stabilize the patient until definitive repair at 3-5 months of age.

5. Subsequent Procedures Following Initial Palliation

"Following the Starnes procedure, subsequent interventions should progress toward either single-ventricle palliation or biventricular repair (I-C)."

Performing the Starnes procedure does not obligate a single-ventricle pathway. Echocardiographic evaluations every 2-4 weeks and magnetic resonance imaging (MRI) every 3-4 months are essential to determine RV viability for biventricular repair. The feasibility of such repair depends on the size and function of the RV assessed objectively.

Biventricular repair may involve removing the intraluminal pulmonary artery patch and reconstructing the tricuspid valve. If the RV is insufficiently developed, a 1.5-ventricle repair, combining a bidirectional cavopulmonary shunt (BCPS) with partial RV function, may be appropriate. Preservation of the pulmonary valve and careful placement of patches to avoid damaging the conduction system are critical technical considerations.

COMMENTARY:

The consensus document on managing EA in neonates and infants is an invaluable resource for practitioners caring for these patients. The committee has meticulously reviewed the literature to provide evidence-based recommendations for optimal clinical practice. The document delves into outcomes of various surgical techniques, with or without modifications, and I strongly recommend it to anyone involved in treating EA.

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José Joaquín Domínguez del Castillo

Repair of Aberrant Subclavian Artery in Adults: The Importance of Timely Intervention

A retrospective analysis of anatomical characteristics and outcomes following surgical repair of aberrant subclavian arteries in adults at a high-volume U.S. center (Mayo Clinic).

An aberrant subclavian artery was historically considered a rare diagnosis. The combination of an aberrant left subclavian artery and a right aortic arch forms a vascular ring capable of causing tracheoesophageal compression. Similarly, a left aortic arch with an aberrant right subclavian artery may also produce a similar pinch mechanism. Many aberrant subclavian arteries are associated with dilatations at their aortic origin, referred to as Kommerell diverticula (KD). These diverticula carry a risk of aneurysmal degeneration, dissection, and aortic rupture.

In recent years, advancements in imaging techniques and systematic study of the aortic arch in neonates have led to an increase in incidental diagnoses of these conditions. However, due to the lack of consensus on measurement methods and the limited data available, criteria for repair and resection of diverticula remain inconsistent and poorly defined.

This single-center retrospective study included adult patients who underwent surgical repair of an aberrant subclavian artery or KD over a twenty-year period (01/01/02 – 12/31/21). A total of 37 patients were included, with follow-up data available for >97% of cases beyond one month. KD was defined when the diameter of the aberrant artery at its aortic origin was ≥ 50% larger than that of the ipsilateral carotid artery. Additionally, the authors introduced the "ASCA/Thoracic Inlet Index," calculated as the ratio between the diameter of the aberrant artery at its thoracic outlet and the anteroposterior diameter of the thoracic inlet, with a reference normal value of 0.18. They evaluated symptom improvement and anatomical imaging characteristics across various groups.

The mean age of the patients was 46 ± 17 years. Of the total, 62% were classified as left aortic arch with aberrant right subclavian artery (LAA + ARSA), while 38% had a right aortic arch with aberrant left subclavian artery (RAA + ALSA). At the time of diagnosis, 84% of the patients were symptomatic, and 51% had a KD meeting surgical indication criteria. Symptomatic patients exhibited larger KD diameters: 20.60 mm (interquartile range: 16.42-30.68 mm) in patients with ≥ 3 symptoms; 22.05 mm (interquartile range: 17.52-24.21 mm) in those with 2 symptoms; and 13.72 mm (interquartile range: 12.70-15.95 mm) in patients with only 1 symptom. Regarding surgical outcomes, while no mortality related to the intervention was reported, 30% of patients experienced complications (vocal cord dysfunction 11%, chylothorax 8%, Horner syndrome 5%, spinal deficit 5%, stroke 3%, transient dialysis requirement 3%), and 59% required aortic replacement. Indications for surgery included persistent symptoms, size/growth of KD, size/growth of the aberrant artery, thoracic aneurysm, type B dissection, and/or contained rupture. After a mean follow-up of 2.3 years, most patients reported resolution of dysphagia (92%) and dyspnea (89%), although symptoms of gastroesophageal reflux persisted in nearly half (47%).

The authors concluded that KD aortic diameter correlates with the number of symptoms and that surgical repair of KDs, along with their aberrant arteries, resolves symptoms in most cases. However, they emphasize the importance of proper indication due to the complexity of these procedures and their associated complication rates.

COMMENTARY:

The fact that prevention is one of medicine's most powerful tools is no secret. However, historically, surgeons have often perceived it as outside their scope. It is easy to think that our role is to address the patient's current problem, despite many of our surgical indications being based on anticipating future issues to avoid reaching a point where surgery carries unacceptable risk or becomes excessively complex.

Fortunately, we are increasingly aware that managing cardiovascular surgical pathology should not be limited to the surgical act itself. We recognize that many of our interventions and the materials we use are not definitive. We strive to design the best therapeutic sequence for our patient's life expectancy, even if debates such as those surrounding TAVI in our country make us feel like we take one step forward and two steps back.

This approach becomes particularly complex when discussing scenarios far apart in time. Childhood and adulthood are often perceived as completely separate. In a country where the large number of centers performing pediatric cardiac surgery is hardly justifiable (at least if we seek excellence in outcomes), there are still many populations linked to centers exclusively handling adult patients where the diagnosis, follow-up, and management of congenital cardiovascular pathologies remain somewhat neglected.

This study is an excellent example of the importance of understanding the natural history of a pathology and addressing it in a multidisciplinary manner, applying the available evidence. Over the past years, we have observed how, across Europe, centers specializing in congenital heart diseases that have implemented systematic pre- and postnatal aortic arch study protocols have gone from rarely performing these types of surgeries to occasionally doing them weekly. Studies like this make us realize the impact of applying such protocols. Generally, these childhood interventions carry very low risk, are often performed using minimally invasive approaches, do not require aortic replacement or cardiopulmonary bypass, and result in hospital stays of just 3-4 days. In contrast, as shown by the authors, surgical complexity increases significantly in adulthood, along with morbidity. KD tissue in adults is more fragile and frequently associated with aneurysmal dilation. Nearly 60% of cases required aortic replacement, with 11% necessitating total arch replacement. It should not go unnoticed that 8% of patients arrived at the hospital with type B dissection or contained rupture, raising the question: what percentage never made it to the hospital? Additionally, it must be acknowledged that while surgery provides high symptom resolution, it is not absolute. A lifetime of airway and esophageal compression can lead to tracheomalacia and/or esophageal dysfunction that may not fully resolve upon relieving the compression.

But one question remains: what should we do with patients referred to our clinic with asymptomatic KD or dilation? What should we do with incidental findings? In this article, the authors recommend intervening in children if the KD is >1.5 times the size of the aberrant artery and in adults when the KD measures 4 cm or exhibits growth >0.5 cm/year. However, it is worth noting that patients presenting with dissection/rupture had KDs smaller than 4 cm. Other authors (e.g., Idrees et al.) advocate for more aggressive indications, proposing surgery if the KD exceeds 3 cm. Meanwhile, other studies suggest that in asymptomatic cases, conservative management may be appropriate (Hale et al.). We have seen that surgical approaches are complex in many cases and not without complications. The reality is that we do not fully understand the actual risk of dissection or rupture, which are not minor complications.

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Esteban Sarria García

The challenge of complex reoperations for aortic pathology in congenital heart disease: the reality we must face and how to address it

Review of congenital heart diseases associated with aortic pathology, new theories on tissue biomechanics and pathogenesis, as well as appropriate strategies and planning for reinterventions.

The article under analysis today provides a comprehensive review of pathologies involving dilation of the aortic root and arch, the implicated pathophysiological and tissue mechanisms, and offers a detailed description of the various technical and strategic aspects.

Advancements in the understanding of the pathogenesis and molecular mechanisms involved in aortic dilation in conditions such as bicuspid aortic valve and other connective tissue diseases have grown significantly over the past decades. However, dilation of the "neo-aorta" is also present in other entities more characteristic of congenital heart diseases (Norwood techniques, Ross procedure, arterial switch, and repair of conotruncal defects), which remain less understood and pose greater therapeutic complexity and challenges.

In coarctation of the aorta, a well-described form of aortopathy is particularly associated with the bicuspid aortic valve. Histological studies demonstrate that this is more of a genetic problem than a purely biomechanical one and that, following initial repair, patients are not free from complications such as re-stenosis, aneurysms, and pseudoaneurysms, which are in turn related to the technique used in the repair (higher risk if residual native tissue remains, as seen in patch aortoplasty).

Cases of tetralogy of Fallot and truncus arteriosus are typically repaired in the first months of life. However, their follow-up is frequently complicated by aortic root and neo-aortic dilation. Intervention is usually indicated due to valvular insufficiency, though cases of rupture or dissection have been reported up to 50 years after the initial repair.

Neo-aortic dilation in Norwood surgery cases may be due to the patch itself, degeneration of the native wall, or biomechanical causes. Data on these patients are scarce, and reoperations are often indicated due to sequelae (aortic insufficiency) or pulmonary compression.

Regarding tissue biomechanics, ex vivo and in vivo studies demonstrate behavior similar to aneurysmal tissues, with loss of elasticity in patients with congenital heart disease after the initial surgical repair.

Indications for repair continue to be extrapolated from the guidelines established for aneurysm growth diameters in non-congenital conditions. However, a better understanding of biomechanics and methods for their assessment in congenital heart disease patients could provide more consistent information for guiding interventions in these cases.

The pillars of reconstruction in complex reoperations are safety, organ protection, and repair effectiveness. In most cases, peripheral cannulation and re-entry under cardiopulmonary bypass in patients with previous surgeries (often multiple) and a dilated aorta contribute to reducing complications and improving outcomes. In pseudoaneurysm cases, endoclamping and endovascular cardioplegia techniques can be helpful. It is also

essential to consider that these patients may be cyanotic with extensive collateral circulation, which increases bleeding risk, or may have transfusion-related sensitization. Anatomical variations (such as the LeCompte maneuver or right ventricle-to-pulmonary artery conduits) must also be considered.

For cerebral and systemic protection, axillary artery cannulation is a good option. The authors recommend an 8-9 mm graft insertion for reoperations, combined with hypothermia and cerebral monitoring. However, this strategy must be individualized based on anatomical variations, which may require dual cannulation (axillary and femoral) depending on the state of the aortic arch or the presence of systemic-pulmonary fistulas, potentially causing pulmonary overcirculation. Similarly, retrograde cerebral protection should account for possible venous return anomalies. For myocardial protection, the authors recommend antegrade induction and continuous retrograde maintenance with miniplegia to avoid excessive crystalloid solution delivery, as well as the systematic use of intracavitary vent catheters.

Regarding repair technique, the goal should be to address complications and prepare, optimize, and simplify future reinterventions. Comprehensive imaging studies and access to a full arsenal of open, hybrid, and endovascular techniques, complementary to one another, are necessary. The authors have developed a modified frozen elephant trunk technique (termed B-SAFER, or branched stented anastomosis frozen elephant trunk repair) that simplifies and shortens the procedure by incorporating a more proximal anastomosis and eliminating multiple anastomoses in branches through the use of branched stents.

In conclusion, the authors provide a complex review of recommendations, based on experience, to address the myriad scenarios requiring treatment of aortic pathology—one of the Achilles' heels of congenital heart disease repair in adult patients.

COMMENTARY:

With the increasing number of patients with severe congenital heart diseases surviving childhood and reaching adulthood, cardiovascular surgeons face a growing, highly complex population in which even conditions more characteristic of "acquired" heart diseases are becoming increasingly frequent. For instance, aneurysmal dilation of the neo-aorta is a "familiar" occurrence in series of patients undergoing the Ross procedure. In other entities, due to the historical development of techniques (Norwood, arterial switch) and patient prognosis, it is less well-known.

As the authors explain, indications are based on extrapolation from knowledge derived from clinical guidelines for adult patients with aortic pathology. However, the complexity of cases, anatomy, and surgical planning necessitate meticulous preparation for interventions.

This article does not present a historical review of results, institutional experience, or a multicenter data analysis. Rather, it reviews the presentation of aortic and arch pathology in congenital heart disease patients. Notable novel aspects include theoretical considerations on the pathogenesis of aortic pathology in these patients and broad treatment guidelines emphasizing their institutional practices. Particularly interesting is the presentation or description of the B-SAFER technique, which achieves aortic arch replacement with shorter circulatory arrest and execution times and eliminates multiple sutures in the supra-aortic trunks by incorporating branched stents. Finally, the authors

document this experience with illustrative cases, offering opportunities for continued learning in a field with significant room for advancement.

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Gertrudis Parody Cuerda

Patent ductus arteriosus in very-low-birth-weight preterm infants: is there a place for early surgery?

This retrospective study evaluates the outcomes of surgical closure of haemodynamically significant patent ductus arteriosus (hsPDA) in very-low-birth-weight preterm neonates.

The ductus arteriosus is a vascular structure that connects the aorta and the pulmonary artery. Essential during fetal life, it typically closes spontaneously after birth. Patent ductus arteriosus refers to the failure of ductal closure beyond the neonatal period, which is particularly common in preterm infants. The global incidence of PDA in preterm neonates ranges from 50% to 70%, reaching up to 80% in very-low-birth-weight neonates. Ductal patency in preterm infants results in left-to-right blood flow shunting. This shunt between the systemic and pulmonary circulations leads to pulmonary hyperperfusion with cardiac chamber overload and simultaneous systemic hypoperfusion, a phenomenon commonly referred to as "ductal steal." Thus, the failure of early ductus arteriosus closure in preterm infants is associated with an increased risk of comorbidities such as intraventricular hemorrhage, necrotizing enterocolitis, pulmonary hemorrhage, and bronchopulmonary dysplasia, among others.

To date, the management of PDA in preterm neonates remains a contentious issue in perinatal and neonatal medicine. Historically, therapeutic approaches for PDA included active interventions such as pharmacological or surgical closure. However, over the past two decades, a conservative management strategy has gained popularity, emphasizing avoidance of potentially harmful drugs or surgical procedures. Recently, a new perspective has emerged: prolonged pulmonary overcirculation caused by hsPDA has detrimental effects on the pulmonary vascular bed, increasing the risk of bronchopulmonary dysplasia and pulmonary hypertension. Hence, is active treatment of hsPDA justified? If so, should surgical closure be performed? And, what is the optimal timing for intervention?

To address these questions, the article under discussion conducted a single-center retrospective observational study involving very-low-birth-weight preterm neonates (<1500 g) with haemodynamically significant PDA who received active treatment between September 2014 and March 2021. Exclusion criteria included the absence of echocardiographic evaluation during hospitalization, major congenital anomalies, death within the first 48 hours of life, and critical intrauterine or perinatal illness. The decision for hsPDA closure was based on clinical and echocardiographic criteria. Pharmacological closure was achieved using intravenous or oral ibuprofen. Surgical closure was considered in cases where pharmacological treatment failed or was contraindicated and was performed via left posterior thoracotomy through the third or fourth intercostal space using a titanium clip.

The study compared hospital outcomes among (i) primary surgical closure versus primary ibuprofen treatment; (ii) early primary surgical closure (before the 14th postnatal day) versus late primary surgical closure (from the 14th postnatal day onward); and (iii) primary surgical closure versus secondary surgical closure following ibuprofen failure, using 1:1 propensity score matching. Additionally, logistic regression analysis was performed to estimate the risk of the combined outcome of post-ligation cardiac syndrome (PLCS) and acute kidney injury (AKI) after surgical closure, stratified by gestational age.

A total of 145 very-low-birth-weight preterm infants with hsPDA requiring active treatment were analyzed. No statistically significant differences were observed in hospital mortality or severe bronchopulmonary dysplasia between the primary surgical closure and primary ibuprofen groups. The rate of severe bronchopulmonary dysplasia was significantly higher in the late primary surgical closure group compared to the early group (72.7% vs. 40.9%; p = .033). Outcomes were similar between the primary surgical closure and secondary surgical closure groups following ibuprofen failure. However, the probability of PLCS/AKI was significantly higher in the secondary surgical closure group compared to both early and late primary surgical closure groups (early 15.2% vs. late 28.1%; p < .001; late 28.1% vs. secondary 38.6%; p < .001) among extremely preterm neonates (gestational age <28 weeks). After 28 weeks, the probability of PLCS/AKI was low, with no statistically significant differences between groups.

The authors concluded that surgical closure is not inferior to pharmacological closure in this patient cohort. Considering the harmful effects of prolonged left-to-right shunting in the presence of hsPDA, appropriate and timely decisions should be made to minimize the risk of severe bronchopulmonary dysplasia and PLCS/AKI following surgical closure.

COMMENTARY:

To date, the medical community has not reached a consensus on the indication for surgical closure of haemodynamically significant patent ductus arteriosus in preterm neonates or the ideal timing for intervention. In general, surgical closure has been reserved for neonates in whom medical treatment is ineffective or contraindicated, given that it is considered an invasive procedure not devoid of major complications, especially in such a fragile population. Previous publications revealed potential adverse effects of surgical closure on respiratory and neurological outcomes. However, Weisz et al. pointed out the presence of selection and confounding biases in those series and reported a lack of association between surgical closure and adverse outcomes, such as neurodevelopmental impairment, bronchopulmonary dysplasia, retinopathy of prematurity, or death, compared to conservative management. In the present study, the comparison between primary surgical closure and primary ibuprofen treatment showed no differences in complication rates.

Regarding primary surgical closure of hsPDA, the authors observed a lower incidence of severe bronchopulmonary dysplasia with early surgical closure compared to late closure. Similarly, Lee et al. previously reported that early surgical closure (before the 10th postnatal day) following refractory medical treatment reduces the risk of necrotizing enterocolitis, severe intraventricular hemorrhage, and culture-proven sepsis, while also facilitating early extubation. Other related studies have also indicated that prolonged exposure to hsPDA is associated with increased suboptimal outcomes, including bronchopulmonary dysplasia. These findings reflect the deleterious effects of pulmonary overcirculation in the presence of hsPDA, which leads to alterations in pulmonary compliance, impaired gas exchange at the alveolar-capillary membrane, and eventual development of pulmonary vascular disease due to pulmonary hypertension.

The authors also highlighted that secondary surgical closure after ibuprofen failure is associated with a higher risk of post-ligation cardiac syndrome and acute kidney injury in neonates under 28 weeks of gestational age. This underscores the role of PDA in the development of the immature heart and kidneys, which depends on organ maturation at birth and throughout the postnatal period. Renal dysfunction in these patients is multifactorial, involving incomplete nephrogenesis, compromised renal perfusion due to “ductal steal,” and ibuprofen-induced nephrotoxicity. Post-ligation cardiac syndrome,

which occurs in the context of left ventricular systolic dysfunction in response to a sudden increase in afterload following surgical closure, is influenced by myocardial maturation dependent on gestational age.

While this study is highly rigorous, it presents certain limitations that warrant discussion. First, inherent constraints of the retrospective design may have led to the omission of potential clinical confounders not documented in medical records. Second, although the treatment approach for hsPDA was guided by established clinical and echocardiographic criteria, the ultimate decision depended on the discretion of the attending medical team. As a result, there may be variability in treatment strategies. Furthermore, the single-center nature of the study limits the generalizability of the findings to other institutions. Despite these limitations, the results of this study are encouraging and provide valuable insight into a field characterized by significant uncertainty. Nevertheless, randomized controlled trials are essential to draw definitive conclusions and to develop standardized treatment protocols that could improve clinical practice in neonatal intensive care units.

In summary, based on the evidence presented, the following conclusions can be drawn:

1. Primary surgical closure represents a valid treatment alternative within the therapeutic arsenal for haemodynamically significant PDA, even in very-low-birth-weight preterm neonates.

2. Early surgical intervention may be associated with potential advantages in terms of reducing neonatal morbidity.

3. Efforts should focus on minimizing the risks associated with both severe bronchopulmonary dysplasia and post-ligation cardiac syndrome/acute kidney injury, while ensuring timely decision-making to mitigate the harmful effects of prolonged ductal patency.

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Cristina Contreras Lorenzo

Can impaired exercise capacity help predict increased mortality risk in adults with congenital heart disease?

This study, derived from the Swedish National Registry, aims to analyze the correlation between exercise capacity and survival in a cohort of adult patients with congenital heart disease.

Early diagnosis, along with advancements in medical and surgical management, has significantly increased the survival of patients with congenital heart disease, enabling most to reach adulthood. Nevertheless, their lifespan remains shorter than that of the general population. Long-term follow-up of these patients has introduced challenges such as functional assessment for surgical indications and escalation to alternative therapeutic options.

Given this context, it is essential to develop tools that allow precise risk stratification for each patient. Reduced exercise capacity is linked to poorer outcomes, not only in the general population but also in conditions like heart failure or pulmonary hypertension. Among patients with congenital heart disease, exercise testing provides an objective evaluation of functional capacity and correlates not only with symptoms but also with prognosis.

The study presented here seeks to analyze the association between exercise capacity and mortality in a cohort of adult patients with congenital heart disease included in the Swedish National Registry. Additionally, a secondary aim is to identify mortality predictors within this population.

The wide variability in outcomes and prognosis associated with different types of congenital heart disease complicates the identification of universal parameters for early detection of patients likely to experience unfavorable progression. Various factors may serve as risk indicators, and this study evaluates several of them. Functional capacity is often used as a criterion for invasive strategies, making its correlation with prognosis crucial to supporting clinical decisions.

This retrospective observational study analyzes data from the SWEDCON (Swedish Registry of Congenital Heart Disease), which encompasses all seven healthcare regions in Sweden. The study included patients over 18 years of age with congenital heart diseases of varying complexity. Data from their first exercise test and clinical assessment were collected. Patients without clinical data within two years of the exercise test were excluded. Exercise capacity was assessed through cycle ergometer tests conducted between 1990 and 2017. Predicted maximal exercise capacity, measured by workload, was calculated based on sex, age, and height using formulas proposed by Brudin et al. The classification according to the percentage of predicted maximal workload achieved was as follows: good exercise capacity (>70% of predicted value), moderately reduced exercise capacity (50-70% of predicted value), and severely reduced exercise capacity (<50% of predicted value).

A total of 3,721 patients were included in the analysis, with a mean age of 27 years (20.8-41) and 44.6% female representation. The cohort was predominantly composed of patients with congenital heart diseases of moderate complexity (52%), although most were in NYHA Class I. The mean exercise capacity was 77% ± 20%, with differences noted across various congenital heart diseases: higher in moderate complexity lesions and lower in severe cases. The mean follow-up duration was 9.4 years, during which

5.8% of the patients died. Deceased patients were generally older, had worse exercise capacity, experienced greater symptom burden, used more medications, and were in higher NYHA classes.

Kaplan-Meier survival curves demonstrated that survival was directly proportional to exercise capacity: 91% for the group achieving >70% of predicted maximal workload, 80% for those achieving 50-70%, and 67% for those achieving <50%. In summary, reduced exercise capacity was significantly associated with lower survival rates.

The secondary objective involved identifying mortality predictors through univariable and multivariable Cox regression analyses. Univariable analysis revealed that moderately and severely reduced exercise capacity increased mortality risk by 2-6 times (HR 2.3; 95% CI: 1.7-3.2; $p < .001$) and (HR 5.6; 95% CI: 4.0-7.9; $p < .001$), respectively, compared to patients with good exercise capacity. Other factors associated with higher mortality included advanced age, higher NYHA class, lower self-reported physical activity, presence of symptoms, pacemaker use, increased cardiovascular medication, and ventricular dysfunction. In multivariable analysis, congenital heart disease complexity combined with moderately or severely reduced exercise capacity was associated with a 2-3 times greater mortality risk.

Based on these findings, the authors concluded that reduced exercise capacity, along with greater congenital heart disease complexity, is associated with increased mortality risk. Prospective studies are needed to validate these results.

COMMENTARY:

The significance of this study lies in its large sample size and adequate follow-up duration, establishing it as the most comprehensive investigation into the relationship between exercise capacity and mortality among patients with congenital heart disease. Consequently, the study provides sufficient statistical power to establish mortality as a robust primary outcome and achieve statistical significance. Additionally, the inclusion of patients from centers with varying levels of specialization and congenital heart disease complexity enhances the study's external validity and facilitates the generalization of its findings to different clinical settings.

Although this study utilized peak workload as the measure of exercise capacity, this parameter demonstrates a strong correlation with peak oxygen consumption, which is more commonly employed in clinical practice. The findings align with previous studies analyzing the functional capacity and prognosis of specific congenital heart disease subgroups.

Another notable conclusion of the study is the tendency to perform exercise tests primarily on patients with more complex congenital heart diseases. However, as highlighted in other research, mortality among patients with less complex congenital heart diseases remains higher than that of the general population. Therefore, emphasizing the potential benefit of exercise testing in this patient group is crucial.

Key limitations of the study include its retrospective nature and potential variability in exercise test protocols over the years covered by the registry. As noted by the authors, the underrepresentation of exercise testing in patients with less complex congenital heart diseases—who exhibit lower mortality rates than those with more complex lesions—might have underestimated the role of exercise capacity in predicting mortality.

In congenital heart disease patients, quality of life and functional capacity are pivotal in evaluating the success of interventions. Functional capacity quantification is often challenging, particularly in this patient population. The NYHA classification provides a subjective evaluation of functional capacity, which correlates well with exercise limitations in these patients. However, compared to objective exercise capacity measures, it tends to underestimate the degree of limitation. Patients with congenital heart disease often have reduced awareness of their exercise limitations, likely due to the gradual onset and early development of these limitations. This phenomenon is particularly notable in patients with right-sided heart lesions, who often report minimal symptoms until advanced stages, potentially impacting surgical decisions, exercise prescriptions, and prognostic outcomes.

In conclusion, incorporating objective measures of exercise capacity into follow-up assessments and integrating these findings into clinical decision-making is essential for managing patients with congenital heart diseases of any complexity. This is especially pertinent given that studies such as the one presented demonstrate a significant association between easily accessible parameters like exercise capacity and patient mortality. Designing prospective studies to confirm these results and integrate exercise testing into routine follow-up protocols for these patients would be highly beneficial.

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Blanca Torres Maestro

Pectus and Cardiac Surgery: The Key Lies in Timing

A multicenter review of the experience with concomitant repair of pectus excavatum and correction of congenital heart defects in a single surgical procedure.

Pectus excavatum (PE) is the most common congenital chest wall deformity, with a prevalence exceeding 1% in certain populations. Its presence may be associated with connective tissue disorders and/or congenital heart defects, which may also require surgical correction. Additionally, PE can develop during adolescence following cardiac surgery performed in early childhood. Although PE may be present at birth, it typically progresses with age, becoming symptomatic in adolescence when it reaches severe stages.

A thorough evaluation is essential to determine surgical indications, particularly to rule out other potential causes of symptoms. Conventional studies (ECG, chest X-ray, blood tests) are necessary, along with pulmonary function tests and imaging studies, such as CT or MRI.

Surgical indications are based on clinical findings and imaging studies. One of the most commonly used and valuable parameters is the Haller index (transverse diameter divided by anteroposterior diameter). Normal values range from 2.5 to 2.7, with correction recommended for indices above 3.25.

In many cases, the aesthetic impact of PE alone may justify surgery. In others, the indication is established by the physiological impact of PE compression on cardiopulmonary function, including reduced maximal oxygen uptake, impaired diastolic function, decreased cardiac output, and pulmonary restriction. These effects worsen with age as chest wall compliance decreases, leading to exertional dyspnea, exercise intolerance, palpitations (especially due to supraventricular tachycardias), chest pain, and other symptoms.

Correcting the defect can be expected to significantly improve clinical outcomes, as thoracic decompression enhances respiratory parameters (normalization of FEV1 and improved maximal oxygen uptake), increases right ventricular stroke volume, and consequently improves cardiac output.

The Nuss technique is the preferred method for repairing PE in pediatric populations. This minimally invasive procedure involves inserting curved bars (convex-shaped) along the ribs, passing behind the sternum to elevate the depressed area. First described by D. Nuss in 1998, it preserves costal cartilages, unlike conventional techniques such as Ravitch. The procedure involves bilateral mid-axillary incisions (approximately 3-4 cm) at the subpectoral plane, with bars introduced through intercostal spaces in the defect area, guided by videothoracoscopy. The bars are maneuvered through the chest wall, anterior mediastinum, and then extracted subpectorally at the contralateral incision. A retractor elevates the sternum, increasing anterior mediastinal space to minimize the risk of injuring mediastinal structures.

This article discusses recommendations from the Mayo Clinic group regarding the management strategy for patients undergoing PE repair after congenital heart defect (CHD) surgery in infancy or requiring concomitant correction of CHD and PE.

An specific action plan was stablished for each scenario:

1. Repair of Pectus Excavatum in Patients Previously Operated for Congenital Heart Defects: A hybrid approach is recommended, involving a resternotomy followed by the Nuss technique. This minimizes the risk of cardiac damage during dissection to insert the bars by allowing constant visualization of their trajectory. A protective membrane should be placed over the anterior heart surface to prevent direct contact with the bars. The sternum is conventionally approximated using cerclages attached to the retractor, which facilitates elevation for bar passage. Direct visualization eliminates the need for videothoracoscopy. Bars should remain in place for 3-4 years; this duration may be extended in cases of connective tissue disorders due to the risk of recurrence.

2. Concomitant Repair of Pectus Excavatum and Congenital Heart Defects: Whenever feasible, both corrections should be performed in a single surgical procedure. The significant impact of PE on cardiac function, particularly in the immediate postoperative period when myocardial edema, hyperdynamic states, or ventricular dysfunction may occur, underscores this recommendation. Several groups report positive clinical and aesthetic outcomes with medium-term follow-ups, highlighting the safety of this approach. However, in cases of hemodynamic instability or significant postoperative bleeding following cardiac surgery, PE repair may be delayed by 24-72 hours.

Regarding technique, initial sternal approximation with wires is performed, followed by thoracic wall elevation using a retractor to create space for bar placement.

COMMENTARY:

The overall incidence of major complications in PE repair using the Nuss technique is low. As noted, the hemodynamic benefits are significant, leading to substantial improvements in patients' quality of life. The Nuss technique is particularly advantageous in pediatric populations, as it preserves costal cartilage, reduces bleeding risk compared to traditional techniques, and avoids cartilage devascularization, which minimizes recurrence risks.

Whenever possible, both procedures should be performed concomitantly. However, in cases of significant bleeding or hemodynamic instability following cardiac surgery, PE repair may be considered within 24-72 hours after ensuring clinical stability. At La Paz Hospital, our approach involves addressing both pathologies concomitantly, deferring PE correction by 24-48 hours post-CHD repair. Current evidence supports good outcomes, although caution is advised when drawing conclusions due to limited case numbers. As with all rare pathologies, patients should ideally be treated in specialized centers with close collaboration between congenital cardiac and thoracic surgery teams.

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Bunty Ramchandani

Competitive sports and congenital heart disease

Comparison of guidelines from various American and European scientific societies regarding participation in competitive sports among patients with congenital heart disease.

Physical activity provides well-known benefits, including improved mental health, reduced incidence of certain diseases, increased ability to perform basic daily activities, and enhanced muscular and bone strength. Among individuals with congenital heart disease (CHD), patients with better physical conditioning have demonstrated lower mortality rates; thus, physical activity in this population reduces mortality. Conversely, patients with CHD are not exempt from the adverse consequences of a sedentary lifestyle, notably metabolic syndrome. However, there is no zero-risk scenario for engaging in sports, especially competitive environments where exceeding individual limits is often the norm.

This article aims to summarize and compare the recommendations from American guidelines, published in 2015 and endorsed by the American Heart Association (AHA) and the American College of Cardiology (ACC), with European guidelines, published in 2020 and supported by the European Association of Preventive Cardiology (EAPC), the European Society of Cardiology (ESC), and the Association for European Paediatric and Congenital Cardiology (AEPC).The 2015 AHA/ACC recommendations updated the previous 2005 guidelines, incorporating new sections on Marfan syndrome and sickle cell disease. These guidelines focus on patients aged 12 to 25 years but acknowledge applicability beyond this age range. Recommendations are based on various anatomical defects, with most evidence rated as Class C (expert opinions and consensus) and some specific defects rated as Class B (observational studies).

The AHA/ACC evaluates sports based on two parameters:

- Dynamic component: involving continuous movement, such as running.
- Static component: involving minimal movement, such as archery.

Each sport is categorized by dynamic intensity (A to C) and static intensity (I to III).

Recommendations by anatomical defect:

- Simple shunts: Activity level depends on the hemodynamic significance of the shunt. For patients with pulmonary hypertension, sports are restricted to IA category.
- Pulmonary valve stenosis: The severity of stenosis determines the recommendation, with mild cases (<40 mm Hg) unrestricted, while moderate or severe cases (>60 mm Hg) are limited to IA and IB sports. Severe pulmonary insufficiency with right ventricular dilation also restricts activity to IA and IB.
- Aortic valve stenosis: Recommendations are based on mean and peak gradients. Mild cases (<25 mm Hg mean gradient) have no restrictions, moderate cases (25-40 mm Hg mean gradient) are limited to IA, IB, and IIA

sports, and severe cases (>40 mm Hg mean gradient) are restricted to IA sports.

- Coarctation of the aorta: Recommendations for unrepaired cases depend on hemodynamic assessment and imaging. Repaired cases with normal hemodynamics and no dilation of the ascending aorta can participate in all sports except IIIA, IIIB, IIIC, and contact sports. Patients with aortic dilation are restricted to IA and IB sports.

- Pulmonary hypertension: Defined as mean pulmonary artery pressure >25 mm Hg, restricting sports to IA. Updated definitions lowering the threshold to 20 mm Hg were not included in the 2015 guidelines.

- Ventricular dysfunction after surgery: Patients with an ejection fraction (EF) of 40%-50% are limited to IA/B sports. EF <40% restricts activity to IA.

- Unrepaired cyanotic defects: Participation is restricted to IA sports, provided clinical stability.

- Repaired tetralogy of Fallot: Patients without arrhythmias, right ventricular outflow obstruction, or reduced EF (>50%) have no restrictions. Otherwise, sports are limited to IA.

- Transposition of the great arteries: For atrial switch repairs, restrictions include no Class C or III sports due to arrhythmia and ventricular dysfunction risk. Patients with arterial switch repairs and no dysfunction have no restrictions; mild dysfunction limits sports to IA/B/C and IIA.

- Fontan palliation: Recommendations are individualized. Asymptomatic patients with good hemodynamics may participate in IA sports.

- Ebstein anomaly: Patients with mild/moderate tricuspid regurgitation and normal right ventricular size have no restrictions, while severe cases are limited to IA.

The 2020 European guidelines shifted focus from anatomical defects to individualized assessment based on hemodynamic and electrophysiological parameters. This updated philosophy emphasizes maximizing safe participation rather than restriction. Targeted at patients over 16 years old, these recommendations are based on expert consensus (Class C evidence).

Sports are categorized into four types:

1. High-power sports (e.g., sprinting, weightlifting).

2. Skill-based sports (e.g., golf, archery).

3. Mixed sports (e.g., basketball, soccer).

4. Endurance sports (e.g., cycling, marathons).

The five-step algorithm includes:

1. Comprehensive history and physical examination.
2. Hemodynamic and electrophysiological assessment at rest.
3. Assessment during exercise.
4. Recommendations based on total findings.
5. Follow-up after implementing recommendations.

Ideally, a complete cardiopulmonary test should include: peak oxygen consumption, heart rate reserve, effective ventilation slope, gas exchange, ischemia, blood pressure, among others. If these data are not available, graded exercise tests should be used. After obtaining and analyzing all the metrics, a patient risk profile is created. The degree of restriction will be determined by the abnormal metric.

As a side note, there are injuries that have their own recommendations in different guidelines: patients with automatic defibrillators, cardiomyopathies, congenital coronary anomalies, arterial hypertension and hereditary arrhythmias. Patients who take anticoagulants of any kind are advised not to participate in contact sports. Cyanotic patients, with unrepaired injuries or with pulmonary hypertension, are advised not to participate in sports at high or moderate altitude.

COMMENTARY:

The article by Shibbani et al. does a great job comparing the similarities and differences of the guidelines on both sides of the Atlantic. The lack of updating of the American guidelines leads to some inconsistencies such as the case of a patient with aortic stenosis, a mean pressure of 45 mm Hg where he would be restricted to class IA sport. This patient would not be offered balloon valvuloplasty because a peak-peak gradient of > 50 mm Hg is required. So we would have a patient with severe aortic stenosis who is restricted to most sports, but is not offered any corrective treatment. On the other hand, the same patient can receive two diametrically opposed recommendations according to the guidelines with which he is assessed, further reason for the need for an update of the American guidelines. Finally, neither of the two guidelines mention the participation of young children in competitive sport, a gap that needs to be addressed in future updates

More than an update, what is needed is a harmonization of the recommendations issued by the different societies so that the message we transmit to our patients is consensual, clear and common.

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Lucía Deiros Bronte

New Guidelines for Transthoracic Echocardiography by the American Society of Echocardiography: Key Points Not to Miss

Highlights of the most relevant aspects of the guidelines on transthoracic echocardiography applicable to the field of pediatric cardiology.

Transthoracic echocardiography (TTE) is an essential tool in pediatric cardiology due to its wide availability and safety. The last guidelines on this topic were published in 2006, and advancements in the technique have allowed innovations such as three-dimensional transthoracic echocardiography (3D TTE) and strain imaging (deformation techniques) to redefine the imaging paradigm in pediatric cardiology departments. These new guidelines provide details on both conventional techniques and more recent advancements.

It is worth noting that, unlike adult patients, children present unique and critical considerations in this type of echocardiography (e.g., small children with high heart rates or older patients who have often undergone interventions and may present with poor acoustic windows).

For beginners to TTE, these guides highlight echocardiographic planes and the overall essence from preparation to performance of TTE. However, basic concepts of TTE such as the difference between pulsed wave (PD) and continuous wave (CW) Doppler, for example, are taken for granted (PD: allows the measurement of velocity at a specific point and only measures up to a velocity limit, e.g. the aortic valve. CW: measures velocity along a column, e.g. left ventricular outflow tract or LVOT, aortic valve and ascending aorta; it will give us the total velocity without limit, but without specifying where there is a greater degree of flow acceleration and, therefore, stenosis). For experienced echocardiographers, they highlight misconceptions that are rooted in the world of TTE, which we assume to be true in clinical practice and which we will detail in this commentary.

Indications

TTE should be performed in every child with suspected heart disease, congenital (CHD) or acquired heart conditions, genetic or systemic diseases with potential cardiac involvement, and those with a family history of cardiovascular disease. Examples of initial indications for TTE include abnormal findings on fetal echocardiography, signs suggestive of heart disease, or children undergoing treatments with potential cardiac toxicity, such as oncological therapies.

On the other hand, follow-up TTE is indicated for all congenital and acquired heart diseases, regardless of treatment status, as well as for pulmonary hypertension and monitoring of cardiotoxic treatments.

Technical Aspects

All pediatric echocardiography laboratories must be equipped with transducers of various frequencies. Low frequencies are recommended for older children to minimize ultrasound attenuation caused by body mass, while high frequencies are essential for younger children to provide greater precision. Equipment must support various functionalities of TTE.

The standards for image optimization should include patient preparation, image acquisition, and storage to allow for the review of previous studies, offline quantification, and anonymized analyses. Every pediatric TTE must include a comprehensive evaluation of anatomy, ventricular function, and cardiovascular physiology. This is achieved through a combination of two-dimensional imaging, color Doppler, pulsed (PW) and continuous Doppler (CW), tissue Doppler imaging (TDI), 3D TTE, and strain evaluation.

Linear measurements must always be performed along the ultrasound beam's axis, as axial resolution is superior to lateral resolution. The distance between the transducer and the structure being measured should be minimized. Doppler studies (PW and CW) must always be performed in planes parallel to blood flow. Prior to using PW or CW Doppler, color Doppler interrogation should be performed with an appropriately sized color box (neither too large nor too small), and velocity ranges adjusted to maintain a frame rate equal to or above 20 Hz.

Simultaneous use of two-dimensional imaging and color Doppler (dual mode) significantly reduces the frame rate and should only be employed when assessing low-velocity structures such as pulmonary veins and coronary arteries.

Standard Echocardiographic Views and Anatomical Orientation

The updated guidelines provide a detailed description of standard echocardiographic views, including anatomical structures and techniques for obtaining them. In pediatric cardiology, images must be anatomically oriented, ensuring that anterior or superior structures are displayed at the top of the monitor and right-sided structures are shown on the left. In apical and subcostal views, the apex of the image should be displayed at the bottom for consistency.

A systematic cardiac segmental analysis should be performed in every echocardiogram, beginning with subcostal or parasternal long-axis views. Particular emphasis is placed on subcostal, suprasternal, and right parasternal views, which hold greater importance in pediatric imaging compared to adult echocardiography.

Segmental Anatomical and Functional Analysis Protocol

Pulmonary and Systemic Veins:

TTE is the primary imaging technique for evaluating venous connections, abnormal drainage, size, and the presence of obstructions (e.g., turbulence on color Doppler, loss of normal phasic variation, or increased velocities). The assessment of systemic and pulmonary venous drainage must be included in all initial pediatric TTEs using two-dimensional imaging, color Doppler, and spectral Doppler.

The superior vena cava (SVC), inferior vena cava (IVC), hepatic veins, and the right atrium-to-coronary sinus connection should be evaluated using subcostal, parasternal, and apical posteriorly inclined views. In adolescents and adults, right parasternal views enable clear imaging of the SVC and IVC.

In children, no studies have established a reliable correlation between IVC size and right atrial pressure. Contrast echocardiography with agitated saline is useful in diagnosing systemic venous anomalies and obstructions. Suspected IVC interruption should be evaluated in subcostal views. Suprasternal views allow visualization of the innominate

vein's drainage into the SVC and identification of retroaortic innominate veins, left SVCs, or dual SVC systems.

Pulmonary veins must be assessed in suprasternal short-axis views, where the typical "crab" image shows the right inferior pulmonary vein connecting to the left atrium. However, this view does not exclude anomalous drainage of the right pulmonary vein into the SVC; subcostal and right parasternal views are preferable for identifying such drainage. Apical posteriorly inclined views can show pulmonary drainage but do not differentiate between upper and lower veins or between left and right.

Total anomalous pulmonary venous connection (TAPVC) should be suspected in subcostal views if a significant right-to-left shunt is visible through the foramen ovale, combined with a small left atrium. Partial anomalous pulmonary venous connection (PAPVC) may not associate with right ventricular dilation, requiring exclusion of connections such as the right superior pulmonary vein draining into the SVC, the right inferior pulmonary vein draining into the IVC, the left superior pulmonary vein draining into the innominate vein, or the left inferior pulmonary vein draining into the coronary sinus.

Atria and Atrial Septum (AS):

TTE must evaluate atrial size, morphology, and venous and atrioventricular (AV) valve connections. The atrial septum should be examined in all initial pediatric TTEs.

Atrial size is analyzed using apical four-chamber or subcostal long-axis views, with subcostal short-axis and parasternal views as supplementary options. The 2010 guidelines suggest measuring atrial dimensions (major and minor axes) in apical four-chamber views. While M-mode measurements of left atrial (LA) diameter relative to the aortic root were previously used to assess ductus arteriosus impact, they correlate poorly with LA volume and are not included in neonatal TTE guidelines.

Standard practice includes calculating LA volume using LA area and length measurements obtained in apical views during end-systole before mitral valve opening. These measurements are crucial for assessing diastolic function and are especially relevant in cases of mitral valve dysfunction, left-sided volume overload, hypertrophy, or diastolic dysfunction. Normal LA volume values are established for children, and LA strain can be used to analyze left ventricular (LV) diastolic function. 3D TTE has been utilized for measuring LA volume and strain in healthy pediatric populations.

Suspected secundum or sinus venosus atrial septal defects (ASD) are indicated by right atrial (RA) or right ventricular (RV) dilation. Subcostal and right parasternal views provide optimal ASD evaluation due to the ultrasound beam's perpendicular orientation. Color Doppler confirms defects, and spectral Doppler assesses shunt direction. Defect size should be measured in orthogonal planes, including superior, inferior, anterior, and posterior edges. 3D TTE is particularly helpful for these measurements.

Atrioventricular Valves (AV):

AV valve assessment in TTE should include annular size, leaflet anatomy, papillary muscles, and chordae tendineae. Standard measurements involve the annular diameter during diastole, from inner edge to inner edge, at the highest leaflet insertion points in apical and parasternal views. Routine area measurements are not performed in children due to the scarcity of normal reference values and limited validation.

Anatomical and functional AV valve analyses require multiple planes and perspectives. For stenosis, color Doppler evaluates the time integral to calculate mean gradients for quantitative analysis. High heart rates in children may confound mean gradient assessment, as do factors like nonparallel Doppler angles, AV valve regurgitation, or congenital heart defects that increase AV valve flow (e.g., atrial or ventricular septal defects). For mitral stenosis, TTE must measure pulmonary pressures.

In cases of valvular regurgitation, pediatric-specific considerations such as multiple jets and undefined severity grades necessitate qualitative evaluation via color Doppler or indirect severity indicators. Preferred parameters include atrial and ventricular dilation or the presence of reversed flow in pulmonary or systemic veins. Effective regurgitant orifice and regurgitation fraction are minimally validated in children, though vena contracta measurements, typically adopted from adult values, are gaining traction in pediatric labs.

Right Ventricle (RV)

The RV is challenging to evaluate through TTE due to its trabeculated structure, complex geometry, and retrosternal position. Comprehensive assessment requires imaging in subcostal, apical, parasternal, and modified planes such as the RV-focused three-chamber apical view (obtained medially on the chest) and the right anterior oblique subcostal view (achieved by counterclockwise rotation of the transducer from the subcostal long-axis view, visualizing the inflow and outflow tracts simultaneously).

Morphological abnormalities in congenital heart disease (CHD) affect RV dimensions and function, with significant interindividual variability. Therefore, a complete RV analysis must include qualitative assessment and multiple parameters to evaluate abnormal hemodynamic conditions influencing RV measurements (e.g., estimating pulmonary artery systolic pressure [PASP] via tricuspid regurgitation velocities, assuming right atrial pressure inaccurately).

RV size assessment through TTE shows weak correlation with linear two-dimensional parameters, moderate correlation with two-dimensional area measurements, and strong correlation with 3D TTE-derived volumes compared to MRI. Linear dimensions (basal, mid, and longitudinal diameters) are obtained in apical views during end-diastole, while area measurements are taken in apical views during end-systole (frame prior to tricuspid valve opening) and end-diastole. 3D TTE is increasingly used for volume calculations, providing valuable insights despite limitations in children, such as volume underestimation and limited data on normative values and validity in geometrically altered RVs.

Functional assessment parameters like tricuspid annular plane systolic excursion (TAPSE) and fractional area change (FAC) offer insight into systolic performance. TAPSE evaluates longitudinal displacement of the tricuspid valve annulus in apical four-chamber views as a measure of RV systolic function. Its precision improves with color Doppler, particularly in pressure overload scenarios, though it lacks representation of apical function and circumferential/radial shortening. FAC considers systolic and diastolic areas, providing information on radial and longitudinal function.

Additional functional measurements, including RV volumes, ejection fraction (EF), and strain analysis via 3D TTE, correlate better with MRI data and are particularly useful in conditions like pulmonary hypertension or tetralogy of Fallot. RV strain is measured in apical four-chamber views, showing high reproducibility when the same platform is used for longitudinal analysis.

Left Ventricle (LV) and Interventricular Septum (IVS)

The LV and IVS are evaluated using apical, parasternal, and subcostal views. Serial measurements of LV size, global/regional systolic function, and diastolic function are critical in pediatric TTE. Linear measurements of the LV are taken during end-diastole and end-systole.

While adult guidelines recommend measuring LV dimensions in parasternal long-axis views, pediatric guidelines suggest parasternal short-axis views for improved accuracy. LV diameter is used as a size proxy, though linear one-dimensional measurements are representative only when LV geometry is circular.

Wall thickness measurements during diastole/systole should avoid including RV trabeculations, particularly in asymmetric hypertrophy cases. Dimensional and functional assessments are primarily performed in two-dimensional mode due to the reduced accuracy and reproducibility of M-mode.

Volume measurements via the biplane Simpson method in two- and four-chamber apical views are standard practice, including for children. 3D TTE provides superior correlation and reproducibility with MRI compared to M-mode and two-dimensional approaches, enhancing systolic/diastolic functional assessments. Global LV evaluation combines M-mode, two-dimensional, 3D TTE, and strain analysis. In cases with altered LV geometry or segmental wall motion abnormalities, strain and 3D TTE volumes are preferred.

The IVS must be evaluated in all initial pediatric TTEs. It should present a circular contour in subcostal and parasternal short-axis views. Doppler and color Doppler are employed to identify septal defects, determine shunt direction, and assess the defect's size, location, and surrounding structures. PW and CW Doppler quantify shunt flow and defect restriction.

Right Ventricular Outflow Tract (RVOT) and Pulmonary Valve (PV)

The RVOT is a complex muscular structure best visualized in subcostal, anteriorly inclined apical, and parasternal long- and short-axis views. These align with the Doppler beam to optimize flow evaluation. In tetralogy of Fallot, subcostal and modified right anterior oblique views are particularly useful for visualizing the RVOT, tricuspid valve, and conal septum.

RVOT dimensions are measured from inner edge to inner edge during end-diastole. Proximal RVOT measurements (from free anterior wall to aortic annulus) are obtained in parasternal short-axis views, while distal measurements (immediately before the PV) are taken in parasternal long-axis views.

The PV is evaluated in the same views as the RVOT, with morphology best assessed in parasternal views. The valvular annulus is measured from inner edge to inner edge during maximum systolic opening in parasternal long-axis views (avoiding short-axis views, as this is a common but incorrect practice).

Doppler techniques are essential for assessing PV obstruction and regurgitation. PW Doppler is applied above and below the valve to evaluate dynamic stenosis or multilayered obstructions. Peak velocities for stenosis or regurgitation are measured using color Doppler, with detailed annotation of the acquisition plane in reports to mitigate

errors related to RVOT and PV Doppler measurements. Morphology and size should guide interpretation in cases where:

- Large shunts equalize pulmonary and systemic pressures.
- Pulmonary hypertension is physiologically present in neonates.
- Severe tricuspid regurgitation or low RV output alters gradient estimations.

Left Ventricular Outflow Tract (LVOT) and Aortic Valve (AV)

The LVOT represents the area below the aortic valve, bounded by the interventricular septum (IVS) and the anterior mitral valve leaflet. Unlike the RVOT, the LVOT lacks a muscular subaortic cone, with fibrous continuity between the AV and mitral valve.

The LVOT is best measured in parasternal long-axis views during mid-systole, 3–10 mm below the aortic annulus. The AV is assessed in systole, with measurements taken from inner edge to inner edge at the point of maximum opening in parasternal long-axis views. Morphological evaluation is performed in parasternal short-axis views to visualize all three aortic leaflets simultaneously. 3D TTE can be employed for detailed morphological analysis and frontal plane imaging of the valve.

Doppler interrogation of the LVOT and AV should utilize subcostal long-axis, apical three-chamber, right parasternal, and suprasternal views. Color Doppler is used to detect areas of aliasing, followed by PW Doppler to exclude stenosis at the LVOT, AV, or supravalvular levels. Color Doppler also measures peak gradients across the LVOT.

In adults, aortic regurgitation is quantified using pressure half-time and ascending flow slope evaluation; however, these techniques lack validation in children. Pediatric assessment relies on qualitative jet evaluation via color Doppler and indirect parameters such as diastolic flow reversal in the aorta and LV dilation. Doppler evaluation for stenosis includes peak and mean gradients obtained from multiple planes. Since gradients in apical views are often lower than those in right parasternal views, the report should specify the acquisition plane.

Arteries and Branches

TTE must evaluate the size, morphology, and flow of both pulmonary arteries. Proximal pulmonary artery (PA) and branch measurements are performed in parasternal short-axis views during mid-systole at maximum expansion, from inner edge to inner edge. Mild tilts in the plane may reveal branch origins, with asymmetry potentially indicating pulmonary sling.

Right PA evaluation is optimal in parasternal short-axis views, while parasternal long-axis and high left parasternal views are superior for the left PA. Color Doppler is applied to detect stenosis or patent ductus arteriosus (PDA) with diastolic flow in the PA. Doppler interrogation should be conducted in parasternal short-axis views or modified anterior apical views when assessing the proximal PA.

Coronary arteries, due to their small size and superficial location, require high-frequency transducers with reduced ultrasound sector width and optimized frame rates. The size, origin, and proximal course must be analyzed. Parasternal short-axis views assess the

proximal left coronary trunk, circumflex artery (Cx), left anterior descending artery (LAD), and the proximal right coronary artery (RCA). Parasternal long-axis views reveal the anterior RCA origin and the Cx in the left atrioventricular (AV) groove. Clockwise rotation and posterior tilting of this view display the posterior descending artery in the interventricular groove. Apical posteriorly tilted views show the distal RCA over the right AV groove, while anterior tilting reveals the left coronary artery and its bifurcation into the LAD and Cx.

Artery size should be measured at maximum expansion, recording z-scores and serial measurements for longitudinal evaluation. Color Doppler is critical for diagnosing anomalous origins, with two-dimensional and Doppler modes required to confirm anomalies. Reversed flow suggests origin from the PA or coronary ostial atresia.

Serial aortic measurements are essential for a wide range of conditions. Parasternal long-axis views are used for proximal aortic segments, including the annulus, sinuses of Valsalva, sinotubular junction, and ascending aorta at the level of the right pulmonary artery. In children, aortic dimensions are measured in mid-systole at maximum expansion from inner edge to inner edge, unlike adult guidelines that recommend diastolic measurements from anterior edge to anterior edge.

For the aortic arch, suprasternal long-axis views allow analysis of the proximal transverse arch, distal transverse arch, descending thoracic aorta, and the aortic isthmus. Measurements can be obtained at each of these levels. Suprasternal short-axis views using two-dimensional and color Doppler assess arch laterality and brachiocephalic trunk bifurcation. Increased distance between the second and third branches, narrowing of the isthmus, and posterior notching with turbulent flow raise suspicion of aortic coarctation.

Doppler interrogation of the arch is mandatory to assess shunt direction and degree of restriction in cases of PDA. Ascending aortic Doppler evaluation is conducted from suprasternal long-axis, apical three-chamber, right parasternal, or subcostal views, particularly when subvalvular or valvular stenosis is suspected. In small children, exclusive use of three-chamber views may underestimate gradients. Sequential PW and CW Doppler should be used to detect obstructions, while abdominal aorta flow is assessed in subcostal short-axis views.

COMMENTARY:

TTE reaffirms that, in many aspects, children are not just small adults. Beyond anatomical differences, cardiovascular physiology also introduces unique challenges and complexities. One of the main limitations in pediatric echocardiography lies in quantifying the severity of valvular disease. This limitation arises due to the following factors:

- Peak instantaneous gradients differ from peak-to-peak gradients.
- Physiological states such as fever can lead to gradient variability.
- The pressure recovery phenomenon causes discrepancies between gradients measured by TTE and catheterization, with this effect being more pronounced in younger children compared to adults and in mild stenosis compared to severe cases.

- Left ventricular dysfunction may be associated with lower gradients, even in severe stenosis.

- Gradients measured in neonates may be lower than those observed in older children and adults.

As such, assessing severity must incorporate valve morphology and z-scores. While valve area estimation through planimetry or continuity equation can be useful, particularly with 3D TTE, significant variation due to minimal plane changes, limited temporal resolution, and random measurement error have prevented its standardization for quantifying aortic stenosis severity in children.

As a general rule, the report generated from any echocardiographic study must use terminology that is universally understood within the center and include a summary, z-scores, and normality values. All findings should be described in a structured format with segmental analysis. Doppler gradient acquisition planes and z-scores used for measurement must be explicitly noted to ensure accurate temporal comparison. It is important to remember that using different z-scores across studies may obscure a patient's progression. Reports should be archived for a reasonable period following the study, and findings must be communicated promptly to referring physicians.

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Bunty Ramchandani

The choice between a univentricular or biventricular pathway: A binary decision?

Review article on the contemporary management of borderline left ventricles.

The borderline left ventricle (LV) encompasses a broad spectrum of congenital heart conditions. Controversy exists over what constitutes a borderline ventricle, raising uncertainties about whether to attempt a biventricular repair or commit to a univentricular pathway. When referring to small left ventricles, hypoplastic left heart syndrome (HLHS) often comes to mind, with its most severe forms involving atresia of the aortic and/or mitral valves. Cases with valve atresia are not candidates for biventricular repair; therefore, a borderline LV must have patent valves and some degree of left ventricular development. Other conditions involving small LVs include critical aortic stenosis, congenital mitral stenosis, unbalanced atrioventricular canals (frequently associated with coarctation of the aorta), and hypoplasia of the aortic arch. Additionally, variations such as double-inlet ventricles, double-outlet right ventricles with mitral valve hypoplasia, or overriding atrioventricular valves often lead to a univentricular approach.

The decision between pathways is often challenging, with dire consequences if a biventricular strategy is chosen for an LV unable to support it. Conversely, the univentricular pathway poses long-term complications that are difficult to manage.

A universal guideline for dichotomizing cases into biventricular or univentricular pathways cannot be established. This review aims to synthesize current evidence on algorithms and scoring systems to guide management strategies tailored to specific pathologies.

In cases of critical aortic stenosis, the Rhodes score, developed by the Boston Children's group, considers the heart's long axis, indexed diameter of the aortic root, mitral valve area, and indexed LV mass to determine the most appropriate pathway. Application of this score concluded that neonates with critical aortic stenosis, a mitral valve area above $Z < -2$, and biventricular physiology had a survival rate exceeding 90%. Following the Rhodes score, the American Congenital Heart Surgeons Society introduced the CHSS-1 score, identifying several risk factors for hospital mortality. This was later refined into the CHSS-2 score, emphasizing the minimum left ventricular outflow tract diameter for biventricular circulation suitability, identifying the risks of pursuing a circulation pathway not aligned with the patient's anatomy.

Unbalanced atrioventricular canals with right ventricular dominance constitute a challenging cohort. Here, the indexed left-to-right atrioventricular valve area ratio determines the feasibility of a biventricular repair. Ratios above 0.67 make biventricular repair viable, while those below 0.5 preclude survival with such an approach.

In cases of HLHS, the 2V score incorporates echocardiographic parameters—mitral and aortic annulus dimensions, LV and right ventricular lengths, pulmonary artery diameter, and body surface area—to guide clinical decisions. Studies based on this score concluded that the mitral and aortic annuli are critical determinants in choosing a circulation pathway. Building on this research, Tchervenkov's group identified a subset favorable for biventricular repair in 1998: patients with hypoplastic LVs and outflow tracts, small but non-stenotic aortic and mitral valves, and no evidence of endocardial fibroelastosis. Select HLHS patients demonstrated growth of cardiac structures,

particularly the aortic valve, during the first two years post-surgery, supporting individualized approaches to enhance LV development for biventricular circulation.

Based on this premise of growth potential, various strategies have emerged to precondition borderline LVs for biventricular circulation. The Boston strategy begins with conventional neonatal Norwood palliation. At 4–6 months, during the bidirectional Glenn procedure, valve repairs and fibroelastosis resection are performed. In select cases, an obstructive membrane is placed in the pulmonary artery to prevent high Glenn pressures, a technique termed “super-Glenn.” A restrictive atrial septal defect (ASD) of 4–5 mm is left in all patients. Follow-up every 2–4 months monitors left heart cavity growth. Candidates with an LV end-diastolic volume >40 mL/m² and an end-diastolic pressure <12 mmHg are considered for biventricular conversion.

The Giessen strategy involves a hybrid approach with bilateral pulmonary artery banding and ductal stent implantation during the neonatal period. A restrictive ASD ensures left atrial pressure remains below 15 mmHg, with a 5–10 mmHg gradient across the ASD. This approach buys time to decide on the definitive circulation pathway at 4–6 months.

Birmingham’s reverse double switch strategy for patients with Shone’s syndrome and elevated LV end-diastolic pressures involves leaving the LV as the subpulmonary ventricle, combined with a bidirectional Glenn. While innovative, its mid-term outcomes are pending.

Determining whether a borderline LV can support biventricular circulation is complex and pathology-specific. Decisions must be informed by cardiac structure measurements and growth potential.

COMMENTARY:

Our left ventricle (LV) traces its origins to an ancient ancestor—a fish from the Chordata phylum (animals whose embryos exhibit a dorsal cord, precursor to a backbone) appearing 500 million years ago during the Devonian period. These fish had a univentricular heart pumping blood to the systemic circulation and respiratory organs, the gills. Mammals, emerging 180 million years ago in the Jurassic period, developed a right ventricle, which pumps blood to the lungs, alongside the ancestral LV, now responsible for systemic circulation. The LV’s evolutionary refinement through natural selection has resulted in a lower frequency of left-sided congenital defects compared to right-sided abnormalities or septal defects.

The univentricular pathway remains a double-edged solution. Despite improved surgical outcomes across stages—10–20% mortality for Norwood, 95% survival for Glenn, and 90% survival for Fontan—long-term results are less encouraging: 50–70% mortality at 10 years, with 5% of patients requiring transplantation. Complications such as protein-losing enteropathy, plastic bronchitis (occasionally unresolved even post-transplant), arrhythmias, valvular insufficiencies, thrombosis, cirrhosis, and ventricular dysfunction often emerge, with limited therapeutic options. Consequently, striving for biventricular circulation, whenever feasible, is imperative.

Ultimately, while the decision is binary, it need not be made during the neonatal period, when the patient’s evolution remains uncertain. The mentioned strategies allow deferring the decision after assessing the growth potential of cardiac structures.

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Juan-Miguel Gil-Jaurena

Minimally invasive surgery for congenital heart disease: an expert commentary

An update on minimally invasive surgery applied to the treatment of congenital heart diseases, authored by Dr. Juan-Miguel Gil-Jaurena.

During the recent EACTS congress in Lisbon (October 10-12, 2024), a multicenter study on minimally invasive pediatric cardiac surgery involving over 3000 patients was presented. The study includes data from 10 European centers and one American center (USA) from 1999 to January 2024, focusing on lateral accesses (submammary, horizontal, and vertical axillary incisions, predominantly). The authors emphasized the gradual increase in alternative approaches to the conventional median sternotomy, along with the inclusion of more complex pathologies. As expected, simple defects such as atrial septal defects (ASD), ventricular septal defects (VSD), partial anomalous pulmonary venous connections (PAPVC), and intermediate atrioventricular canal defects like ostium primum ASD predominate. All these defects share a common approach via the right atrium. Groups with greater expertise have expanded their repertoire to include aortic root pathology (valvular and subvalvular) in addition to right-sided conditions (outflow tract anomalies and tetralogy of Fallot). No patient required conversion to median sternotomy. Complications, all minor, were infrequent. The results gain significance when benchmarked against the European Congenital Heart Surgeons Association (ECHSA) database, showing favorable outcomes compared to similar pathologies treated with median sternotomy during the same period. A draft of the study is under review by the European Journal of Cardiothoracic Surgery, and we look forward to its publication soon.

Interventional cardiology is advancing rapidly, driven by the efforts of our colleagues and industry support. The appeal of avoiding a surgical procedure and a sternotomy scar is an undeniable argument for patients (or their parents, in this case). I will not delve into long-term comparative results, a topic for other forums and more specialized voices. Beyond progress in valvular and coronary pathology in adults, children are also candidates for minimally invasive approaches. I recommend a recent review by the Toronto group on the subject, which provides a comprehensive overview of the English-language literature (including a very extensive appendix) and a detailed description of various alternatives to sternotomy. Central cannulation and repair through the same incision stand out in all these approaches. The review is complemented by the use of thoracoscopy and peripheral cannulation, adapted from minimally invasive mitral surgery in adults, pointing toward the future with endoscopic and robotic surgery. The support of peripheral cannulation in these advanced techniques varies according to weight criteria (15-50 kg, depending on the authors) and femoral arteries >5 mm in diameter. Several pioneering centers in minimally invasive access for congenital heart disease exist, primarily in Europe and, more recently, in the United States. Most describe a trajectory through various anterior and posterior-lateral approaches, with a clear trend toward vertical axillary incision.

Our group has been performing minimally invasive surgery for 25 years, with the program at Gregorio Marañón Hospital (Madrid) starting in 2013. Patience is essential when beginning a minimally invasive surgery program. While simple cases (such as ASD) are appropriate to start, it is difficult to justify a complication or poor outcome for the same reason. Gaining the support of anesthesiologists, perfusionists, surgical assistants, etc., (just within the operating room) is crucial to get off to a good start. Hence, the first patients are carefully selected until some experience is gained, and all those involved in the

operating room feel comfortable (or "relatively uncomfortable," at least). In less than 12 years, we have reached 500 extracorporeal circulation (ECC) procedures for congenital heart disease, as presented at the recent SECCE congress in Madrid (June 5-7, 2024).

As guidance, we use a lower mini-sternotomy approach for cases under 10-15 kg, axillary access for patients between 15-30 kg, and submammary incisions for adolescent girls with developed breasts. As noted in the studies reviewed, ASD, VSD, PAPVC, and ostium primum ASD are the most common defects, with a gradual inclusion of less frequent conditions (complete atrioventricular canal, aortic valvuloplasty, subaortic membrane, mitral, tricuspid, or pulmonary valve disease, etc.). Although less common, we incorporate peripheral cannulation combined with thoracoscopy to minimize submammary incision in females and use the periareolar route in males. It is essential to highlight the peculiarities of the size and vasoreactivity of femoral arteries in children. After 12 years and with all service members familiarized, 98% of ASDs and 70% of VSDs are treated in our center through a minimally invasive approach (personalized according to patient weight and height). The experience gained (while maintaining caution) encourages us to push boundaries. Our smallest patient, a neonate with a VSD corrected through a lower mini-sternotomy, and a pulmonary prosthesis in an adolescent via left axillary access, serve as examples.

Every team initiating a minimally invasive surgery program must ensure a minimum number of procedures for surgeons, anesthesiologists, perfusionists, and others to gain experience. Similarly, families seeking such procedures will turn to centers proven in this regard. The growing competition from percutaneous procedures compels us to explore less invasive accesses that reduce the impact of cardiac surgery on quality of life. For children with no anticipated future interventions (e.g., ASD, VSD), a minimally invasive access allows their scar to remain hidden for life. Without compromising surgical outcomes, minimally invasive surgery offers a cosmetic advantage appreciated by patients and, in our case, their parents. *Think mini*.

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Section IV:

Heart transplant, heart failure and mechanical circulatory support

Álvaro Pedraz Prieto

Controlled Circulatory Death Cardiac Donation: Turning Necessity into Virtue

A retrospective analysis of the United Network for Organ Sharing (UNOS) database on heart transplants from controlled circulatory death (DCD) donations performed in the U.S. from October 2018 to December 2022.

Despite advances in mechanical circulatory support devices (MCS), heart transplantation remains the treatment of choice for advanced heart failure. Its primary limitation is the restricted number of available organs, leading to an imbalance between transplant candidates and donors. Consequently, efforts to expand the donor pool are continuous. Until recently, this pool included only patients declared brain dead. Now, it also includes those for whom therapeutic efforts are limited due to futility, with an anticipated fatal outcome in the short term, either due to an advanced, irreversible medical condition (extensive brain damage, terminal chronic diseases) or patient preference (aid in dying). This is known as donation after circulatory death (DCD).

The increase in DCD over recent years has been remarkable and is expected to continue. However, its unique aspects compared to brain death donation raise concerns regarding post-transplant outcomes. Consequently, not all waitlisted (WL) patients are considered eligible for DCD organs. To address this, the authors analyze the impact of DCD adoption in the U.S., reviewing the national transplant database from October 2018—when WL prioritization criteria changed—until December 2022.

In this analysis, WL patients were divided into two groups: those eligible only for brain death donation (thus, not DCD candidates) and those eligible for both brain death and circulatory death donations. The authors pursued two objectives:

1. Evaluate the impact of DCD on the WL: They compared one-year transplant incidence, WL removal due to death/clinical deterioration, and one-year survival post-WL inclusion (sum of patients alive on the WL and those transplanted within a year). Parameters were analyzed in subgroups based on blood type, transplant priority, MCS use, and center, dividing centers by DCD eligibility rates (0%, <50%, or >50%).

2. Assess DCD's impact on post-transplant survival: They compared one-year survival post-transplant between the two groups, with and without propensity score adjustment. Additionally, a sub-analysis within the DCD group assessed the impact of retrieval technique (ultra-rapid vs. normothermic perfusion recovery).

During the study, 14803 WL patients were included, with 2516 candidates for DCD hearts. Compared to the 12287 non-DCD candidates, these 2516 were older, had more comorbidities (diabetes, renal impairment), and less long-term MCS presence. In the unadjusted analysis, there were no differences in one-year cumulative transplant incidence. However, after adjusting for blood type, region, heart failure etiology, etc., DCD candidates were 23% more likely to be transplanted. Additionally, DCD candidates had a lower WL removal rate due to death/clinical deterioration. Finally, listing at a DCD program center increased transplant probability and reduced WL removal risk, with the highest survival rates among centers where >50% of WL patients were DCD candidates.

During this period, 12238 isolated heart transplants were performed: 602 DCD and 11636 from brain death donors. Among DCD recipients, there was a higher proportion of males, blood type O, prior cardiac surgery, and prolonged MCS. The unadjusted one-

year survival analysis found no differences (91.3% in non-DCD vs. 92.7% in DCD). Propensity-score-adjusted analysis between two comparable groups of 257 patients showed no survival differences (92.5% in non-DCD vs. 92.8% in DCD), though the DCD group had a higher incidence of postoperative dialysis. Lastly, within the DCD group, no differences were found between extraction methods in terms of postoperative complications or one-year survival.

The authors conclude that DCD increases transplant probability and reduces WL removal due to death/clinical deterioration, all while maintaining good one-year survival outcomes.

COMMENTARY:

DCD continues to grow, with more transplant groups adopting it. In the U.S., the number of DCD heart transplants rose from 103 in 2020 to 301 in 2022, though it remains a minority, accounting for only 4.9% of transplants from 2018 to 2022. Furthermore, only 17% of WL patients were DCD candidates.

Analyzing the UNOS database and adjusting for factors affecting transplant likelihood, the authors found DCD increased transplant probability and reduced WL removal due to death or deterioration, especially in some priority statuses (status 3 and 4). Patients most benefitting were those listed as priority 4, those with long-term MCS, and blood type B. However, these findings might not fully apply elsewhere, given the unique prioritization and geographic factors in the U.S.

Regarding transplant outcomes, although previous reports suggest similar results to brain death donation, most studies had smaller sample sizes. This study found comparable one-year survival between both groups in both unadjusted and propensity-adjusted analyses. However, the DCD group had a higher incidence of postoperative dialysis, which the authors link to right ventricular failure and longer “cross-clamp” times in DCD. These prolonged times only occurred in ultra-rapid retrieval cases using Transmedics OCS®, allowing longer preservation times (mean of 6.1 hours). Within the DCD group, there were no significant differences between retrieval methods.

The main study limitations include its retrospective nature and the use of a general database, which lacked specific variables relevant to this study. This affects the DCD retrieval method comparison, making it somewhat suboptimal. Additionally, many centers simultaneously participated in a Transmedics OCS® trial, a possible confounder. Only short-term (one-year) survival results were reported, leaving open the question of long-term outcomes.

In summary, incorporating DCD into our transplant program will increase our donor pool and reduce wait times. The technique’s complexity, logistical challenges, and even ethical aspects should not deter its adoption given its positive outcomes.

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Elio Martín Gutiérrez

Heart Transplantation from Pig Xenografts to Humans: Chimera, Science, and Hope

Update on research, experiences, and future perspectives of porcine-to-human cardiac xenotransplantation.

If the dog is man's best friend, it seems that pigs may soon be the best allies of cardiac surgeons and their patients awaiting a transplant. This porcine heart xenotransplantation project pushes to the limit the saying that "nothing is wasted from a pig." The demand for organs is progressively increasing in a population with higher expectations for both quality and quantity of life, paralleled by an almost epidemic rise in advanced heart failure. Although Spain leads in organ donation and heart transplantation (as demonstrated in our blog analysis of the 2022 Spanish heart transplant registry), the supply-demand imbalance remains. Various alternatives have been proposed to compensate for this disparity:

- Acceptance of older and hepatitis C-positive donors, topics we have discussed in our blog.

- The implantation of intracorporeal ventricular assist devices (VADs) as a bridge to candidacy or to reduce mortality on the waiting list. However, in some cases, conversion to destination therapy is the least harmful option when an organ does not arrive or an indication is lost. The REGALAD registry on long-term VAD use in Spain, as well as updates on current status and advances in VAD technology, have also been covered in recent blog posts.

- Controlled circulatory death donation, which has shown promising growth. However, in our country, this has not succeeded in increasing the number of transplants. Despite demonstrating good outcomes that may even surpass those from brain death, it seems that many controlled circulatory death donors in centers where this is practiced are the same candidates as those for brain death. Thus, it merely advances the process and limits organ deterioration in potential donors. This practice is primarily confined to transplant centers, with organs from peripheral centers primarily resulting from brain death. Expanding ECMO-supported portable systems for controlled circulatory death in other centers may enhance organ availability. Although we have yet to analyze articles on controlled circulatory death donation in Spain in our blog, we have discussed the situation in the United States through commentary in 2023 and 2024.

In June 2022, we witnessed one of the milestones in medical history, the first genetically modified porcine heart xenotransplantation performed by the University of Maryland team in Baltimore. Although the procedure was marred by complications, including intraoperative aortic dissection that required correction, the patient survived for two months, ultimately dying from an unexplained condition suggestive of early rejection. Unfortunately, this truncated hope received little attention in the media or on social networks, raising concerns about the direction of our society. Such news remains almost anecdotal, failing to compare to the publicity LIFE magazine gave Barnard's milestone.

This was not the first xenotransplantation attempt; Hardy at the University of Mississippi had already performed one using a chimpanzee heart in 1964, though the patient died two hours later. The official explanation for what appeared to be a hyperacute rejection

was that the organ was too small to sustain human cardiac output. After a long period without further attempts, the above-mentioned procedure was followed by two new implants with analogous methodology in June and July 2022 by the New York University team on brain-dead patients who had previously donated their bodies to science. Both procedures were successful for 72 hours, with adequate functioning of the implanted hearts, though the experiment was limited in duration for ethical reasons. The Maryland team performed a second human transplant in September 2023, with the patient dying four days later, likely due to rejection. Both candidates, aged 45 and 58, had been deemed ineligible for transplants due to comorbidities.

While xenotransplantation has been discussed, aside from sourcing from an animal rather than a human, what implications does this entail and why has it taken 60 years to achieve, even with limited success? Both humans and many anthropoid primates (such as baboons used in pre-human experiences) develop immunity to antigens present in porcine tissues. This is highly relevant for the construction of valvular prostheses, where these antigens are destroyed by decellularization and aldehyde solutions. However, this is not feasible in a living organ, leading to an antigen-antibody reaction that results in hyperacute rejection. Without delving too deeply, it is worth mentioning the alpha-Gal, Sd, and Neu5Gc antigens. Humans naturally produce antibodies against the latter two due to dietary contact. To ensure biocompatibility, genetically modified donor pigs are triple knock-out, meaning they do not express any of these three antigens. Although this may seem sufficient, two more hurdles remain for achieving biocompatibility:

- The first relates to immune damage unrelated to antigen-antibody complexes, such as ischemia-reperfusion injury. While we know little about the human heart's behavior in this situation, in porcine hearts, the expression of human CD46, CD55, and CD59 genes—regulators of complement activation absent in pigs—is promoted, limiting human complement damage to animal tissues.

- The second hurdle involves porcine vascular bed dysregulation in response to human blood's hemostatic function, as porcine endothelium does not interact or fulfill the antithrombotic role as in humans. In fact, the porcine model for hemostasis is suboptimal, showing a procoagulant state compared to humans. This facilitates hemostasis after tissue injury, but what is valid in a pig's body is not for a porcine heart in a human body. This procoagulant endothelium state would lead to obstructive/thrombotic microangiopathy of the graft, compensated by enhancing the expression of anticoagulants like thrombomodulin and endothelial protein C receptor factor in genetically modified pigs.

The Maryland group has continued research and collaborates with other teams, such as the German team responsible for the work analyzed here. This document summarizes experiences shared during a xenotransplantation workshop. Among the advances and future prospects, the following can be highlighted:

- Preservation of organs under low ischemic aggression, as porcine hearts are more sensitive than human ones. They advocate for preservation under perfusion at 8°C, with hyperoncotic, cardioplegic, oxygenated blood solution enriched with hormones and nutrients, minimizing time to implantation. This solution was used for the first case in Maryland.

- Development of custom immunotherapies, given that the antigenic profile of donors is more controlled, based on selective CD40 blockade with monoclonal antibodies, cortisone, and antiCD20 (rituximab). This pharmacological protocol limits renal damage and reduces the need for serum level monitoring compared to agents used for human-to-human organs.

- Control of organ growth: Donor pigs at the time of sacrifice are significantly young, reaching 200-300 kg with hearts of 1 kg, overly large for an adult human. This disproportion posed a serious challenge in the animal model, where recipients were baboons weighing barely 20 kg. As has occurred with kidney transplantation, the organ would continue to grow, leading to disproportion in the human recipient if long-term survival is achieved. Projects are underway to develop genetically modified pigs of breeds that reach 70-90 kg in adulthood to address this issue.

- Selection of recipients more compatible with porcine donors. Beyond the three previously mentioned antigens that are genetically modified in pigs, other antigenic reactions may occur or humans may naturally have immunity against other uncontrolled antigens. Identifying sensitized human receptors could improve compatibility. After the second human implant, a rejection component was suspected.

- Microbiological control: Essential to limit zoonosis transmission to humans. The most concerning agents are hepatitis E virus, porcine cytomegalovirus or roseolovirus. The last two viruses resemble human herpesviruses and were transmitted to the first human recipient, potentially contributing to the fatal outcome. Strict pig testing and rigorous rearing control from birth are proposed to prevent transmission, avoiding nursing by sows, a primary transmission source. Porcine endogenous retroviruses (PERV) have three subtypes (A-B-C). While it is possible to breed pigs free from PERV-C, types A and B can infect human cells, although their significance remains uncertain.

The report provides various reflections on the ethical principles of the procedure and the legal framework governing it. Ethically, a well-developed and experience-backed technique justifies its use in patients who have been rejected for heart transplantation, aiming to achieve outcomes comparable to those of previous alternatives, such as mechanical circulatory support. For patients not eligible for support or transplant, it could be an option given their grim prognosis. With improved survival, it could even be considered for patients awaiting a human organ, especially in regions with limited availability. Some countries, such as Japan, have a scarce organ availability due to restrictive death definitions, only recognizing cardiorespiratory death. Legally, the EU has a regulatory framework for advanced therapy medicinal products that includes animals and human recipients, though it appears to be designed primarily for devices or animal products rather than whole organs. Consequently, the European Medicines Agency (EMA) has set up a commission to address this legal gap.

COMMENTARY:

This work provides an update on a fascinating yet controversial topic. Filled with a pioneering spirit reminiscent of the early days of cardiac transplantation, its acceptability in today's healthcare context is driven by an international project's scale, aimed at "manufacturing" organs for a growing number of patients with dire prognoses. Centers

worldwide are joining the Maryland initiative, sharing knowledge toward a common goal. Amidst the appearance of a chimera lies a vast body of serious, groundbreaking research. We hope it comes to fruition within our professional lifetimes. Though our country may not participate in this project, we can at least take pride in our saying, "we love everything about pigs," and now, even their hearts.

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Bunty Ramchandani

Total Artificial Heart: A Therapy That Fails to Gain Traction

A retrospective study analyzing the evolution of all SynCardia® total artificial heart (TAH) implants as a bridge to transplantation in the United States from 2005 to 2018.

Patients with advanced heart failure requiring ventricular assist device (VAD) therapy often exhibit a degree of right ventricular dysfunction. Nevertheless, most can be managed with left VAD (LVAD) implantation. Right ventricular dysfunction varies in severity and is difficult to predict, yet up to 20% of LVAD patients develop right ventricular failure. In such cases, TAH could offer an alternative support option. SynCardia Systems® has FDA approval for its TAH as a bridge to transplantation since 2004. Despite this, most transplant centers do not offer TAH to patients with severe biventricular dysfunction awaiting transplantation. Indeed, in US mechanical support registries, TAH comprises less than 2% of implanted VAD therapies, highlighting the limited use of the only FDA-approved device for biventricular dysfunction patients.

The article aims to evaluate the use and outcomes of TAH patients in the United States. Data from the UNOS (United Network of Organ Sharing Standard Transplant Research File) database were analyzed for all TAH implants in the US from 2005 to 2018.

Over this 13-year period, 471 patients with an average age of 47 years were treated with TAH, with males representing 87%. Among the 161 centers involved, 11 had performed more than 10 implants, classifying them as high-volume centers and accounting for nearly half of the studied cohort (212 patients). Patients treated at high-volume centers showed a higher incidence of renal failure requiring dialysis and worse hemodynamic parameters at implant time. A growing trend in TAH implants was observed, with a peak in 2013, followed by a gradual decline. High-volume centers generally had better outcomes. The cumulative incidence of mortality at 6 months and 1 year was 19% and 20%, respectively, for high-volume centers and 30% and 34% for others. The cumulative incidence of cardiac transplantation following TAH support at 6 months and 1 year was 51% and 65% at high-volume centers, and 47% and 58% at lower-volume centers. Finally, post-transplant mortality rates at 1 and 2 years after TAH therapy were 15% and 21% at high-volume centers compared to 25% and 31% at others. Cox multivariable regression analysis indicated that TAH implants at centers with fewer than 10 cases increased mortality during therapy (HR: 2.2; $p < 0.001$) and post-transplant mortality (HR: 1.5; $p = 0.39$).

The authors concluded that despite the low usage of TAH, it remains a valid bridging option for patients with severe biventricular dysfunction, particularly when performed at high-volume centers. The inferior outcomes observed at low-volume centers raise considerations for specialized training, certification, and minimum case volume requirements before initiating a program with this therapy.

COMMENTARY:

The SynCardia TAH is a pneumatic pulsatile pump used in cases of severe biventricular dysfunction. It is the only bridge-to-transplant device of its type approved by both the FDA and the European Union's CE mark. The SynCardia technology builds on the Jarvik 7 platform, developed nearly 40 years ago. Copeland pioneered TAH as a bridge-to-transplant strategy after using the Jarvik 7 in a 25-year-old transplant-listed patient experiencing deterioration due to refractory ventricular arrhythmias in 1985. The success of this case led to the CardioWest Total Artificial Heart trial, published in 2004 by the same surgeon, which generated the evidence necessary for FDA approval. The trial

compared TAH to a control group without circulatory support, demonstrating improved survival up to transplant (79% vs. 46%) and at one year (70% vs. 31%). Other TAH devices exist, including the AbioCor, approved for compassionate use as destination therapy in 2006 (with only one implant), and the CARMAT device, currently in clinical trials.

Despite Copeland's 2004 findings, TAH use remains limited and is in decline. Notably, post-2013 outcomes appear worse than pre-2013. The Interagency Registry for Mechanically Assisted Circulatory Support's overall results differ from the CardioWest trial, with a 59% transplant survival rate and a 34% one-year mortality incidence. The steep learning curve is evident, with one-year TAH survival rates at 72% in high-volume centers and 53% in others. This learning curve and disappointing results may contribute to TAH's waning popularity. Some teams prefer more frequently used devices, implanting two HeartMate 3 devices (one per ventricle, off-label) or one HeartMate 3 for the left and one CentriMag for the right. Furthermore, UNOS's revised priority criteria, which give short-term mechanical support patients the same or higher priority than long-term support patients, complicate TAH utilization. Finally, choosing TAH as therapy represents an irreversible decision, requiring either a transplant or, unfortunately, death while waiting, which complicates treatment decisions and acceptance of suboptimal organs once the decision is made.

This study has several limitations, including those inherent to its retrospective design. Using the UNOS database limits access to detailed information on major complications, such as stroke-induced neurological events. No control group was available for comparison, and patients in whom TAH was used as a bridge to candidacy are not captured in the UNOS database. Lastly, this study spans 13 years, encompassing multiple eras and protocol changes, necessitating caution in interpreting the results.

In conclusion, TAH is a therapy falling out of favor. In some countries, such as Spain, this therapy has not found its place. As the editorial to this article suggests, only time will tell whether TAH is forgotten or finds its niche.

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Lucía Valmisa De La Montaña

Current Status and Advances in Long-Term Ventricular Assistance

This JACC scientific statement summarizes the progress and challenges of durable ventricular assist devices (VADs) for patients with advanced heart failure, contextualizing current therapy and outcomes, and discussing future technology and priorities.

The use of durable mechanical support, such as VADs, is a significant but often underutilized treatment for advanced heart failure (HF) patients. Despite advancements in medical therapy for stage C HF patients, survival rates for advanced HF remain under 20% at 5 years. In this context, VADs have become a substantial treatment option to improve both quality of life and survival for these patients.

This review provides a detailed and updated view on VAD use, analyzing indications, timing of referral, patient selection, surgical considerations, knowledge gaps, and future directions.

COMMENTARY:

The purpose of this blog entry is to summarize the key points from this document:

– Survival outcomes, adverse effects, and quality of life.

Innovations in VAD technology have reduced adverse event risk. Currently, the average survival rate for patients with a VAD is similar to heart transplant survival at 3 years, with a 5-year survival rate close to 60%. However, adverse events remain significant. Only 30% of patients are free from hospitalization in the first year post-implant. Among adverse event types, stroke and infection carry the highest mortality risk. One of the most common complications associated with VAD is mucocutaneous bleeding, affecting approximately 25-30% of patients during the first year after implantation. This phenomenon is due to vascular changes in response to continuous pump flow, acquired von Willebrand syndrome, and the combination of dual therapy with anticoagulants and antiplatelet agents. A recent study (ARIES HM3) demonstrated safety and bleeding reduction by excluding aspirin from the antithrombotic regimen in VAD patients.

In addition to prolonging survival, VAD aims to improve patient quality of life. The MOMENTUM 3 study showed significant improvements in health-related quality of life post-VAD implantation. Most patients (95%) who received the HeartMate 3 VAD in the study were in NYHA functional class IV before implantation. Of these, 77% improved to functional class I or II at 6 months, with these results remaining consistent up to 24 months.

– Implant Indications.

Despite multiple parameters, predicting events in advanced HF patients remains challenging, and they are often referred too late to specialized centers. Several relevant clinical findings help identify these patients. Ultimately, patients with persistent HF symptoms despite optimal medical treatment, with severely reduced left ventricular ejection fraction (LVEF) and significantly impaired functional capacity, should be immediately referred to a heart failure program for invasive option assessment. The American Heart Association recommends VAD therapy in advanced HF patients with severely reduced LVEF in NYHA functional class IV who depend on inotropes or short-term ventricular support (recommendation IA). For patients not dependent on inotropes or short-term support, the recommendation is IIaB.

Traditionally, VAD use has been categorized into several strategies: bridge to transplant, bridge to decision/candidacy, bridge to recovery, and destination therapy. In recent years, there has been a significant increase in VAD implantation for destination therapy, covering approximately 81% of patients, while its use as a bridge to transplant has substantially declined, representing about 5% of patients.

– Patient Selection.

Before VAD implantation, a multiorgan assessment of the patient's progression is necessary. Irreversible organ damage (neurological, renal, or hepatic) is considered an absolute contraindication. Age should also be considered. Unlike transplantation, there is no age limit for VAD implantation. Although advanced age could be seen as a relative contraindication, an INTERMACS analysis showed that 4.8% of VAD recipients between 2010 and 2020 were over 75. Recent studies show that VAD implantation in the elderly is associated with functional capacity and quality-of-life improvements similar to those in younger patients.

Regarding obesity, it is not an absolute contraindication, though each center sets its limits. However, large registry data indicate obesity is associated with higher mortality and morbidity.

Right ventricular dysfunction is a significant cause of morbidity and premature mortality post-VAD implantation. Predicting the risk of right ventricular dysfunction remains a challenge. Risk scores combining clinical and hemodynamic profile variables exist, but none has positioned itself as a standard model.

– Surgical Considerations.

Key points in VAD implantation include aligning the inflow cannula from the left ventricular apex with the mitral valve; suturing the outflow cannula in the greater curvature of the ascending aorta at an angle to minimize aortic insufficiency; and tunneling the percutaneous cable through the rectus muscle of the upper abdominal wall before exiting the upper left or right quadrant.

Although median sternotomy is the most common approach for VAD implantation, an anterolateral thoracotomy approach has emerged as an alternative with certain advantages, particularly preserving the geometry of the right ventricle. The ongoing SWIFT study investigates various non-median sternotomy approaches. Preliminary results show no significant differences in hospital stay, transfusion needs, adverse effects, or quality of life between sternotomy and thoracotomy approaches.

When managing valve disease during these implantations, each valve must be approached specifically. While moderate or severe aortic valve insufficiency generally requires repair or replacement, some controversy remains about handling other valves. Recent study data suggest that correcting significant tricuspid valve insufficiency does not necessarily reduce the incidence of right ventricular dysfunction after VAD implantation. Similarly, mitral valve insufficiency raises questions, as recent MOMENTUM 3 study results indicate that preoperative mitral insufficiency decreased significantly in patients following VAD implantation.

– Knowledge Gaps and Future Directions.

Despite technological advances and improved outcomes over the last two decades, VAD use requires adjustments for widespread adoption in advanced HF patients. One area needing reconsideration is improving the use of these devices as adjunctive therapy to heart transplantation and identifying transplant candidates with myocardial recovery potential who could benefit from VADs to delay or avoid transplantation.

Additionally, enhancing both quality of life and survival by synergistically combining a device with heart transplantation in a single patient, especially in younger patients, is essential.

Goals have been set to maximize patient benefit, and if implemented and streamlined, these advancements could double the significant progress achieved so far. These developments include improvements in patient and caregiver education, adverse event reduction, and technological advances in devices. With these actions, VAD use is expected to expand as awareness of contemporary mechanical support outcomes grows and device innovation advances.

Undoubtedly, the advent of continuous axial flow systems, along with the growing experience of teams—often compelled by the increasingly frequent donor shortages—has propelled this therapy's promising path forward. Consensus documents like this one represent a recap of our current knowledge and, more importantly, what we need to know to make it a more widely used therapy. The history of VAD systems marks a milestone in medicine, with our specialty holding an undeniable prominence, and its story continues to be written today.

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David Couto Mallón

The Role of Invasive Hemodynamic Study in Patients Treated with Continuous-Flow Left Ventricular Assist Devices: Understanding the Device to Optimize Outcomes

This state-of-the-art document discusses current guidelines on indications and utility of invasive hemodynamic assessment in patients with advanced heart failure (HF) undergoing treatment with continuous-flow left ventricular assist devices (LVADs).

The advent of LVADs marks a significant milestone in managing patients with advanced HF. Since their approval, LVAD implantation rates have steadily increased. Advances in technology, particularly the development of smaller, continuous-flow devices, have extended LVAD survival to match that of heart transplant at two years.

However, LVAD patients experience a high rate of complications and hospital readmissions post-implant. A thorough understanding of the unique physiology and hemodynamics of LVAD patients is essential to optimize device support and manage LVAD-related complications, with the aim of not only reducing morbidity and mortality but also enhancing quality of life and exercise capacity.

This consensus document reviews the specific requirements for invasive hemodynamic assessment (IHA) in LVAD patients and identifies clinical scenarios where IHA can be most beneficial for the healthcare provider managing these patients.

The authors emphasize thermodilution as the most reliable and reproducible method for cardiac output (CO) measurement, showing a closer correlation with the direct Fick method than the indirect Fick calculation. Additionally, they highlight the importance of adequate anticoagulation levels during the procedure. The consensus specifies that IHA holds particular value in the following scenarios for LVAD patients:

Optimizing LVAD Function. Determining the optimal pump speed for LVAD function requires individualized assessment that considers both the effective CO and left ventricular unloading (evaluated through pulmonary capillary wedge pressure [PCWP] and pulmonary pressure). Additionally, the document addresses ventricular interdependence (monitoring right ventricular [RV] end-diastolic pressure to prevent RV failure) while aiming for intermittent aortic valve opening and avoiding pulmonary decoupling. To optimize LVAD function, IHA is recommended at three months post-implant, using an invasive ramp study to determine the ideal level of LVAD support. This test involves gradually increasing LVAD speed from a minimum tolerated value to a maximum, identifying the speed that best improves the patient's hemodynamics. A promising, albeit limited, method is adjusting LVAD function to match patient activity levels, pinpointing cases where ventricular unloading or CO during exercise are inadequate through IHA.

Identifying Causes of LVAD Dysfunction. Low-flow LVAD alarms are common, and non-invasive studies like echocardiography may fail to identify the cause. In such cases, it is crucial to determine whether the alarm is due to an issue with LV preload (e.g., hypovolemia, RV failure, cardiac tamponade) or an obstruction in LVAD flow (e.g., hypertension, outflow graft twist or obstruction, or LVAD thrombosis). For hypovolemia, reduced pressures in the right atrium, pulmonary artery, and PCWP are expected, whereas cardiac tamponade or RV failure would show increased right atrial pressure with a low PCWP. If LVAD flow is obstructed, PCWP will rise.

Assessment of Pulmonary Vascular Resistance (PVR). A significant proportion of patients receiving LVADs as a bridge to transplant have severe combined pre- and post-

capillary pulmonary hypertension. The impact of LVADs on PVR is seen early; however, reassessment of PVR is recommended between 3-6 months post-implant to capture any significant decrease, as further changes beyond six months are rare.

Determining Candidates for LVAD Weaning Due to Cardiac Function Recovery. IHA directly measures CO and PCWP response when LVAD support is reduced or briefly interrupted, determining whether the patient can tolerate discontinuation of the device.

COMMENTARY:

This document underscores the importance of invasive hemodynamic evaluation in LVAD-supported advanced HF patients. For years, cardiac surgeons and cardiologists have focused on pre-implant IHA, primarily to confirm low CO status and identify patients at high risk for RV failure post-implant—a critical factor in selecting optimal candidates. Improvements in candidate selection, technological advances, and better understanding of patient complications and their management have led to progressively improved post-implant survival rates. However, managing and optimizing LVAD patients remains complex. According to international records, only 30% of LVAD patients achieve optimal outcomes after one year: alive or transplanted, in NYHA class I or II, with no adverse events or fewer than three rehospitalizations per year. An LVAD patient is still considered an HF patient, which remains the main cause of hospital readmission.

Echocardiography remains a valid tool for routine monitoring of these patients; however, it is insufficient for in-depth assessment of specific clinical concerns. The utility of echocardiography is further limited with third-generation devices (e.g., HeartMate 3, HVAD), which distort LV geometry and cause leftward horizontal displacement of the LV compared to second-generation devices. Three-dimensional echocardiography likely offers more valuable information for third-generation devices, although implementing it in daily practice remains challenging.

Significant evidence shows that optimized LVAD support substantially reduces adverse events and enhances patients' quality of life. This article highlights the applications and value of IHA in achieving better patient outcomes. Programs conducting post-implant IHA demonstrate that over 50% of discharged patients present elevated central venous or PCWP during follow-up IHA, presenting a substantial opportunity to optimize both LVAD support and HF medical management. The RAMP-IT-UP study found that patients monitored with IHA received more than twice the HF medication adjustments compared to those under standard follow-up, resulting in improved survival and fewer adverse events. Hemodynamic optimization correlates directly with lower HF readmissions and reduced hemocompatibility-related adverse events, including gastrointestinal bleeding, LVAD thrombosis, and stroke.

The 2023 guidelines from the International Society for Heart and Lung Transplantation for LVAD patients align with this document’s authors, identifying IHA as essential for comprehensive LVAD patient management, aiming to reduce morbidity and mortality and, in particular, to appropriately assess patients with persistent HF signs and symptoms. Implementing post-implant IHA across advanced HF programs offering LVAD therapy is recommended. Developing strategies to extract the most valuable information from IHA while minimizing patient risk remains a topic for further research. New advances, including remote pulmonary artery pressure monitoring and HF monitoring through implantable cardiac devices, hold great potential for the future.

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Sonia Mirabet Pérez

Advanced therapies for heart failure: heart transplantation vs. LVAD. How to choose? expert opinion

An expert commentary by Dra. Sonia Mirabet about choices for advanced heart failure therapies.

Approximately 10% of patients with heart failure (HF) are in an advanced stage, characterized by persistent, limiting symptoms, frequent hospitalizations, poor quality of life, and high mortality despite receiving optimal guideline-directed therapy. In this context, advanced therapies such as heart transplantation (HT) and long-term left ventricular assist devices (LVADs) are considered. As we more accurately identify patients with advanced HF, the number of candidates for these therapies is expected to progressively increase.

HT continues to represent the treatment of choice for a selected group of advanced HF patients, yet despite expanded organ acceptance criteria and the incorporation of controlled donation after circulatory death (DCD), donor availability remains limited. On the other hand, technological advances have improved survival and reduced complications associated with new long-term LVADs, making them a viable alternative to HT.

Although both options improve survival and quality of life in patients with advanced HF, there are some differential characteristics. The latest data from the National Transplant Registry report a survival rate of 83% at one year and 74.9% at three years post-HT, with an average survival of approximately 14 years. Despite the risk of rejection and the side effects associated with immunosuppressive therapy, including infections and malignancies, most patients do not require hospitalization in the first year or later, maintaining a good quality of life. As for LVADs, the most recent data with HeartMate 3® devices show that, although one- and two-year survival rates are similar to HT, the five-year survival rate is 58%. While thrombotic complications and device dysfunction have significantly decreased, hemorrhagic complications and infections continue to be frequent, with 90% of patients being hospitalized in the first year post-implantation. LVADs provide only univentricular support and rely on an external battery, with all the associated implications, but they allow modification or reversal of transplant contraindications while the patient is being assisted and can improve HT candidacy if waiting times are prolonged.

Given all these considerations, how do we choose between HT and LVAD? The selection process for advanced HF patients is complex and requires an individualized, multidisciplinary approach that assesses eligibility for HT and/or LVAD without considering these options as mutually exclusive. Many of the variables considered in the evaluation process for HT and/or LVAD eligibility are common to both procedures, such as age, diabetes mellitus, renal or hepatic insufficiency, frailty, substance use, social support, and the presence of systemic diseases, as they will influence morbidity and mortality regardless of the chosen treatment. The assessment for HT involves identifying and evaluating, in particular, those conditions that increase the risk of mortality and could prevent the survival benefits of transplantation, impact the quality-of-life post-transplant, or worsen with immunosuppression. It is essential to rule out neoplasms, irreversible pulmonary hypertension, technical difficulties that may represent a formal contraindication to transplantation, or non-adherence that could contribute to poor outcomes. The LVAD assessment should focus particularly on evaluating the risk of right ventricular dysfunction (RV), identifying anatomical or physiological contraindications for

LVAD, ruling out coagulopathies, and analyzing social support and the presence of caregivers who will help improve follow-up after implantation.

In a schematic way, after careful evaluation of the advanced HF patient, we may encounter four scenarios:

1. The patient is eligible for HT but not for LVAD and therefore should be placed on the transplant waiting list.

2. The patient is eligible only for LVAD, and the device should be implanted (usually due to age beyond the accepted criteria for HT or significant comorbidities contraindicating HT).

3. The patient is eligible for LVAD but currently ineligible for HT due to a modifiable contraindication (irreversible severe pulmonary hypertension, substance use, or psychosocial issues, adherence problems, recent neoplasms with favorable prognosis, obesity, etc.). In this case, an LVAD should be implanted, and HT eligibility should be reevaluated during follow-up.

4. The patient is eligible for both HT and LVAD, and HT should be preferred for better medium-to-long-term survival outcomes and lower morbidity. LVAD could be considered as a bridge to transplantation in clinically unstable patients or those with extended waiting times.

If the patient we are evaluating is in INTERMACS 2-3, how do we choose? Should we opt for urgent transplant or implant LVAD and reevaluate HT candidacy? The option of urgent HT in patients supported by short-term ventricular assist devices is a high-risk procedure, associated with higher mortality compared to elective transplant, requiring careful consideration of HT in order to optimize the distribution of limited organs. However, post-implantation mortality after LVAD in patients supported by ECMO is also high, so again, individualized and multidisciplinary decisions are required, considering the specificities of local donation and transplantation programs. Data from the ASIS-TC Registry, a multicenter Spanish registry on the use of short-term mechanical circulatory support devices as a bridge to urgent HT in Spain, show that from 2010 to 2020, 84.5% of urgent patients reached HT, with an average support duration of 6 days under urgency 0, achieving a one-year post-HT survival rate of 77.5%, influenced by the MCS device used.

These results support urgent HT as a reasonable and acceptable option for patients supported by short-term MCS devices, especially in environments with shorter waiting times. The higher mortality in urgent HT cases requires distribution criteria that ensure equitable access to HT, prioritizing clinically severe patients while avoiding futility. In 2023, new HT allocation criteria were established in Spain, defining strict criteria for multiorgan failure for urgency status, eliminating the temporary duration of short-term circulatory support as long as there are no complications, and facilitating HT access for non-LVAD candidates. In this way, more clinically severe patients are prioritized while improving post-HT survival. These criteria were previously analyzed in a prior blog commentary. It will be necessary to evaluate the clinical outcomes of these new criteria after implementation. In other environments, such as central European countries where waiting times are longer even in urgent situations, the option of urgent HT is less feasible. In 2020, the results of an observational study conducted in 11 European centers in Germany, Italy, Austria, and the Netherlands were published, including 531 patients who

underwent LVAD implantation from ECMO support between 2010 and 2018. The average duration of ECMO support before LVAD implantation was 5 days, the 30-day survival rate was 77%, and the one-year survival rate was 53%. The predictors of mortality identified were age, female sex, lactate levels, BMI >30 kg/m2, MELD score, presence of atrial fibrillation, and previous cardiac surgery. 42% developed RV dysfunction requiring mechanical support. 21% of the patients received a heart transplant during follow-up. A recent study compared the outcomes of patients supported by ECMO prior to HT or LVAD implantation, analyzing data from the UNOS and INTERMACS registries. Although both strategies are rare, of 20,939 LVAD implants, only 2.8% were ECMO-to-LVAD (ECMO-LVAD), and of 30,093 heart transplants, only 1.1% were ECMO-to-HT (ECMO-HT). In fact, the change in transplant distribution criteria in the USA in 2018, where ECMO now has the highest priority, has led to a significant increase in ECMO-assisted transplanted patients. In general, ECMO-HT patients were younger, more often female, and had non-ischemic etiologies compared to ECMO-LVAD patients. ECMO-HT patients with RV dysfunction had better outcomes, and ischemia time was a significant predictor of mortality in the ECMO-HT strategy. Mortality rates for ECMO-HT and ECMO-LVAD strategies were similar (29.3% at 1 year, 33.4% at 2 years, and 38.2% at 5 years for ECMO-HT vs. 30.8% at 1 year, 37.4% at 2 years, and 43.5% at 5 years for ECMO-LVAD), with authors concluding that ECMO-LVAD is a non-inferior strategy in terms of mortality compared to ECMO-HT, and further studies are needed to identify which patients are better candidates for one strategy or the other.

In recent years, due to improved LVAD device outcomes, new potential scenarios for their indication have emerged. The possibility of myocardial recovery in assisted hearts may lead to using devices to delay or avoid the need for a transplant, especially in treatment-naïve patients. Predictors of myocardial recovery before LVAD implantation include certain etiologies (myocarditis, anthracycline-induced cardiomyopathy, peripartum cardiomyopathy), shorter time from symptom onset to LVAD implantation, age at implantation, preserved renal function, lower natriuretic peptide levels, and smaller left ventricular dilation (LVEDD <6.5 cm). The latest Mechanical Circulatory Support Guidelines from the International Society for Heart and Lung Transplantation (ISHLT) recommend consideration of ventricular support as a bridge to recovery in selected, optimally treated patients, including cardiac rehabilitation, with close follow-up and meticulous evaluation as a Class IIa recommendation and level B evidence.

Choosing the advanced therapy for a patient with HF is a complex process. The first step is to correctly identify patients with advanced HF and refer them to specialized units for early evaluation. It requires an individualized, multidisciplinary approach and simultaneous evaluation of both options. Contraindications must be ruled out, the patient's clinical situation carefully assessed, and management strategies established according to their evolution, while also informing and discussing the different therapeutic options with the patient. Technological advances in devices and their impact on morbidity and mortality, along with the evolution of donation and transplantation activities, may influence and modify our decisions in the future.

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José Manuel Martínez Comendador

HeartMate 3 in Patients with Extracorporeal Life Support: Improved Outcomes over Previous Devices and Comparable to Transplantation?

Three-year results of the ECSL Registry in extracorporeal life support patients receiving HM3 implants from January 2016 to April 2022 across 14 centers, compared to other long-term devices.

Extracorporeal life support (ECLS) through short-term ventricular assist devices (VADs) has enabled immediate mechanical circulatory support (MCS) for patients in cardiogenic shock, aiming to achieve rapid resuscitation and stabilization. When weaning from ECLS is not feasible and patients meet eligibility criteria, the sole survival options are durable MCS via long-term ventricular assist devices (LVADs) or cardiac transplantation.

In Spain, we are fortunate to have the world's leading organ donation system, as demonstrated by the annual Spanish heart transplant records. Consequently, our use of durable ventricular assist devices (DVADs) is ten times lower than in the United States, as highlighted when analyzing the Spanish REGALAD registry. This results in the majority of critically ill patients on short-term support, for whom weaning is not possible, being referred for heart transplantation instead of DVAD implantation. Data from the ASIS-TC Registry, a multicenter Spanish database on the use of short-term mechanical circulatory support as a bridge to urgent heart transplantation, showed that from 2010 to 2020, 84.5% of urgent patients reached transplantation with an average support duration of six days under urgency level 0. This organizational advantage in transplantation, almost exclusive to Spain, would be unthinkable in most industrialized countries due to limited donor organ availability. For this reason, in much of Europe and the United States, durable MCS with DVAD remains the primary life-saving option for most ECLS patients.

The long-term ECLS registry is a multicenter study (13 European centers) that includes patients who transitioned from ECLS to a DVAD-based MCS system. Initiated in 2018, this registry encompasses patients with various DVAD types since 2010. Over the study period, several pump types were implanted, primarily Heartware™ in the initial phase and HeartMate 3™ (HM3) more recently. Abbott's HM3™ is a new-generation, magnetically levitated centrifugal pump clinically introduced in Europe during the CE-mark trial in 2015. Interim results published at one and two years with HM3 demonstrated survival rates above 80%. However, the published trial data mainly included a less critically ill patient population compared to that of this registry. Therefore, the primary objective of this multicenter study was to evaluate the outcomes of patients who received HM3™ support after ECLS within the real-world context of a European multicenter registry involving different DVAD types, including HM3™.

To this end, patient data for those undergoing HM3™ implantation from January 2016 to April 2022 at 14 centers were collected and evaluated. The inclusion criteria encompassed patients with any type of ECLS, primarily veno-arterial extracorporeal membrane oxygenation (VA-ECMO), with or without intra-aortic balloon pump or Impella™ (Abiomed™), prior to HM3™ implantation. The obtained outcomes were reported and compared with those of patients receiving other types of DVAD.

A total of 337 patients were candidates for some form of DVAD following ECLS. Of these, 140 received HM3™ support. The other pump types included 170 Heartware™ (Medtronic™) (86%), 14 HeartMate II™ (7%), and 13 (7%) other pumps. Major postoperative complications included right heart failure, which required temporary right ventricular assist devices (RVAD) in 60 patients (47%). Postoperative stroke and pump thrombosis rates were significantly lower in HM3™ recipients compared to those receiving other DVADs, with stroke rates at 16% versus 28% ($p = 0.01$) and pump

thrombosis at 3% versus 8% ($p = 0.02$). Thirty-day, one-year, and three-year survival rates for HM3™ recipients were 87%, 73%, and 65%, respectively, compared to survival rates of 81% at 30 days, 56% at one year, and 48% at three years among other DVAD recipients.

The authors conclude that, within this patient population supported by short-term VADs, the survival outcomes for patients transitioned to HM3™ are acceptable and superior to those observed with other DVADs.

COMMENTARY:

As medical technology advances, so do patient outcomes. This is evident in the study by Saeed et al., which demonstrates significantly improved outcomes in survival, stroke rates, and pump thrombosis with newer DVADs, specifically HeartMate 3™ (HM3), compared to its predecessor, Heartware™. The Heartware™ device was withdrawn from the market in 2021 due to safety concerns, primarily related to device failures.

The same research group previously published the largest series using the ECLS registry from 2010 to 2018, which included 531 patients. They reported a one-year survival rate of 53% in this specific patient cohort, which is lower than the survival rate observed in traditional DVAD candidates without ECLS. This survival rate aligns with that found in the current study (56%) when comparing the non-HM3™ group, mainly patients with Heartware™ DVADs. However, survival in patients with HM3™ was significantly better, reaching 73%, thereby demonstrating the superiority of this new device.

On the other hand, these excellent results with HM3™ allow us to compare them with those of heart transplantation in Spain under similar clinical conditions. According to the ASIS-TC multicenter registry, as previously discussed, the one-year survival rate among ECLS-supported patients prior to transplantation from 2010 to 2020 was consistently above 70%, varying depending on the support device used: 79.4% with intra-aortic balloon pump, 84.9% in patients with percutaneous devices, 79.9% in those with continuous flow surgical devices, 74.4% in patients supported with continuous flow BIVADs/RVADs, and 67.8% in ECMO patients. Therefore, we could suggest that the one-year survival rate of transplanted patients in this clinical context is comparable to that of patients with HM3™.

Without listing the well-known limitations of these studies, two aspects are worth noting: one related to the timing of DVAD implantation and the other concerning the high incidence of temporary right ventricular support use observed:

The average duration of VA-ECMO support before DVAD implantation was only five days, similar to previous reports from the same registry. Likewise, in Spain, according to the ASIS-TC registry, the median support time before heart transplantation is also short, at six days under urgency level 0. Thus, in this study, the wait time before DVAD implantation for ECLS patients was as brief as the wait time for transplants in Spain. This is significant because studies have shown that prolonged VA-ECMO duration is a negative predictor of survival, which this study could not demonstrate due to the limited support time.

Additionally, no algorithm was used in this study to suggest the ideal wait time before DVAD implantation based on etiology. Given that 55% of patients were ischemic, and these patients may sometimes recover or regain cardiac function, it is possible that a proportion of them could have recovered enough function to avoid durable MCS.

One of the major limitations of this study was the lack of a clear definition of right ventricular failure (RVF), as it did not adhere to the criteria established by the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS). This may explain

why limited information is available on the use and dosage of inotropes. Likewise, there was no standardized protocol for RVAD use.

That said, the use of temporary right ventricular support in the HM3™ group was 47%, compared to 39% with other DVADs, reflecting a high incidence similar to that previously reported by the same group (42%). This frequent use of right ventricular support may be partially attributed to recent advancements in devices that facilitate its use. The Protek Duo™ dual-lumen cannula (LivaNova™), available since 2016, allows for a percutaneous right ventricular assist device (RVAD) implantation via the jugular vein in a simple and effective manner, avoiding direct cannulation of the pulmonary artery as previously required. Therefore, the high incidence of temporary RVAD use may result from a lower threshold for indication due to its prophylactic use and ease of implantation rather than strict criteria for right ventricular dysfunction. Moreover, the Protek Duo™ cannula allows for DVAD implantation while the right ventricular support is active, which stabilizes the patient during the procedure and facilitates RVAD weaning shortly after durable device implantation.

Studies like the one by Saeed et al. are a great advancement for science. At last, we can say that we have technology capable of achieving short- and mid-term outcomes comparable to heart transplantation in ECLS-supported patients, something that was previously unattainable.

In Spain, due to its unique infrastructure, most patients are quickly referred for transplantation without the need for DVAD. However, in dramatic cases where prolonged wait times are anticipated, an HM3™ bridge may be considered with supporting evidence.

Thanks to technological and scientific advances in this field, the near future—whether through transplantation (perhaps someday with xenograft options) or through the continued development of advanced devices like HM3—offers new hope where uncertainty once reigned.

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Lucía Matute Blanco

Shared care: the key to success in the follow-up of patients with left ventricular assist devices

A literature review including five articles—four review articles and one prospective study—aimed to analyze and synthesize current scientific evidence on the use of a shared care model in the management of patients with left ventricular assist devices.

Even under optimal medical treatment, patients with advanced heart failure (HF) have a poor prognosis, with heart transplantation being the preferred treatment. However, access to heart transplantation is limited. To address this, left ventricular assist devices (LVADs) have been introduced as an alternative therapeutic option, either as a bridge to transplantation or as destination therapy. Managing these patients is complex, often leading to serious complications, frequent readmissions, prolonged hospital stays, and high healthcare costs. Therefore, rapid access to advanced units is essential. However, care for LVAD patients is traditionally concentrated in a few specialized implanting centers.

The implementation of a shared care model (SCM) is defined as the joint involvement of primary care physicians and specialists in the planned care of patients with chronic diseases, coordinated through enhanced information exchange beyond routine hospital discharges and referrals. This allows geographically separated care teams to provide high-quality, patient-centered care through coordinated collaboration. However, when focusing on the management of LVAD patients, evidence supporting these principles is unavailable. The aim of this work is to compile and discuss current scientific evidence on the use of SCMs in the management of LVAD patients.

This study is a literature review that incorporated two key search elements: LVADs and shared care. The search included all scientific literature written in English and published before June 3, 2023. Out of 1559 records retrieved, five studies were included in the review: four review articles and one prospective study. All articles originated from the United States and were published between 2015 and 2023.

Five main themes were identified:

1. Definition and Objectives: The core of a shared care model is a collaborative approach between the LVAD implanting center and geographically distant, non-implanting care sites. The primary goal is to improve patient satisfaction and quality of life while maintaining LVAD-related clinical outcomes.

2. Criteria for Shared Care Partnerships: Key criteria include:

    - A multidisciplinary shared care team led by an advanced HF cardiology specialist with expertise in LVADs, supported by advanced practice nursing.

    - Approximately 50% of follow-up care provided at the shared care center.

    - Use of standardized collaborative protocols.

- Effective communication and collaboration among all SCM members.

3. Perceived Benefits: Benefits include enhanced patient satisfaction, improved quality of life, reduced stress for patients and caregivers, and better continuity of care. For the healthcare system, SCMs enable high-quality, patient-centered care while extending services beyond implanting centers.

4. Perceived Concerns and Challenges: Issues include a lack of experience at non-implanting centers, the need for continuous staff training, and the potential fragmentation of care.

5. Clinical Outcomes: The prospective study included in the review found that the absence of LVAD-specific care was associated with higher rates of mortality, pump thrombosis, and device-related infections. SCMs showed promise in improving patient outcomes but require well-designed communication structures and standardized protocols.

As the number of LVAD patients grows, SCMs are increasingly necessary to maintain accessible care. While SCMs appear promising, evidence on their clinical impact and their effect on healthcare systems remains limited. Future studies should focus on the prospective evaluation of SCMs to establish standardized, evidence-based protocols.

COMMENTARY:

The implantation of LVADs is becoming increasingly common in patients with advanced HF, with their care and follow-up predominantly concentrated in specialized tertiary hospitals. However, the growing workload at implanting centers presents significant challenges in providing care to patients residing in remote areas. An emerging approach to managing LVAD patients is the use of a shared care model (SCM), facilitating collaboration between implanting centers and local, non-implanting hospitals.

This review explores and synthesizes current scientific evidence on the application of SCMs in the management of LVAD patients. This model is defined as a collaboration between the LVAD implanting center and non-implanting centers for continuous patient care. The shared goal is to improve patient satisfaction and quality of life while preserving clinical outcomes associated with LVADs.

The findings indicate that the primary benefits of SCMs include improved patient satisfaction, contributions to enhanced quality of life, and reduced stress for both patients and caregivers, as well as better continuity of care. At a healthcare system level, SCMs enable the delivery of continuous, high-quality, patient-centered care beyond the boundaries of the implanting center.

Shared care models generally require the commitment of a multidisciplinary team, supervised by a specialist in advanced HF and LVADs, and coordinated by advanced practice nursing staff, who act as the frontline contact for patients. Training in the basic principles of LVAD care and maintaining clinical competencies are crucial to ensure the delivery of safe, high-quality care. A prospective study included in the review demonstrated that the lack of LVAD-specific care was associated with poorer survival rates and higher incidences of pump thrombosis and infections related to LVADs.

Additionally, SCMs require a robust communication structure between implanting centers and shared care sites, structured coordination, and the engagement of all involved

parties. Follow-up protocols are essential, including standardized guidelines based on prospective studies, to ensure the safe and effective shared care of LVAD patients.

Future research should prospectively investigate the impact of SCMs on patient outcomes, implanting centers, and shared care sites. Although further evidence is needed, SCMs represent a promising organizational system that should be established as a quality standard in the care of LVAD patients.

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Elio Martín Gutiérrez

ECMO-VA Weaning: Survival Beyond Mechanical Support

Outcomes of VA-ECMO weaning for cardiogenic shock of various etiologies at Columbia University Irving Medical Center, assessed at both 30-day/hospital discharge and 1-year follow-up among survivors.

The progressive increase in experience with short-term circulatory support devices, such as VA-ECMO, has provided a survival opportunity for patients with heart failure in its various presentations. Although less common due to increased experience among surgical teams and new perfusion and cardioplegia techniques, postcardiotomy shock remains one of the etiologies associated with the poorest outcomes in this field. Beyond intraoperative complications, the growing complexity of patients, as well as graft failures in the context of heart transplantation, are some reasons why certain patients continue to require this type of support.

There are still significant gaps today regarding the criteria and management of these patients. In fact, if any consensus exists, it pertains to increasingly specific indications for candidates for this type of support. However, some situations, such as postcardiotomy VA-ECMO support, are generally considered a bridge to decision in extremely severe conditions, potentially resulting in the desirable recovery, transition to other support, or even heart transplantation in rare cases. Thus, once the support is initiated, there is substantial variability, changes in plans, and management difficulties concerning the initially proposed bridge goal. Here, the skill and expertise of the team remain essential in the care of these critically ill patients. No consensus exists either on what may be considered a successful weaning from this support, nor do we have predictors to assess factors that might forecast successful weaning or protocols based on solid scientific evidence to guide this process. We continue to rely on individual protocols from reference centers and reports of various experiences.

The authors describe their experience from 2015 to 2020 with patients who received VA-ECMO support at their institution (Columbia University Irving Medical Center). These patients were managed by a multidisciplinary team of surgeons and cardiologists, including both interventional and heart failure specialists. The center has developed a highly protocolized strategy, specifically in managing postcardiotomy shock as well as other forms of cardiogenic shock, with distinct protocols detailed in this publication. Some notable aspects of their protocol include:

They describe different short-term support device indications, including intra-aortic balloon pump (IABP), ImpellaCP® or 5.5®, or VA-ECMO, depending on etiology, univentricular or biventricular involvement, and shock severity (as per the SCAI classification previously discussed on the blog), along with technical aspects related to cannulation approach and the necessity of associated respiratory support. All this information is detailed in a practical decision-making protocol worth reviewing as an algorithm.

The decision for left ventricular unloading was systematically applied when the pulmonary capillary wedge pressure exceeded 25 mmHg, there was no pulsatility in invasive arterial monitoring, and/or the aortic valve did not open on echocardiographic evaluation (a topic also discussed in previous blog posts). Distal limb perfusion was monitored using near-infrared spectroscopy (NIRS), with a distal perfusion catheter inserted only in cases of poor perfusion/tissue saturation results.

Decisions on weaning were made by a multidisciplinary "shock team," where one of the objectives before conducting support flow reduction tests was to minimize vasopressor doses. To initiate weaning, several criteria had to be met:

- Patient phenotype compatibility (although few details were provided on this, it likely involves aspects such as clinical viability, absence of irreversible neurological damage, and no severe or uncontrolled infections).

- Recovery of organ failures, or at least non-substitutable ones like respiratory failure, requiring a PaO2/FiO2 ratio greater than 100. However, they also seem to require the absence of failure in other systems, such as renal function, which is replaceable.

- Pharmacological support, including both inotropic and vasopressor agents, was required to be at "reasonably" low levels.

To initiate weaning, once all criteria were met, a systematic three-step approach was followed, aligned with ELSO recommendations:

1. Protocolized Weaning Assessment: This involved reducing the support flow rate by increments of 0.5 L/min, with at least a 1-minute wait to observe hemodynamic responses after each change. If the patient responded well, they would proceed to the next step. If failure was demonstrated, flow would be increased to the minimum level where stability was maintained, holding it for 8-24 hours before the next assessment. The target was to reach 2 L/min, at which point attention should be given to the anticoagulation doses used.

2. Support Discontinuation Assessment: Following 8-24 hours of stability at the 2 L/min level achieved in the previous phase, support flow was reduced further in 0.5 L/min increments, waiting at least 1 minute for observation between changes until reaching 1.5 L/min, ideally reducing to 1 L/min. If the patient failed to maintain stability, support would be increased back to 2 L/min for an 8 - 24 hours stabilization period.

3. Decannulation: If the patient demonstrated adequate hemodynamic response, they were considered candidates for support discontinuation and decannulation, a procedure that should also be protocolized according to patient characteristics, clinical circumstances, and technical aspects of the previous cannulation (operating room vs. bedside), aiming to prevent complications during this procedure in such critically ill patients.

Of the 538 patients reported to require VA-ECMO support, 510 were deemed eligible for the study. The etiologies for which this support was required were diverse, with postcardiotomy shock (36.2%, although the number of surgeries performed at the institution in this period, which would allow calculation of this rate, is unknown), primary graft dysfunction post-transplantation (21.5%), acute myocardial infarction, and extracorporeal cardiopulmonary resuscitation (13% each) predominating. A previous blog entry provides an interesting analysis of extracorporeal CPR.

A total of 249 patients (48.8%) were successfully decannulated. However, with no clear criterion for successful weaning, of these 249 patients, 120 survived at least 30 days post-decannulation, and 129 were discharged within 30 days following circulatory support weaning. The remaining patients included 227 (44.5%) who died, of whom 42

died while on circulatory support and 185 following weaning within 30 days. Thus, a total of 476 patients (93.3%) were decannulated, highlighting the outstanding outcomes of this team. The remaining 34 patients (6.7%) received destination or long-term therapy, which consisted of heart transplantation in 3 cases and an intracorporeal ventricular assist device in 31 cases.

Based on these data and the clinical characteristics of the cohort, the authors conducted various analyses using multivariate models focused on successful weaning and short-term survival, with limited validity due to the heterogeneity of the population. The multivariate analysis identified younger age, etiologies like acute myocardial infarction, heart failure decompensation, or extracorporeal CPR, absence of renal failure, adequate albumin and bilirubin levels, and normal mean hemodynamic parameters as independent predictors of successful decannulation. Postcardiotomy shock (HR 2.6) and primary graft dysfunction (HR 7.5) were adverse predictors.

Among decannulated patients, they identified poor prognosis predictors for in-hospital mortality before discharge or within 30 days post-decannulation, which would formally question the classification as successful weaning: concomitant IABP (likely due to inherent left ventricular dysfunction, HR 1.3), acute myocardial infarction (HR 4.7), renal failure history (HR 3.4), and/or need for renal replacement therapy (HR 3.1), and cerebrovascular accident (HR 1.9).

One-year outcomes indicated survival in 33 out of 34 patients with long-term ventricular assist or heart transplant, and in 218 out of 249 (87.5%) patients who met successful weaning criteria with in-hospital survival beyond 30 days.

COMMENTARY:

The outcomes demonstrated by this team are exceptionally challenging to achieve, particularly in terms of the decannulation rate, underscoring their expertise and experience. Their multidisciplinary, protocolized approach stands out, following the available consensus evidence while adapting to their internal workflow. They serve as a model to emulate and may be paving the way toward optimizing results by following objective criteria and consensual protocols, rather than the variability that still prevails in settings like ours, across hospitals and even within individual centers. In this way, far from the approach of “this is how we do things here,” a homogeneous response to common scenarios is fostered, corrective measures are applied when results fall short, and generational knowledge transfer is promoted since the protocols belong to the institution rather than to individual professionals. No matter how expert or interdisciplinary a team may be, they cannot afford different standards of care depending on individual judgment, especially when managing such high-cost resources and critically ill patients.

Despite these benefits, the relevance of predictors for successful weaning and survival is less significant. Although extensive experiences like this are limited in the literature, it still represents a highly heterogeneous sample of VA-ECMO indications for cardiogenic shock across various etiologies. These etiologies carry with them unique patient clinical profiles and morbidities associated with hemodynamic failure and the critical context, which do not necessarily translate to the experience of other centers. Reported VA-ECMO weaning rates range from 30-60%. According to recent ELSO registry data, successful weaning was achieved in 59% of cases, but only 44% survived to hospital discharge. The authors do not improve weaning outcomes but do achieve better survival, extending across follow-up. This suggests an excellent patient selection protocol for successful weaning, which, in my view, represents one of the study’s most valuable lessons.

However, it may be a highly restrictive protocol that guarantees results but may exclude other patients who might benefit from weaning, thus prolonging support and its associated morbidity. Indeed, the absence of significance as a poor prognostic factor post-successful weaning in postcardiotomy shock likely reflects selective progression of candidates to support discontinuation. As a result, we are again dependent on institutional practices, which lead to varying outcomes. Conversely, we might critique the increasingly early use of VA-ECMO for postcardiotomy shock, a trend that persists today, sometimes even without maximum inotropic doses or progression from IABP. This may yield better outcomes in one of the worst support indications, potentially leading to overuse.

The responsible, protocolized use of mechanical circulatory support remains a necessity. For now, we find ourselves at a bridge-to-decision, awaiting further studies like this one to continue teaching effective practices that result in favorable outcomes, distancing from heroic and personalized care of these patients. We must also remember that none of these mechanical support systems are actual “therapies.” Therefore, I believe we should abandon this term and stop perceiving them as solutions, as they cure nothing but merely maintain sufficient circulatory status for recovery or long-term cardiac function replacement.

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José Manuel Martínez Comendador

Impella CP® in Myocardial Infarction with Cardiogenic Shock: First Evidence in Over 20 Years

This international, multicenter clinical trial (DanGer study) evaluates the effects of routine implantation of the microaxial flow pump (Impella CP®) compared to conventional treatment in patients with acute myocardial infarction complicated by cardiogenic shock.

Between 5% and 10% of patients experiencing ST-segment elevation myocardial infarction (STEMI) develop cardiogenic shock (CS), over half of whom die during hospitalization. To date, no mechanical circulatory support (MCS) device has shown improved outcomes in clinical trials for these patients. This study aims to determine whether the routine use of a microaxial flow pump brings significant benefits in terms of reducing mortality among patients with STEMI complicated by CS.

The DanGer study (Danish-German Shock Trial) is an international, multicenter, randomized trial that enrolled STEMI patients with CS (stage C, D, or E). One group received standard care with an additional microaxial flow pump (Impella CP®), while the other received only standard treatment. The primary outcome assessed was all-cause mortality at 180 days, with secondary analysis including adverse events such as severe bleeding, limb ischemia, hemolysis, device failure, and worsening aortic regurgitation.

A total of 360 patients participated, with 355 included in the final analysis (179 in the microaxial flow pump group and 176 in the standard care group). The median age was 67 years, and 79.2% were men. All-cause mortality was 45.8% in the microaxial pump group and 58.5% in the standard care group (hazard ratio = 0.74; 95% confidence interval [CI]: 0.55-0.99; $p = 0.04$). Regarding adverse events, the composite safety event occurred in 24.0% of patients in the microaxial flow pump group versus 6.2% in the standard care group (relative risk, 4.74; 95% CI: 2.36-9.55). Additionally, renal replacement therapy was needed in 41.9% of patients in the microaxial flow pump group versus 26.7% in the standard care group (relative risk 1.98; 95% CI: 1.27-3.09).

The investigators concluded that routine use of a microaxial flow pump alongside conventional treatment in patients with STEMI-associated CS led to reduced all-cause mortality at 180 days compared to those receiving standard care alone. However, a higher incidence of composite adverse events was noted in the microaxial flow pump group.

COMMENTARY:

The DanGer study results mark a milestone as the first to show significant mortality reduction through the routine implantation of an MCS device for STEMI-associated CS. This study provides a solid scientific basis supporting routine MCS use in STEMI-related CS. The lack of clear evidence to date, disappointing and surprising to many, could largely be attributed to inadequate study designs in previous trials.

The DanGer study stands out due to its sound design, which resulted in a low crossover rate between groups, inclusion of less critical CS patients, exclusion of patients in a coma, evaluation of study endpoints over a more extended period (180 days instead of 30 days), and a higher rate of pre-Impella® percutaneous revascularization, among other factors. As discussed below, these features clearly favor the Impella®.

Before delving into a detailed analysis, it is essential to review and contextualize available evidence. For over two decades, researchers have sought a strategy (pharmacological, surgical, interventional, device use, etc.) to reduce the high mortality

associated with STEMI-related CS (approximately 50%). Only the 1999 SHOCK study and the 2017 CULPRIT-SHOCK trial demonstrated mortality improvements by establishing early culprit-lesion coronary revascularization as the fundamental treatment. Other studies have attempted to achieve similar results using pharmacologic strategies (TRIUMPH, PRAGUE-7, SOAP-2) or non-pharmacologic approaches, like the SHOCK COOL trial exploring hypothermia. Despite the advent and growing use of MCS devices, attempts to prove their efficacy in this context have been unsuccessful, as evidenced by trials such as IABP-SHOCK II with intra-aortic balloon pumps (IABP), ISAR-SHOCK with Impella 2.5®, IMPRESS with Impella CP®, and studies like EURO-SHOCK and ECLS-SHOCK with VA-ECMO, where none achieved the expected benefits. Nevertheless, based on positive results from non-randomized studies and expert group experiences, the 2021 clinical guidelines justifiably maintained a class IIa recommendation with a level C evidence for MCS devices, relegating IABP to a IIIB indication.

The DanGer study took ten years to recruit 360 patients, highlighting the dedication and perseverance of the investigators. This is particularly noteworthy given that microaxial flow pumps were not widely used, and evidence was limited at the time. Additionally, it underscores the challenges of conducting such studies, including patient selection and informed consent. Notably, no differences in observed mortality occurred over this long period among Impella® patients.

As previously mentioned, a standout feature of the study was its well-structured protocol, which minimized disproportionate crossovers between groups. Escalation of support was permitted in both groups, but Impella CP® use in the control group was kept to a minimum. In the control group, 37 patients (20.7%) ultimately needed additional support: 28 chose VA-ECMO (seven transferred from Impella®), five received a long-term LVAD (three after VA-ECMO, one after Impella 5.0® implantation, and another with direct implant), and one received Impella 5.0®. Three patients in the control group transitioned to the Impella CP® treatment group. In the Impella-treated group, 28 patients (15.6%) required escalated support: 14 opted for VA-ECMO, four for VA-ECMO + Impella 5.0®, and ten for a long-term LVAD.

The inclusion and exclusion criteria were similar to previous studies. However, previous studies reported a significantly higher percentage of patients with prior cardiopulmonary resuscitation: 45% in IABP-SHOCK II and 77.7% in ECLS-SHOCK, compared to 20.3% in DanGer Shock. Additionally, DanGer Shock excluded patients who, post-resuscitation, presented with a Glasgow score <8, an exclusion not applied in other MCS studies like IMPRESS, where this exclusion might have yielded benefits. Consequently, DanGer included patients with higher neurological recovery potential and a greater likelihood of benefiting from MCS. Furthermore, these patients were less critical than those in ECLS-SHOCK, as indicated by the average initial lactate levels (4.5 mmol/L vs. 6.9 mmol/L).

Furthermore, it is essential to note that the primary endpoint of mortality was assessed at 180 days, unlike IABP-SHOCK II or ECLS-SHOCK, which did so at 30 days. Although the SHOCK study showed no benefit at 30 days, it did at 180 days. The pathophysiological potential of left ventricular unloading, demonstrated in animal studies, might partly account for this improvement beyond 30 days. This suggests that assessing mortality at 30 days might be premature for determining the benefits of MCS interventions.

Additional positive characteristics of this study include the high rate of primary angioplasty performed in 85% of cases, which helps reduce ischemic injury. The study also highlighted the mandatory use of a Swan-Ganz catheter and MCS for a minimum of 48 hours before beginning weaning, ensuring adequate ventricular rest and avoiding excessive vasopressor use.

While 180-day mortality improved significantly with microaxial flow pumps, complications like moderate to severe bleeding and limb ischemia were more common. It is crucial to note that patients with peripheral artery disease were excluded, implying that these complications could be even higher in real clinical practice without appropriate preventive measures. Vascular ultrasound to aid vascular access, distal perfusion catheters, or even Impella® implantation through the subclavian artery using a Dacron graft, as performed at our Cardiac Surgery Department in A Coruña, could help reduce these complications.

This study's importance is highly relevant, as it surpasses the "no benefit" barrier for routine MCS use in STEMI-related CS, potentially marking the beginning of a new era in managing this condition. We await results from ongoing observational studies and the RECOVER IV trial (comparing Impella® use before percutaneous intervention to conventional treatment), expected to conclude in 2027, to confirm these findings.

Nonetheless, several unresolved uncertainties and complex questions remain:

What is the optimal timing for device implantation? Before or after percutaneous coronary intervention for the culprit STEMI lesion?

Are clear protocols or even dedicated CS teams needed? Undoubtedly, many hospitals will adopt this approach.

In which cases is combining microaxial flow pumps with other MCS devices like VA-ECMO appropriate?

Is it cost-effective? With an NNT of 8 and an Impella CP costing approximately €15000, saving a life would cost at least €120000. Before routinely implementing these devices, we must ensure they are effective. Inappropriate use not only adds unnecessary costs but is associated with severe complications, potential device shortages, and ICU bed scarcity.

Who should implant these devices? The on-call interventionalist before or after percutaneous intervention, or the cardiac surgeon in an urgent or semi-scheduled operating room using alternative access routes like the subclavian artery, as done in our hospital when cardiac surgeons perform the procedure.

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Olalla García

Intraoperative Extracorporeal Support in Lung Transplantation: Where Are We Heading?

A review of the Journal of Clinical Medicine on intraoperative support during lung transplantation compares the use of ECMO with cardiopulmonary bypass.

Lung transplantation is sometimes the final therapeutic step for patients with end-stage lung diseases such as pulmonary fibrosis, chronic obstructive pulmonary disease (COPD), and pulmonary hypertension. Traditionally, cardiopulmonary bypass (CPB) has been the preferred intraoperative support technique, providing complete hemodynamic support while maintaining oxygenation and decarboxylation during surgery. However, CPB use is associated with significant complications, including systemic inflammation, coagulopathy, and a higher risk of bleeding due to the need for heparinization.

With advancements in medical technology, extracorporeal membrane oxygenation (ECMO) has emerged as a viable alternative, offering many benefits of CPB with a reduced complication profile. ECMO uses a smaller, closed circuit and requires lower anticoagulation doses, reducing bleeding risks and coagulopathy-related complications. However, ECMO adoption has not been uniform, and debates continue regarding the optimal choice of intraoperative support.

This review was conducted through a comprehensive PubMed search for studies on the use of intraoperative mechanical circulatory support in lung transplantation. Both prospective and retrospective studies evaluating the clinical outcomes of patients undergoing lung transplantation with CPB or ECMO were selected. Inclusion and exclusion criteria were rigorous, prioritizing recent, relevant, and well-designed studies. Study characteristics, patient populations, interventions, and clinical outcomes were analyzed. Data were synthesized using descriptive and comparative statistical techniques to evaluate the findings of the included studies.

The main findings indicated that ECMO was associated with better clinical outcomes than CPB. Reviewed studies showed that ECMO was linked to lower in-hospital mortality, reduced need for blood and platelet transfusions, and fewer postoperative complications. Additionally, patients receiving ECMO support tended to experience a significant reduction in primary graft dysfunction and postoperative mechanical ventilation time. For example, the study by Lus et al. found that ECMO use during lung transplantation resulted in a 10% in-hospital mortality rate compared with 30% in patients receiving CPB. Another study by Bermúdez et al. reported that patients on ECMO had an average ventilation time of 48 hours, significantly shorter than the 72-hour average for CPB patients. Additionally, ECMO showed a lower incidence of complications such as excessive bleeding and acute renal failure.

In conclusion, the authors suggest that ECMO should be considered the standard intraoperative support for lung transplantation due to its demonstrated benefits in survival and complication reduction. The adoption of ECMO could significantly improve postoperative outcomes and patient quality of life, especially for those with high-risk preoperative factors.

COMMENTARY:

The critical analysis of this work reveals several significant strengths and weaknesses. First, the systematic review is well-structured and addresses a clinically relevant question. Understanding the outcomes of the CPB versus ECMO comparison is crucial to improving lung transplantation outcomes and reducing complications associated with

intraoperative mechanical circulatory support. The evidence presented suggests that ECMO is superior to CPB in several important aspects, including in-hospital mortality and postoperative complications.

One of the main strengths of this work is the thoroughness of the literature search and inclusion of recent, relevant studies, providing a solid foundation for the authors' conclusions and recommendations. Additionally, the detailed comparison of clinical outcomes between CPB and ECMO offers valuable insights into the benefits and drawbacks of each modality, which is of great value to medical teams performing lung transplants. However, some limitations should also be considered. The variability in the designs of the included studies and the differences in patient populations may affect the generalizability of the results. For example, some studies may have included patients with more severe preoperative conditions, which could influence observed outcomes. Indeed, since the evidence used is not based on randomized studies, the need for more effective circulatory support, as CPB is capable of providing, leads to patient selection in this group with poorer clinical conditions. Furthermore, most of the reviewed studies are retrospective, introducing potential selection and information biases, as older studies more frequently used CPB than recent studies.

Nevertheless, in clinical practice, the routine implementation of ECMO could transform the intraoperative management of lung transplantation. ECMO offers not only survival benefits but also enhances postoperative recovery by reducing the need for prolonged mechanical ventilation and ICU stays. This, in turn, may reduce the costs associated with postoperative care and improve patient quality of life. Moreover, this work raises new questions about optimizing ECMO protocols. For instance, what are the best criteria for selecting patients who would benefit most from ECMO? How can the risk of ECMO-associated complications be further minimized? These are important areas for future research that could help refine and enhance ECMO use in lung transplantation. Another area of interest for future research is the cost comparison between CPB and ECMO. Although ECMO may reduce postoperative complications and ICU stays, its initial implementation may be more costly due to technical requirements and staff training. Detailed economic evaluations could provide a better understanding of ECMO's cost-effectiveness compared to CPB.

In summary, this systematic review provides robust evidence of the benefits of ECMO in lung transplantation, offering clear answers to a crucial clinical question and raising new questions about its application and optimization in daily practice. Adopting ECMO as the standard of care could significantly impact clinical outcomes for lung transplant patients, improving both postoperative survival and quality of life. The implementation of standardized protocols for ECMO use, along with additional research on its costs and long-term benefits, could solidify its position as the preferred support modality in lung transplantation.

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José Manuel Martínez Comendador

Mechanical circulatory support of short duration in cardiogenic shock secondary to AMI: real-life analysis

Observational and retrospective study based on a large North American database comparing outcomes of the use of short-term circulatory support and the timing of its implantation in patients with cardiogenic shock due to AMI.

Cardiogenic shock (CS) related to acute myocardial infarction (AMI) is a clinical condition with persistently high mortality rates over the past two decades, despite improvements in "door-to-balloon" times, advancements in revascularization techniques, and the introduction of short-term ventricular assist devices.

Extracorporeal cardiopulmonary resuscitation via early implementation of a VA-ECMO in patients experiencing cardiac arrest, analyzed in randomized clinical trials (RCTs) such as the INCEPTION trial, does not seem to offer significant survival benefits. Similarly, early implantation of these devices in other RCTs, such as ECMO-CS in the context of CS of various etiologies, also failed to show relevant benefits. Specifically in the case of CS secondary to AMI, the results are mixed. While the ECLS-SHOCK study found no significant differences in 30-day mortality, the DANGER study became the first to demonstrate a survival benefit at 180 days with the early use of Impella CP®.

Nevertheless, both studies reported a mortality rate of over 45% in the intervention groups, underscoring the considerable challenge of improving survival in these patients, regardless of the strategies employed. All these studies have been analyzed and commented on in previous blog publications.

CS is a syndrome where response time is crucial. While some patients can be effectively managed with medical treatment, others, depending on the severity of CS and factors such as comorbidities or coronary reserve, require therapeutic escalation through ventricular assist devices to prevent irreversible multi-organ failure.

Primarily supported by observational studies, the most recent guidelines from the American Heart Association (AHA) and the European Society of Cardiology (ESC) recommend mechanical support in cases of persistent hemodynamic deterioration despite inotropic and vasopressor support. However, they do not clearly indicate the optimal timing for such implementation. Similarly, the aforementioned RCTs do not provide a definitive conclusion regarding the ideal timing (if it exists) to initiate the use of these devices.

The study we will discuss below, unlike those mentioned previously, seeks to analyze this issue in a real-life setting, as it is an observational and retrospective study conducted in the United States. It used data from the NRD (Nationwide Readmissions Database) to examine 4,494,888 patients hospitalized for AMI between 2016 and 2020. Among this group, 6.5% (n=294,839) experienced CS, and 37% of them (n=109,148) received short-term mechanical circulatory support (MCS) devices: intra-aortic balloon pump (IABP) in 62.1%, Impella CP® in 29.7%, and VA-ECMO in 8.2%. Patients with CS were divided into three groups: no circulatory assistance (n=185,691), early MCS implantation within the first 24 hours (n=76,906), and late MCS implantation after the first 24 hours (n=32,241).

The results were presented comparatively between patients with and without MCS, as well as between those with early versus late MCS.

1. Patients with MCS vs. Without MCS

Patients without MCS were older (69 vs. 66 years, $p < .001$), had a higher proportion of women (38% vs. 30%, $p < .001$), and presented more comorbidities such as COPD, atrial fibrillation, or chronic kidney failure. Conversely, the group with MCS showed a higher proportion of anterior AMI (31.4% vs. 12.8%, $p < .001$) and STEMI (57.8% vs. 37.7%, $p < .001$). Additionally, patients with MCS were more likely to receive coronary revascularization, either percutaneous (55.3% vs. 28.5%) or surgical (25.6% vs. 10%).

Although in-hospital mortality was higher in patients without MCS (36.4% vs. 33.9%, $p < .001$), complications were more frequent among those who received assistance, including major bleeding (28% vs. 21%, $p < .001$), stent thrombosis (3% vs. 1.2%, $p < .001$), and arterial ischemia (2.1% vs. 0.9%, $p < .001$).

2. Early vs. Late MCS

Patients with late MCS were older, had more comorbidities, and had a higher proportion of women. In the early group, there were more cases of STEMI (68.1% vs. 31.9%, $p < .001$) and anterior AMI (37.9% vs. 14.9%, $p < .001$), as well as a greater use of percutaneous revascularization (60.7% vs. 41.7%, $p < .001$). However, the late MCS group underwent more surgical revascularizations (39% vs. 20%, $p < .001$).

Although there were no significant differences in overall mortality between the groups (33.7% vs. 33.9%, $p = .683$), multivariate analysis showed that early MCS implantation was associated with lower in-hospital mortality (HR 0.9; 95% CI 0.85–0.94; $p < .001$). This benefit was observed regardless of the device used: IABP (HR 0.9; $p = .001$), Impella (HR 0.92; $p = .04$), and VA-ECMO (HR 0.85; $p = .041$).

The late MCS group presented more complications, such as ischemic stroke (3.6% vs. 2.8%, $p < .001$), major bleeding (33.7% vs. 25.8%, $p < .001$), and a greater need for renal replacement therapy (13.1% vs. 7.9%, $p < .001$). They also experienced longer hospitalizations (15 days vs. 7 days, $p < .001$) and higher costs. The predictors of mortality among patients with MCS were identified as in-hospital sudden death, STEMI, anterior AMI, advanced renal failure, diabetes, obesity, cirrhosis, and being female.

The authors concluded that among patients receiving MCS for CS secondary to AMI, early use of MCS was associated with fewer complications, shorter hospital stays, lower hospital costs, and reduced mortality and readmissions at 30 days.

COMMENTARY:

One of the main contributions of this study, beyond the specific findings regarding the use of MCS in the context of shock, is the detailed perspective it offers on the situation of CS secondary to AMI in real-world clinical practice. The study is based on the NRD database, which includes approximately 60% of the United States population—a considerable sample size that supports the robustness of its findings. The incidence of CS in patients with AMI was 6.5%, of which 37% received some type of MCS. This translates to over 100,000 patients who received MCS, a figure unimaginable if we look back 20 years.

Secondly, the results of this study stand out for the relatively low hospital mortality observed in patients with and without MCS, with 33.9% in the MCS group and 36.4% in the non-MCS group. These figures are notably lower than the mortality reported in the RCTs mentioned in the introduction, which hovers around 50%. It should be noted that, in most of the RCTs, patients presented with a degree of severity of cardiogenic shock classified as D and E according to the SCAI classification, validated in 2019. This suggests that the participants of these trials were likely in worse clinical conditions

compared to those analyzed in this study based on real-world clinical practice. From these findings, it can also be inferred that, regardless of whether MCS is used early or late, the decision to implement these devices seems to be generally based on sound clinical judgment and aligned with the outcomes obtained.

Thirdly, it is particularly striking to observe the low rate of coronary revascularization, despite being an intervention with a level of evidence IA according to AHA guidelines. Only 38.5% of AMI patients complicated with CS without MCS were revascularized, while in the MCS group, the figure rose to approximately 80%. However, this percentage remains relatively low considering that emergent revascularization is the strategy with the highest evidence for reducing mortality in this patient group.

It is important to acknowledge the observational and retrospective nature of the study, as well as the inherent limitations of using coding systems to determine diagnoses and procedures, which can introduce selection and confusion biases. These limitations include the lack of specific criteria for defining CS and establishing clear indications for circulatory support. Moreover, the study does not provide detailed data on essential aspects of acute cardiac care, such as hemodynamic status, use of vasoactive drugs, or the precise timing of the support implantation relative to coronary intervention. These data would have been fundamental to better understanding at which stage treatment escalation is decided and to more accurately assess the severity of shock.

In my view, the significant importance of this study lies in its description of the real incidence and prognosis of CS in the context of AMI in the U.S. population, as well as the contemporary use of short-term MCS. Additionally, it expands the limited evidence available regarding the (cautiously taken) benefit of early use of these devices in patients with advanced CS and poor prognosis, especially before the development of multi-organ failure. Lastly, we must not forget that in CS secondary to AMI, emergent revascularization remains a fundamental strategy. However, the results of this study indicate that its implementation is suboptimal, both in terms of quantity and effectiveness, even in patients equipped with assist devices. Until this is addressed, we will never be able to objectively assess the real efficacy of these devices.

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Alberto Jiménez-Lozano

Emergent revascularization strategy after acute coronary syndrome requiring extracorporeal cardiopulmonary resuscitation: surgery or PCI?

This study compares the outcomes of surgical versus percutaneous revascularization strategies in patients with triple vessel disease and acute coronary syndrome requiring extracorporeal cardiopulmonary resuscitation (ECPR), based on retrospective data from two reference centers.

The choice between urgent surgical revascularization (CABG) or percutaneous coronary intervention (PCI) in patients undergoing ECPR after acute coronary syndrome (ACS) remains controversial.

Following the SHOCK trial and similar studies, PCI became a common strategy for patients with refractory cardiac arrest associated with ACS, aiming to reduce the time from symptom onset to revascularization—a delay inevitably associated with surgery. However, survival rates in that study were similar between both revascularization methods. Combined with the widespread use of ECMO and advancements in surgical techniques in recent years, this controversy persists, particularly in patients with complex coronary anatomies, such as triple vessel disease. The absence of robust comparative studies in this population further underscores this ongoing debate.

This study analyzed retrospective data from two tertiary hospitals in Taiwan, including patients treated with ECPR between 2010 and 2022 for both in-hospital and out-of-hospital cardiac arrest. Of 327 patients initially selected, 215 were included (40 CABG and 175 PCI). Propensity score matching (1:1) was used to balance baseline characteristics (demographics and resuscitation parameters) among the 40 CABG patients and an equal number of PCI patients, with 95% presenting triple vessel disease. Outcomes such as in-hospital and midterm survival and successful ECMO weaning rates were evaluated.

The analysis revealed higher success rates for ECMO weaning (71.1% vs. 48.7%; p = .05) and in-hospital survival (56.4% vs. 32.4%; p = .04) for CABG compared to PCI. However, no significant differences were observed in midterm survival among hospital survivors, though CABG demonstrated a trend toward fewer reinterventions (p = .07).

COMMENTARY:

While this study provides valuable insights into revascularization strategies in the complex context of ECPR, its methodological limitations should be considered.

The primary limitation is the retrospective design, which inherently limits causal inferences for various reasons. Patient allocation to treatment was determined by the attending medical team's decisions, suggesting that treatment modalities were likely influenced by multiple factors beyond those included in the propensity score analysis (e.g., ventricular function was not assessed). Another key limitation of the design is the selection of 40 CABG-treated patients and their comparison to a matched subset of 40 PCI-treated patients, excluding 72% of initially included PCI-treated patients. Moreover, the relatively small sample size reduces the statistical power to detect differences in both outcomes and baseline characteristics, despite matching. For instance, the CABG group had twice the coronary disease burden and four times the proportion of patients with NYHA functional class III or IV, with p = .05 and .08, respectively.

Another significant consideration is the longer ECMO-to-revascularization time in the CABG group. Cases defined as "emergent" included all revascularizations performed within 48 hours, an arbitrary criterion that does not align with the common definition of

an emergency. This discrepancy could be a critical factor requiring further investigation, as delays in revascularization are typically associated with worse outcomes.

Despite these limitations, the study's findings suggest that CABG may offer initial advantages in terms of in-hospital survival and reduced need for reinterventions in selected patients. Future studies should aim for prospective designs and randomized comparisons between CABG and PCI. Additionally, incorporating post-hospitalization functional status variables would provide a more comprehensive view of each strategy's impact on patients with such critical conditions.

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Gonzalo López Peña

What Do We Know About Prosthetic Valve Thrombosis in Veno-Arterial ECMO Settings?

A single-center retrospective study analyzing a case series over four years involving patients who underwent valve replacement surgery and required veno-arterial extracorporeal membrane oxygenation (VA-ECMO) in the immediate postoperative period.

Prosthetic valve thrombosis is an uncommon complication, with incidences reported to be below 6% for mechanical valves and under 1% for biological valves, with the mitral position carrying higher risk compared to the aortic position. In cases of postcardiotomy shock, circulatory support with VA-ECMO might be required, some of whom have prosthetic valves. These cases might present an increased risk of prosthetic thrombosis due to the hemodynamic alterations induced by ECMO. Several case series have been published, though there is no specific evidence or recommendations regarding its management.

The goal of the article under review is to describe the incidence, management, and outcomes of patients who developed prosthetic thrombosis while on VA-ECMO support after valve replacement surgery. This study was conducted at the Pitié-Salpêtrière Hospital in Paris, exclusively including patients from this center. Inclusion criteria encompassed adult patients who received VA-ECMO via peripheral access after valve replacement surgery between January 2015 and October 2019. Indications for VA-ECMO support were based on clinical criteria of postcardiotomy cardiogenic shock. Peripheral femoro-femoral cannulation was performed in all cases, and some patients received intra-aortic balloon pump (IABP) support due to echocardiographic findings of left ventricular dysfunction and/or limited opening of the aortic valve/prosthesis. ECMO flow was adjusted according to contractility and cardiac output, with daily echocardiographic assessments. Anticoagulation was maintained with continuous unfractionated heparin infusion, targeting an activated partial thromboplastin time (aPTT) ratio of 1.5–2. Cannulas and oxygenators were inspected daily by perfusionists, and replacements were performed if thrombi were detected around the membrane.

The primary objective was to determine the incidence of prosthetic thrombosis during VA-ECMO support or within days following weaning. Secondary objectives included hospital and 30-day survival, as well as adverse events related to peripheral VA-ECMO in these patients.

From 2015 to 2019, 1936 patients underwent valve replacement surgery, of whom 152 (7.8%) required VA-ECMO. Among them, 69/152 (45%) received combined IABP and VA-ECMO support. Prosthetic valve thrombosis occurred in 9/152 patients. Of these, 7 underwent biological aortic valve replacement, and 2 underwent double valve replacement with mechanical aortic and mitral prostheses. Five cases developed thrombosis within the first 24 hours, while the remaining four occurred between days 4 and 17. The cumulative incidence of prosthetic thrombosis was lower in patients with IABP and VA-ECMO compared to VA-ECMO alone (1.4% vs. 13.7%; $p = .021$). Embolic events (peripheral and cerebral) were more frequent in patients with prosthetic thrombosis compared to those without (22.2% vs. 4.2%; $p = .02$). No statistically significant differences were found regarding prosthesis position and embolic events. Survival among patients with prosthetic thrombosis was 22% (2/9), compared to 31% in those without thrombosis. Among the nine cases, five were managed by converting to biventricular bicentrifugal support (Abbott Centrimag®). The two survivors were treated with unfractionated heparin infusion without additional surgery.

The authors identified the main limitations of their study as the inability to perform multivariable analysis due to the low number of cases (n = 9) and the single-center design, which limits external validity. They concluded that peripheral femoro-femoral VA-ECMO combined with IABP is associated with a lower risk of prosthetic thrombosis, and this finding appears to be independent of prosthesis type or position.

COMMENTARY:

This article presents the largest case series to date of prosthetic valve thrombosis in patients on femoro-femoral VA-ECMO support. The study identifies two thrombosis patterns: early (within the first 24 hours) and late. The primary hypothesis for early thrombosis involves polytransfusion of blood products and prothrombotic agents immediately after surgery, while late thrombosis could be explained by the inflammatory response induced by prolonged ECMO support and the increased afterload generated by peripheral VA-ECMO.

Another notable finding is the lower cumulative incidence of prosthetic thrombosis in patients managed with combined VA-ECMO and IABP compared to VA-ECMO alone. The retrograde flow generated by femoro-femoral VA-ECMO in a myocardium compromised by postcardiotomy shock is detrimental to recovery, and the authors advocate for the combined VA-ECMO + IABP strategy whenever possible.

As for recommendations, the initial management of chronic-subacute prosthetic valve thrombosis usually requires valve replacement surgery or thrombolysis. Extrapolating this scenario to patients with VA-ECMO in postcardiotomy shock is not considered viable by the authors. Instead, they propose alternatives such as converting to biventricular support to maintain intracavitary flow and enhancing anticoagulation with unfractionated heparin infusion.

A limitation of the study lies in the choice of peripheral arterial cannulation, justified by a 2020 study concluding that high-flow central arterial cannulation in the immediate postoperative period leads to intracardiac stasis and increases thrombosis risk. Among peripheral cannulation options, the femoral artery is preferred over the axillary artery, as the latter has been associated with higher risks of accidental decannulation and bleeding.

Peripheral VA-ECMO offers clear advantages over central VA-ECMO, such as reduced risks of mediastinitis and bleeding with a closed chest, as well as better ventilation capacity, minimizing the risk of atelectasis.

Regarding prosthesis position and its relationship to peripheral embolisms, the authors highlight previous series reporting higher embolism rates in mitral prostheses. For instance, a cohort of patients with peripheral VA-ECMO showed a 21% embolism rate among mitral prosthesis carriers, contrasting with the 7% reported in this cohort. However, these are case series with insufficient numbers to generate strong evidence. Therefore, it seems premature for the authors to assert that variables like prosthesis type and position do not influence embolism genesis.

Although this study features a relatively large cohort, it remains insufficient to establish strong, reproducible recommendations for all cardiac surgery centers. A systematic review of cases from multiple centers is likely the best long-term solution, enabling the development of unified criteria for managing this rare but critical complication, which remains a significant concern for critical care units handling VA-ECMO patients.

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Francisco Noriega Sánz

What can structural interventions offer in heart failure? Beyond valvular diseases

A bibliographic review of the current percutaneous devices available for the treatment of heart failure, including interventions on cardiac valves, left ventricular remodeling, or other approaches.

Pharmacological therapies constitute the cornerstone of treatment for patients with heart failure. However, the presence of structural abnormalities worsens their prognosis. Certain procedures, such as cardiac resynchronization therapy, ventricular assist device implantation, or structural interventions on specific valvular diseases, have demonstrated efficacy in selected scenarios. Others are in the process of being implemented into routine clinical practice.

This article aims to summarize the various percutaneous interventions that can be performed in patients with heart failure. It categorizes the procedures according to their mechanisms of action: promoting left ventricular reverse remodeling, reducing pulmonary capillary pressure, or correcting valvular abnormalities.

Percutaneous devices targeting left ventricular reverse remodeling physically alter the shape or size of the ventricle. The objective of these devices is to reduce ventricular diameter, either epicardially via surgical access, endocardially through a retroaortic approach, or intramyocardially via the coronary sinus. The most advanced device, the AccuCinch Ventricular Restoration System®, is anchored below the mitral annulus through a retroaortic arterial approach and has demonstrated reductions in left ventricular end-diastolic volume, along with improvements in quality of life and 6-minute walk tests one year post-procedure. Other devices, aimed at modifying ventricular geometry, include surgical exclusion of necrotic regions via mini-thoracotomy or transcatheter apex isolation, currently under development.

Reduction of pulmonary capillary pressure is achieved by creating an interatrial shunt with left-to-right flow. Two mechanisms are proposed for maintaining shunt patency long-term: device implantation or tissue ablation/excision. The most evidence exists for percutaneous devices such as the Corvia Atrial Shunt® and the V-Wave Ventura Interatrial Shunt®, which, while not showing benefits in terms of mortality, heart failure, or stroke, are associated with improved quality of life and ventricular remodeling parameters in selected populations.

Cardiac valve interventions are divided into those targeting the aortic, mitral, or tricuspid valves. The most robust evidence pertains to the aortic valve, with transcatheter aortic valve implantation (TAVI) being a Class I recommendation for patients over 65 years old with severe symptomatic aortic stenosis, or for asymptomatic patients under 80 years old with reduced ventricular function (LVEF < 50%). A new prognostic staging classification for aortic stenosis, based on imaging evaluation of extravalvular cardiac involvement (left ventricle, mitral valve/left atrium, pulmonary pressure/tricuspid valve, and right ventricle), is currently under consideration. Specific scenarios demonstrating TAVI's safety and efficacy include patients with cardiac amyloidosis (greater one-year survival compared to placebo), degenerated aortic bioprostheses (excellent three-year outcomes for initial prostheses larger than 23 mm), or cardiogenic shock (TAVI implantation with mechanical circulatory support is a safe procedure with similar mortality to elective procedures beyond the first month). Special mention is made of aortic insufficiency, with two specific prostheses described: Trilogy Valve® and J-Valve®, the former showing evidence of safety and efficacy, and the latter in feasibility phase.

Regarding the mitral valve, percutaneous mitral valvuloplasty is described for rheumatic mitral stenosis, along with percutaneous options for previous surgical treatments (valve-in-valve and valve-in-ring), with better outcomes for transcatheter prosthesis implantation on mitral bioprostheses compared to annuloplasty. However, the true development of percutaneous procedures lies in native mitral valve regurgitation, where devices are categorized by mechanism of action: annular reduction, chordal repair, edge approximation, and transcatheter prosthesis implantation. Annular repair with the Carillon Mitral Contour System® via the coronary sinus demonstrates reduced mitral regurgitation and improved functional class. NeoChord DS 1000® is a chordal replacement device with transapical access, with transseptal venous access in development. Mitral edge-to-edge repair with devices such as MitraClip® and PASCAL® is widely implemented in patients with cardiomyopathy and secondary mitral regurgitation, where benefits in morbidity and mortality have been shown over a five-year follow-up. For patients ineligible for edge-to-edge therapy, transcatheter prosthesis implantation, either transapically (Tendyne®) or via transseptal venous access (Intrepid®), can be considered.

Finally, tricuspid valve procedures include edge approximation, annular reduction, and orthotopic or heterotopic valve replacement. Edge-to-edge therapies (TriClip® and PASCAL®) and annular reduction (Cardioband®) have demonstrated symptomatic improvement. Orthotopic transcatheter prosthesis implantation (EVOQUE®) shows improved functional class, quality of life, and 6-minute walk tests, with a trend towards reduced mortality. Other orthotopic prostheses, such as Lux Valve® or Cardiovalve®, are under development. Lastly, heterotopic prostheses implanted in the venae cavae, such as TRICENTO® and TricValve®, may provide symptomatic relief in inoperable patients and those not eligible for other percutaneous therapies.

COMMENTARY:

This article comprehensively reviews the various options structural interventions offer to patients with heart failure. Hemodynamic changes, neurohormonal activation, and a proinflammatory state promote ventricular remodeling and impair myocardial contractility. While pharmacological therapies positively influence ventricular remodeling, concomitant structural abnormalities limit their efficacy. Thus, structural interventions are proposed at various levels to enhance contractility and reduce interstitial fibrosis, wall stress, filling pressures, or vascular resistance.

The most substantial evidence exists for valvular procedures, such as TAVI for aortic stenosis or edge-to-edge repair on mitral or tricuspid valves, demonstrating prognostic or symptomatic improvements to varying extents. Although ventricular remodeling or interatrial shunt therapies show promise, they lack robust results. Ongoing studies will confirm in the coming years whether these therapies can be incorporated as part of the therapeutic arsenal for heart failure patients.

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Section V A:

Aortic valve disease

Victoria Garay Airaghi

Evaluation of frailty in cardiac surgery during surgical and transcatheter aortic valve replacement: consensus document

This consensus document, prepared by the European Association for Cardio-Thoracic Surgery (EACTS), the European Association of Preventive Cardiology (EAPC), and the European Society of Cardiology (ESC), addresses the comprehensive assessment of frail patients before procedures, aiming to determine intraoperative risk, short-term mortality, and the likelihood of neurological complications. The goal is to provide patients with improved information regarding their post-intervention functionality and quality of life.

In clinical practice, this patient population is complex, often presenting with multiple comorbidities and unique functional, cognitive, and social characteristics that may or may not correlate with their chronological age. The available literature on this topic is highly heterogeneous, prompting the collaboration of various participants from European societies involved in this effort to establish a consensus document on the evaluation and management of frailty in patients undergoing TAVI or cardiac surgery.

A multidisciplinary working group was created, comprising surgeons, cardiologists, geriatricians, and anesthesiologists, all of whom declared the absence of conflicts of interest. A biostatistician participated as an advisor for the literature review and methodology development process. A systematic review was conducted in Medline, using search terms that included frailty assessment, transcatheter aortic valve interventions, and cardiac surgical procedures. The primary inclusion criterion required that studies evaluate the predictive ability of a specific frailty assessment tool for one of the outcomes of interest.

Articles meeting inclusion criteria were reviewed independently by two researchers, with a third researcher resolving any discrepancies. Out of 1,181 publications reviewed, 254 were included in the final analysis. Given the wide variety of tools investigated and the methodological heterogeneity, the researchers reached a consensus by considering the frequency with which certain tools were described and their demonstrated success in predicting specific outcomes. These findings were complemented by the expertise of the working group members.

The following points summarize the key findings of the consensus:

1. Frailty and Outcome Prediction After Cardiac Surgical Procedures:

Frailty is a predictor of short-term (30 days), medium-term, and long-term (1 year) mortality following cardiac surgery, as well as neurological complications, delirium, and length of hospital stay. Traditional risk scales such as EuroSCORE and STS tend to underestimate surgical risk as they do not incorporate frailty parameters. The tools recommended are based on studies with large sample sizes (n > 10,000):

- Gait Speed (5 meters): Recommended as a predictor of perioperative, medium-, and long-term mortality following cardiac surgery.

- 6-Minute Walk Test: Useful specifically for predicting medium-term mortality, particularly in patients being assessed for heart failure.

- Katz Index of Activities of Daily Living (0 points: total dependence, 6 points: maximum independence):Identified as an independent predictor of mortality in 2 of 6 studies but not recommended as a predictive tool.

- Psoas Muscle Area Index (PAI) and Sarcopenia Evaluation: Sarcopenia correlates with frailty. PAI is recommended for medium- and long-term mortality prediction in cardiac surgery patients, but not for perioperative mortality. Tools such as CT or bone densitometry can be used to assess mortality risk. Additionally, PAI predicts prolonged hospital stay and discharge to intermediate care or non-home settings.

- Fried's Frailty Phenotype (3 or more positive criteria): A valid tool for predicting all types of mortality, postoperative delirium, prolonged hospital stay, quality of life, and the likelihood of hospital readmission or discharge to intermediate care.

- Clinical Frailty Scale (CFS): A simple, non-instrumental classification (1: athletic/robust, 7: completely dependent) recommended for predicting short- and medium-term mortality, but not long-term mortality.

- Short Physical Performance Battery (SPPB): Assesses balance, gait speed, and chair stand test. Predicts medium-term mortality and prolonged hospital stay.

- Edmonton Frail Scale (EFS, 0: no frailty, 12-17: severe frailty): Could be used to predict prolonged intensive care unit stays.

- Cognitive Assessments: Tools such as the Mini-Mental State Examination (MMSE) and Montreal Cognitive Assessment (MoCA) are effective in estimating delirium risk in this patient profile.

2. Frailty and Outcome Prediction After TAVI Procedures

Frailty is a predictor of short-, medium-, and long-term mortality after transcatheter aortic valve implantation (TAVI). The recommended assessment tools include:

- Gait Speed (5 meters): Recommended for medium- and long-term mortality prediction and, to a lesser extent, short-term mortality. It also predicts prolonged hospital stays and post-TAVI delirium.

- Serum Albumin: A concentration below 3.5 g/dL predicts medium- and long-term mortality.

- Katz Index of Activities of Daily Living (ADL): Useful as a predictor of short-, medium-, and long-term mortality. This is not the case for the Lawton Index (instrumental ADLs).

- Handgrip Strength: Assessed using a dynamometer, it is a predictor of medium-term mortality in this group.

- CFS and Psoas Muscle Area (as measured by CT): Recommended for predicting short- and long-term mortality. Additionally, the Bern Scale (5 items) is suggested for evaluating these parameters.

- Mini-Mental State Examination (MMSE): Limited evidence supports its use as a predictor of long-term mortality, and data on short-term mortality are inconsistent. However, it is useful for predicting post-TAVI delirium.

Frailty as a Predictor of Neurological Complications, Delirium, and Prolonged Hospitalization/Ventilation After TAVI

- Nutritional Status: Poor nutrition is strongly correlated with postoperative complications and delayed recovery. Serum albumin is a reliable indicator of nutritional status, while body mass index (BMI) shows inconsistent results.

- Gait Speed (5 meters): A predictor of neurological complications and prolonged hospital stays.

- MMSE: Useful in predicting delirium risk during hospital stays, often resulting in extended hospitalization.

- Sarcopenia Assessment (Psoas Muscle Measures): Strongly predicts prolonged hospital stays; routine CT scans can easily provide this data.

Frailty as a Predictor of Quality of Life, Discharge Location, Readmission, and Functional Decline After TAVI

- CFS, Fried Criteria, and Gait Speed (5 meters): Predictors of quality of life, especially for defining discharge to locations other than the patient's home.

- Fried Criteria and Gait Speed: These also help predict hospital readmission and functional decline post-TAVI.

3. Management of Frail Patients and Integration of Frailty Assessment in Routine Clinical Practice

- Use of Serum Markers: Parameters such as serum albumin have been analyzed in several studies as indirect indicators of frailty. Comprehensive nutritional assessments incorporating serum albumin levels are highlighted as potential tools for evaluating patient status. This remains an open field for further research.

- Using Diagnostic Records to Identify Frail Patients: Identifying frailty through a scoring system that groups established diagnoses related to frailty could be an interesting proposal. However, no validated model is currently available.

- Prehabilitation: Once frailty is identified, the next step involves reducing or managing its impact through prehabilitation programs. These include strength training exercises, respiratory muscle training, nutritional interventions, and

health education. Moreover, social and cognitive aspects are integrated, such as cognitive-behavioral therapy for patients with prior anxiety disorders, which has been shown to decrease hospital stay, reduce depressive symptoms, and improve perceived quality of life within four weeks post-discharge. These interventions yield positive outcomes but require additional studies for validation.

The evaluation of frailty has become an essential tool for estimating perioperative/interventional risk on an individualized basis. It also provides insights into quality of life and reduces the likelihood of institutionalization. This working group conducted a thorough literature review to produce a consensus statement on assessing frailty to predict outcomes such as in-hospital mortality, length of stay, readmission, neurological sequelae, and quality-of-life parameters. Frailty evaluation, result interpretation, and decision-making should always be performed within a multidisciplinary team.

COMMENTARY:

The population is not only aging chronologically but also presenting with increased complexity, which must not be overlooked in clinical practice. These challenges, perceived by all healthcare professionals, urge us to seek high-quality consensus documents to ensure optimal interventions. The summarized results provide highly relevant guidelines for multidimensional patient evaluation (already selected for these procedures but potentially classified as robust, pre-frail, or frail). Consolidating these tools and corroborating their predictive value serves as an excellent starting point for implementing improvement measures.

Frailty is one of the major challenges in geriatrics, highly prevalent among elderly patients treated by medical and surgical specialties beyond geriatrics. This growing demand for care fosters the concept of transversal geriatrics, applying geriatric medicine principles in non-geriatric units to ensure a multidisciplinary approach in other services. Comprehensive geriatric assessments and frailty detection in these patients provide prognostic information, aid decision-making, and support tailored treatment selection. The shared objective is person-centered care with optimized comprehensive management—a reality that will continue to expand across more hospitals. Geriatricians consider this a significant healthcare challenge of the 21st century.

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Elio Martín Gutiérrez

New Device for Saline Test in Aortic Valve Repair

Description of an experience with a novel device for evaluating aortic valve competence during repair procedures by root pressurization with saline solution.

Unlike some interventional valve repair techniques, surgical techniques still encounter two unresolved challenges. First, although surgery has a broader technical arsenal, greater range of approaches, and more extensive experience, it remains reliant on performing procedures under cardioplegia conditions. The initial drawback is that surgical techniques necessitate extrapolating echocardiographic analysis to segmental analysis of the valve (aortic, mitral, or tricuspid), whereas, for example, interventional techniques like mitral or tricuspid clipping enable precise targeting due to the presence of the PISA and vena contracta. This limits the ability to add corrective or additional repairs immediately. The second challenge is that the positioning of the heart under cardioplegia differs from that required for proper valve closure, which aims to restore competence. Thus, while atrioventricular valves, which must close during systole, are repaired with the heart in diastolic arrest, the aortic valve, which should close under diastolic root pressurization, is repaired in an open position.

In atrioventricular valve repair, the saline test has been proposed as a ventricular pressurization method to assess valve competence. Now a classic technique, it has garnered equal supporters and detractors. For many, good ventricular pressurization and competent valve display often predict favorable echocardiographic results. Conversely, confidence in the technique and completed coaptation surface corrections may warrant assessment even when the test outcome is unsatisfactory, independent of cardiopulmonary bypass. Numerous factors, including ventricular pressurization in diastole, pericardial traction, sternal retractor opening, and atrial exposure, may influence test results. Certain authors have noted that saline-filled left ventricles facilitate air ascent toward the aortic root, potentially leading to coronary air embolism. Thus, they suggest pressurization via antegrade cardioplegia administration, which, with an exposed mitral valve, will render the aortic valve incompetent and permit left ventricular pressurization.

However, the aortic valve repair remains challenging as it is performed in an open field, making pressurization techniques for competence assessment more complex. Therefore, confidence in the procedure predominantly underlies evaluation post-cardiopulmonary bypass separation. Appropriate commissure reimplantation, free-edge length balance, restoration of normal root architecture, and, consequently, the coaptation surface all contribute to potential successful outcomes. Negative intraventricular pressure generation through aspiration via the vent catheter to mimic root pressurization has been suggested, though it further departs from replicating physiological conditions.

In this context, a Dutch team describes their experience with a device for in-situ pressurization of the aortic root with saline solution to assess valvular competence. The device, seemingly a prototype with no commercial reference, comprises a cylinder pneumatically anchored to the conduit or ascending aorta. It seals with a pneumatic system, followed by saline infusion to achieve root pressurization. The infusion utilizes one of the extracorporeal circulation machine's rotors, analogous to a cardioplegia line. Finally, an anti-reflux valve in the cylinder allows for thoracoscope introduction to observe valvular competence. The authors recommend using 10 mm thoracoscopes with a 30° angle, though 0° thoracoscopes are also viable. Competence evaluation is based on saline leakage (regurgitation) once Dacron graft porosity leakage is ruled out. Laboratory

tests estimate the latter as minimal, approximately 2 cc/cm2/min, though no reference cut-off is provided.

The center's experience, initiated in 2019, involved 24 patients undergoing root reimplantation surgery. System pressurization reached 60-70 mmHg in 22 cases, with final echocardiographic aortic insufficiency grade 1+ or lower in all. Mean saline leakage was 90 cc/min. In 5 cases, the device prompted corrective valve repairs, while in two cases, valve replacement preceded further procedural continuation. Competence assessments were always conducted prior to coronary button reimplantation.

The authors conclude that the device facilitates intraoperative evaluation of the repaired aortic valve under conditions closer to physiological pressurization, enabling targeted adjustments through direct visualization. Thus, the device can be a valuable tool for intraoperative aortic valve assessment during repair procedures, enhancing procedural predictability and efficiency.

COMMENTARY:

The innovation capacity of this group is noteworthy. Though in initial stages, this tool appears promising for intraoperative corrective decision-making, similar to the role the saline test has long played for mitral and tricuspid valves. While it may require refinement before commercialization, many devices initially exhibited less ergonomics than they now offer. Consider the initial TAVI and TEVAR introducers, surgical arrhythmia ablation devices, pacemaker generators, and implantable ventricular assist devices, among others.

Innovation is essential in our field, unprejudiced and beyond the "we've always done it this way" mentality. Some devices will find their path, others may not. However, innovation is not a straight line from idea to success; it involves many steps, including failures, before a project comes to fruition.

The authors suggest the device is potentially applicable in any aortic valve analysis. While valuable for root reimplantation and remodeling techniques, it might also apply to isolated aortic valve repair or homograft/autograft (Ross) implantation. Nonetheless, the following precautions are advised without diminishing the authors' optimism:

– Application for native aortic root pressurization, as would occur in Ross, homograft, or isolated valve repair surgeries, has not been described, so device functionality in these contexts remains unknown.

– In these surgeries, pressurization would occur with coronary ostia present, necessitating cardioplegia washout with saline. An alternative could involve crystalloid solution infusion for pressurization, though this might disrupt myocardial protection protocols.

– Re-correction rate was under one-fourth of procedures, with structural valve issues in two cases likely prompting replacement without re-evaluation. Therefore, only in three of the 22 procedures did pressurized assessment influence corrective decisions (13%), with excellent subsequent echocardiographic results.

– Assuming that any repaired valve's competence alone equates to proper function is oversimplified. The opening (gradient), leaflet mobility with stress zones, coaptation reserve, and dynamic conditions all affirm successful repair. Thus, confirming a repaired aortic valve's functionality under static root pressurization remains an imperfect evaluation. Although a "passive" valve compared to atrioventricular valves, the aortic root also exhibits systo-diastolic dynamics, reminding us of the saline test's limitations discussed earlier.

Hence, innovation is challenging, with more obstacles than victories. Nonetheless, it is necessary to advance cardiac surgery toward modernity. Its future partly depends on this progress, as innovation in competing fields won't cease and has led them to their present accomplishments. Industry commitment is also a significant factor, but the drive of pioneers willing to publish such valuable experiences completes the synergy. Only thus can we envision a horizon where, deceptively, it seems everything has been invented.

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Jorge Alcocer Dieguez

Bicuspid Aortic Valve Repair: Importance of Annular and Sinotubular Junction Stabilization

A retrospective, multicenter analysis of outcomes in valve repair for aortic insufficiency caused by bicuspid valvulopathy with or without associated aortopathy, with a follow-up period of 10 years.

The bicuspid aortic valve (BAV) is the most common congenital cardiac anomaly in the general population, with a prevalence of 1-2%. Valve repair in aortic insufficiency, with or without an associated aortic aneurysm, has gained interest over valve replacement due to the reduced complications associated with prosthetic valves, such as structural degeneration, endocarditis, and hemorrhagic complications arising from anticoagulation. Therefore, the European valvular disease guidelines recommend valve repair in aortic root replacement surgery (reimplantation or remodeling), regardless of the degree of aortic insufficiency (class I), and in isolated aortic insufficiency (class IIb), for both bicuspid and tricuspid valves.

Valve repair in aortic insufficiency (AI) with BAV has been standardized in several previous publications by the same group (Lansac et al.), according to three different BAV phenotypes based on the diameter of the proximal aorta:

1. Isolated Aortic Insufficiency without Aortic Dilation (Aortic Diameter < 40-45 mm): In addition to leaflet repair, which includes plication of the fused leaflet to equalize the free edge of both leaflets, a simple (subvalvular) or double (subvalvular and sinotubular junction (STJ)) external annuloplasty is performed.

2. Aortic Insufficiency with Suprasinusal Ascending Aorta Aneurysm (Root Diameter < 45 mm and Supracoronary Aorta > 45 mm): Leaflet repair is performed along with replacement of the supracoronary ascending aorta, with or without partial aortic root replacement (hemi-remodeling of the non-coronary sinus) and subvalvular external annuloplasty.

3. Aortic Insufficiency with Aortic Root Aneurysm (Root Diameter > 45 mm): Leaflet repair is performed along with complete aortic root replacement using the remodeling technique, together with a subvalvular external annuloplasty.

The objective of this study was to evaluate long-term outcomes of valve repair in BAV-related AI with or without associated aortopathy.

The authors retrospectively analyzed 343 consecutive patients with isolated AI and BAV, with or without aortopathy, who underwent surgery between 2003 and 2020 in four Parisian centers. Clinical and echocardiographic data were evaluated perioperatively and during follow-up. Survival, valve-related reintervention rate, cumulative incidence of AI grade >2+ and >1+, as well as severe structural valve degeneration (mean gradient > 40 mmHg, 20 mmHg increase from discharge, and/or AI grade >2+), were analyzed. Additionally, a subgroup analysis was conducted based on whether STJ stabilization was performed and commissural orientation (symmetrical >160° or asymmetrical <160°).

Of the 343 patients, 81.3% (279 patients) were able to undergo valve repair. Thirty-day survival was 99.6%, and the 30-day reintervention rate was 1.4%. The mean

transvalvular gradient at discharge was 7.7 mmHg. Patients with commissures aligned to a symmetrical orientation had a significantly lower gradient compared to those who did not (7.58 mmHg vs. 9.63 mmHg; $p < 0.001$).

At the 10-year mark, survival was 93.9%, similar to that of the general population of the same age and sex. The cumulative incidence of reoperation was 6.3% (n=10), and the incidence of AI grade >2+ was 5.8% (n=9). Severe structural valve degeneration was reported in 10.2% (n=11), with a stroke incidence of 8.0% and a bleeding incidence of 1.5% over 10 years.

Based on the surgical technique, the authors compared 248 patients with STJ stabilization (isolated valve repair with double external annuloplasty, supracoronary ascending aorta replacement with annuloplasty, or root remodeling with annuloplasty) versus 31 patients in whom STJ stabilization was not performed (isolated valve repair with simple subvalvular annuloplasty). Patients with STJ stabilization had a lower reoperation rate (2.6% vs. 22.5%; $p = 0.0018$) and AI grade >2+ (1.2% vs. 23.6%; $p < 0.001$) over nine years.

Regarding commissural orientation, patients with initial symmetrical orientation (>160°) or who underwent symmetrical commissural adjustment (<160°) had a lower reintervention rate and AI recurrence (AI >2+) compared to those without symmetrical commissural orientation (<160°).

Bicuspid aortic valve repair, adapted to aortic phenotype and using annuloplasty techniques, is associated with excellent long-term outcomes. Additional STJ stabilization via external annuloplasty and symmetrical commissural adjustment are crucial to achieving durable valve repair outcomes.

COMMENTARY:

A recent meta-analysis commentary on the SECCE blog suggests that aortic root remodeling is associated with a higher reintervention rate compared to aortic valve reimplantation after four years. This finding, presumably associated with the absence of annular stabilization in the remodeling technique, has led various groups, such as Schäfers and Lansac, to standardize the use of aortic annuloplasty techniques (GoreTex® sutures, external rings, or subcoronary Dacron bands) as an essential component of isolated or concomitant aortic valve repair procedures for associated aortic aneurysms.

The Lansac group has standardized valve repair for both bicuspid and tricuspid aortic valves according to the accompanying aortic phenotype, incorporating external annuloplasty with a ring or Dacron bands. In this article, Shraer et al. (Lansac group) report the results of valve repair in BAV with different associated aortic phenotypes and perform a subgroup analysis based on the presence or absence of associated STJ stabilization and symmetrical commissural adjustment after repair. Although the patient cohort is considerable, subgroup analyses may have limited statistical power due to smaller sample sizes.

The main contributions of this article to current evidence on BAV repair can be summarized as follows:

- Standardization of Surgical Technique: The excellent long-term outcomes in this patient series, with a 10-year survival rate of 93.9% and a low

cumulative reintervention rate (6.2%), support a systematic approach to this condition and validate the European clinical guidelines advocating valve repair over replacement in patients with isolated AI with or without associated aortic aneurysm.

- STJ Stabilization: This study identifies the lack of STJ stabilization as a significant risk factor for AI recurrence and reintervention, recommending techniques that stabilize both the aortic annulus and the STJ to improve the durability of this procedure. These techniques include double external annuloplasty in isolated valve repair without aortic dilation, and supracoronary ascending aorta replacement or aortic root remodeling with external annuloplasty in cases of concomitant aortic aneurysm.

- Promotion of a "Symmetrical" Repair: Patients with symmetrical repair (orientation >160°) had a significantly lower transvalvular gradient at discharge and 10-year follow-up compared to those without such symmetry. Additionally, these patients experienced a lower reintervention rate and AI recurrence during follow-up. Symmetrical commissural orientation after BAV repair is an essential factor for improved valve hemodynamics and greater long-term durability, making it a critical objective in this patient subgroup.

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Bunty Ramchandani

New "Y"-Incision Aortic Root Enlargement: Yang's Procedure

Review of the surgical technique for "Y"-incision aortic root enlargement and its short-term outcomes in 119 patients.

It is commonly believed that the size of the aortic annulus, and thus the size of the aortic prosthesis that can be implanted, depends on the patient's height; however, the actual requirement is determined by their volume. Thus, patient-prosthesis mismatch (PPM) occurs when the implanted prosthesis size fails to meet the patient's cardiac output requirements, leading to increased transvalvular gradients. This condition impacts the left ventricle, causing overload, hypertrophy, and eventual dysfunction, increasing morbidity and mortality associated with both the procedure and postoperative course. Younger patients and those with pre-existing ventricular dysfunction are most susceptible to PPM. Significant debate surrounds effective orifice area (EOA) measurements, with considerable variability in reported values among manufacturers. Furthermore, various aortic root enlargement techniques exist without a clear consensus on the optimal approach, with the Nicks technique being the most popular despite its limited efficacy. Recently, in 2020, Dr. Bo Yang described a novel "Y"-incision method for aortic root enlargement. Today's article provides a brief overview of the technique, along with short-term results from the first 119 patients.

For the surgical technique, the following steps are recommended:

1. Cannulate the aorta near the innominate artery to facilitate the subsequent reconstruction of the ascending aorta.

2. Perform a transverse aortotomy either entirely, 2-2.5 cm above the sinotubular junction, or partially.

3. Following excision and debridement of the diseased aortic valve, make an incision between the commissure of the noncoronary and left coronary sinuses, extending to the aortomitral junction. Extend the incision in a "Y" shape at the aortomitral junction, running parallel to the aortic annulus towards the nadirs of the annular segments of both aortic leaflets, reaching the fibrous trigones on either side. It is crucial to avoid fully severing the fibrous trigones, stopping approximately 2-3 mm from the myocardium on the left side and the membranous septum on the right. This maneuver significantly opens the aortic root. If the incision does not reach the fibrous trigones, the patch for enlargement will be too small and potentially insufficient to achieve the desired prosthetic size.

4. Measure the distance between both nadirs and cut a rectangular Dacron patch approximately 5 mm wider to accommodate the suture line. Typically, the patch measures around 3.75 cm or more; the wider the patch, the greater the root enlargement.

5. Suture the patch to the aortomitral junction/mitral annulus with a 4-0 monofilament suture, starting from the left trigone to the right. When reaching

the nadirs of both cusps, the suture continues cranially towards the ascending aorta and the transverse aortotomy.

6. Insert the sizer and select the size that makes contact with all three nadirs of the enlarged root, potentially increasing the prosthetic size by approximately three units over the initial size. Once the appropriate size is chosen, mark the plane and height for the sutures on the Dacron patch, ensuring proper patch extension to locate the correct plane.

7. Once the prosthesis size is determined, orient the struts so that one lies between the right-left commissure, thereby preventing coronary ostia obstruction. The height of the valve anchoring points on the patch should match those at the level of the divided commissure of the noncoronary-left coronary sinuses, aligning with the commissures of the remaining sinuses of Valsalva. If the anchoring points are placed too low, achieving an adequate prosthetic size may be limited, as the technique primarily enlarges the root rather than the aortic annulus. As a result, part of the patch and most of the anchoring suture will be ventricularized. Furthermore, forcing an oversized prosthesis in this scenario may obstruct the right coronary ostium, given its anterior and cranial angulation. Conversely, if the valve anchoring points are placed too high, the prosthesis may tilt posteriorly and cranially, jeopardizing the left coronary trunk and compromising valve hemodynamics by not aligning coaxially with the left ventricular outflow tract. It is essential to distribute the valve anchoring points on the patch uniformly so that one post is positioned between the left and right coronary sinuses' commissures. In the case of a purely bicuspid valve, the post should be positioned midway between the coronary ostia.

8. Begin by tying the sutures between the nadirs of the noncoronary and left coronary cusps to prevent paravalvular leaks, as this is the lowest point of the aortic annulus.

9. Finally, close the aortotomy using the "roof" technique: trim the Dacron patch into a triangular shape with the tip about 2 cm above the posterior post of the bioprosthesis. This approach prevents kinking between the aorta and the enlarged root, eliminates the sinotubular junction, and prepares the area for future percutaneous valve-in-valve (ViV) procedures, reducing the risk of a Valsalva sinus sequestration and undesirable coronary occlusion.

In the first 119 consecutive cases with "Y"-incision root enlargement, the median patient age was 65 years, with 67% being female and one-third being reoperations. There were two cases of acute endocarditis. The preoperative mean transvalvular gradient was 36 mmHg, with a mean native valve area of 0.9 cm^2. The median aortic annulus size increased from 21 mm to 29 mm following root enlargement. There was one postoperative death, one stroke, and two cases of complete atrioventricular block requiring pacemaker implantation (one in a patient operated on for active endocarditis with a Gerbode-type fistula: aortic root-right atrium). No cases of renal failure requiring renal replacement therapy, mediastinitis, or bleeding were reported. A median follow-up of one year confirmed via CT scan that the aortic root had expanded from 27 mm to 40 mm. Follow-up echocardiograms showed a mean transvalvular gradient of 6 mmHg with a valve area of 2.2 cm^2.

The authors, including Dr. Bo Yang, conclude that "Y"-incision aortic root enlargement is a safe and more effective technique than classical methods.

COMMENTARY:

The first complications due to PPM were described in 1978. Since then, the importance of EOA indexed to the patient's body surface area has gained attention. PPM is considered moderate if this ratio is <0.85 cm^2/m^2 and severe if <0.65 cm^2/m^2. Updated definitions in the VARC3 guidelines now consider PPM moderate if <0.70 cm^2/m^2 and severe if <0.55 cm^2/m^2 for patients with a BMI >30 kg/m^2. The degree of PPM significantly impacts short- and long-term morbidity and mortality. Severe PPM leads to increased readmissions for heart failure post-intervention, accelerated bioprosthesis deterioration, a 56% increase in perioperative mortality, and a 26% increase in mortality over time. This mortality increase is most notable in patients with left ventricular dysfunction. In cases of moderate PPM, the literature presents contradictory results, making root enlargement to prevent it still a debated issue.

Root enlargements can be classified as anterior and posterior. The anterior enlargement, the Konno-Rastan procedure, uses an incision through the right coronary sinus and interventricular septum, allowing a size increase of up to three or four units. Due to its technical complexity, it is rarely used in acquired heart disease and is mostly reserved for congenital heart disease with multilevel stenosis. Posterior enlargements include the Nicks procedure, the Manouguian procedure, and its variant, the Núñez procedure. The Nicks technique extends the aortotomy through the noncoronary sinus. Conversely, the Núñez and Manouguian techniques extend the incision through the commissure between the left and noncoronary sinuses, with the Núñez stopping at the aortomitral junction, whereas the Manouguian proceeds to the anterior mitral leaflet, sometimes requiring left atrial roof opening. Nicks and Núñez enlargements typically allow for a one-size prosthetic increase as they only affect the root and not the aortic annulus. The Manouguian procedure achieves a two- to three-size increase but risks distorting mitral valve function, as it is the only technique that entirely divides and enlarges both the annular and basal rings, including the aorto-ventricular junction. Yang's procedure, like the others, does not enlarge the basal ring of the aortic root. However, this is not an issue, as there are no documented cases of subvalvular stenosis. Basal rings of the aortic root are generally normal-sized even in the most stenotic valves and usually do not limit flow.

"Y"-incision root enlargement allows for a multi-size prosthetic increase, addressing short-term PPM and potentially averting it in future ViV procedures, as outcomes for valves smaller than 23 mm are suboptimal. Nevertheless, the technique has limitations. The transition from the aortomitral junction to the anterior mitral leaflet may not always be clear, and suturing in this area could jeopardize mitral valve function by restricting the anterior leaflet. Additionally, the rectangular Dacron patch may distort the coronary arteries, leading to kinking. Finally, it is uncertain whether this enlargement may ultimately distort the root, making TAVI prosthesis implantation unfeasible due to potential coronary trunk obstruction.

Only time will tell if these concerns prove real or are mere cautionary considerations. However, it is clear that our duty is to continue delivering the excellent outcomes of surgical aortic valve replacement we have achieved to date. PPM diminishes bioprosthetic durability and freedom from reintervention rates. The only setting where the

aortic root can be enlarged to prevent it is in the operating room, and the decision rests in our hands.

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Alessia Miraglia

Bicuspid Aortic Valve: Inconvenient Truths and Challenges in Clinical Management

A prospective cohort study conducted at Uppsala University Hospital in Sweden aimed to identify potential risk factors contributing to in-hospital heart failure and postoperative mortality following aortic valve replacement in patients with tricuspid and bicuspid valves.

It is well-known that aortic stenosis (AS) is the most prevalent valvular pathology globally, and the theoretical echocardiographic and symptomatic criteria for indicating surgical intervention are well-established. However, in patients with a bicuspid aortic valve (BAV), certain grey areas in its pathophysiology could prompt a reevaluation of the optimal "timing" for intervention in these cases. Thus, the authors proposed a study to delve into this aspect based on some lesser-known evidence. In 2021, in the *Journal of the American College of Cardiology: Cardiovascular Imaging*, Yang et al. observed that patients with BAV are associated with a higher risk of congestive heart failure (CHF) compared to the general population. A meta-analysis published that same year in *Echocardiography* by Chen et al. demonstrated that the hearts of BAV patients, even if asymptomatic and without valvular dysfunction, undergo structural left ventricular (LV) remodeling as early as adolescence and young adulthood. These findings corroborate evidence published in 2019 by Mahedevia et al. in the *International Journal of Cardiovascular Imaging*, showing that BAV patients typically experience increased afterload due to an eccentric BAV opening. This eccentric jet, over time, contributes to aortic remodeling, characterized by reduced elasticity of the ascending aorta and subsequent dilation.

Given the limited scientific evidence on the correlation between baseline left ventricular ejection fraction (LVEF), global longitudinal strain (a measure of ventricular function derived from two-dimensional echocardiographic imaging), and diastolic dysfunction in patients with severe AS, the purpose of the study by our colleagues in Uppsala was to analyze whether preoperative LVEF in 271 patients (152 with BAV) with severe AS (without coronary artery disease requiring revascularization or other associated valvulopathy) could influence an increase in mortality or hospitalizations. To exclude cases of CHF directly caused by surgery, patients readmitted for CHF within 30 days post-surgery were excluded from the study.

Patients were followed from January 2014 to May 2021, with a primary focus on the incidence of left ventricular failure. The statistical analyses showed that, compared with patients with tricuspid aortic valve (TAV), BAV patients presented preoperatively with the following:

- Greater degree of left ventricular hypertrophy (LVH) and higher indexed left ventricular mass (LVMI)
- Higher prevalence of LV diastolic dysfunction
- Reduced LVEF
- Elevated levels of pro-BNP and, consequently, greater presence of CHF

- Higher prevalence of preoperative conditioning with levosimendan

An association was confirmed between higher LVMI and increased prevalence of diastolic dysfunction in both patient groups (BAV and TAV), whereas the presence of coronary artery disease was significantly more common in TAV patients (likely related to the more degenerative nature and higher atherogenic burden associated with TAV AS, not to mention the higher age in this cohort).

Logistic regression confirmed a direct association between LVMI or LVH and the degree of LV diastolic dysfunction. Additionally, Cox regression analysis showed a direct correlation between valve morphology (BAV) and CHF incidence. The explanation for these phenomena lies in the underlying pathophysiology: a stenotic aortic valve chronically increases afterload, resulting in ventricular remodeling with concentric hypertrophy, decreased compliance, increased LV stiffness, and ultimately LV diastolic dysfunction.

Lastly, another aspect that warrants attention is the “pressure recovery” (PR) phenomenon. This term refers to the pressure increase distal to the valvular stenosis due to the reconversion of the kinetic energy from the jet into potential energy, which could lead to an overestimation of echocardiographic valvular gradients that would differ from the lower (and actual) gradients measured by catheterization. Based on our colleagues' findings, PR is more prevalent in patients with limited aortic remodeling, as typically seen in TAV patients, especially if the ascending aorta and/or the root are small (<30 mm). However, PR is not routinely used in AS studies. Therefore, it is logical to deduce that in BAV patients, who more frequently have associated aortic dilation, AS severity may be underestimated, potentially delaying the recommendation for invasive treatments until more advanced stages of the valvular disease. The clinical relevance of PR remains controversial. Some studies indicate it is negligible, with a maximum impact of 10 mmHg on peak gradients. However, in hypoplastic aortas (15-30 mm), it could be significant. Additionally, studies suggest that patients in whom PR was systematically incorporated into gradient calculations and who exhibited higher PR values showed lower CHF and sudden death rates, likely associated with lower true degrees of AS severity.

COMMENTARY:

Despite being a single-center study, the findings suggest that surgeons might consider revisiting the timing and echocardiographic criteria for early surgical indication in patients with AS, particularly in young BAV patients.

Could PR be a relevant phenomenon that might aid in decision-making? Opinions on this are divided. The majority of studies by echocardiographers and hemodynamicists suggest that PR is not impactful enough to cause significant discrepancies in severity assessment via Doppler echocardiography or hemodynamic study, as we previously discussed.

BAV remains a congenital heart disease warranting early diagnosis and patient follow-up from childhood, given the higher likelihood of developing AS earlier than TAV patients. We must recognize that delaying surgery for these patients results in operating on an “organized” and “hostile” structural heart disease, with poorer preoperative LVEF and an associated postoperative CHF that poses challenges for correcting established ventricular remodeling.

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Bunty Ramchandani

More Data on Aortic Root Enlargement Using Y-Incision Technique (Yang Procedure)

Retrospective, single-center study on the initial 50 cases of aortic root enlargement using Yang's technique.

The concept of patient–prosthesis mismatch (PPM) has been recognized since the 1970s, and the adverse effects of this mismatch have been well documented in numerous publications over the past two decades. In essence, PPM occurs when the implanted prosthesis is too small for the patient. This issue arises in approximately 5-10% of valve replacements, although large registries and studies indicate that aortic root enlargement techniques are employed in only 1-4% of patients. Severe PPM is defined as an indexed effective orifice area (iEOA) less than 0.65 cm^2/m^2. It is known that this condition is associated with increased morbidity and mortality, symptom persistence, and early degeneration of bioprostheses.

Today's article builds upon previous publications by Dr. Yang on his novel technique for aortic root enlargement, aimed at demonstrating its efficacy and safety. Data were collected from the first 50 consecutive cases operated within a year and a half since its description (August 2020 – February 2022). Both isolated root enlargement and concomitant surgeries were included.

The median age was 65 years, with 70% of the cohort being female and one-third undergoing reoperation. In two-thirds of cases, the surgery was performed in isolation. The preoperative mean aortic transvalvular gradient was 40 mm Hg, and the average native aortic annulus diameter was 21 mm. Following root enlargement, the median prosthesis size implanted was 27 mm, with half of the patients receiving a size 29 mm or the largest size permitted by the manufacturer. The median annulus increment was 3 sizes. Nearly 90% of patients required no blood transfusion during surgery or hospitalization. There were no major postoperative complications, including mortality, permanent dialysis-dependent renal failure, mediastinitis, or reoperation due to bleeding. One case of stroke occurred in a patient with a previous history of cerebrovascular accident. Follow-up computed tomography (CT) aortograms at 3 months showed an increase in root diameter from 27 mm to 40 mm, with no cases of pseudoaneurysm. The postoperative mean gradient was 7 mm Hg, and the mean valve area was 1.9 cm^2 at both 3 and 12 months. Additionally, improvements were observed in mitral and tricuspid valve function related to reduced afterload. At 18-month follow-up, 100% of the cohort was alive.

Dr. Bo Yang and his team consider the Y-incision aortic root enlargement procedure a safe and effective technique for increasing the aortic annulus by 3-4 sizes.

A more detailed description of the technique is available in a previous blog post.

COMMENTARY:

There are many types of valve prostheses available on the market: mechanical, biological, bovine, porcine, etc. These come in boxes decorated with various references such as serial numbers, expiration dates, and lot numbers, yet they lack the one metric that should matter most to us as surgeons—the internal diameter of the valve, i.e., the effective orifice through which all the blood of our patients must flow. This information is conspicuously absent, and the closest approximation we have is the so-called valve size, which bears no relationship to the true orifice of the prosthesis. Depending on the brand,

there may be a discrepancy of more than two valve sizes (over 4 mm) between the valve label and its true internal diameter. Furthermore, valve sizes from one manufacturer do not necessarily correspond to those from another, necessitating the use of brand-specific sizers. This would be like measuring the distance between two points based on the feet of Michael Jordan or Michael Jackson. Everyone would see the absurdity in this, yet such comparisons are permissible in the field of cardiac valve prostheses.

Why do we have so much discrepancy between different brands and measurements of the true effective orifice? All this confusion and complication began about 20 years ago with ISO standards, where the concept of tissue annulus diameter was introduced, referring to the diameter of the valve annulus after leaflet excision. Manufacturers were allowed to label prostheses based on the tissue diameter for which they were intended. Here is where considerable variability arises, particularly with supravalvular prostheses, where dimensions can be oversized. However, the relationship between tissue diameter and internal valve diameter is not always consistent. This is because we do not have standardized descriptions or definitions for the various components of valve prostheses: stent diameter, stent height, external suture ring—some parameters with lax definitions. Defining the internal diameter of a valve is more complex than we might imagine; should we measure it with a Hegar dilator? At what height do we consider the true internal diameter? Some prostheses have a diameter reduction at the cranial end. Do we measure it according to pressure drop at a known flow rate? Or is an optical measurement better? Even assessing the hemodynamics of prostheses is complex. In vitro studies are conducted with Newtonian fluids, while the viscosity of blood varies depending on its components and the applied force. Consequently, laboratory results diverge significantly from real life. If we examine various studies to determine PPM for different commercial brands, we would be surprised by the limited sample sizes on which they are based. We would realize that for certain prosthetic sizes, it is even nonexistent.

When operating on an aortic valve, we must know the true internal diameter of the prosthesis we plan to use. We must know this before bringing the patient into the operating room, despite all the confusion factors previously mentioned. This decision becomes critical when dealing with small annuli, as we risk causing PPM. We must be prudent in enlarging the aortic root and understand the hemodynamic needs of our patient, comorbidities, life expectancy, clinical situation, surgical complexity, and finally, the unique characteristics of the prosthesis we intend to choose.

Yang's procedure is an intriguing option for enlarging the aortic root and avoiding moderate or severe PPM. However, we should be aware that the results of this series are limited by the typical restrictions of a single-center, retrospective study with a small sample size, short follow-up, and, most importantly, the outcomes reflect those of a single surgeon. The results are surprisingly favorable as no reoperation for bleeding was reported, despite the aggressive nature of the root enlargement.

In conclusion, we must offer our patients the surgery they need, not the one we would prefer to perform. Aortic root enlargement makes sense to avoid moderate or severe PPM. It remains to be demonstrated whether the aggressive oversizing of prostheses provides any long-term benefit, especially if aimed primarily at obtaining larger prostheses for future valve-in-valve percutaneous approaches. As a surgical community, we need to standardize the definitions of the different components of prostheses and conduct studies based on these new universal definitions. In other words, we should measure distances in metric units and not based on the feet of Michael Jordan or Michael Jackson.

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Luis Eduardo López Cortés

What Type of Prosthetic Aortic Valve Would You Choose in a Case of Infective Endocarditis Before the Age of 65?

A multicenter Italian study presents outcomes comparing mechanical and biological prostheses in aortic valve replacement due to infective endocarditis in young patients.

This study analyzes a cohort from the prospective registry conducted by the Italian Society for Cardiac Surgery and the Italian Group of Research for Outcome in Cardiac Surgery since 1979. The analysis included the first possible or proven episode of infective endocarditis in patients aged 40–65 who required aortic valve replacement. Patients who underwent valve repair, received a homograft or autograft, underwent aortic root or ascending aorta replacement, received concurrent valve procedures, or lacked survival data were excluded.

Out of 4365 patients operated on from 2000 to 2021, 549 (12.6%) met the criteria for analysis. Propensity score matching and a 15-year survival analysis using Cox regression were performed. The overall mechanical-to-biological prosthesis ratio was 0.95, with a significant increase in bioprostheses ($p < 0.0001$) over the last 5 years (mechanical-to-biological ratio of 0.73), especially in the 40–49 age subgroup. Patients who received mechanical valves were younger (median age 52 vs. 57 years; $p < 0.001$) and more frequently female (23.9% vs. 14.2%; $p = 0.006$). Patients with bioprostheses had higher rates of heart failure symptoms (21% vs. 10.4%; $p = 0.001$), cardiogenic shock (9.6% vs. 4.9%; $p = 0.048$), and preoperative orotracheal intubation (10% vs. 3%; $p = 0.002$). They also had higher EuroSCOREs (median 6.45 vs. 4.68; $p= 0.005$) and longer extracorporeal circulation (mean 90 min vs. 79 min; $p = 0.004$) and aortic clamping times (mean 73 min vs. 65 min; $p = 0.001$). Microbiological distribution was similar regardless of the prosthesis, with approximately 30% of cases having negative cultures. Early postoperative mortality was 6.2%, with similar rates in the mechanical and bioprosthesis groups (4.1% vs. 8.2%; $p = 0.07$; OR = 0.48; 95% CI = 0.229–1.005). For long-term prognosis, 42 (15.7%) patients in the mechanical group and 66 (23.5%) in the bioprosthesis group died. Survival rates at 1, 5, 10, and 15 years were 93.9%, 89.7%, 80.3%, and 70.1% in the mechanical group, and 87.5%, 78.2%, 63.9%, and 57.5% in the bioprosthesis group, respectively. There were two deaths (0.7%) from major bleeding in the mechanical group versus one (0.4%) in the bioprosthesis group.

Despite including numerous variables in the propensity score analysis, the model's area under the receiver operating characteristic curve was 0.70. Survival curves showed a sustained advantage for mechanical valves (HR = 0.55; 95% CI = 0.32–0.93). Patients with mechanical valves had a lower cumulative incidence of recurrent infective endocarditis (2.6% vs. 5%), confirmed in the adjusted analysis (HR = 0.26; 95% CI = 0.077–0.933; $p = 0.039$).

COMMENTARY:

This study aligns with previous publications, although with a longer follow-up period. Its main objective was to determine whether one type of prosthetic valve should be preferred for young patients requiring aortic valve replacement for infective endocarditis. Key findings indicate a recent trend towards bioprosthesis in this age group, with mechanical valve recipients showing better survival and a lower probability of recurrent endocarditis. No significant differences in early postoperative mortality were observed.

Although clinical factors often guide valve choice, this decision is usually a joint one with the patient, especially in cases of infective endocarditis in patients around 60, where intraoperative findings play a crucial role. Despite the classic premise that biological materials reduce reinfection risk, this cohort's data indicate better prognoses for patients with mechanical prostheses. However, these results may be influenced by baseline differences and residual confounding, as mechanical valve recipients were younger, predominantly female, and in better clinical condition at surgery. While propensity matching was employed, residual confounding remains likely, evidenced by the model's area under the curve value and statistically significant prognostic differences that persisted post-matching. This residual confounding must be considered when interpreting the results.

Unfortunately, after reviewing this and similar studies, I am still unsure which valve type I would choose if a surgeon left the decision to me. Thus, it seems that a specific criterion cannot yet be applied, differing from other causes of aortic valve disease unrelated to infective endocarditis.

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Miguel Ángel Medina Andrade

Evolution of Aortic Valve Replacement in Asymptomatic Patients with Severe Aortic Stenosis

This single-center, observational, retrospective study evaluates early valve replacement in asymptomatic adults with severe aortic stenosis.

Severe aortic stenosis is defined as an aortic valve peak velocity exceeding 4 m/s, mean pressure over 40 mm Hg, or a valve area less than 1 cm² (indexed ≤0.6 cm²/m²). Current consensus guidelines recommend close monitoring of patients with severe aortic stenosis, particularly to detect symptoms or left ventricular systolic dysfunction, which is defined when the ejection fraction falls below 50%. However, recent years have seen a shift from expectant management in asymptomatic severe aortic stenosis due to the poor prognosis associated with sudden complications, including sudden death. Consequently, various international groups are advocating early aortic valve replacement (AVR) before symptom onset to potentially reduce left ventricular dysfunction and mortality. Studies have identified predictors of poor prognosis, highlighting the long-term survival benefit of early AVR in asymptomatic patients.

The present study analyzes the advantages of early AVR in asymptomatic patients with a mean follow-up of 8.5 years. It is a retrospective analysis based on data from 2002 to 2020, collected from routine follow-ups or cardiology visits and supplemented with mortality data. Survivors were assessed through one-year echocardiographic and survival tracking, with comparisons made by age and sex in a cohort format. Pre-AVR echocardiographic data were obtained preoperatively and included parameters such as left ventricular mass index, left atrial diameter, right ventricular systolic pressure, mean E/E' ratio, and E/A ratio, as per current echocardiographic guidelines. Post-discharge follow-up echocardiograms were recorded, with a total of 594 studies in 201 patients. The mean echocardiographic follow-up duration was 6.2 ± 0.2 years, with 25% followed for over 2 years, 75% for more than 7 years, and 10% for more than 13 years. Adverse effects analyzed included persistent or progressive left ventricular hypertrophy and diastolic dysfunction post-AVR. Mortality from all causes was analyzed according to the STS Adult Cardiac Database specifications, and survival was evaluated with Kaplan-Meier analysis, comparing age- and sex-matched survival with the U.S. general population.

In total, 272 consecutive patients with a mean age of 66.5 years, 41% of whom were female, were included. The average STS risk score was 1.94%, and 23 patients (8.5%) underwent concomitant aortic surgery. The preoperative aortic valve gradient was 45.4 mm Hg, the mean left ventricular mass index was 101 g/m², the average E/E' ratio was 14.5, and the median left ventricular ejection fraction was 60% (IQR 55-65%). There was no operative mortality, and complications in 49 patients included atrial fibrillation and acute renal failure. The median hospital stay was 6 days (IQR 5-7 days). Symptom-free survival rates were 100%, 88%, 72%, and 52% at 1, 5, 10, and 15 years, respectively. The long-term evaluation of left ventricular remodeling and diastolic dysfunction was reliable at 15 years. Severe left ventricular hypertrophy was present in 21% of patients, and 46% had diastolic dysfunction, both of which were present preoperatively. Male sex and higher preoperative left ventricular mass index correlated with an E/E' ratio >14. In the follow-up period, 44 deaths occurred, and Cox univariate analysis identified an elevated E/E' ratio and moderate or severe preoperative left ventricular hypertrophy as risk factors for reduced survival.

In conclusion, this study proposes early AVR in patients with asymptomatic severe aortic stenosis, though further studies with larger populations and extended follow-up are needed.

COMMENTARY:

Current clinical guidelines, with a IIa recommendation, identify two circumstances favoring early intervention: ventricular dysfunction associated with an ejection fraction less than 50% and severe aortic stenosis with a post-valve velocity over 5 m/s or an indexed aortic valve area (AVA) of ≤0.6 cm^2/m^2.

The primary findings of this study were that: 1) asymptomatic patients with severe aortic stenosis exhibit greater left ventricular hypertrophy and advanced diastolic dysfunction; 2) AVR improved left ventricular hypertrophy, but diastolic dysfunction did not improve, especially in patients with a preoperative E/E' >14; 3) AVR in asymptomatic patients with preserved left ventricular systolic function demonstrated excellent outcomes with no postoperative mortality; and 4) moderate to severe left ventricular hypertrophy predicts long-term diastolic dysfunction and reduces long-term survival.

Study limitations include: 1) observational and single-center design; 2) no serum proBNP-NT measurement in a relatively young (mean age 66 years) and possibly active population; 3) non-standardized data collection in echocardiograms; the E/E' ratio, a reliable diastolic dysfunction predictor, is recommended to be supplemented by the E/A ratio, tricuspid regurgitation velocity, and indexed left atrial volume.

In essence, this study evaluates the long-term outcomes of AVR in asymptomatic patients with severe aortic stenosis and preserved left ventricular function, essential for determining the appropriate timing of aortic valve replacement. Understanding the prognostic implications of severe asymptomatic aortic stenosis is crucial, as these patients may experience sudden acute events or sudden death before symptom onset, guiding a more proactive treatment approach. Severe aortic stenosis also interacts with other cardiovascular and metabolic diseases that impact long-term prognosis, as do delays in healthcare access, especially in resource-limited settings. Thus, early intervention in this pathology is compelling, while acknowledging that not all patients are clear surgical candidates, as reflected by the low-risk profile of the cohort in this study.

Current evidence advises caution in patient selection, avoiding any expectation of mandatory treatment; evidence of significant improvement in adverse prognostic indicators remains insufficient.

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Laura Sánchez Campaña

Aortic Valve Replacement with Carpentier Edwards Magna Ease® Bioprosthesis: A Decade of Follow-Up

This article retrospectively analyzes clinical and hemodynamic outcomes in 689 adults who underwent surgical aortic valve replacement with the Carpentier Edwards Magna Ease® bioprosthesis over a ten-year follow-up.

Aortic valve replacement (AVR) remains the standard treatment for advanced aortic valve disease, supplemented by transcatheter aortic valve implantation. In the 1970s, bovine pericardial prostheses were introduced to enhance hemodynamic outcomes and mitigate the risk of structural valve degeneration compared to their porcine predecessors. Over time, successive generations of these prostheses have improved durability.

The Carpentier Edwards Magna Ease® bioprosthesis, introduced in 2008, evolved from previous Carpentier Edwards PERIMOUNT® models. While short- and mid-term results for this device have shown promise, long-term outcomes in clinical practice have yet to be thoroughly explored. This study aims to assess long-term clinical outcomes, hemodynamic performance, and durability of this bioprosthesis.

From January 2010 to December 2012, 871 patients underwent AVR with the Carpentier Edwards Magna Ease® bioprosthesis. Isolated and combined procedures (e.g., coronary artery bypass grafting, mitral valve surgery, or ascending aorta procedures) were included. Patients under 18, cases involving concomitant aortic annular enlargement, and bioprosthesis placement in other positions (mitral/pulmonary) were excluded. Retrospective preoperative, intraoperative, and postoperative data were collected from the remaining 689 cases in an anonymized database.

The primary endpoint was the likelihood of structural valve degeneration (SVD). Additional variables included clinical and echocardiographic outcomes and major events, such as mortality, endocarditis, non-structural prosthetic degeneration, and the need for repeat AVR.

The mean follow-up period was 7.9 ± 2.5 years. The average age was 70.8 years, with a predominance of male patients (64.4%). Severe aortic stenosis was the main indication for surgery (82.6%). More than half of the patients underwent isolated AVR (55.3%), with coronary artery bypass grafting being the most common concurrent procedure. The mean ICU stay was 2.6 days, and the mean hospital stay was 8.9 days. Postoperative complications included atrial fibrillation in 28.4% of patients, with 2% requiring pacemaker implantation, and only two patients required reoperation due to paravalvular leak.

At ten years, the cumulative incidence of cardiovascular mortality was 6.7%, with a 1.9% rate of repeat aortic valve surgery. Endocarditis accounted for 52.3% of reoperation cases. The cumulative incidence of moderate SVD was 3.6%. Prosthetic mean gradient exhibited a slight increase over time, rising from 11.3 ± 5.2 mmHg in the first year to 12.6 ± 7.4 mmHg at ten years ($p < 0.01$).

Subgroup analysis indicated a higher incidence of events among younger patients: structural valve degeneration (9.7% for <65 years vs. 2.7% for >75 years, $p = 0.013$) and prosthesis reoperation (7.8% for <65 years vs. 0.4% for >75 years, $p = 0.02$). No

significant differences were found based on prosthetic size. Infectious endocarditis incidence was similar across age and prosthetic size categories ($p > 0.05$).

The authors conclude that the long-term outcomes of the Carpentier Edwards Magna Ease® bioprosthesis, in terms of freedom from structural valve degeneration or prosthetic endocarditis, hemodynamic values, and clinical outcomes, are superior to those of other aortic bioprostheses and previous generations. These findings extend the positive results observed at mid-term follow-up (3–5 years).

COMMENTARY:

This study is one of the few that evaluates long-term outcomes for the Carpentier Edwards Magna Ease® bioprosthesis. The third-generation bioprosthesis is widely used in our region, and the data collected, including serial testing and prosthesis-related events, optimally represent its ten-year performance.

This study provides a new perspective on AVR, offering an optimal prosthesis choice for patients over 60–65 years of age. Following this publication, we might aim to optimize outcomes in younger patients, where a higher complication rate is observed, considering their longer life expectancy. Extended follow-up beyond ten years would be valuable to assess how the prosthesis performs in younger patients over time.

Thanks to this study, we have reliable data on this bioprosthesis, ensuring a low risk of reoperation and long-term complications post-AVR. This information addresses patient concerns regarding surgery, offering statistically significant and reasonable prognostic data.

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Pascual Ortiz Rodriguez

Biological Aortic Valve Replacement in Young Patients with Bicuspid Aortic Valve: Is It Still a Viable Option?

This article analyzes outcomes from 498 patients under the age of 65 with bicuspid aortic valve (BAV) undergoing aortic valve replacement (AVR) with bioprostheses due to aortic stenosis (AS).

Bicuspid aortic valve (BAV) is among the most common congenital malformations, though its true prevalence in the population is likely underestimated, as it often functions normally and may remain asymptomatic when pathological changes occur, thus being diagnosed incidentally. One of its clinical presentations, which is also the focus of this study, is aortic stenosis (AS). It is noteworthy that there is a strong association between BAV and aneurysmal pathology of the aortic root and ascending aorta.

When younger patients with BAV present AS, several factors must be considered in determining an appropriate approach. These include choosing a prosthesis that provides durable valve replacement and strategies to address the potential need for future interventions. This article aims to evaluate short- and long-term outcomes of surgical aortic valve replacement (SAVR) in patients under 65 with AS, focusing on bioprosthetic valve durability and reintervention needs. Additionally, it compares the combined approach of AVR and aneurysm repair in patients with BAV to AVR alone.

All patients under 65 who underwent SAVR for AS were included, excluding those who underwent concomitant treatments (except aneurysm repair and atrial fibrillation ablation) or had mechanical valves or non-elective surgeries.

Unicentric data from 498 patients under 65 years, collected between April 2004 and September 2022, were analyzed. Patient follow-up included clinical and echocardiographic data, with a mean echocardiographic follow-up of 5.0 years (range: 2.0–9.6 years), during which patients received an average of four echocardiograms. Clinical follow-up averaged 5.0 years (range: 1.8–9.9 years).

Among BAV anatomic presentations, 83% displayed Sievers type I morphology, predominantly with left-right fusion. Patients undergoing valve replacement with simultaneous aneurysm repair (AR) had a higher likelihood of moderate/severe aortic insufficiency (35%) compared to those who underwent AVR alone (25%; $p = 0.02$). The mean aortic diameter of patients undergoing AVR compared to those with concurrent aneurysm repair was 3.8 cm and 4.8 cm, respectively ($p = 0.001$).

In terms of operative mortality, no significant differences were found between the two cohorts, with an overall operative mortality of 1.0% (0.7% AVR vs. 1.4% AVR + AR; $p = 0.77$). Similarly, permanent pacemaker implantation prior to hospital discharge was required in 1.8% of patients with isolated AVR vs. 1.4% in those with AVR + AR. However, patients undergoing AR exhibited a higher incidence of post-surgical strokes: 3.2% AVR + AR vs. 1.1% AVR; $p = 0.99$.

Patients undergoing isolated AVR had shorter hospital stays compared to those who had both AVR and AR, with a mean of 4 vs. 5 days, respectively ($p = 0.001$). Only 5% of patients who underwent AVR experienced bioprosthetic valve failure within the first three years post-surgery.

After an average follow-up of 5 years, only 37 patients required reintervention. At 10 years, overall survival was 90%, with no differences between groups. The cumulative probability of reintervention at 5 years was 0.3%. No mortality trend differences were observed between patients based on age and sex.

Based on the data, researchers concluded that, given the high prevalence of AS due to BAV in patients under 65, excellent postoperative results, and the minimal reintervention needs presented by both isolated AVR and AVR + AR, surgical intervention with bioprosthetic implantation remains a sound approach for initial treatment of these patients, whether the valve pathology is isolated or associated with concomitant aortic disease.

COMMENTARY:

This article advances the discussion on care approaches for valve pathology, specifically AS associated with BAV. The findings reinforce that surgical intervention aligns with recommendations from previous studies for addressing AS in patients with low surgical risk and minimal comorbidities, such as those under 65.

Another notable aspect is the comparison between patients undergoing isolated AVR and those who had concurrent aortic aneurysm repair, demonstrating comparable outcomes in most variables, including mortality, reintervention needs, and immediate postoperative outcomes. This lack of statistically significant differences supports a more aggressive surgical approach in low-risk patients with aneurysmal disease (repair at 4.5 cm systematically). However, it is also significant that in isolated AVR patients, the onset of aortic pathology did not occur post-correction of valve disease, suggesting a linkage between both pathologies until surgical intervention. Thus, if the aorta shows no significant pathology at the time of surgery, isolated AVR may be safely considered.

In summary, this article builds upon our understanding of managing this pathology and opens avenues for future research on valvular disease in younger patients and on the clinical heterogeneity of bicuspid aortic valve (BAV).

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Beatriz Vera Puente

Reducing Limitations in the Use of Sutureless Prostheses: Study on the Need for Permanent Pacemaker Post-Implantation

International multicenter SURD-IR registry report on pacemaker implantation following sutureless and rapid-deployment prostheses.

Degenerative aortic valve disease represents the most prevalent valvular condition in our setting, with aortic valve replacement being the treatment of choice for severe cases. In recent years, new valve replacement techniques have emerged, blending traditional surgical aortic valve replacement (SAVR) principles with transcatheter aortic valve implantation (TAVI) approaches. This development has led to the advent of sutureless (SS) and rapid-deployment (RD) bioprostheses.

The aim of this study is to determine whether the need for permanent pacemaker implantation is genuinely higher in SS and RD prostheses, to investigate underlying mechanisms, and to clarify potential confounding factors.

This investigation is based on data from the SURD-IR international multicenter registry, involving 19 centers. A total of 4166 patients undergoing SAVR between January 2008 and April 2019 were included and divided into two cohorts for subgroup analysis due to structural differences between the prosthesis types: sutureless (SS) and rapid-deployment (RD). The incidence of permanent pacemaker implantation during hospitalization was analyzed. A reduction in implantation rates from 8.1% to 5.9% across the study population was observed starting in 2017, leading to the division of each cohort into early and late groups based on this finding.

Patients in the late group were significantly younger and had lower EuroSCORE II values in both cohorts. In the SS cohort, the late group showed not only younger age but also a significantly higher incidence of aortic regurgitation. Although smaller prostheses were increasingly used, the reduction in pacemaker implantation rates was also significant with the use of larger prostheses (L and XL). The incidence of concomitant procedures (mainly revascularization and myectomies) also decreased significantly in the late group compared to the early group.

In patients receiving an RD prosthesis, the incidence of concomitant procedures, particularly septal myectomy, increased from 1.9% to 3.8% in the late group, with a nonsignificant increase in pacemaker implantation rates observed in this group as well.

This study indicates a decrease in pacemaker implantation in SS prostheses while remaining stable in RD prostheses. However, significant temporal differences, such as the reduction in mean age or lower incidence of pure stenosis, should be considered. Appropriate patient selection and greater precision in prosthesis sizing may explain these findings.

Limitations of this study may include variations in data collection as it is a multicenter, retrospective study. Additionally, the main focus is conduction disturbances, yet preoperative electrocardiographic data are not provided.

COMMENTARY:

In recent years, significant changes have occurred in the treatment of aortic valve disease, and the introduction of transcatheter prostheses has revitalized valve

replacement techniques. The emergence of sutureless and rapid-deployment bioprostheses offers advantages such as reduced ischemia and extracorporeal circulation times. However, concerns about potentially higher complication rates compared to conventional SAVR have limited their use.

One such complication is the need for permanent pacemaker implantation, traditionally higher than with conventional SAVR and comparable to TAVI. This study aims to clarify some of the mechanisms underlying the increased pacemaker incidence, using a well-divided cohort design. Although both types of bioprostheses (SS and RD) share common characteristics, they are structurally distinct, potentially explaining differing incidence rates. However, the real differentiating factor in the results is that the temporal subgroups in the SS cohort are not comparable, given the significant differences in baseline patient characteristics.

It is in these differences that we should perhaps focus, as it is among younger patients with a lower incidence of severe stenosis that sutureless prosthesis outcomes improve substantially. This finding echoes an established lesson: appropriate patient selection often yields better outcomes.

Consequently, innovations initially designed to meet the needs of older patients requiring shorter surgical times may also be suitable solutions for lower-risk patients, allowing them to benefit from the same advantages without incurring higher complication rates.

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José Manuel Martínez Comendador

Sutureless Perceval® Valve Procedures: Thirteen-Year Experience in 784 Patients

This retrospective analysis examines both short- and long-term outcomes (spanning thirteen years) of patients treated with Perceval® sutureless valves at a single Belgian center.

There is an increasing body of evidence supporting percutaneous aortic valve implantation (TAVI) for treating aortic stenosis, including low-risk patients (as studied in PARTNER 3 and DEDICATE trials, previously analyzed on this platform). This evidence primarily stems from clinical trials comparing TAVI with surgical aortic valve replacement (SAVR) using conventional sutured prostheses, with limited studies contrasting TAVI with sutureless surgical valves. The Perceval® sutureless prosthesis (Corcym®), crafted from bovine pericardium on a self-expanding nitinol stent and introduced in 2007, has consistently demonstrated excellent clinical outcomes, safety, and adaptability, facilitating minimally invasive approaches and combined surgeries (results validated in meta-analyses and several studies reviewed on this platform). Among the few drawbacks identified was the high pacemaker implantation rate, initially linked to oversizing. However, this has been mitigated by the sizing adjustment strategy introduced in 2017, confirmed by a recent international multicenter registry (SuRD-IR) involving 19 centers (also reviewed on this platform). Another concern was limited long-term data on the prosthesis's durability due to a lack of studies. This study aims to shed light on the long-term experience and outcomes of the sutureless Perceval® valve at UZ Leuven Hospital (Belgium) after 13 years of cumulative experience.

A retrospective analysis was conducted on postoperative and follow-up data of all patients treated with this sutureless prosthesis (isolated or combined surgery) between 2007 and 2019. A total of 784 patients were treated. The mean age was 78 years, with a EuroSCORE II of 4.2% (interquartile range, 2.6%-7.2%). SAVR accounted for 45% of cases; 30% involved concomitant coronary surgery, and the remaining 25% consisted of other types of intervention. Median ischemic times were 38 minutes for isolated SAVR, 70 minutes for coronary cases, and 89 minutes for multiple valve surgeries. Prosthesis implantation success was 99.1%, and in-hospital mortality was 3.3%. Postoperative stroke or transient ischemic attack (TIA) occurred in 1.9% of patients, and 1% required dialysis post-surgery. Median survival was 7.0 years, with a cumulative follow-up of 2797.8 patient-years. The freedom from reintervention at 1, 5, and 10 years was 99%, 97%, and 94%, respectively.

The authors conclude that these data represent the longest available follow-up for the Perceval sutureless prosthesis. Favorable early outcomes, with low rates of early mortality, stroke, and other major complications, were observed. The valve's durability is promising, with low valve degeneration rates and a limited need for reintervention.

COMMENTARY:

The study discussed today was conducted in a center with extensive experience in the use of the Perceval® prosthesis. Similarly, the Complexo Hospitalario Universitario de A Coruña (CHUAC) has also accumulated significant experience with this prosthesis. From 2013 to January 2024, we performed SAVR with Perceval in 1,559 patients, marking the largest single-hospital series worldwide to date. While our results are pending publication

in the coming months, we will use this platform to preview, share, and compare them with the findings of this study.

The ease of implanting this prosthesis, which requires only three guiding sutures and minimal manipulation of the aortic root, allows for reduced surgical and ischemic times. This results in several clinical benefits, such as low mortality rates despite high-risk profiles, a low incidence of adverse events like stroke, and a reduction in dialysis requirement, among others. Additionally, this type of prosthesis enables the use of minimally invasive techniques in isolated SAVR cases. In experienced hands, it can be an effective solution in complex cases such as reoperations, endocarditis, extended combined surgeries, or calcified aortic roots.

The overall 30-day mortality rate in this study was low (3.3%), slightly lower than predicted. Similarly, the overall mortality at CHUAC was 3.4%, with an isolated SAVR mortality rate of 1.8% achieved via ministernotomy.

In the study by Lamberigts et al., only 45% of cases were isolated SAVR (75.7% in our series), with 30% involving concomitant coronary surgery (15.9% in our case) and the remaining 25% representing other types of intervention (8.4% at CHUAC). Our experience illustrates the versatility of this prosthesis in diverse clinical contexts, as reflected in the 43 cases of endocarditis, 89 reoperations, and 86 concurrent mitral surgeries performed.

At Leuven Hospital, 47.9% of isolated SAVR cases with the Perceval® prosthesis were performed via minimally invasive surgery. This percentage significantly increased to 84% in the last two years. In contrast, the minimally invasive surgery rate for sutured prostheses generally reached only 20%. At our hospital, 73.7% of isolated SAVR cases with sutureless prostheses were performed via ministernotomy, underscoring and confirming the ease of performing minimally invasive surgery with these prostheses.

Additionally, it is worth highlighting the short ischemic (51 minutes) and cardiopulmonary bypass (CPB) (81 minutes) times achieved in this study, similar to other notable published registries. However, our surgical times were clearly superior, with isolated SAVR ischemic times of 31 minutes or 38 minutes for the overall series. Furthermore, we published years ago that this prosthesis democratizes the surgical technique, as no significant differences were observed among surgeons in terms of surgical times or clinical outcomes. This suggests that it is a reproducible technique that minimizes operator-dependent disparities.

The incidence of postoperative complications in this series was also low. The combined incidence of stroke and TIA was 1.9% (1.5% at our hospital), and the dialysis requirement rate was 1% (1.6% at our hospital). The relatively long hospital stay (2 days in the ICU, 11 on the ward) can be explained by peculiarities such as limited patient transfer to other hospitals for recovery completion in this elderly cohort. At CHUAC, our stay was significantly shorter, with 2.5 days in the ICU and 6.1 days on the ward, aligning more with expected outcomes for this patient type and procedure.

In terms of long-term outcomes, with a median follow-up of 7 years, a very low reintervention rate was observed. The 1-year survival of 91.5%, with a 1-year reoperation-free survival rate of 99.2%, is comparable to other studies using conventional prostheses. Five- and ten-year survival rates of 70.8% and 27.3%, respectively, align with those expected for a population with a mean implantation age of 78 years. However, among surviving patients at ten years, the incidence of serious prosthesis-related complications, such as structural valve deterioration (SVD) or endocarditis, was low (22.3%). The five-year survival rate of 78.8% in our A Coruña

series slightly exceeds that of this study, possibly due to the lower mean patient age in our series (74 vs. 78 years).

The ten-year freedom from reintervention in this study was 94%. Most reinterventions were due to endocarditis, with only three cases of SVD. These results corroborate previous publications from our group, where, with an average echocardiographic follow-up of over three years, no severe SVD and a very low rate of moderate SVD were observed. It is important to note that in cases of severe SVD in a Perceval® prosthesis, TAVI valve-in-valve has emerged as a valid and safe alternative, as demonstrated in multiple publications. On the other hand, the Lamberigts et al. study found a low endocarditis incidence, with a 0.46% annual rate, similar to that of other studied prostheses.

The hemodynamic outcomes in the Leuven series were favorable, with mean and peak gradients of 11 mmHg and 20 mmHg, respectively, and an EOA of 1.5 cm^2 at the latest follow-up. These results are practically superimposable to those in our series. Paravalvular leak incidence was only 1.3%, comparable to results in our center.

Avoiding prosthesis oversizing is critical to prevent complications such as elevated gradients or an excessive need for pacemaker implantation, as demonstrated by our hospital over seven years ago and corroborated in the recent international multicenter registry (SuRD-IR). This has been confirmed again in a sub-study of this series, analyzing patients before and after 2017, when the sizing technique was modified to select a prosthesis smaller than initially recommended. The overall pacemaker implantation rate was 8.8%, surpassing the rate observed in our hospital (overall rate of 5.06%), compared to the 13.1% rate in 2014.

In summary, the results of this study, as well as those from our CHUAC series soon to be published, support the positive short-term and, more importantly, long-term outcomes of this sutureless prosthesis, as previously observed in earlier studies. Additionally, they confirm its versatility across various contexts, the reduction in surgical times, and the simplicity of use in minimally invasive surgeries without any penalty.

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Elisabet Berastegui Garcia

Mini-Approaches and Sutureless Prostheses… TAVI Is Not the End of Aortic Valve Surgery: Expert Commentary

Commentary by the expert Dr. Elisabet Berastegui on the role of minimally invasive surgery combined with sutureless bioprostheses in the current context.

In the field of aortic valve surgery, no absolute truth exists regarding which type of prosthesis may prove most durable and resilient, especially considering outcomes like zero endocarditis or minimized morbidity. Given the absence of an ideal substitute, the pursuit of the best option must remain our guiding principle.

Aortic stenosis is the most prevalent valvular heart disease, accounting for up to 12% of cases in individuals over 75 years, with approximately 4% meeting criteria for severe disease. The primary etiology is degenerative, particularly in developed, aging countries like Spain.

Aortic valve replacement (AVR) remains the sole therapy with proven impact on the natural history of aortic stenosis. Although surgical AVR has long been the gold standard, transcatheter aortic valve implantation (TAVI) has emerged as the treatment of choice for inoperable and high-risk patients and as a viable alternative for those at intermediate risk. Recently, sutureless AVR (SU-AVR) has been introduced as another alternative to conventional AVR. The Perceval S bioprosthesis (Corcym Srl, Sallugia, Italy) is the most widely used sutureless aortic bioprosthesis, with over 10000 implants globally. It has demonstrated a reduction in operative times and excellent medium- to long-term outcomes in terms of morbidity and mortality, particularly in challenging cases (small aortic roots or annuli, reoperations, etc.), as discussed in previous blog entries.

Some of the longest series, such as that by Dr. Meuris, now exceed 12 years of durability with favorable outcomes in terms of freedom from reintervention or valve-in-valve implantation.

Sutureless prostheses and TAVI are complementary procedures within the therapeutic arsenal for managing high-risk aortic valve disease patients. In the case of sutureless prostheses, they have also contributed significantly to advances in minimally invasive surgery, which clearly offers not only aesthetic benefits but also a reduction in postoperative morbidity (hospital and ICU stays, intubation duration, etc.).

The increase in early diagnosis through health education programs beyond tertiary care has already borne fruit in the diagnosis of aortic disease, with a corresponding rise in the number of patients referred for either surgical treatment or TAVI. Therefore, caution is warranted when interpreting study outcomes. For example, major trials such as AVATAR demonstrate the superiority of surgical treatment over conservative management in terms of morbidity and mortality. However, the favorable results of EARLY TAVR and EVOLVED should be critically evaluated for not emphasizing two crucial factors:

1. Evaluation of percutaneous treatment of aortic stenosis versus conservative management.

2. Consideration of cardinal factors such as patient age or valve anatomy, given that patients with bicuspid valves experience poorer durability and complication rates (pacemaker need, embolic events) in this profile. Approximately one month ago, and as recently published on our blog, the AUTHEARTVISIT study offered a realistic view of TAVI survival, consolidating

one of the largest published experiences to date. It reinforces the need for critical evaluation of observational versus multicenter studies, highlighting TAVI's survival reality and reinforcing the benefits of surgical treatment.

Consequently, our focus should be on enhancing surgical processes: minimally invasive surgery with sutureless prostheses, as well as improved patient preparation and recovery protocols (e.g., implementation of RICC pathways), to optimize short-term outcomes, hospital stays, and initial morbidity associated with surgery.

Despite the advent of minimally invasive surgery in Spain in the early 1990s, the rise and establishment of minimally invasive programs have been driven by SU-AVR, simplifying procedures and reducing operative times. Numerous individual studies and meta-analyses highlight aesthetic and recovery benefits, along with reduced transfusion needs, renal insufficiency, etc. Relative contraindications for minimally invasive surgery include reoperations, emergency surgery, or severe thoracic deformities, yet the convenience of minimally invasive approaches has led to their consideration in a growing number of groups for isolated aortic valve surgery and aortic root or ascending aorta surgery.

The emergence of robotic surgery has also impacted minimally invasive surgery in recent years. However, it has yet to achieve the necessary weight to establish it as the gold standard, being technically demanding and selectively adopted by specific groups. Thus, minimally invasive surgery, with its reproducibility via third-fourth intercostal J-shaped, inverted T, or anterior right second intercostal space incisions, or even periareolar approaches, must be recognized as the gold standard for isolated AVR.

Despite the considerable number of us performing minimally invasive aortic procedures, our society lacks comprehensive "evangelization" and dissemination of our outcomes. We must emphasize observational studies and group experience descriptions, particularly publishing results in aortic surgery. SU-AVR in minimally invasive settings allows us to compete at the same level in high- and moderate-risk surgical scenarios as TAVI.

Emphasis should be placed on the durability of sutureless prostheses versus TAVI, with studies showing a 92% freedom from reintervention rate in younger patients (under 75 years), as well as the impact of pacemaker implantation on quality of life, which remains significantly higher in TAVI (8-30% in some series) compared to 3-5% in SU-AVR.

In conclusion, offering the best therapeutic option in our commitment to patient care is essential in our quest for excellence. We must support minimally invasive techniques with sutureless prostheses as an ideal therapeutic option in aortic valve disease for patients over 70. The future must be shaped by continuous learning, fitting for a modern, evolving medical field. Our collaboration with hemodynamics specialists should be diplomatic and equal, sharing a unified goal: to pursue the best therapeutic option for our patients. Only by adapting to new strategies (expanding minimally invasive surgery) and learning through continuous feedback can we overcome the hesitation seen in some groups where TAVI activity is more aggressive. And certainly, promoting favorable outcomes in terms of morbidity and durability of AVR is paramount. Observational and longitudinal studies bear scientific weight, potentially exceeding that of randomized studies, in an era where Bayesian statistics is gaining prominence over probabilistic methods.

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Miguel González Barbeito

State-of-the-art in sutureless aortic valve replacement: where do we stand?

Critical evaluation of the methodology and results of the review published in JACC on the main studies investigating the efficacy and safety of sutureless aortic prostheses compared to conventional aortic valve replacement.

Aortic valve replacement (AVR) has seen significant advancements with the introduction of sutureless valves nearly a decade ago. These valves promised to improve surgical outcomes, reduce postoperative complications, and facilitate minimally invasive approaches. This summary focuses on the critical evaluation of the methodology and results of the extensive review recently published in *JACC* that encompasses all major studies investigating the efficacy and safety of these valves compared to conventional aortic valve replacement.

In the referenced article, a systematic literature review was performed, including only two randomized clinical trials (only one with a substantial sample size), one weighted study, and mostly retrospective observational studies comparing sutureless or rapid deployment prostheses, such as Perceval® and Intuity®, with conventional valves. Studies reporting data on 30-day mortality, postoperative complications, and long-term outcomes (within the limitations of analyzing prostheses with just a decade of usage in our setting) were included. The search was conducted in databases such as PubMed, Cochrane Library, and ClinicalTrials.gov, using specific terms related to sutureless aortic valves.

The methodologies of the reviewed studies varied, but many employed multicenter designs, increasing the external validity of the findings. However, limitations were observed in some studies, such as sample size and heterogeneity of patient populations. Most studies included patients with severe aortic stenosis, excluding those with significant comorbidities that could affect outcomes.

The reviewed results indicate that sutureless valves may offer advantages in terms of perioperative times and reduced need for blood transfusions. Specifically, a reduction in aortic cross-clamp time and overall surgery duration was reported, which we know can directly contribute to faster postoperative recovery. Additionally, 30-day mortality rates were comparable between sutureless and conventional valves, suggesting that the safety of these valves is acceptable.

Regarding postoperative complications, studies showed a lower incidence of reintervention-requiring postoperative bleeding in patients receiving sutureless valves. However, some research highlighted an increase in the incidence of mild-to-moderate valvular dysfunction during long-term follow-up, raising questions about the durability of these valves compared to conventional ones.

Long-term results, though promising, require extended follow-up to evaluate the functionality and durability of sutureless valves. Some studies have reported similar reintervention rates between the two groups, but the lack of long-term data in broader populations limits the ability to draw definitive conclusions.

In summary, the evidence suggests that sutureless aortic valves may be a viable and safe option for aortic valve replacement, with potential benefits in surgical time and postoperative complications. However, further research is needed to address concerns regarding the durability and long-term function of these valves compared to traditional techniques.

COMMENTARY:

The literature review on sutureless aortic valves reveals an encouraging landscape regarding their efficacy and safety. The methodologies employed in the analyzed studies, although varied, generally rely on multicenter designs that strengthen the validity of the results. However, it is crucial to consider the inherent limitations of these studies, such as sample size and heterogeneity of the populations, which may influence the generalizability of the findings.

The results indicate that sutureless valves offer significant operative advantages, such as reduced aortic cross-clamp time and decreased need for blood transfusions. These aspects are particularly relevant as it is widely demonstrated in our specialty that minimizing surgical trauma can translate into faster recovery and fewer complications.

Despite the excellent results, concerns about long-term valvular dysfunction and durability of these valves must not be underestimated. The need for prolonged follow-up is evident, and therefore, more studies focused on prosthetic valve degeneration for this type of prosthesis are required.

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José Manuel Martínez Comendador

Cardiac Surgery Following TAVI: Confirming Concerning Outcomes

A retrospective analysis was conducted to evaluate the evolution and outcomes of cardiac surgery in patients with prior TAVI, utilizing data from the STS database from 2012 to 2023.

Surgical aortic valve replacement (SAVR) has consistently demonstrated favorable outcomes in both short- and long-term contexts. The advent of transcatheter aortic valve implantation (TAVI), initially designed for patients with prohibitive surgical risk and later extended to those with intermediate or even low risk, particularly those over 75 years of age, has led to exponential growth in its application across industrialized nations. This trend has consequently increased the number of patients with these percutaneous biological prostheses. Over time, it is expected that some of these prostheses may experience structural degeneration or prosthetic dysfunction due to complications such as endocarditis or paravalvular leaks, necessitating further surgical intervention. Moreover, these patients may develop other cardiovascular conditions, especially given that lower-risk patients with high long-term survival prospects are now being treated, which were either not present or untreated at the time of the TAVI procedure, thus requiring subsequent intervention. It is anticipated that in the coming years, the number of reinterventions in patients with these prostheses will increase in line with their expanded use.

This study aimed to analyze the current trends and outcomes of cardiac surgery in patients who had previously undergone TAVI in the United States. For this purpose, the Society of Thoracic Surgeons (STS) Adult Cardiac Surgery Database was used to evaluate all adult patients who had undergone cardiac surgery after receiving a TAVI between January 2012 and March 2023. A general cohort and two subcohorts were identified: non-SAVR cardiac surgeries and SAVR after TAVI. These cohorts were analyzed through descriptive statistics, trend analysis, and 30-day outcome evaluation.

A total of 5457 patients were identified, of whom 2485 (45.5%) underwent non-SAVR cardiac surgery and 2972 (54.5%) underwent SAVR. The frequency of cardiac surgery after TAVI increased by 4235.3% overall, with an annual increase of 144.6% throughout the study period. Operative mortality and stroke rates were 15.5% and 4.5%, respectively. Existing STS risk models performed poorly, as observed versus expected mortality ratios were significantly disparate. Among those who underwent SAVR after TAVI, preoperative surgical urgency, age, dialysis, and concomitant procedures were associated with increased mortality, while the type of explanted TAVI prosthesis was not.

The authors concluded that the demand for cardiac interventions, including SAVR after TAVI, is rapidly increasing. Associated risks are higher, and outcomes are worse than anticipated.

COMMENTARY:

Since TAVI approval for intermediate- or low-risk patients (over 75 years of age) as it was deemed non-inferior to SAVR in this patient group, and with the aging population, the indications for TAVI use have grown exponentially. However, numerous criticisms surround the conduct and evaluation of results from these clinical trials, which are shifting TAVI indications. These criticisms include highly selected study populations (patients

without bicuspid aortic valves, average age above 70 years, preserved cardiac function, etc.), high pacemaker implantation and paravalvular leak rates, lack of long-term durability data, and 5-year results seemingly favoring surgery (as recently discussed on our blog). Conversely, the favorable outcomes of SAVR in low-risk, younger patients and even those with bicuspid aortic valves fuel ongoing controversy.

Regardless, TAVI's advancement is relentless, meaning we face the inevitability of reintervening on many of these patients in the near future. Two contrasting reintervention approaches merit attention: valve-in-valve versus surgical reintervention. These two alternatives yield notably different outcomes, as we discussed in detail on our blog. For example, Makkar et al., in a recent study published in *The Lancet*, demonstrated that redo-TAVI using the "valve-in-valve" technique with balloon-expandable prostheses resulted in low procedural complication rates and mortality and stroke rates comparable to those seen in patients undergoing TAVI for native aortic valve stenosis with a similar clinical and predicted risk profile. This suggests that "valve-in-valve" could be a reasonable option for selected patients with dysfunctional percutaneous bioprostheses, where feasible. Conversely, many patients with dysfunctional percutaneous prostheses are unsuitable for percutaneous treatment, as in cases of endocarditis, paravalvular leaks, mismatch with the second implant, technical factors such as coronary occlusion risk, among others. Thus, surgical treatment remains the only viable alternative. Reintervention in patients with percutaneous prostheses proves to be a high-risk operation, as demonstrated in numerous publications, including Fukuhara et al., which we reviewed on our blog nearly a year ago.

The present study refutes what seemed to be a trend in outcomes and provides valuable insights into this type of intervention:

- Firstly, the annual incidence of cardiac surgery following TAVI is exponentially increasing, particularly SAVR, since low-risk TAVI approval in 2019.

- Secondly, the observed operative mortality for SAVR following TAVI is high, with an overall mortality rate of 15.8%, consistent with previous studies.

- Thirdly, TAVI explant and subsequent surgical implant required an operation involving the aortic sinuses or root in 28.8%, with full root replacement necessary in 13.4%.

Given all the aforementioned doubts about the outcomes of recent low-risk clinical trials, we now face the fact that the risk of mortality and morbidity associated with SAVR following TAVI is 5 to 10 times higher than with a primary SAVR. This further complicates decision-making by the Heart Team when evaluating aortic stenosis in patients potentially eligible for either alternative.

Several contemporary reports, including large institutional series, have observed a recent increase in high-risk TAVI explant and SAVR for premature structural valve degeneration or paravalvular leaks. Other national multicenter registries further confirm the technical complexity and elevated mortality of TAVI explant and SAVR, ranging from 13% to 19%. The present study provides the most up-to-date STS analysis, examining national trends and outcomes for this rapidly expanding operation. Compared to the predicted risk of primary SAVR for aortic stenosis, typically between 1% and 2% mortality for most patients, the mortality risk for non-urgent SAVR following TAVI was over 15%. The corresponding increase in major morbidity risk, such as stroke (4.5%) and renal failure (11.1%), and the need to perform an aortic or root procedure in nearly a third of

patients, clearly differentiate non-AVR cardiac surgery and SAVR following TAVI as more complex operations from both technical and outcome perspectives. This might warrant exploration of a new independent risk model for these operations in the future.

There are no significant tips or tricks regarding surgical technique, but from the description of multiple published clinical cases, several recommendations can be drawn:

- The recommended approach is median sternotomy, as hemi- or mini-sternotomy may be insufficient for repairing damage and/or replacing the aortic root, performing coronary bypass surgery, or conducting concomitant mitral valve surgery.

- Retrograde cardioplegia administration is highly recommended due to the low viability of direct cardioplegia perfusion through the coronary ostia.

- A high aortotomy is advised, especially with self-expanding prostheses, following a “J” shape. Once the prosthesis is identified, the aortotomy is extended to the aortic annulus in the noncoronary sinus.

- The next step is to find a dissection plane between the aortic valve and the prosthesis. Cold solution is recommended to help contract the nitinol frame of self-expanding prostheses (cold cardioplegia aids in this effect). For balloon-expandable prostheses, two Kocher clamps or similar tools can be used to maneuver and deform the frame.

- Some authors also recommend placing a silk or 3-0 polypropylene suture through each of the three proximal cells of the prosthesis and tightening it to counteract the radial force during extraction, allowing a deeper dissection to the prosthesis's lowest point.

Despite these steps, damage to the aortic root is often inevitable when tissues are calcified, fragile, and highly compressed.

The STS database, although voluntary, is estimated to capture 97% of all procedures performed and is considered one of the most rigorously validated surgical registries in healthcare, with 98% audited accuracy in 2022. However, this database presents other relevant limitations, such as the lack of predicted SAVR mortality risk calculation at the time of TAVI or information on the temporal relationship between prior TAVI and subsequent cardiac surgery. It also lacks specific echocardiographic parameters that could provide additional insights into aortic valve pathoanatomy, and follow-up imaging was not available. The reported outcomes are limited to 30 days, restricting the current observations to short-term insights.

In light of these findings, TAVI explant could become a high-risk procedure that will likely grow increasingly common in cardiac surgery. Prior to performing this procedure, thorough preoperative planning is essential due to the significant technical challenges involved in explanting the percutaneous prosthesis without damaging the aortic root. With this in mind, as TAVI indications continue to expand, it is incumbent upon surgeons to advocate for rational decision-making within the Heart Team to make the best choice for patients with aortic stenosis.

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Elio Martín Gutiérrez

The Dark Side of TAVI: Results from the International Explant Registry

Periprocedural and one-year mortality and perioperative outcomes from TAVI device explants across various etiologies, as recorded in the EXPANT-TAVR international registry.

The saying goes, "what is too good cannot be entirely good." The advantages of TAVI have been widely celebrated, reaching unprecedented implantation rates worldwide. This unbridled success stems from multiple factors, which, to this day, remain unexamined independently and objectively. Perhaps the truth, after all, is what hurts the most—and interests the least.

In this tendency towards a darker turn, the work before us aims to shed light and reveal the truth. And who better than registries for this purpose? In a globalized world with highly advanced and computerized centers, one can register nearly everything. This is the case for the EXPLANT-TAVR registry, a multicenter international study with the participation of 44 renowned institutions in the Western world. However, although Europe (primarily Germany, as well as France and Italy) and the USA remain the international leaders in this area, the absence of data from Asian countries and emerging cardiac intervention and surgery leaders such as African and, notably, South American countries is noticeable.

The registry focuses exclusively on TAVI device explants occurring during post-implant follow-up. The reasons for these explants included various indications categorized as infectious (prosthetic endocarditis) and non-infectious (structural degeneration, prosthesis-patient mismatch, paravalvular leak, and thrombosis). These categories align precisely with VARC criteria, and, for non-infectious cases, a committee (a true Heart Team) determined whether patients were surgical candidates rather than percutaneous solutions.

The study conducted straightforward yet insightful comparisons, providing data that, at the very least, will capture our attention. In total, 372 patients were included in the study, with explants performed between 2011 and 2022. These comprised 188 non-infectious cases and 184 endocarditis cases. A propensity analysis was performed to enable comparison, using the endocarditis group to compare outcomes based on whether it occurred before or after 18 months post-implantation.

Among the non-infectious explant causes, the most common were structural dysfunction (55.9%), paravalvular leak (43%), and prosthesis-patient mismatch (20.2%). Two of these factors are often regarded in the TAVI world as at least comparable, if not superior, to surgical bioprostheses. Of course, without knowing the proportion that these 372 explants represent relative to implant volumes—averaging 34 cases per year (<1 per center)—they may not seem very frequent (especially given the implant volume of the participating centers).

The authors found that patients requiring explantation due to endocarditis were older than those with dysfunction-related causes. The postoperative outcomes for endocarditis patients were, as expected, worse, with extended stays in both the intensive care unit and the hospital. Endocarditis significantly affected balloon-expandable prostheses more (61.5% vs. 38.5%; $p < 0.001$), while non-infectious dysfunction more commonly affected self-expanding devices (58.3% vs. 41.7%; $p < 0.001$). Some complication rates were

notably high for explant procedures, such as the need for pacemaker implantation (18-19%), stroke (higher for endocarditis patients at 8.6% versus non-infectious dysfunction at 2.9%; $p = 0.032$), and severe bleeding (11-12%). All of this resulted in mortality rates, after group adjustment, of 15-17% at 30 days and 32-34% at one year, with no significant differences between the two etiologies. An interesting finding was the time from implantation to the adverse event, which was markedly shorter for endocarditis (mean 10.4 months, with a concerning accumulation of early cases) compared to structural dysfunction (mean 19.9 months, with a more extended time of occurrence); log-rank $p < 0.001$. Regarding the analysis of survival by early or late onset of endocarditis (cut-off at 18 months), results were surprisingly better for early cases, with a one-year mortality of 19.3% compared to 26% for late explants, $p = 0.038$. This finding seems to obscure the aggressiveness of endocarditis as the periprocedural mortality prevails due to the ease of device explantation, the primary Achilles' heel of this complication, which we will analyze next.

This significant work sets some of the reference points for expected outcomes in addressing such complications. The authors conclude that the EXPLANT-TAVR registry confirms that TAVI explantation is a high-risk procedure for mortality and postoperative complications, particularly when endocarditis is the etiology.

COMMENTARY:

This registry confirms nearly identical results regarding the high mortality of patients undergoing cardiac surgery after receiving prior TAVI, comparable to the most relevant studies available to date and analyzed here on this blog (the STS database registry from 2012 to 2023 and the Michigan and STS Transcatheter Valve Therapy registries from 2012 to 2019). The most significant novelty of the EXPLANT-TAVR registry is that it demonstrates this high mortality even in cases without endocarditis, confirming the poor prognosis for these patients in the medium term.

Some arguments and critiques of the study have been made before: limited sample size for subgroup analysis, lack of representation of activity in less “elite” settings, lack of knowledge of actual rates at which these complications occur (which would allow them to be contextualized for clinical decision-making), and the absence of surgical technique details.

On the last point, I would like to offer a reflection on the technique. Given the current heterogeneity and the likely need to be prepared for root and coronary ostia injury, experience from some groups seems to be shaping the technique to face this “disaster” scenario. First, it is essential to differentiate between the explant of balloon-expandable and self-expanding prostheses. The primary difference lies in the aortotomy approach, which is performed at a similar height to that of a standard aortic valve replacement in the former. In the latter case, accessing the aortic valve posteriorly would be impeded if the aortotomy were performed above the stent level. This requires a superior aortic incision near the “fat whisker” of the aorta, releasing adhesions of the upper aortotomy to access the root. For both TAVI types, the technique of dividing the device by cutting the stent mesh seems to prevail. Removing the TAVI leaflets, leaving only the stent, facilitates the use of cutting tools on the stent itself. Various instruments have been suggested: powerful scissors, such as Mayo scissors, wire-cutting shears for sternotomy cerclages, etc. However, a specific type of scissor used in dentistry for cutting wires in dental bridges and orthodontic brackets could be highly useful and should be included in our instrument kits. Designed for steel wire cutting, they allow stent cutting cell by cell. Another useful instrument can be an endarterectomy spatula to separate the stent from the aortic wall and then from the native valve leaflets. Experience with Perceval® explantation has shown that it tends to coil up once sectioned. However, this does not

seem to occur with TAVIs, which demonstrate greater radial force, necessitating the use of ligatures or sutures on the stent to fold it as it is separated from the aortic wall, or resorting to the martensitic state properties of nitinol when cooled (tips and tricks recently analyzed on our blog).

A second reflection stems from a section of the study that highlights concerns regarding TAVI-related endocarditis. Although the study does not provide microbiological data, two causal agents are noted in two specific periods. The first, staphylococci, relates to periprocedural contamination. Given that TAVI involves crimping and percutaneous approaches, contamination may occur more frequently. The authors call for extreme antiseptic measures, noting the high standards of the centers included in the registry. Having visited some of these centers, I can attest to the scrupulousness of the surgeons and especially interventional cardiologists compared to what we are accustomed to in our units. Indeed, the authors report a lower rate of staphylococcal endocarditis in surgical prostheses than in TAVIs, although they provide no data. In our setting, underdiagnosis and underreporting of this complication likely occur, as these patients are often deemed non-surgical. The second agent is enterococci, particularly faecalis, associated with a higher incidence of urinary tract infections or intestinal translocation in an elderly population. This is complemented by a call for antibiotic prophylaxis precautions in TAVI recipients and aggressive infection treatment.

Ultimately, the saga continues with the analysis of a complication as devastating as TAVI explantation. While this study shows some expected aspects regarding outcomes, it is still a field that combines lack of experience and sporadic presentation, lending a heroic undertone. Unfortunately, in surgery, good outcomes stem from standardization, and heroics are best left to the cinema. We must minimize the occurrence of these complications through optimal patient selection, bearing in mind that, although infrequent, they are not impossible. Surgeons are well aware of the outcomes of a first reintervention on a bioprosthesis, which are far less severe due to lower risk of injury to the aortic root structures. Combating the radial force of the stent is key. And since these procedures will likely increase, until then, may the force be with us… to keep cutting stent cells.

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Irene Toribio García

Is the Heart Team Dispensable in Catheter-Based Aortic Bioprosthesis Implantation Procedures?

Multicenter German Analysis of the Incidence and One-Year Outcomes of Emergency Conversion to Surgical Procedure During Transcatheter Aortic Bioprosthesis Implantation.

Aortic stenosis is the most prevalent cardiac valve pathology in the population, affecting approximately 12% of those over the age of 75, with severe cases present in 3.4%. The primary etiology of this condition is degenerative, particularly in developed and aging countries like Spain.

It is well known that the classic definitive treatment of choice for this condition has traditionally been surgical aortic valve replacement (SAVR), and it continues to be for patients with low surgical risk. However, in recent years, there has been an observed increase in transcatheter aortic valve implantation (TAVI), primarily among patients with intermediate and high surgical risk, although it is now also being considered in some low-risk cases.

On the other hand, there are two main challenges in universalizing TAVI as the treatment of choice: one is determining the ideal procedure based on patient type; the other is the controversy over whether this procedure should be performed in centers with on-site cardiac surgery. Regarding the procedure, recent results from the PARTNER 3 study indicate similar outcomes between surgical and percutaneous approaches in low-risk patients, which we will discuss in detail later. As for the formation of a Heart Team, having multidisciplinary teams, including cardiac surgeons to support the rest of the team in urgent conversions from percutaneous to surgical procedures (emergency open-heart surgery or E-OHS), seems logical, especially for certain risk groups.

This brings us directly to the featured article of this entry, a multicenter analysis conducted in Germany between 2009 and 2021, involving 14 centers, on outcomes following E-OHS in patients undergoing TAVI. Out of the total 40557 patients who received TAVI, 216 required conversion to open surgery; however, only 152 met the inclusion criteria for this study. The main inclusion criterion consisted of patients who underwent transfemoral TAVI and experienced major intraprocedural complications requiring immediate open conversion. Exclusion criteria included non-transfemoral access, clinical and hemodynamic post-TAVI status, as well as interventions considered “minor” during the procedure (pacemaker implantation, pericardiocentesis, pleural drain insertion, etc.). Notably, all procedures were performed with a full Heart Team and, therefore, in centers with immediate cardiac surgery availability. The primary endpoint was all-cause one-year mortality. Secondary endpoints included intraprocedural mortality, in-hospital mortality, and various postoperative complications.

For statistical analysis, the sample was divided according to different surgical risk groups based on the cutoffs established in the European clinical practice guidelines (CPG) using the EuroSCORE II scale: low-risk patients with EuroSCORE II <4%, intermediate-risk patients with a score between 4–8%, and high-risk patients with >8% risk. Respectively, these groups consisted of 46, 37, and 69 patients, making the high-risk group the largest, comprising nearly half of the total included patients. Variables indicating the need for surgical conversion included valve displacement or positioning failure (the most common, found in 31.6% of cases), left ventricular perforation, aortic annular rupture, events compatible with acute aortic syndrome, and/or dissection/obstruction of a coronary artery. Intraprocedural mortality was 12.5%, while in-hospital mortality rose to

49.3%, leaving 58 survivors. Common intraoperative complications included acute renal failure requiring renal replacement therapy, low cardiac output syndrome, and major bleeding, without forgetting stroke/neurological damage events, a complication that must always be considered in such patients and in this critical context, as we will discuss later.

While statistical analysis showed no significant differences in intraprocedural mortality between groups, the authors observed a significant increase in in-hospital mortality in the high-risk group (59.4%). The estimated one-year mortality rate in Kaplan-Meier curves was 57.2%, also significantly higher in the high-risk group.

Among the indications for E-OHS, coronary obstruction was identified as an independent predictor of increased one-year mortality rate, with no other statistically significant differences noted in other variables.

In summary, half of the patients requiring E-OHS from a TAVI procedure survived the immediate postoperative period. Among them, those in the low and intermediate-risk groups had better outcomes than those in the high-risk group. Additionally, among those requiring surgical conversion, a low post-surgery event rate was observed, contributing to the high likelihood of adequate recovery and eventual discharge.

COMMENTARY:

Current guidelines from the European Society of Cardiology recommend TAVI for patients >75 years and/or at high surgical risk or considered inoperable, with a level of evidence I. Following the introduction, several studies have been published in recent years comparing TAVI with SAVR in high and intermediate-risk surgical patients, with some even suggesting potential benefits in the low-risk group.

One of the most recently published studies supporting the percutaneous approach was DEDICATE, a clinical trial in which the authors concluded that TAVI was non-inferior to SAVR concerning all-cause mortality or stroke at one-year follow-up among patients with severe aortic stenosis and low surgical risk (although these results were questionable due to study design, among other factors, as previously discussed in this blog).

However, the opposing side of this scientific evidence is portrayed in the extensively discussed PARTNER 3 study. Contrary to supporting the results of other studies, this trial shows that among low-risk patients with severe symptomatic aortic stenosis who underwent TAVI or surgery, there were no significant differences between groups in the two primary composite outcomes at five years (with an initially favorable trend for TAVI reversing at one and two years of follow-up). In fact, the short-term specific benefits of TAVI (lower mortality and stroke, shorter hospital stay, reduced rehospitalization, and lower bleeding rates) were diminished over time, with increased mortality and stroke rates in the TAVI group from the first year of follow-up. Thus, it is easy to understand why SAVR remains the therapy of choice for low-risk patients.

So, what do we need to address these dichotomies in scientific evidence? Is the TAVI procedure still as safe and effective as we thought? Probably, this controversy highlights a reality we must not overlook and that, in fact, I would like to emphasize:

- First, the gap in evidence regarding the prognosis of patients undergoing such interventions in terms of risk stratification. We are currently extrapolating TAVI risk based on risk scales traditionally used for surgery, and this is the case because a specific risk calculation system has not yet been developed

for these patients undergoing percutaneous procedures, despite the expansion of the technique and the volume of data available today. Some have even proposed basing the indication on an arbitrary age criterion rather than focusing efforts on more prudent patient selection, as initially proposed with risk scales. Clearly, this shows that we cannot apply a class effect between the two treatments, and the need for a definitive risk quantification tool in this particular population is becoming increasingly urgent.

- Moreover, many published studies do not have consistent inclusion (such as the type of individuals recruited, the type of percutaneous access, the types of valves used, etc.) and exclusion criteria (in fact, in this article, reference is made to a series of minor complications which, in my opinion, due to their incidence and impact on prognosis, introduce a bias per se at the time of analysis). This could potentially be a confounding factor that might go unnoticed without a thorough analysis of the collected data, and which, in my opinion, inexorably biases the evidence obtained, causing the current dichotomies we encounter.

- Finally, returning to the title, while the percutaneous implant is a less invasive intervention than its surgical counterpart, with overall fewer risks, at least in the short term, it is still associated with potentially fatal complications. This is unacceptable in intermediate and, especially, low-risk patients (since in our setting, they constitute a significant proportion of the target population). Despite the high mortality, it is necessary to put it into perspective, considering that having the support of a cardiac surgery team for an emergency surgical conversion can save more than half of the patients who would otherwise present intraprocedural injuries incompatible with survival beyond the catheterization lab or hybrid operating room.

Therefore, maintaining programs without a supporting cardiac surgery team seems negligent. The perspective of cardiovascular surgeons remains indispensable, from the initial patient assessment, technical implant alternatives (including open vascular access and managing their complications), to active participation during the procedure, beyond mere coverage for potential complications. Indeed, beyond the already argued surgical risk, the surgeon's role is essential in determining whether, in the event of a severe complication, the patient is “operable” (able to receive extracorporeal circulatory support to resolve the complication or undergo conventional SAVR), “assistable, non-operable” (able to receive extracorporeal circulatory support as a bridge to recovery from hemodynamic complications or for intraprocedural complication management but not for conventional SAVR), or “non-assistable, non-operable” (close to the context of high surgical risk and potential futility, which would be the only alternative to consider in centers without Heart Team support). These practices were more frequent in the early days of TAVI programs over a decade ago. However, they have fallen out of favor and are now rare in our setting. The full integration of the surgeon into the Heart Team is a reality outside our borders from which we cannot, nor should we, remain isolated.

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Elio Martín Gutiérrez

Winning Without Convincing: Bayesian Analyses and Non-Inferiority Studies in Trials Comparing TAVR and Surgical Aortic Valve Replacement

Review of a Bayesian Meta-Analysis of Non-Inferiority Studies Comparing Surgical Aortic Valve Replacement with Transcatheter Aortic Valve Implantation.

In recent years, there has been an increased need to understand new quantitative analysis methodologies applied in key works within the cardiology and cardiac surgery literature. Discussions regarding prospective or retrospective study designs, bias control, confounders, and the statistical tests applied have given way to the primacy of randomized controlled trials as the highest quality evidence, enhanced by methodologies addressing, among others, non-inferiority and Bayes' theorem.

Although the results of the present analysis are relevant, they do not require extensive discussion. Instead, it is the methodology that necessitates careful consideration to understand the basis for the authors' conclusions. In brief, this meta-analysis aggregates 5-year mortality outcomes from key comparative studies of TAVR and surgical aortic valve replacement (SAVR), all of which employed non-inferiority methodologies. This meta-analysis encompassed a full risk spectrum, including the PARTNER 1A, PARTNER 2A, PARTNER 3, CoreValve US, SURTAVI, NOTION, Evolut Low Risk, and UK-TAVI trials. Consequently, 8698 patients were included, with 4443 undergoing TAVR and 4255 undergoing SAVR. Following a Bayesian meta-analysis, the authors concluded that TAVR cannot be considered non-inferior to SAVR based on 5-year mortality outcomes; in other words, SAVR was significantly superior in this mid-term follow-up.

COMMENTARY:

In traditional statistical inference, we determine that the occurrence of a phenomenon differs significantly between groups when, with a margin of error below a predetermined criterion (alpha error, typically 5%), it is deemed not due to chance. The absence of differences, or the probability of a phenomenon occurring above this 5% threshold, would classify it as equivalent. Non-inferiority studies focus on this concept of equivalence, but from a different perspective. Simply stated, they aim to determine whether the difference in the occurrence of a phenomenon between two groups falls within a pre-specified interval, outside of which it would be considered clinically relevant. The objective, therefore, is not to establish the degree to which the phenomenon occurs nor the differences between groups but to assess its clinical impact according to a defined non-inferiority margin. The boundaries of this margin are determined by differences in occurrence rates reported between groups. Exceeding this margin leads to a rejection of non-inferiority or, conversely, to a finding of superiority for one group over the other. With this type of analysis, it is reasonable to assume that they are less stringent than "traditional" inference methods, as achieving non-inferiority, the primary goal, is easier than identifying statistically significant differences. Additionally, they are less dependent on statistical power, which is inherently tied to sample size, and whose insufficiency is one of the main reasons for failing to detect statistically significant differences in "traditional" statistics.

If non-inferiority analysis appears convoluted, Bayesian statistics may seem even more "alien." This approach involves calculating the probability of a future event through a predictive distribution based on Bayes' theorem, all within a known and real initial

probability margin. Essentially, it serves as a statistical "crystal ball." However, it sometimes merely amplifies future trends based on current, non-significant or non-inferior results. Ultimately, it is clear that both concepts are well-suited to each other. With the former, it is easy to conclude “equivalence,” and with the latter, future trends can be predicted based on that initial result.

To introduce a personal opinion that many share, these methodologies have been incorporated into various clinical trials in controversial fields due to their suitability for producing favorable results: false equivalence in the former, and false anticipation of benefits in the latter, thereby forming a rapid, industry-serving body of evidence. Applying this rationale to TAVR versus surgical aortic valve replacement makes the trajectory clear: establish short-term non-inferiority to justify a seemingly less invasive technique and, subsequently, with known early benefits in the first one or two years due to reduced surgical burden, anticipate future results that reinforce the indication even in clinical guidelines.

Thus, the proposed analysis, having employed actual mid-term results, once past the well-known two-year survival curve threshold, seems to offer results “outside the script,” as it amplifies trends that, in many studies, are already significantly superior for the surgical option. We must also consider that, despite randomization, patients undergoing TAVR in high- and moderate-risk studies were especially comorbid, which could have impacted the results when considered in a combined analysis.

Although this study draws attention to the unchecked advance of interventional procedures by yielding positive results for surgery, perhaps its primary relevance is demonstrating that these methodologies, so distinct from “traditional” ones, skew the data and introduce biases. Put simply, the “hunter has been hunted,” or performing Bayesian analysis with data beyond two years of follow-up has given the TAVR industry a dose of “its own medicine.” In a consensus document previously reviewed on this blog regarding left main coronary artery disease treatment, certain types of analyses, such as all-cause mortality or composite events, were proscribed. Let us hope that, at last, the EBM principle will be embraced in structural interventions: “evidence-based medicine” rather than “evidence-biased medicine.”

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Elio Martín Gutiérrez

Aortic Stenosis and Coronary Artery Disease: Surgery Is Superior to Percutaneous Intervention

A meta-analysis by a Japanese research group compares mid-term survival outcomes for patients with concomitant aortic stenosis and coronary artery disease who underwent either entirely surgical or percutaneous treatment options.

The highly controversial and now notorious clinical guidelines table, which arbitrarily set the age criterion of 75 years for assigning transcatheter aortic valve implantation (TAVI) or surgery for low-risk aortic stenosis, also recommended favoring surgery in patients with correctable concomitant conditions, such as coronary artery disease. This was nuanced with more flexible treatment indications based on the surgical or interventional approach. In surgery, treatment was mandated for all lesions >70% (Class I) and for 50-70% (Class IIa) lesions when concomitant, whereas interventionists were only required to treat proximal lesions >70% (Class IIa).

Due to a lack of updates, current guidelines are now outdated, leading many to disregard them, resulting in disorderly patient assignment to invasive procedures in medical-surgical or Heart-Team sessions, increasingly deviating from ethical and scientific rigor. Concomitant coronary artery disease in aortic valve disease is common, with many patients now relegated to TAVI procedures under the justification of balancing supply and demand by correcting the increased afterload condition. However, this leaves coronary artery disease unresolved, relegated to optimal medical treatment with no prognostic benefit in multivessel disease.

The study by Sakurai et al., conducted by a Japanese group and marked by cultural aspects that emphasize scientific rigor, provides valuable insights. The team conducted a meta-analysis comparing outcomes in cohorts from major studies that contrast TAVI versus surgery, selecting patients who received concomitant revascularization (simultaneous in surgery and sequential or simultaneous in intervention). This should alert us that, given the selected nature of clinical trial cohorts, randomization effects are lost, and the studies thus become purely observational prospective studies.

Notable aspects of the meta-analysis include a comprehensive database search with a declared strategy, strict bias analysis through multiple methods, and transparent reporting of data and potential biases in the appendices.

Studies comparing TAVI and surgical aortic valve replacement (SAVR) published until November 2010 were included, with selected cohorts receiving revascularization (percutaneous coronary intervention [PCI] vs. coronary artery bypass grafting [CABG]), suggesting that raw data from original studies were provided in some cases. MEDLINE, EMBASE, and Cochrane databases were analyzed, ultimately including 2 randomized studies (NOTION and PARTNER 3) and 6 observational ones. This encompassed 104220 patients with a weighted mean follow-up of 30.2 months. TAVI + PCI was associated with higher all-cause mortality (HR = 1.35; $p = 0.003$), the need for additional revascularization during follow-up (HR = 4.14; $p = 0.001$), a higher need for pacemaker implantation within 30 days post-procedure (OR = 3.79; $p = 0.002$), and vascular complications related to valve and/or coronary access (OR = 6.97; $p = 0.004$). Conversely, TAVI + PCI was associated with lower 30-day renal failure rates (OR = 0.32; $p = 0.0001$), while 30-day rehospitalization rates, stroke during 30-day and follow-

up, 30-day mortality, 30-day myocardial infarction, and major post-procedural bleeding were comparable to those observed in SAVR + CABG.

No significant publication bias was detected for the observational cohort-based meta-analysis, nor was there a change in trend for the effect sizes in the previously reported outcomes upon sensitivity analysis. The authors conclude that in patients with aortic stenosis and concomitant coronary artery disease, TAVI + PCI is associated with higher mid-term mortality compared to the pathology's treatment with SAVR + CABG. The Heart-Team must heed this evidence in patient assignment to the best treatment alternative, especially in those with acceptable surgical risk.

COMMENTARY:

The study under review is highly relevant, and its findings should be taken into account in future recommendations or clinical guidelines. Although coronary artery disease and aortic stenosis representation in clinical trials is lower than in real life, registries report that 38% of aortic stenosis patients require concomitant revascularization. Not surprisingly, two age-related diseases with an atherosclerotic basis frequently coexist.

The study underscores the superior results of the surgical option, with no significant procedural penalties, achieving up to 30% more survival rates and reducing major cardiovascular events to one-third or one-fourth in future instances. As previously discussed, patients without revascularized coronary disease will have a poor prognosis if TAVI is viewed as a panacea. Patients have the right to have multiple diseases, even cardiac, and we, as healthcare professionals, are obliged to treat all their conditions using the best available means.

When coronary disease is not treated simultaneously, as is the case with surgery, additional morbidity arises, notably in repeated procedures, which increase the risk of vascular complications by more than six-fold. Furthermore, for cases lacking planned revascularization, it is widely known that managing coronary disease in the presence of an implanted TAVI is challenging. In fact, other studies highlight untreated coronary disease as an independent predictor of post-TAVI mortality. While not all patients with concomitant coronary disease and aortic stenosis are low-risk, expected survival must guide treatment options beyond the arbitrary age criterion, a criterion more akin to market research than solid scientific foundation. Lastly, some outcomes shown by the TAVI + PCI approach may be influenced by incomplete revascularization. However, it has been demonstrated that compared to non-revascularization, results are practically equivalent, at least for functionally significant lesions.

For now, it seems that the status quo persists, as exemplary studies like this often fail to impact the established paradigm. Nevertheless, results as clear as these, shown with full transparency, should not be forgotten; instead, they should transcend recommendations documents and, ultimately, clinical practice. The literature flood of commercial evidence is a trend, where quantity does not necessarily equate to quality, and it buries significant findings like those in this study. Our mission is to unearth these findings and ensure they gain the weight they deserve.

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Elio Martín Gutiérrez

Better Outcomes of Surgical Aortic Valve Replacement Versus TAVI in Low-Risk Patients in the AVALON Registry: Continuation or Conclusion?

Five-year results from the AVALON registry on percutaneous versus surgical treatment of aortic stenosis in low-risk patients, compared to updated evidence from key clinical trials for the same patient profile.

The rich repertoire of Spanish proverbs, often imbued with subtle irony, aptly reflects the longstanding debate between surgical aortic valve replacement (SAVR) and transcatheter aortic valve implantation (TAVI) in patients with low surgical risk. Phrases like “haste makes waste,” “greed spoils all,” “patience is a bitter-rooted tree that bears sweet fruits,” or “when you were a hammer, you showed no mercy; now as an anvil, be patient,” could well describe the vicissitudes we are all familiar with.

The study presented focuses on findings from the AVALON registry (Aortic Valve Replacement in Elective Patients from the Multicenter Aortic Valve Registry), a multicenter registry encompassing cases treated with TAVI and surgery across three tertiary centers in Poland. The TAVI approach was exclusively transfemoral, and only elective procedures targeting the aortic valve were performed, without any associated surgical or interventional procedures.

Between 2015 and 2019, 2393 patients were included—1764 underwent surgery and 629 received TAVI. This registry, similar to the all-comers NOTION study, commenced when TAVI was already an established option for patients with low surgical risk. However, the surgical group had a lower predicted risk (EuroSCORE II: 1.41) compared to the TAVI group (3.43). Additionally, the nearly 1:3 ratio of patients in the surgical group relative to TAVI reflects Poland’s patient allocation policy, reserving low-risk patients for surgery and using TAVI for those at moderate to high surgical risk. To address this, the authors conducted a propensity score analysis based on a comprehensive set of preprocedural variables, resulting in two homogeneous groups of 593 patients. The standardization focused on clinical variables rather than technical aspects, which might have influenced patient selection. However, given the study’s emphasis on post-treatment survival, the chosen variables hold relevance, with mean EuroSCORE adjusted to 2.02 vs. 2.46, representing low surgical risk.

Periprocedural complication rates were not significantly different between groups. Hospital mortality was 0.3% for surgery versus 0.9% for TAVI, with severe bleeding events at 5.2% and 2.7%, respectively; renal failure at 4.7% vs. 2.4%; neurological complications at 1.9% vs. 0.3%; and pacemaker implantation at 1.9% vs. 2.7%, all respectively.

Starting from comparable periprocedural mortality—contrary to common clinical trial findings—and with an average follow-up of 2.7 years, extending to a maximum of 6 years, surgery demonstrated a 30% lower mortality rate (HR = 0.7; p= 0.48). This divergence emerged after the initial two years, during which both approaches yielded overlapping outcomes, but diverged thereafter. Notably, the patient profile that showed the greatest survival benefit from surgery versus TAVI included males, age <75 years, smokers, with EuroSCORE <2, hypertension, atrial fibrillation, renal insufficiency, and/or ischemic heart disease (without concomitant revascularization).

The authors conclude that survival rates did not differ between TAVI and surgery during the first two years post-procedure. However, beyond this period, surgery was associated with improved survival.

COMMENTARY:

The AVALON registry results align with the five-year findings from trials like PARTNER 3, which we previously discussed on the blog, and anticipate the outcomes from the five-year Evolut Low Risk study expected this year. Initially, TAVI and surgery yield comparable survival, but this balance shifts after two years, favoring surgery. When, as in the AVALON registry, surgery does not start at a disadvantage of higher periprocedural mortality, results beyond two years appear significantly more favorable than those seen in clinical trials. This similarity in outcomes up to discharge, and subsequent divergence, could result from the meticulous selection criteria: the absence of disproportionately higher numbers of additional procedures in the surgical group compared to TAVI, as commonly seen in clinical trials.

Several factors have been proposed to explain this “catch-up” or “overtake” by surgery: paravalvular leakage, pacemaker implantation, new bundle branch blocks, thrombosis, suboptimal patient selection with incomplete procedures in TAVI cases, tolerance for non-revascularization or existing valve dysfunctions, and prosthesis durability.

The exact cause for these findings within this registry remains uncertain due to insufficient data. However, recent clinical trial outcomes suggest that, although considered low-risk, TAVI patients still presented higher risk profiles than the surgical group. This is evidenced, for instance, by the lower rate of concomitant procedures (primarily revascularization) not performed in TAVI cases, serving as a rationale that may help justify increasingly less favorable results.

The only clinical trial extending beyond five years is NOTION, with a mean EuroSCORE II of 3%. Rates of moderate or severe paravalvular regurgitation were 8.2% vs. 0%, attributable to older-generation TAVI prostheses; this is reflected in the 43.7% vs. 8.7% pacemaker requirement rates. Reintervention and endocarditis rates were also numerically higher in the TAVI group, while overall survival did not significantly differ. Nonetheless, postoperative results were notably worse than in AVALON, partly due to the high rate of Abbott Trifecta® valve implants. Given the high incidence of early degeneration, surgical survival outcomes may have been compromised. By contrast, the dominant prosthesis in AVALON was Hancock II, known for durability yet unable to match the transvalvular gradients of pericardial prostheses, which in PARTNER 3’s five-year results are numerically superior to TAVI. Representation of minimally invasive techniques remains minimal, absent in NOTION and at only 3% in AVALON.

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Elio Martín Gutiérrez

Summer Hits: DEDICATE Trial, TAVI's New Success Story in Low-Risk Patients

In-depth analysis of the German multicenter DEDICATE study presents one-year outcomes in low-surgical-risk TAVI patients compared to aortic valve replacement, allowing the inclusion of patients younger than 75 years.

With summer and conference season approaching, as we await updates from major trials PARTNER 3 at 5 years and Evolut-Low Risk at 6 years—both increasingly favorable to surgical options—the DEDICATE study emerges as the latest "hit" in support of percutaneous solutions. This German multicenter experience distinctly diverges in design from previous, heavily sponsored trials. Essentially, it seems to address design and interpretation issues that previously raised impartiality concerns in these clinical trials. While published in *The New England Journal of Medicine (NEJM)*, a journal that, in my personal view, tends to obscure data in numerous supplementary appendices, this work brings a refreshing level of transparency, characteristic of German rigor. This publication seems crafted to present a concise manuscript where "what you see is what you get." Delving into the results at the source requires a careful review of the supplementary material, which, despite its transparency, almost acts as a "deterrent by complexity" for those seeking a straightforward message.

Before analyzing the study, I feel compelled to issue two critiques relevant to future works addressing this controversy. In an era where TAVI implants have significantly outpaced surgical prostheses, continuing to perform non-inferiority analyses solely to achieve easier statistical significance seems inappropriate. TAVI has now established itself as a leading therapeutic alternative and, therefore, should be evaluated on equal footing with surgery. Secondly, while discussions of surgical risk remain necessary, as low-risk is the last stronghold for surgery, it is striking that the leading therapeutic alternative lacks widely accepted risk estimation systems in clinical practice. This likely stems from a need that, evidently, it does not have.

Moving into the study details, this was a randomized, multicenter trial (38 German centers), analyzed by intention to treat with a somewhat redundant non-inferiority design, including 1414 patients, of whom 701 underwent TAVI and 713 underwent surgical aortic valve replacement. This trial thus represents the largest published to date in this setting, following the Evolut-Low Risk with 1403 patients, PARTNER 3 with 950, UK-TAVI with 412, and NOTION with only 276 patients. Both groups had low surgical risk, with a mean STS score of 1.8% across the series. Eligible patients were those in whom either therapeutic option was feasible and who presented with severe symptomatic aortic stenosis. Regarding age, study protocol modifications allowed for the inclusion of patients under 75 years old (approximately 38% in both groups) and those younger than 70 years (11-13%), reflecting typical German clinical practice. Although the mean surgical risk was low, 3.9% of patients in the TAVI group and 4.9% in the surgical group had intermediate risk (STS score >4%). Notable exclusion criteria included congenital bi- or unicuspid valve disease, significant concomitant coronary or valvular disease, left ventricular dysfunction with an ejection fraction <20%, or left ventricular hypertrophy with outflow tract obstruction. Importantly, associated procedures were far fewer than in previous trials: 11 coronary revascularizations, 6 AF surgical ablations, 6 ascending aortic replacements, 1 mitral valve surgery, and 2 tricuspid valve surgeries. However, there were still 26 procedures that did not involve pure aortic valve replacement, whereas

none of the TAVI procedures included concomitant interventions. In fact, percutaneous revascularization within a month prior to randomization was an exclusion criterion.

The procedures performed also differed significantly from previous clinical trials. In this non-sponsored study (notwithstanding the extensive conflicts of interest among the authors), operators had complete freedom in choosing the devices and access route. This freedom was made possible by funding from the German Center for Cardiovascular Research and the German Heart Foundation, independent from the biomedical industry. Regarding the surgical approach, the valve sizes typically associated with the German population predominated, with the majority being Edwards® pericardial prostheses in various versions, followed by a concerning 15% St. Jude Trifecta, given concerns over long-term structural degeneration. Sutureless prostheses accounted for 15.8% of implants, divided between the Edwards Intuity® and Corcym Perceval® models. Minimally invasive approaches comprised only 38% of the series. For the percutaneous option, 97.3% used the transfemoral approach, with transapical and transaxial routes being rare. The implanted prostheses were two-thirds balloon-expandable (almost exclusively Edwards Sapien® 3/3 Ultra), with the remaining third being self-expandable (split between Boston Acurate® Neo/Neo 2 and the Medtronic CoreValve/Evolut® variants).

Although the NEJM article does not detail short-term outcomes, these results are of particular interest and may hold the key to understanding long-term findings. Notably, after randomization, 100 patients assigned to the surgical arm were not operated on, with 70 crossing over to TAVI treatment. This crossover occurred in only 18 TAVI-assigned patients, of whom 12 subsequently underwent surgery. As a result, the entire published intention-to-treat analysis is somewhat questionable, with a more reliable approach found in the per-treatment analysis, accessible in supplementary materials. As previously mentioned, patients were eligible for both surgical and percutaneous options. Surgical outcomes, particularly in the German healthcare context, were remarkably ordinary and lacked the excellence associated with such a high-standard setting. For instance, mean extracorporeal circulation time was 88 minutes; mean aortic cross-clamp time was 61 minutes; mean ICU stay was 2 days, and mean hospital stay was 9 days, with only 40.4% of patients discharged home (43.9% were discharged to rehabilitation centers). Major bleeding events requiring transfusion occurred in 13.8% of cases, with transfusions exceeding three units of red blood cells in 13% of patients. The surgical group had a stroke rate of 3.1% (compared to 1.9% in the TAVI group, where cerebral embolic protection devices were used in over 5% of cases), mild or greater paravalvular leakage at 4.9% (compared to 20.9% in the TAVI group), and a pacemaker implantation rate of 3.4% (compared to only 8.7% in the TAVI group). This resulted in a 30-day mortality rate of 1.5% versus 0.7% for the TAVI group.

The authors conducted a one-year follow-up, although they promise to extend this to five years per the study protocol. While the one-month mortality curve did not show significant divergence, the upward trajectory over the subsequent year raises concerns, with one-year mortality reaching 5.6% for TAVI and 10.1% for surgery. These results are similar in the intention-to-treat analysis published. Throughout this period, the surgical group experienced a range of adverse outcomes leading to the death of 42 patients (compared to 18 in the TAVI group) from causes such as sepsis (8 cases), cardiogenic shock or heart failure (8 cases), COVID-19, endocarditis, intracranial hemorrhage, cancer, respiratory failure, and arrhythmias (2 cases each). Despite seemingly comparable preoperative characteristics, the adverse progression in some surgical patients significantly impacted one-year survival. In the TAVI group, outcomes were also worse compared to clinical trials, where one-year mortality in Evolut-Low Risk was 2.4% for

TAVI and 3% for surgery, while PARTNER 3 reported 1% for TAVI and 2.5% for surgery. However, for the surgical group, the results were comparatively even less favorable.

The authors conclude that among patients with severe aortic stenosis at low surgical risk, due to the study's design, TAVI was not inferior to SAVR regarding all-cause death or stroke at one year.

COMMENTARY:

The subsequent promotion and dissemination of DEDICATE trial findings came promptly after its recent publication. Social media and interventional cardiology forums have resonated with this “new success story,” as it has been labeled. Some of the more aggressive advocates, based on the inclusion of younger patients below the age of 75, have questioned the timeline for lowering the TAVI age threshold in this patient population. Others, observing one-year trends, argue that these results provide sufficient grounds for robust conclusions to further TAVI indications in all contexts. It is likely we are witnessing the emergence of a new hallmark study, as previous sponsored clinical trial trends have not been as favorable as expected.

In presenting the raw results, we aimed to shed light on the factors behind the more than 5% difference between the two options at one-year follow-up. Given the limited losses to follow-up (13 in the TAVI group and 18 in the surgery group), this discrepancy likely lies in details that, as mentioned before, NEJM publication conceals within a plethora of data and appendices. One of the primary factors could be patient crossover; 100 patients in the surgical group, a seventh of the cohort, were not treated as initially planned. Alongside the questionable validity of the published intention-to-treat analysis, the per-treatment results may reflect an imbalance in pre-procedure characteristics between groups. Indeed, preoperative morbidity is presented only in the intention-to-treat analysis, not in per-treatment appendices, which detail only 30-day and mid-term outcomes. Another notable aspect is the worse postoperative course for surgical patients, with an average hospital stay of 9 days and less than half discharged home. Whether this reflects a peculiarity of the German healthcare system is uncertain, but these results are more consistent with those reported for TAVI, with 75% of cases discharged home and a mean hospital stay of 5 days. Minor penalizations in the surgical group likely contributed to the unfavorable short-term outcomes, such as an exceedingly high bleeding event rate, the disproportionate impact of associated procedures between both therapeutic options, and unaccounted morbidities in preoperative characteristics or risk scores that contributed to mortality events like COVID-19, cancer, sepsis, or intracranial hemorrhage (14 cases not found in the TAVI group, where mortality was mainly cardiovascular, including one case of aortic dissection).

In conclusion, it is essential to highlight the apparent impartiality of this study. Despite receiving funding from public organizations, the abundance of conflicts of interest among the authors is notable. Given the reimbursement system in Germany’s healthcare, there remains a reasonable concern regarding potential biases favoring a more profitable therapeutic option. In other words, instead of being sponsored by a single entity, this study appears to have garnered the support of most transcatheter industry representatives.

There are still questions to be resolved regarding the long-term follow-up results. Trends do not bode well for the surgical option, and it is unclear how various factors will influence future outcomes, including prosthetic degeneration (notably in sutureless and St. Jude Trifecta® prostheses in the surgical group), progression of mild or greater paravalvular

regurgitation from 4.9% to 8.8% in the surgical group and from 20.9% to 24.3% in the TAVI group after one year, moderate or greater mitral insufficiency in one-year follow-up at 5.4% for TAVI and 4.7% for surgery, or moderate or greater tricuspid insufficiency at 5.5% in TAVI and 9.8% in surgery. For now, we can only wait and hope that these results will be taken cautiously... but the replay of this summer's "hit" seems assured until we know the outcome by heart.

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Elio Martín Gutiérrez

AUTHEARTVISIT study: the Austrian paradigm

This retrospective observational study, adjusted through propensity score analysis, utilized data from the Austrian National Health System registry to compare mid- to long-term survival in patients treated with surgery or TAVI between 2010 and 2020.

Publications addressing the surgery versus TAVI debate for severe aortic stenosis remain frequent. The growing interest in this topic, competition to dominate specific patient subgroups, and aggregation of data, experience, and follow-up have strengthened the quality of studies—even those reliant on observational evidence from well-constructed registries.

This particular study has sparked significant discussion on social media and in specialized press for contradicting the prevailing notion that TAVI should at least be noninferior, if not superior, to surgical alternatives for any patient group. Critical voices quickly emerged, denouncing a study of surprising robustness that demands attention. As cardiovascular professionals, we must examine its strengths and weaknesses objectively, irrespective of its conclusions.

The study used data from the Austrian public national health system, covering 98% of the population. Data were retrieved using MEL (Medizinische Einzelleistung, German coding system) and ICD (International Classification of Diseases) codes for pre-procedural morbidity, applied treatments, and follow-up outcomes, including reintervention, pacemaker implantation, stroke, myocardial infarction, and heart failure. Patients requiring concomitant procedures (including coronary revascularization), mechanical surgical prostheses, or percutaneous revascularization within four months before or after the procedure were excluded. Follow-up extended up to 12 years, with patients included between 2010 and 2020.

The cohort comprised 18,882 patients, 11,749 undergoing TAVI and 7,133 undergoing surgery. Surgery dominated in 2010 but trends reversed in 2019, with TAVI experiencing exponential growth thereafter. Patients were categorized into two age groups to assess the impact of age—a critical factor in treatment assignment. In the 65–75 age group (7,575 patients), 85.6% underwent surgery and 14.4% TAVI. Among those >75 years (11,307 patients), 46.6% underwent surgery and 53.4% TAVI. Analyses compared raw and propensity score-adjusted survival data, adjusting for 15 preoperative variables.

Overall, all-cause mortality was 50% higher in the TAVI group than in the surgical group (HR = 1.5; $p < .001$) over a median follow-up of 5.8 years. This result held after propensity score adjustment. Survival differences became statistically significant two years post-procedure. Median estimated survival was 8.8 years for surgery versus 5 years for TAVI. Subgroup analyses showed nearly 2.5 times higher mortality in the 65–75 age group with TAVI ($p < .001$), regardless of propensity score adjustment. For patients >75 years, excess mortality was 1.3 times higher ($p < .001$).

To explain this higher long-term mortality in the TAVI group, post-procedural morbidity was analyzed. Pacemaker implantation was required in 11.2% of TAVI patients versus 4.5% of surgical patients. Excluding those who died within one month, pacemaker implantation significantly increased follow-up mortality (HR = 1.1; $p = .02$). Of 287 patients requiring reintervention, 232 had surgery, and 55 had TAVI. However,

reintervention rates were not significantly different between groups, nor were new myocardial infarction, stroke, or heart failure incidences.

The authors concluded that, based on the results of their national registry, the choice of TAVI as a therapeutic alternative was associated with higher all-cause mortality rates compared to the surgical option, particularly in the subgroup of patients aged 65 to 75 years.

COMMENTARY:

AUTHEARTVISIT has caused a true upheaval in TAVI's aspirations to reduce the age of indication. With its strengths and weaknesses, it consolidates one of the most extensive published real-world datasets to date.

Nevertheless, the AUTHEARTVISIT study depends on observational evidence and, like many other works of its kind, shares the same strengths and weaknesses. On one hand, more than an observational study, it is a registry that incorporates the advantages of multicenter design, real-world data presentation, and a nearly population-wide sample, including treatment candidates from almost the entire country. While the idiosyncrasy of the healthcare system and type of funding are important in such analyses, Austria's European healthcare system has similarities to ours, making the practical outcomes—including patient allocation to one therapeutic alternative or another—more comparable to ours than, for example, the American system. Being a registry, it includes historical data from over a decade ago, where although no drastic changes occurred, older devices and less development in the TAVI sphere could unequally penalize groups. Data recovery from a health system registry, unlike institutional databases or society records like our RECC or the STS, often incurs inaccuracies and provides more limited data. Thus, the primary value of this study lies in the crude results provided, as propensity score adjustment is fundamentally flawed. Evidence of this is its inability to alter trends shown by crude data in groups likely non-comparable, as no adjustment for surgical risk—so influential during the study's period in allocating patients to one therapeutic alternative or another—was performed. Consequently, if propensity score adjustment is already a suboptimal method for sample adjustment in retrospective studies, it becomes utterly useless when lacking sufficient representative variable volumes. Moreover, this defect compromises other subanalyses attempted in the study, but due to their deficiency, they do not warrant mention, such as the Cox survival analysis.

In comparison, the alternative evidence lies in powerful, hyper-funded randomized clinical trials (RCTs). These paradigms of evidence-based medicine, which should guide such controversies, also possess a series of shortcomings. Their primary strength is randomization, the best method to achieve group comparability, far superior to the flawed propensity score adjustment. However, unlike the presented registry, where patients with "pure" valvular disease are studied, the aggregation of concomitant procedures unequally affects the groups, introducing confusion into the results. This is because such trials pursue, and achieve, rapid recruitments with smaller volumes than registries, but with sufficient statistical power and no impact of biases like historical cohort utilization. Being experiments, they exhibit meticulously calculated designs with inclusion criteria that limit external validity and generalizability to the population we treat. In fact, many low-risk trials randomize patients who could easily be treated with either therapeutic alternative. And while it is widely known that surgery cannot achieve everything…neither can TAVI. Thus, well-known suboptimal cases exist where the percutaneous option may have been forced, presumably in favor of less invasiveness (first-degree atrioventricular block, right bundle branch block, irregular distribution of annular or outflow tract calcification, predominant aortic insufficiency, borderline vascular access, presence of other valvular diseases, or coronary disease), while a surgical option could have been

offered. Since TAVI procedures surpassed surgical ones more than five years ago, the reverse is far less common. Finally, RCTs are, by definition, multicenter, though participants are also often selected by volume, experience, and outcomes, providing less generalizable evidence compared to real-world registry results. It is desirable that the distorted presentation of results be progressively abandoned, offering transparent outcomes like those in observational studies, moving away from non-inferiority analyses and composite events.

In summary, the TAVI versus surgery debate is reaching new horizons. It has now extended to two irreconcilable factions: the “RCT advocates,” predominant in cardiology, who champion randomized evidence; and the “registry advocates,” who praise real-world data evidence. Perhaps both alternatives, well executed, are valuable. But what the AUTHEARTVISIT study tells us is that surgery demonstrates strong outcomes when performed and that Austrian Heart Teams responsible for patient allocation are remarkably well calibrated.

Predicting whether TAVI’s excess mortality is due to greater patient morbidity or frailty, or valve-related events during follow-up, is complex. In other words, whether patients live longer with one valve over another because they were destined to live longer or because of the valve itself, seems difficult to answer. TAVI is a powerful therapeutic alternative, perhaps the most potent available in interventional cardiology alongside acute-phase coronary angioplasty. It clearly improves patient prognosis and quality of life. Therefore, the question is whether it achieves this more effectively than surgery. Studies like AUTHEARTVISIT tell us that globally, it does not, which does not exclude it from being an excellent therapeutic option in numerous scenarios. Thus, to the words of some critics of the study I cite: “Why do patients die? … It’s not the valve’s fault,” they should be reminded of the impact of new left bundle branch block, pacemaker implantation, the role of paravalvular leakage, untreated residual heart disease, future difficulty accessing coronary ostia, mortality in subsequent valvular procedures—both surgical and percutaneous valve-in-valve—and phenomena like thrombosis and embolism, among others, assuming comparable rates of structural degeneration and endocarditis, which is a significant assumption. What is clear is that the surgical option must remain valid, and outcomes, particularly in younger age groups (<75–80 years) with adequate life expectancy, fewer comorbidities, and thus more comparability, are decidedly better.

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Elio Martín Gutiérrez

When the Aortic Bioprosthesis Degenerates: Revalve or Replace?

This American multicenter retrospective study evaluates the medium-term outcomes of patients with degenerated aortic bioprostheses who underwent either percutaneous valve-in-prosthesis procedures or reoperation for valve replacement.

Bioprosthesis degeneration is an event that, in the past, surgeons preferred to avoid and would send patients home after the initial consultation and consent signing, often reassuring them, “don’t worry, this prosthesis will last longer than you.” When early structural degeneration occurred, the initial annoyance was followed by a phase of concern, eventually leading to resignation to a new surgery, which was sometimes delayed if the dysfunction had no symptomatic impact or ventricular function repercussions. Many cases of early degeneration likely slowed the enthusiasm that initially led to the implantation of bioprostheses in younger patients, due to the lack of long-term data we now possess. Despite our hopes, we were essentially replacing one valvular disease with another, inevitably linked to the prosthesis' performance.

The advent of transcatheter aortic valve implantation (TAVI), combined with a more active lifestyle, encouraged the liberal use of bioprosthetic implants, either to compete with the percutaneous option or out of confidence in the concept of re-valving, initially termed “valve-in-valve (ViV)” or, more accurately, “valve-in-prosthesis.” As with all trends, the preference for bioprostheses recurred, further fueled by limitations of mechanical valves, especially the inability to use new oral anticoagulants in patients with atrial fibrillation.

This study raises questions about the appropriateness of the liberal use of bioprostheses and, if degeneration occurs, whether the best option is reoperation (Re-SVA) or percutaneous treatment in patients with comparable and acceptable surgical risk. As a prelude to the results, it is worth mentioning a recently published study comparing bioprostheses to mechanical prostheses for aortic valve replacement in patients of similar age, which found better long-term survival with mechanical prostheses, especially when avoiding patient-prosthesis mismatch and the use of small 19 mm prostheses.

With this premise in mind, we reviewed the study, which included patients from across the United States, from centers located in New York and New Jersey on one coast, and California on the other. Between 2015 and 2020, a total of 1,771 patients with degenerated bioprostheses underwent invasive procedures. After propensity score matching, 375 patients were included in each group: those undergoing ViV versus Re-SVA. As previously noted, the methodology of propensity score adjustment has significant limitations if not executed correctly. However, it is worth highlighting that this study employed an extensive variable model with comprehensive stratification and subsequent bias control, achieving truly comparable groups with notable morbidity. High rates of severe morbidities were reported, including diabetes mellitus in over 40%, peripheral arterial disease in more than 25%, cerebrovascular disease in 20%, atrial fibrillation in nearly half of the sample, chronic obstructive pulmonary disease (COPD) in about one-fifth, and a concerning proportion of patients (20%) with a history of cancer, with a mean age of 68 years. A notable limitation is that patients did not initially undergo isolated aortic valve procedures, as many had concomitant surgeries, though these were comparable between groups. Moreover, a distortion remains, as the study included patients reoperated for procedures unrelated to the aortic valve, with or without associated procedures during follow-up.

The findings were clear:

- A lower rate of periprocedural complications and early mortality with the percutaneous option, likely reflecting good case selection for the interventional approach. These differences did not reach statistical significance for all-cause mortality at two years.

- Higher rates of mortality and heart failure from two years onward with the percutaneous option, with statistically significant divergence of survival curves extending to the maximum five-year follow-up.

The authors concluded that the percutaneous approach yielded poorer long-term outcomes, though they suggested that prospective, randomized studies are warranted to confirm these results, considering potential confounding factors.

COMMENTARY:

The study presented adheres to the familiar narrative in cardiology literature when compared to surgical options: hastily selected patients with a “whatever works” approach, incomplete or omitted data, and conclusions reluctantly accepted when the findings are not favorable to their interests.

First, in studies focused on this subject, the absolute number of bioprosthetic implants remains undisclosed, preventing the determination of degeneration rates or the number of patients with degenerated prostheses who were not deemed candidates for successive treatments. This crucial information is systematically omitted, aligning with the general medical and cardiology approach of treating at all costs, even if this leads to morbidity from previous treatments that generate preventable clinical scenarios. Put differently, by prioritizing beneficence (sometimes questionably, regarding for whom it serves), the principle of primum non nocere—or, at least, minimizing harm—is often overlooked.

As surgeons, we must distinguish ourselves from this approach. In my view, most cases of bioprosthesis degeneration, even if not early, are undesirable events and should unequivocally be considered complications. Exceptions could include cases where the patient consents to bioprosthesis implantation despite a high degeneration risk, for reasons such as avoiding the risks or interference of oral anticoagulation, underlying pathologies contraindicating anticoagulation, or the reproductive desires of young women, among others. However, I do not consider it appropriate to turn this exception into the rule, nor to advise patients toward the “biological pathway,” especially if they are young and low-risk.

Second, the reported outcomes may have been affected by a lack of control over confounding factors, which may have escaped propensity score adjustment. In the absence of randomization, if local Heart Teams chose who to operate on and who to treat percutaneously (with percutaneous treatment theoretically offering better morbidity and mortality profiles given equal risk and strong predictors against technical complications), they likely did so for good reason. This could explain the survival curve divergence observed at the two-year mark.

A more skeptical view would highlight what is not stated over what is. Notably absent are post-procedural gradient data once bioprosthesis dysfunction has been addressed. As a

clue, the heart failure rate aligns with the all-cause mortality rate, suggesting that percutaneous approaches may not be systematically advisable for operable degenerating bioprostheses. This insight is crucial not only for interventional cardiologists but also for surgeons, who must acknowledge responsibility for both the prosthesis agreed upon with the patient and the obligation to reoperate when complications arise. The current approach advocated by interventional cardiology to perform disproportionate and theoretically non-mismatched "oversized" aortic implants for future re-valvings appears unjustifiable. It doubles the procedural risk by adding an "aortic surgery" score item in risk assessments and seems inappropriate when the patient, at that moment, may not benefit and instead may face complications. Besides potential prosthesis-patient mismatch, re-valving carries additional morbidities, such as an increased thrombotic event rate, which was also not reported in this study.

In summary, this commentary, more than the study itself, serves as a call for all members of the Heart Team to exercise responsibility in decision-making with patients. Each prosthesis has its specific indication and therapeutic niche, and as specialists, we are obligated to identify this. Sometimes, certain options may lack glamour, excitement, or immediate benefit; however, given the evidence and independent of industry interests, we are responsible for providing the best option for each patient at the time. If this doesn't satisfy us, perhaps it's time to reflect.

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Bunty Ramchandani

Stroke After TAVI: A Persistent Issue

Analysis of neurological complications within the first five years following transcatheter aortic valve implantation (TAVI) using data from the SwissTAVI registry.

In cardiac surgery, neurological complications rank as the second cause of morbidity and mortality, following heart failure. These complications often leave severe sequelae, necessitating extended care. Stroke incidence attributable to cardiac surgery varies from 0.4% to as high as 14%, depending on the population studied, the type of procedure, and the number of concurrent interventions. According to data from the Society of Thoracic Surgeons (STS) database, stroke incidence shows variability, reaching 1.4% in isolated coronary surgery. This rate increases to between 1.3%-2.3% for isolated aortic or mitral valve repairs, respectively. In combined surgeries involving aortic or mitral valve replacement along with revascularization, stroke incidence rises to 1.9%-3.1%, respectively. For isolated aortic valve replacement, in alignment with the study under analysis, the incidence stands at 1.2%.

Multiple studies on stroke related to cardiac surgery provide daily references, aiding surgeons in informing patients about early and late risks associated with this complication. However, for transcatheter therapies, long-term neurological complication data are lacking. Given the industry's push to expand these therapies to low- or intermediate-risk patients, it is crucial to assess the impact of stroke in patients who have already received a TAVI. Without such data, the extended life years of a younger population with inherently longer life expectancy are at risk.

Today's study aims to investigate the short- and long-term incidence and predictors of stroke following TAVI implantation. The study used the SwissTAVI registry, analyzing all patients enrolled from February 2011 to June 2021. To compare stroke incidence with the general population, data from the 2019 Global Burden of Disease study was employed, using an age- and sex-matched cohort to calculate stroke trends in TAVI-treated patients.

A total of 11,957 patients with an average age of 82 years, half of whom were women, were studied. One-third of patients had a history of atrial fibrillation, and 12% had experienced prior cerebrovascular accidents. The 30-day cumulative stroke incidence was 3%, with more than two-thirds of events occurring within the first 48 hours post-implantation. This incidence rose to 4.3% by the first year and 7.8% by the fifth year. When compared with an age- and sex-matched population, TAVI patients exhibited a higher stroke risk during the first two years: with a standardized stroke ratio (SSR) of 7.26 for men and 6.82 for women in the first year. In the second year, SSR decreased to 1.98 and 1.48 for men and women, respectively. From the third year onward, the stroke risk in the TAVI group became comparable to that of the general population. Age and moderate-to-severe paravalvular regurgitation were independent predictors of stroke within the first 30 days post-TAVI, while dyslipidemia, atrial fibrillation, and prior stroke history were independent predictors of late stroke.

The authors concluded that TAVI patients have an elevated stroke risk in the first two years following the procedure, which aligns with the general population thereafter.

COMMENTARY:

The SwissTAVI registry is a national, prospective, multicenter registry for all patients receiving TAVI treatment in Switzerland. Enrollment in this registry is mandated by the Swiss Federal Office of Public Health and is a prerequisite for reimbursement by health insurance companies. Data from the registry are managed by an independent clinical trials unit that verifies accuracy, completeness, and statistical analysis. Given these strengths and a sample size of nearly 12,000 cases over a decade, this study may be one of the most robust on TAVI-related stroke.

The reasons behind the elevated stroke risk during the first two years post-procedure are unclear. Excluding events occurring within the first 30 days post-procedure, the cumulative stroke incidence in TAVI patients was 1.4% in the first year and 1.2% in the second, decreasing to less than 1% from the third year onwards. One hypothesis for this increased risk involves prosthetic leaflet thrombosis, which lodges in the neosinuses formed between the native aortic valve on which the TAVI stent rests and the prosthetic leaflets. This phenomenon could be clinically relevant in 0.6%-2.6% of cases. Similarly, studies indicate that subclinical leaflet thrombosis prevalence is detected in up to 17% of patients within the first three months, increasing to 31% within the first year. Unfortunately, data beyond one year for this entity is unavailable, and its association with stroke remains inconsistent in the literature. Subclinical thrombosis has been observed to appear and disappear spontaneously, even with anticoagulant therapy. Other theories suggest endothelial dysfunction post-TAVI implantation or, more intriguingly, the onset of atrial fibrillation in up to 20% of patients within months following implantation. In this case, we lack a control group to determine if the incidence of silent atrial fibrillation increases post-procedure relative to a normal population.

In closing, it is essential to consider study limitations. As registry data, critical information such as the incidence of clinical or subclinical prosthetic thrombosis is missing. Anticoagulation therapy protocols are also non-standardized, leaving the decision to the local Heart Team based on patient risk factors. Since 2015, cerebral protection devices have been used in Switzerland, although they are not universally adopted, as hospitals employ varying protocols. This variability introduces a confounding factor in data analysis. The control group was a Swiss population, making it unclear if findings would apply to a Hispanic population. Finally, it is important to remember that the average age of the study population was 82 years, meaning the conclusions should not be extrapolated to younger patients.

In conclusion, this study is among the most significant on late neurological events post-TAVI, showing an elevated stroke risk within the first two years, with most early strokes occurring within the first 48 hours. These findings should prompt reconsideration of using these prostheses in younger patients and reconsider policies for early discharge within 48 hours.

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Carlota Hernández Díez

PARTNER 3 at 5 Years: Low-Risk Patients and TAVI… Quo Vadimus?

Five-year results from the PARTNER 3 trial, which evaluated the balloon-expandable SAPIEN 3® TAVI versus surgical aortic valve replacement (SAVR) in low-risk patients.

In recent years, several studies have compared TAVI with SAVR in patients at high and intermediate surgical risk, yielding favorable outcomes that have supported the expansion of TAVI in these populations. This progress prompted studies involving low-risk patients, such as the Evolut Low Risk (using self-expanding Corevalve® or Evolut® prostheses) and the PARTNER 3 study (using balloon-expandable SAPIEN 3® prostheses).

The PARTNER 3 study included patients with severe symptomatic aortic stenosis who were at low surgical risk (defined by an STS-PROM score <4% and Heart Team consensus) and eligible for transfemoral access. Patients were randomized 1:1 to undergo TAVI with a balloon-expandable valve or SAVR. The primary endpoint was a composite of death, stroke, or rehospitalization (related to the procedure, valve, or heart failure), with a statistically significant reduction observed in the TAVI group at 1 and 2 years. The longer-term durability of these results remained unknown, leading to the extension of follow-up to five years.

A total of 1,000 patients were randomized, with 503 in the TAVI group and 497 in the SAVR group, of whom 948 received the initially intended valve (496 TAVI and 454 SAVR). A notable disproportionate patient loss occurred in the surgical group. Through a telehealth-based tracking, vital status data were obtained for 66 of the 95 patients lost to follow-up. The mean patient age was 73 years, with 69% men and a mean STS-PROM score of 1.9%. The primary endpoint remained the same as in the original study, expressed as estimated percentages using the Kaplan-Meier method. Since patients could experience more than one event or hospitalization during the five-year period, another hierarchical composite primary endpoint was considered, including death, disabling or non-disabling stroke, and days of rehospitalization, expressed through a win ratio analysis. Secondary endpoints at five years included: death, stroke, new-onset atrial fibrillation (AF), reoperation on the aortic valve, endocarditis, prosthetic thrombosis, prosthetic dysfunction, functional status, and quality of life as measured by the Kansas City Cardiomyopathy Questionnaire (KCCQ-OS). A time-to-event analysis was conducted from baseline to 1 year, from 1 to 5 years, and from baseline to 5 years.

The primary composite endpoint (death, stroke, or rehospitalization) from baseline to 5 years occurred in 22.8% of patients in the TAVI group and 27.2% in the SAVR group, with no statistically significant difference (p= 0.07). In an analysis of years 1 to 5, the primary endpoint occurred in 15.7% of TAVI patients and 13.7% of SAVR patients. The win ratio for the other hierarchical composite primary endpoint (death, disabling or non-disabling stroke, and days of rehospitalization) was 1.17, favoring TAVI, although it was not statistically significant (p=0.25). For other five-year outcomes, mortality was 10% for TAVI vs. 8.2% for SAVR, stroke 5.8% vs. 6.4%, rehospitalization 13.7% vs. 17.4%, new-onset AF 13.7% in TAVI vs. 42.2% in SAVR, and pacemaker implantation 13.5% in the TAVI group vs. 10.4% in the SAVR group. As for prosthetic complications, 2.5% of clinically significant prosthetic thrombosis cases occurred in the TAVI group versus 0.2% in the surgical group. Additionally, aortic insufficiency (AI) greater than mild was found in 24.5% of TAVI patients vs. 6.3% of SAVR patients. Prosthetic gradients were similar in

both groups (12.8±6.5 mmHg in TAVI and 11.7±5.6 mmHg in surgery). At five years, 84% of patients in the TAVI group and 86% in the surgical group were alive and in NYHA class I-II.

A significant aspect of this trial is the high number of patients lost to follow-up, particularly in the surgical group, which the authors themselves consider a potential source of bias. Another critique is the discrepancy between numerical figures present in tables and the text, with no explanation offered either in the article or supplementary material (for instance, in Table 1, the patients at risk from years 1 to 5, 490 for TAVI vs. 427 for SAVR, differ from the text on the following page, 453 TAVI vs. 372 SAVR, while primary endpoint percentages remain unchanged at 15.7% for TAVI vs. 13.7% for surgery).

The authors conclude that among low-risk patients with severe, symptomatic aortic stenosis who underwent TAVI or surgery, there were no significant differences between groups in the two primary composite outcomes at five years, with the initial favorable trend for TAVI observed at 1 and 2 years reversing over time.

COMMENTARY:

The expansion of TAVI in patients with severe aortic stenosis at high and intermediate surgical risk has increased significantly in recent years. Current clinical practice guidelines from the European Society of Cardiology recommend TAVI for patients >75 years or at high surgical risk (STS-PROM or Euroscore II >8%) or deemed inoperable. For intermediate-risk patients, decision-making should occur within the Heart Team framework, considering anatomical, clinical characteristics, and patient preferences. However, for low-risk surgical patients, surgical valve replacement remains the treatment of choice. Given the favorable outcomes for TAVI in intermediate- and high-risk patients with limited follow-up due to survival constraints imposed by comorbidities, evaluating this technique in low-risk patients became appealing. As previously discussed, short-term findings were promising, but the five-year PARTNER 3 results cast doubt on the durability of TAVI. Likely, TAVI's short-term benefits (lower mortality and stroke rates, shorter hospital stay, reduced rehospitalization, lower rates of AF and bleeding) diminish over time, with a notable increase in mortality and stroke rates in the TAVI group after the first year of follow-up. Additionally, prosthetic thrombosis, pacemaker implantation, and perivalvular insufficiency incidence were higher in the TAVI group. These complications could lead to worsened clinical and quality-of-life outcomes for patients and a potential need for reintervention, negating TAVI's initial less invasive advantage. It seems prudent to continue evaluating each case within the Heart Team session and to inform low-risk patients of the benefits and risks of each technique, offering the best individualized treatment.

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José Manuel Martínez Comendador

Balloon-Expandable Myval® Bioprosthesis Matches Contemporary Devices: A Surgeon's Perspective

Randomized Clinical LANDMARK Non-Inferiority Trial Comparing the Meril Myval® Balloon-Expandable Prosthesis with Widely Used Contemporary Prostheses (Edwards SAPIEN® and Medtronic Evolut®) in Transcatheter Aortic Valve Implantation

It has been 22 years since the first transcatheter aortic valve implantation (TAVI) was introduced. Since then, the landscape has undergone drastic changes. Initially limited to inoperable patients, TAVI indications have progressively expanded, becoming the treatment of choice for patients over 75 years of age today. This shift has been driven by technical advances, favorable durability data, and a growing body of scientific evidence supporting TAVI's inclusion in major clinical practice guidelines. Most of the current evidence has been provided by observational registries and clinical trials involving prostheses that have been available on the market for many years, such as the SAPIEN® (Edwards Lifesciences, USA) and Evolut® (Medtronic, USA) devices.

As expected, new prostheses are emerging in the market, aiming to establish themselves as viable alternatives in TAVI. One such example is the Myval® prosthesis (Meril Life Sciences Pvt. Ltd., India), featuring an intra-annular balloon-expandable design intended to demonstrate similar clinical benefits.

The LANDMARK clinical study we are analyzing today aims to demonstrate that the Myval® prosthesis is not inferior to widely used contemporary prostheses (Edwards SAPIEN® and Medtronic Evolut®). This trial is randomized, prospective, and multicentric, conducted across 31 hospital centers in 16 countries, including Spain.

Patients selected for the study were adults with severe symptomatic aortic stenosis, indicated for TAVI according to the evaluation of the local heart team. They also required an anatomical compatibility to implant the three prostheses included in the trial, with access mandated via the transfemoral route. Patients were randomly assigned in a 1:1 ratio to receive the Myval® prosthesis or a contemporary prosthesis (50% distribution for Edwards SAPIEN® and 50% for Medtronic Evolut® within this group). Following randomization, device sizing (determined by pre-procedural computed tomography analysis), implantation technique (projection used, need for pre/post-dilatation, etc.), and post-procedural monitoring (including pacemaker requirement) were left to the discretion of the investigative team at each center.

The primary endpoint at 30 days was a composite of seven events: all-cause mortality, stroke, major bleeding, acute kidney injury, major vascular complications, moderate or severe aortic insufficiency, and permanent pacemaker implantation, according to the Valve Academic Research Consortium-3 (VARC-3) criteria. Key secondary endpoints included the individual components of the primary endpoint, in addition to functional class evaluation, quality of life, and hemodynamic parameters of valve function assessed via echocardiography.

A total of 768 patients were included in the study, with 384 randomly assigned to the Meril Myval® prosthesis group and the remaining 384 to the contemporary prosthesis group. Women constituted 48% of the participants, with an average age of 80 years and an average STS score of 2.6% (indicating low surgical risk, <4%). There were no significant differences between both groups regarding these or other baseline characteristics. In the intention-to-treat analysis, the Meril Myval® prosthesis met the

primary endpoint of non-inferiority at 30 days, with an incidence of 25% in the Meril Myval® group versus 27% in the contemporary prosthesis group. The risk difference was −2.3%, with an upper 95% confidence interval limit of 3.8% (*p* for non-inferiority <0.0001). No significant differences were observed in the individual components of the primary endpoint.

The authors concluded that in individuals with severe, symptomatic aortic stenosis, the transcatheter Meril Myval® valve achieved its primary endpoint at 30 days.

COMMENTARY:

In recent years, several randomized trials have compared different TAVI valves. The major studies include:

- SOLVE-TAVI (2020): Compared the self-expandable Medtronic Evolut R® valve and the balloon-expandable Edwards SAPIEN 3®, achieving equivalence in the combined primary endpoint at 30 days.

- SCOPE I and II: Evaluated the Boston AcurateNeo® device, which failed to demonstrate non-inferiority against Medtronic Evolut R® and Edwards SAPIEN 3®, considered standards for their durability and extensive evidence.

- PORTICO-IDE: Demonstrated non-inferiority of the Abbott Portico® valve compared to standard valves.

Now added to this list is the LANDMARK trial, which evaluated the balloon-expandable Meril Myval® prosthesis against Edwards SAPIEN® and Medtronic Evolut®, demonstrating non-inferiority in the 30-day efficacy and safety combined endpoint. Notable findings include a lower pacemaker rate than traditional rates in both groups, 15% with Meril Myval® compared to 17% with contemporary prostheses ($p = 0.49$), which, while low, remains considerably higher than with conventional surgical prostheses. Additionally, if we examine other primary endpoint events, these also had a low incidence, likely reflecting technique improvements:

- All-cause mortality: 2% in both groups ($p = 1.0$).

- Stroke: 3% in both, only 1% disabling ($p = 1.0$).

- Major vascular complications: 2% in both groups ($p = 0.6$).

- Moderate or severe regurgitation: 3% with Meril Myval® versus 5% with the other prostheses ($p = 0.58$).

In interventional cardiology, non-inferiority trials are common to validate new devices and facilitate their adoption in clinical practice. However, while most studies focus exclusively on transfemoral access, mainly performed by interventional cardiologists, it cannot be overlooked that these results are extrapolated to non-transfemoral accesses, such as transcarotid or transaxillary routes. These approaches, in certain Spanish centers like ours, are managed entirely by cardiac surgeons.

At the University Hospital of A Coruña (CHUAC), we have performed over 480 non-transfemoral TAVI procedures since 2009. For the first ten years, the transapical route

was predominantly used, whereas in the last 190 cases, the transcarotid route has been preferred. With this approach, 30-day mortality was 1.6%, despite the high surgical risk of the patients (EuroSCORE II of 7% and an average age of 82 years). The stroke rate was 0.8%, major vascular complications 1.6%, and permanent pacemaker implantation rate 12%. In general, these results are comparable or even superior to those achieved in this trial. Although more than 80% of the implanted prostheses were of the Edwards SAPIEN 3® type, around 10% were Meril Myval® prostheses, providing us with a comparative experience basis between the two.

It is noteworthy that this clinical trial included a patient population with lower surgical risk than previous studies (average STS score 2.6%). Another distinguishing feature is its notable anatomical variability, with 7% of bicuspid valves and 32% small annuli, likely reflecting the broad current indication of TAVI across different patient profiles.

The study has some limitations. The main one is selection bias, as only 15% of patients were included in participating centers, all with favorable anatomies for the prostheses. This may limit the generalizability of the results. Additionally, there were more crossovers in the Meril Myval® group (15 vs. 5), primarily due to the lack of available prosthetic sizes. Finally, patients with 23 mm Medtronic Evolut® prostheses were not included, which may have underestimated the benefit of the supra-annular design in small annuli.

In my opinion, the Meril Myval® prosthesis has two significant advantages over others; the first is the availability of intermediate and even extra-large sizes (accessible with any access type), and the second is the simplicity of the system, which comes preloaded (extravasculature) on the balloon (particularly relevant for non-transfemoral access):

1. Availability of Intermediate Sizes: With 1.5 mm increments instead of the usual 3 mm, Myval® improves adaptation to the patient's aortic annulus. Precise adjustment is crucial, as an oversized prosthesis increases the risk of complications, while an undersized one may lead to paravalvular insufficiency or embolization. In the LANDMARK study, 48% of Myval® patients received an intermediate prosthesis, associated with a lower rate of prosthetic insufficiency and a larger aortic valve area at 30 days compared to Edwards SAPIEN®. Additionally, Myval® offers extra-large sizes (30.5 and 32 mm) for annuli up to 840 mm^2, which may be helpful in patients with non-calcified pure aortic insufficiency or mitral or tricuspid valve-in-valve procedures. Although the LANDMARK study did not include patients with large annuli, future results are expected from a registry dedicated to this group.

2. System Simplicity with Preloaded Balloon Prosthesis: The Meril Myval® system's extravascular preloading simplifies the TAVI process, being especially useful for non-transfemoral accesses like the transcarotid route, commonly performed in CHUAC's cardiac surgery service. In this access, the space between the supraaortic trunks and the aortic annulus is much more limited than in transfemoral access. Myval®'s design eliminates cumbersome steps to position the balloon within the prosthesis in a restricted space, simplifying the procedure and reducing risks. The intravascular loading of prostheses, as with Edwards SAPIEN 3®, includes maneuvers requiring space, and it warrants special attention when the distance between the aortic

annulus and the distal end of the introducer is limited, i.e., in non-transfemoral peripheral accesses.

As therapeutic options in TAVI continue to expand, treatment personalization is becoming increasingly important, choosing the most suitable prosthesis according to the patient's anatomy. Thus, we have moved from searching for the "patient for implantation" to finding "the best implant for each patient." In this context, the Meril Myval® prosthesis has made significant progress with positive 30-day results compared to other prostheses. Nevertheless, further studies and long-term follow-up are needed to determine its definitive place in clinical practice.

Finally, I would like to once again encourage all cardiac surgeons interested in the TAVI field not to give up on their goal. It is crucial to take advantage of all training opportunities, stay updated, and, with determination, promote the implementation of non-transfemoral access in their hospitals. These approaches, due to their surgical nature, are particularly suitable for our specialty, and our results support us.

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Mario Castaño Ruíz

Reflections on PCI and TAVI in the NOTION 3 Study: The Right to Have Two Diseases, Even in the Heart... and to Have Them Treated

Analysis of the NOTION 3 Study and Its Implications for the Treatment Allocation of Patients with Severe Aortic Stenosis and Concomitant Coronary Artery Disease.

In this randomized, open-label, superiority, multicenter, international study, researchers examined the impact of coronary revascularization through percutaneous coronary intervention (PCI) on patients with severe aortic stenosis (AS) eligible for transcatheter aortic valve implantation (TAVI) and concomitant stable coronary artery disease. Although the study was sponsored by Boston Scientific®, the company did not supply any devices and did not participate in any aspect of the study's design, development, or publication.

Patients with severe AS selected for TAVI by the local Heart Team and presenting at least one coronary lesion in a vessel >2.5 mm, with either an angiographic stenosis >90% or an FFR <0.80, were included. Exclusion criteria comprised life expectancy <1 year, acute coronary syndrome (ACS) within 14 days prior to randomization, severe chronic renal disease with a glomerular filtration rate <20 ml/min/m², or left main coronary artery disease. Chronic occlusions did not exclude the patient, and revascularization was left to the operator's discretion. All patients were randomized in a 1:1 ratio to receive PCI for lesions meeting inclusion criteria or to conservative treatment. Although the protocol strongly recommended revascularization prior to TAVI as sequential procedures, concurrent or delayed PCI up to 2 days post-implantation was permitted. Antiplatelet therapy and, when indicated, anticoagulation were administered according to predefined guidelines, with adaptations following the release of the AUGUSTUS study in 2019 and the POPular Trial in 2020, which influenced the antiplatelet strategy as the study progressed.

The primary endpoint was a composite event of death from any cause, myocardial infarction, or urgent revascularization, evaluated until the last included patient had been followed for at least 1 year post-TAVI. Secondary events included the individual components of the primary endpoint, as well as cardiovascular mortality, perioperative or spontaneous myocardial infarction, any need for repeat revascularization, stent thrombosis, hospitalization due to heart failure, stroke, bleeding assessed per VARC-2 criteria, acute kidney injury, and NYHA and CCS functional class at 1 and 12 months post-TAVI. Safety events were defined as any type of bleeding.

Between September 2017 and October 2022, 455 patients were enrolled across 12 hospitals (PCI group: n = 227; conservative group: n = 228), with two-thirds enrolled between 2020 and 2022. The groups were balanced in baseline characteristics, except that a higher proportion of patients in the PCI group were smokers and/or had obstructive pulmonary disease. Most patients were male (67%) and elderly (75% were over 78 years old), with median STS-PROM and SYNTAX scores of 3% (2-4%) and 9 points (6-14 points), respectively. In 12 patients, TAVI was not performed, and PCI was not completed in 8 assigned to the PCI group. Additionally, 11% of patients did not undergo complete revascularization of all lesions initially considered for PCI. In 26% of cases, PCI was performed during or after TAVI.

After a median follow-up of 2 years (1-4 years), the primary endpoint was observed in 25% of the PCI group and 35% of the conservative group (HR = 0.69; 95% CI = 0.49 –

0.97), considering only those patients who ultimately underwent TAVI (modified intention-to-treat analysis). Among secondary events, myocardial infarction and urgent revascularization were more frequent in the conservative group, while incidences of all-cause or cardiovascular death and stroke were similar. Any bleeding occurred more frequently in the PCI group (28% vs. 20%; HR = 1.51; 95% CI = 1.03-2.22), and renal failure was significantly higher in the conservative group.

In the discussion, the authors highlight differences between this study and the ACTIVATION trial, which also investigated coronary revascularization in TAVI patients. NOTION 3 included a larger and more representative population, with differences in the timing of enrollment, age, and surgical risk according to STS-PROM criteria. Additionally, a higher percentage of patients in NOTION 3 presented angina, and revascularization criteria were stricter (>90% stenosis/FFR <0.8 in NOTION 3 vs. >70% lesions in ACTIVATION).

Additionally, note that the included patients had a low SYNTAX score and little representation of patients with multivessel disease. Among the most important limitations are the exclusion of patients with ACS in the previous 14 days and of patients with left main disease, so the results cannot be extrapolated to these populations, and the long inclusion period, which among others. These things led to changes in the criteria and duration of combined anticoagulation plus antiplatelet or double antiplatelet treatments. The fact that two-thirds of patients were included in the last two years of the inclusion period has probably neutralized part of these limitations.

The conclusion of the study is that performing PCI in lesions > 90% or with FFR < 0.8 in TAVI candidate patients with coronary artery disease reduces the incidence of the combined event, subsequent revascularization and the risk of new myocardial infarction, although they advise that the decision should be individualized and must take into account the patient's health status and comorbidities, life expectancy, complexity and severity of coronary heart disease, and patients' risk of bleeding.

COMMENTARY:

This is an important study contributing evidence to the ongoing debate on whether revascularization in TAVI candidates with coronary artery disease results in clinical benefits beyond treating the aortic valve alone. Significant benefits were observed in the revascularized group after only a median follow-up of two years, which was expected given the significance of the lesions targeted for treatment (arteries >2.5 mm with >90% stenosis or deemed significant by functional testing). Results might have been even more striking if the rate of incomplete revascularization in the PCI group had been lower (11% despite low SYNTAX scores). It is likely that the Heart Team's requirement to accept patients for TAVI prior to inclusion excluded those with more complex coronary disease unsuitable for PCI but eligible for valve replacement and surgical myocardial revascularization. It is worth noting that surgery would likely have achieved higher complete revascularization rates, as evidence shows that the extent of revascularization by coronary artery bypass grafting is not influenced by SYNTAX scores, even when highly elevated. Beyond the limitations identified by the authors, the 11% incomplete revascularization rate in the study group warrants an "as-treated" analysis rather than solely an "intention-to-treat" analysis.

Numerous important retrospective studies have reported reduced adverse events following surgical aortic valve replacement and coronary bypass grafting at both short- and long-term compared to non-revascularization, using thresholds of >50% and >70% stenosis for revascularization. This concept, widely endorsed by surgeons, likely explains the notable differences in associated procedures in comparative TAVI vs. surgery studies

across various risk strata, with significantly higher myocardial revascularization rates in the surgical groups almost systematically. While the impact on initial risk and mortality in surgical groups is partially justified by this higher rate of associated procedures, the neutralization of benefits at mid-term likely reflects the higher degree of concomitant coronary disease treatment. Of particular concern, in the PARTNER 3 study, the component of the composite primary event that most favored TAVI was rehospitalizations. Although myocardial infarction is included among safety and efficacy events, the study protocol specifically restricts indexable rehospitalizations to those due to “aortic stenosis symptoms and/or valve implantation complications,” later defined as “hospitalizations related to the procedure, valve, or heart failure.” Finally, these are further divided into: 1) valve-related rehospitalizations, including symptoms due to acute, subacute, or late prosthetic dysfunctions like thrombosis, endocarditis, valve degeneration, prosthesis-patient mismatch, delayed coronary obstruction, coronary embolism, heart failure due to the aortic valve, or hemorrhagic complications; and 2) procedure-related rehospitalizations, including bleeding, vascular complications, stroke/TIA, arrhythmias, and acute kidney failure. The inclusion of acute coronary syndromes of non-embolic or other causes unrelated to delayed coronary occlusion as indexable rehospitalization causes within the primary event is unclear, and if not attributed to the procedure, might downplay the magnitude of this composite event.

The study results strongly suggest that patients with significant lesions in major vessels unlikely to achieve complete percutaneous revascularization should be considered surgical candidates. The study’s follow-up is still short (median of two years), and given the findings in patients with an average age of 74 years and only 25% under 78 years, expanding TAVI without revascularization to younger patients could prove highly detrimental, not only due to the increase in coronary events but also due to the challenges that may arise for revascularization in these patients with percutaneously difficult-to-access ostia and complex ascending aorta management if surgical revascularization is eventually required. It is equally crucial to conduct randomized studies with sufficient patient populations to compare outcomes of TAVI + PCI versus concomitant surgical aortic valve replacement and coronary bypass grafting in this subset of patients with aortic stenosis and ischemic heart disease.

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Luis Nieto

Aortic Stenosis and Stable Coronary Artery Disease: What Should We Address First? TAVI-PCI Study

Analysis of evidence on the optimal timing for performing percutaneous coronary intervention (PCI) in TAVI candidates, along with an outline of the TAVI-PCI study protocol.

Aortic stenosis and coronary artery disease are often concomitant conditions. Sharing multiple risk factors, it is common to encounter patients with both significant valvular and coronary involvement. According to various registries and studies, 30-60% of patients with severe aortic stenosis present with significant coronary artery disease.

Currently, the guidelines from the European Society of Cardiology provide a class IIa recommendation and level of evidence A for revascularization of >70% lesions in patients undergoing TAVI, especially if proximal segments are affected, based on findings from clinical trials such as PARTNER 1 and 2 and EXCEL, among others. Recently, the NOTION 3 trial reinforced the idea that clearly significant lesions, whether identified by angiography or functional assessment, should be revascularized to reduce adverse events in these patients.

Recognizing that significant coronary lesions must be addressed in TAVI candidates with a comorbidity profile or high surgical risk, another challenge arises: timing.

Traditionally, most PCI procedures were performed prior to valve implantation, driven mainly by the complexity of the approach post-valve implantation or to prevent significant hemodynamic compromise during implantation, especially in proximal or left main lesions.

The next most common approach is to perform PCI concomitantly with valve implantation, aiming to reduce bleeding complications (avoiding dual antiplatelet therapy during valve implantation), although at the expense of extending procedural time and complexity.

Finally, and gaining traction, is the option of deferred revascularization post-TAVI, following an improvement in the patient's hemodynamic reserve and avoiding dual antiplatelet therapy during implantation.

The available evidence on revascularization timing is limited in both volume and quality, largely derived from observational studies, registries, and sub-analyses, and mostly pertaining to pre-TAVI or concomitant revascularization, with almost no data on post-TAVI revascularization. Sub-analyses on revascularization in aortic stenosis patients from classic studies like SURTAVI and PARTNER 2 suggest no clear benefit in reducing overall mortality or cardiovascular events for patients undergoing PCI prior to valve replacement. This may be due to the leniency in considering coronary lesions significant, including a substantial percentage of moderate lesions. The RE-ACCESS study, aimed at comparing pre- and concomitant revascularization, demonstrated no superiority between the two. Additionally, the REVASC-TAVI registry (n = 1603, international and real-world) compared all three revascularization strategies, with deferred revascularization showing favorable outcomes over the other two approaches despite its lower utilization (only 10% of cases) and a significant reduction in overall mortality.

As shown, the evidence is sparse and inconclusive, emphasizing the need for studies like the one discussed here: TAVI-PCI (A Randomized Comparison of the Treatment

Sequence of Percutaneous Coronary Intervention and Transcatheter Aortic Valve Implantation), which we will now review.

COMMENTARY:

The TAVI-PCI study is currently in the recruitment phase. It is a prospective, randomized, international, multicenter trial (over 35 centers in Switzerland, Germany, the Netherlands, Austria, and Italy) with a planned enrollment of 934 patients (with 678 already included by June 2024) eligible for TAVI with significant coronary disease (>70% lesions on angiography). Candidates are randomized to receive PCI within 45 days before (pre-TAVI group) or after the TAVI procedure (post-TAVI group). All patients will receive an Edwards SAPIEN 3® or 3 Ultra® valve. The study is designed to assess whether a delayed (post-TAVI) revascularization strategy is "non-inferior" to an early (pre-TAVI) strategy. The primary endpoint is a composite of all-cause death, myocardial infarction, revascularization, cardiovascular death, or major bleeding (as per VARC-2 criteria). The analysis will be conducted on an intent-to-treat basis. Secondary endpoints include individual components of the primary endpoint at 3 months, 1 year, 2 years, and 5 years, stroke, major vascular complications, NYHA functional class, and quality of life as measured by the Kansas City questionnaire.

Sub-analyses are planned within this study, focusing on functional assessment of coronary lesions (via FFR and QFR) before and after TAVI, biomarker use (particularly troponin as a prognostic marker), antiplatelet therapy (duration, drugs, etc.), and the characteristics of revascularization procedures.

Some limitations can already be identified, such as the inclusion of only balloon-expandable valves, associated with less coronary ostia compromise and better coronary access. Furthermore, concomitant PCI is not considered (despite evidence suggesting no clinical difference with pre-TAVI strategy and increased procedural complexity), nor does the analysis initially distinguish between proximal and non-proximal segments.

The direct comparison of both revascularization strategies has been in demand since TAVI became an established therapeutic option. TAVI-PCI stands as one of the first clinical trials to directly compare early versus late revascularization strategies, also aiming to generate hypotheses regarding the interdependence of these clinical entities and their pathophysiological correlation through secondary endpoints.

Future studies should analyze not only timing but also valve type (evidence on self-expanding prostheses should be generated) and scenarios such as the presence of a previous bioprosthetic valve (valve-in-valve). We are currently awaiting the results of the FUTURE TAVI registry, which compares the long-term outcomes of all three revascularization strategies.

Given the characteristics of the current “TAVI population” (elderly, comorbid, and susceptible to complications), decisions on managing valvular and coronary disease should remain individualized and assessed by each center's Heart Team, considering the need for revascularization and its timing. It must be noted that TAVI, based solely on age criteria, is reserved for inoperable or high-risk patients. Concomitant coronary disease, as highlighted in the NOTION-3 study analysis on this blog, remains a surgical indication for operable patients.

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Elio Martín Gutiérrez

Aortic stenosis in asymptomatic patients: Early intervention doesn't make the sun rise any sooner

Review of the current evidence on the invasive treatment of severe aortic stenosis in asymptomatic patients, with special emphasis on the results from the EVOLVED and EARLY-TAVR trials.

Aortic stenosis is a valvular disease that progresses through various stages during a patient's lifetime. As stenosis severity increases, the condition may reach a point of significant transvalvular gradient, progressing through a preclinical stage and subsequently a clinical stage characterized by the onset of symptoms. Once symptoms appear, the natural history of the disease is known to lead to a poor prognosis, making invasive treatment appropriate to correct the stenosis given the limited pharmacological options. However, it is this preclinical stage that is the focus of the current analysis, as some series have described sudden death episodes or hospital admissions due to heart failure decompensation, which could potentially be prevented by early intervention.

That said, invasive management of an asymptomatic patient must always aim for a prognostic benefit, since, by definition, it cannot relieve any symptoms during this phase of disease progression. In other words, the patient "neither knows nor will ever know what to be grateful for from the procedure." If complications occur, the benefit is counterbalanced, and potentially even a detriment is added, to a patient who, we must remember, was asymptomatic until that point.

In the context of severe aortic stenosis, multiple parameters have been identified that may be associated with a poorer prognosis, thus tipping the balance towards intervention during the preclinical phase:

Echocardiography

- AVA <0.75 cm^2 or indexed <0.6 cm^2/m^2
- Vmax 5 m/s
- Severe LVH (asymmetrical septal or indexed LV mass)
- Reduced left ventricular longitudinal strain (<12-16%)
- Left atrial volume >12.2 cm^2/m^2 (to prevent atrial fibrillation)
- Indexed stroke volume <35 cc/m^2

Exercise Testing

- Ischemic changes in ST segment during exercise
- Ventricular arrhythmias during exercise

- Reduction in left ventricular ejection fraction during or after exercise, compared to baseline
- PSAP >60 mmHg during exercise
- Increase in transvalvular gradient >18-20 mmHg during exercise
- VO2 max <14 cc/Kg/min

Computed Tomography

- Aortic valve calcium density >300 AU/cm² in women and >500 AU/cm² in men
- Calcium-score >1200 AU in women and 2000 AU in men

Magnetic Resonance Imaging

- Late gadolinium enhancement indicating myocardial fibrosis of unknown origin

Biomarkers

- Post-exercise NT-proBNP levels elevated compared to baseline

The presence of multiple prognostic markers suggests that no single parameter is perfect, and that an integrated multimodal preoperative assessment, along with patient consensus, should guide the decision towards conservative or invasive management.

Clinical practice guidelines include several recommendations for the intervention of asymptomatic patients, all of them class IIa: presence of left ventricular dysfunction with ejection fraction <50%, objective symptom provocation during exercise testing, tripling of elevated biomarker levels, or presence of critical aortic stenosis with Vmax >5.5 m/s and/or AVA <0.6 cm². In previous editions of the guidelines, pulmonary hypertension during exercise testing was included as a criterion, but it is not present in current guidelines. It is possible that new evidence will shift the treatment paradigm, but so far, severe aortic stenosis in asymptomatic, operable patients has been a domain reserved for surgery, given that asymptomatic patients were not included in major clinical trials.

Previous blog editions analyzed work on asymptomatic patients with severe aortic stenosis. However, from the standpoint of randomized evidence, two clinical trials stand out: the AVATAR trial and the study by Kang et al., both comparing surgical aortic valve replacement to close surveillance, showing limited but significant superiority of the invasive option in terms of survival.

With the advent of TAVI and being thus far an uncharted area for clinical trials, there has been increasing interest in extending indications to this subgroup of patients, based on surgical experience. The first trial to undertake this analysis was the EVOLVED trial, with a superiority design, where 224 patients from 24 centers in the UK and Australia were randomized to invasive treatment versus close monitoring. It is noteworthy that a necessary sample size calculation of at least 356 patients was performed, hence the

study presented limited statistical power. Patients corresponded to a low-surgical-risk population, with preserved ventricular function and low morbidity, with one-third of bicuspid aortic valves allowed in the cohort, three-quarters of which were surgically intervened, while the rest received TAVI. The primary outcome was a composite of all-cause mortality and unplanned hospitalization due to heart failure decompensation, which did not show significant differences between the two management strategies. All-cause mortality was equal in both groups, with a notable difference in unplanned admissions, higher in the monitoring group. In fact, after a median follow-up of 20 months, 77% had already been treated invasively, with almost a third being operated on within the first 12 months. The analysis did not break down results by invasive approach, whether surgery or TAVI, although, as mentioned, the proportion of patients was unequal.

The EARLY-TAVR trial aimed to evaluate whether transcatheter aortic valve implantation (TAVI) could be beneficial as an early intervention in asymptomatic patients with severe aortic stenosis. Unlike the EVOLVED trial, EARLY-TAVR focused solely on TAVI using a transfemoral approach with Edwards Sapien 3® and 3 Ultra® systems. This trial included 901 patients, very close to the 900 initially proposed in the sample size calculation. A total of 75 centers across the United States and Canada participated, selecting patients with low surgical risk (average STS-PROM of 1.8%).

The EARLY-TAVR population presented higher morbidity rates compared to those in the EVOLVED trial, particularly with a higher prevalence of diabetes mellitus and coronary artery disease, affecting over a quarter of patients in both groups, which contrasted with 3-6% prevalence in the EVOLVED cohort. Approximately 8% of patients had a bicuspid aortic valve, and left ventricular function was preserved across the study population. Unlike the EVOLVED trial, EARLY-TAVR did not use predictors of poor prognosis for patient selection. In the EVOLVED trial, inclusion was based on criteria such as left ventricular hypertrophy and/or myocardial fibrosis detected on MRI, which resulted in a high exclusion rate of patients who did not present these prognostic markers.

The primary outcome of the EARLY-TAVR trial was a composite of mortality, stroke, and unplanned hospitalization, and significant differences were observed in favor of the TAVI group, despite the study originally being designed as a non-inferiority trial. Mortality rates were similar between groups, as were stroke rates, while unplanned hospitalizations primarily drove the composite outcome in favor of the TAVI group. During the first six months of the study, one in four patients in the conservative management group underwent TAVI due to symptom onset, and by the end of two years, more than 70% of the conservatively managed patients had received valve intervention. There were no significant differences in procedural or post-procedural outcomes between patients who underwent early TAVI and those who eventually received TAVI after adopting a conservative management approach.

COMMENTARY:

Commentaries on the interpretation of these studies, particularly EARLY-TAVR, have been varied. Some emphasize its somewhat positive outcome, suggesting a potential expansion of treatment scope into previously untouched pathology segments. At last year's TCT congress in Washington, the primary author of the trial, Philippe Généreux, stated, "It seems that there is no advantage in waiting." This was supported by a cautious

statement from Gilbert Tang, who said, “Changes in clinical guidelines or consensus documents are needed to emphasize that patients with asymptomatic severe aortic stenosis require closer follow-up.” However, given the action-reaction dynamics between new evidence and clinical guidelines, it would be no surprise if upcoming changes are directed towards bolstering therapeutic measures rather than conservative management.

Critically, John Mandrola argued that the study “experimented on patients, with much time and money invested, yet yielded little learning.” By including patients prematurely without establishing a reason (as the EVOLVED study did) to treat asymptomatic patients, the study fails to answer the questions that Heart Teams must consider: when, and most importantly, to whom?

This critique is compounded by aspects of the study design, as noted by Josep Rodés-Cabau and John Mandrola, focusing on the rapid symptomatic conversion within the control group. Essentially, the intervention group exhibited a kind of "curative faith" unproven thus far, while the control group experienced an "anxiety-driven rush" to seek treatment as soon as possible. The psychological burden of being assigned to a watch-and-wait approach likely intensified the perception of symptoms, prompting patients to seek hospitalization at the earliest opportunity.

This phenomenon has been documented in similar trials involving potentially malignant diseases, creating a state of "cancerophobia" in patients. Additionally, given that all patients were purportedly asymptomatic—where ergometry results were inconsistent, and sometimes solely based on patient history—there should have been an equivalent number of admissions in the TAVI group while they awaited their procedures. However, those in the TAVI group who began to develop mild symptoms would likely have refrained from hospital admission (especially in systems where healthcare costs are high and public coverage is limited) since they were already scheduled for imminent treatment. This specific bias is precisely what seems to render the outcomes of the study "positive."

In essence, we are again confronted with a study that appears to have a "goal-oriented" design, masking a false impartiality to achieve a predetermined outcome. As it stands, "the purpose of medical science should not be to design studies with positive results, but rather to address clinically relevant questions." Unfortunately, it seems likely that future clinical practice guidelines will extend the indications for TAVI without a firm scientific foundation. To draw from a familiar saying, "greed breaks the sack"—as long as there is money to cover these expenses. If studies like this one influence consensus documents, then good medical practice and ethical research may ultimately be the ones to lose.

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Javier Borrego Rodríguez

Treatment of transcatheter aortic valve thrombosis (TAVI): a critical analysis

A review of the incidence, classification, and potential recommendations for clinical management of thrombosis associated with TAVI.

Transcatheter aortic valve implantation (TAVI) has revolutionized the treatment of severe aortic stenosis, particularly in high-risk surgical patients or those deemed inoperable. However, this technique is not without complications, one of the most significant being TAVI thrombosis, which poses considerable diagnostic and therapeutic challenges. TAVI thrombosis encompasses a spectrum ranging from subclinical leaflet thrombosis (SLT) to clinical valve thrombosis (CVT).

In this article, the group led by Adrichem et al. reviews randomized clinical trials, observational studies, and retrospective analyses evaluating various therapeutic strategies for managing TAVI thrombosis. The interventions addressed include vitamin K antagonists (VKAs), direct oral anticoagulants (DOACs), thrombolytic therapy, and reintervention/surgery.

SLT is characterized by leaflet thickening (hypoattenuated leaflet thickening, HALT) and reduced leaflet motion (RLM). It occurs in approximately 12% to 38% of patients within 30 days post-TAVI and is often an incidental finding during multislice computed tomography (MSCT), as the spatial resolution of transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) is generally insufficient to detect HALT and/or RLM. Studies have shown that between 35% and 54% of HALT cases observed at 30 days resolve spontaneously within a year without changes in the antithrombotic regimen. Conversely, 15% to 20% of HALT cases progress to RLM, and 3% to 9% advance to clinical valve thrombosis (CVT) with manifest symptoms. Although the clinical implications of SLT are not always clear, it has been associated with increased transvalvular gradients, embolic events, and, in some cases, structural valve degeneration.

Clinical thrombosis (CVT) is less common (estimated global incidence 1.2%) but potentially fatal, as it may lead to severe valve insufficiency, heart failure, thromboembolic events, and, ultimately, death. Most CVT cases are reported during the first year post-TAVI, whereas structural valve degeneration predominantly occurs after the first year. In CVT management, normalization of transprosthetic gradients to levels recorded immediately after the initial TAVI procedure may suffice to monitor resolution.

The authors provide practical guidelines for the clinical management of both phenomena:

- Management of TAVI SLT:

The authors highlight how VKAs and DOACs are associated with a lower incidence of HALT and RLM, advocating for a shift from antiplatelet therapy (single or dual) to a VKA- or DOAC-based regimen to treat HALT and RLM when they occur. However, it is important to note that prophylactic use of DOACs after TAVI in patients without a formal indication is contraindicated. Both the GALILEO and ATLANTIS trials showed that combining DOACs with antiplatelet therapy resulted in higher rates of bleeding and all-cause mortality, thus this combination should be reserved for cases without resolution using monotherapy with VKA/DOAC. For monitoring resolution, close follow-up with clinical evaluation and TTE imaging is recommended for

patients with confirmed HALT. Optional MSCT follow-up at 3–6 months can assess HALT resolution.

- Management of TAVI CVT:

Switching to oral anticoagulation is recommended for patients who develop CVT while on antiplatelet therapy. For those with CVT under DOAC therapy, switching to a VKA is advised, as no direct comparisons between different DOACs support switching from one to another. Heparin may be used temporarily until therapeutic INR levels are achieved. After confirming CVT resolution through MSCT and/or normalization of transprosthetic gradients to levels immediately post-TAVI, oral anticoagulation may be discontinued. However, the article highlights frequent recurrences, suggesting follow-up MSCT at 6 months after discontinuing anticoagulation and considering indefinite therapy with VKAs or DOACs in the absence of bleeding complications.
For refractory TAVI CVT cases, slow infusion of low-dose alteplase (25 mg over 25 hours) demonstrated the highest success rates (90%) with few complications, proving effective and safe while avoiding explant or surgical reintervention. Explant surgery in the context of valve thrombosis is a high-risk procedure, as shown in the EXPLANT TAVR registry, which reported 30-day mortality and stroke rates of 13.1% and 6%, respectively. Conversely, redo-TAVI had lower 30-day complication rates, with mortality and stroke rates of 2.9% and 1.4%, respectively.

COMMENTARY:

Although SLT does not always manifest with symptoms or hemodynamic dysfunction, its association with transient neurological events and long-term valve degeneration underscores its clinical relevance. The proposed echocardiographic and MSCT follow-up should be essential; however, its widespread implementation is limited by associated costs and routine availability of these techniques. Additionally, the dilemma between efficacy and safety in anticoagulant selection remains challenging. VKAs, while effective, require intensive and periodic INR monitoring, which can be a barrier for elderly patients or those with multiple comorbidities. On the other hand, DOACs, theoretically more convenient, have shown mixed results in terms of safety, especially when combined with antiplatelets, emphasizing the need to individualize treatment by considering factors such as frailty and bleeding history.

Low-dose slow thrombolysis can be considered in patients with refractory CVT, but current data remain limited to small populations. Randomized trials with larger sample sizes comparing this strategy with other interventions, such as surgical reintervention or other intensive pharmacological strategies, would be beneficial. Furthermore, the article highlights the risks associated with explant surgery in TAVI patients, supporting the preference for redo-TAVI in selected cases.

Evaluating each case collectively within the Heart Team and informing patients about the benefits and risks of each treatment strategy is reasonable to provide the most adequate and personalized treatment. From a practical standpoint, the following considerations can be made:

1. In the absence of a formal anticoagulation indication, VKAs or DOACs are not recommended after TAVI implantation to prevent SLT and/or CVT.

2. If SLT is identified in a patient on antiplatelet therapy, follow-up with TTE/MSCT at 3–6 months is recommended. If evolution toward CVT is observed, switching from antiplatelet therapy to VKAs or DOACs (preferably VKAs) is advised. If DOACs are chosen and there is no resolution of CVT after 3–6 months, a switch from DOACs to VKAs should be considered. If CVT resolves with this regimen and there is no high bleeding risk, indefinite use of DOACs/VKAs can be considered.

3. If CVT persists or progresses despite treatment with VKAs or DOACs, adding antiplatelet therapy is recommended. If CVT resolves with this regimen and bleeding risk is low, indefinite use of DOACs/VKAs + antiplatelets can be considered.

4. If CVT persists or progresses despite treatment with VKAs/DOACs + antiplatelets, consideration should be given to adding the ultraslow, low-dose alteplase infusion strategy (preferably) and/or valve replacement options (redo-TAVI in selected cases, preferably over surgery). If CVT resolves with this regimen and there is no high bleeding risk, indefinite use of DOACs/VKAs +/- antiplatelets can be considered.

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Section V B:

Mitral valve disease

Elio Martín Gutiérrez

Democratizing Mitral Valve Repair Through New Technologies

One-Year Outcomes of a Self-Suturing System for Neochord Implantation and Rapid Knotting, Applied to Both Neochords and Annuloplasty Sutures, in Mitral Valve Repair.

The standardization of surgical procedures is essential to improve outcomes and offer a predictable and competitive therapeutic alternative. Streamlining these procedures also democratizes them, positioning surgical options as a forward-looking choice aligned with modern advancements. Among cardiac valves, the aortic valve has received most of the surgical innovation over the past decades, culminating in rapid-deployment and/or sutureless prostheses that enabled the expansion of less invasive approaches. Mitral valve repair, in contrast, has shifted towards less invasive approaches but remains largely reliant on adapted instruments to replicate conventional repair techniques.

Leaving conflicts of interest apart, in modern healthcare, it is evident that the primary R&D thrust across all specialties is largely driven by private funding from the biomedical industry, without involving conflicts of interest. Innovation produces techniques that, with appropriate clinical judgment and training, are applied daily in patient care. Although these innovations may introduce additional costs, we aim to employ them responsibly and with confidence that they can enhance the outcomes of traditional procedures. This creates a feedback loop that strengthens the treatment of a specific pathology or even an entire specialty. While the regulations of this world may unfortunately demand such alignment, diverging from these norms would condemn us to professional obsolescence. This fate looms even closer as our interventional competitors stay attuned to these dynamics, while we risk falling behind if we fail to follow the guidelines shaping cardiac surgery trends internationally.

The study under review represents the culmination of a one-year follow-up of three devices aimed at simplifying mitral valve repair. These devices are all products from LSI Solutions®, including the well-known titanium clip knotting system COR-KNOT®, as well as lesser-known systems for self-suturing PTFE neochords (Mi-STITCH®) and for mini-clip knotting (Mi-KNOT®). These systems are adaptable to both conventional open approaches and less invasive methods (as described by the authors). The Mi-STITCH® device anchors a neochord loop via two simultaneous suture passes through the free edge of the leaflet and subsequently to the papillary muscle. Its head functions similarly to thoracoscopy systems, with 360º rotation and up to 15º flexion, allowing optimal perpendicularity at the targeted suture sites on the leaflet and papillary muscle. Once the correct chord length is determined, it is secured to the free edge using a titanium mini-clip (Mi-KNOT®). Annuloplasty follows the conventional approach but is simplified by knotting the sutures using the COR-KNOT® system. Studies have shown that up to half or more of the time required for mitral valve repair is spent on annuloplasty suturing, with knotting particularly time-consuming in less invasive approaches.

The experience, documented in ClinicalTrials.gov, was conducted at a single center with 12 low-surgical-risk patients with primary mitral regurgitation. Cases with flail segments were not excluded, and a total of 29 neochords were implanted. Of these, 2 were entirely removed and 6 were removed but replaced using the same system. Four procedures were performed via minithoracotomy, with 7 patients undergoing additional procedures such as tricuspid valve repair, left atrial appendage closure, surgical ablation, or coronary revascularization. No alternative neochord implantation methods were used, but other repair techniques were applied, including leaflet resection in two cases, Alfieri edge-to-edge suturing in one, and cleft closure in five. This variety was likely due to the absence of a restricted case selection, for example, limited to simple posterior leaflet P2 prolapse

repairs. At one-year follow-up, all patients had minimal or mild residual regurgitation at discharge and exhibited good functional status, with only one case showing recurrence of grade 2+ or higher regurgitation.

The authors conclude that the initial outcomes with automated PTFE suture and titanium knotting systems are highly satisfactory, warranting continued follow-up to assess long-term stability.

COMMENTARY:

The experience with LSI Solutions® products is remarkably positive and, with proper training, may further democratize mitral valve repair, even through less invasive approaches. The authors commendably address the inclusion of diverse repair mechanisms in the study, emphasizing that the necessary tools for addressing mitral regurgitation must extend beyond a single technique (such as edge-to-edge repair), highlighting the feasibility of applying classic resection and suturing techniques alongside these devices.

However, it appears that the Mi-STITCH® system may be specifically tailored for P2 prolapse repairs, potentially limiting its versatility for commissural prolapses, multiple posterior leaflet prolapses, or anterior leaflet involvement. Neochord implantation should adhere to the principle of placement in the tributary papillary muscle region (fan-like, without crossing the midline) to avoid interference with the subvalvular apparatus. While this system meets the classic neochord implantation principles, technologies like NeoChord® or Edwards HARPOON®—although off-pump systems—do not. Additionally, the system requires loop configuration measurements, necessitating adaptation by surgeons accustomed to using figure-of-eight or single-step techniques for papillary muscle passage. In this regard, the Mi-KNOT® device presents a promising option by allowing implantation at the precise point determined to be the correct chord length. Indeed, it could potentially be used independently of the other systems. The authors validate chord length determination with the saline test. A critique of the device is its irreversible knotting mechanism, unlike alternatives such as figure-of-eight or Dubai stitch configurations, which are popular for their flexibility. It also violates two classic principles of neochord implantation:

- Neochords were traditionally anchored using another PTFE suture in loop techniques, as materials like polypropylene may eventually sever them. The titanium clip may compromise long-term repair durability.

- The proximity of the metal clip to the coaptation surface, despite its small size, could lead to leaflet erosion and repair failure.

The COR-KNOT® system is an effective option for anchoring annuloplasty sutures, particularly for annuloplasty but also increasingly used in prosthetic implantation techniques.

LSI Solutions® is likely to continue innovating to develop these systems, which appear well-received within the surgical community. With this study and these reflections, I aim not to endorse indiscriminate spending on new tools at the expense of clinical judgment, but rather to encourage responsible innovation. As surgeons, we must demonstrate exemplary stewardship of costly resources for patient treatment. From an efficiency perspective, avoiding waste is as crucial as preventing nocebo effects, yet I am certain that the latter will consign us to clinical irrelevance without the support of the biomedical industry.

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José Manuel Martínez Comendador

Atrial functional mitral regurgitation repair: are all functional regurgitations the same?

A retrospective analysis of outcomes and progression following the repair of "pure" atrial functional mitral regurgitation at a high-volume hospital in the United States.

Historically, mitral regurgitation (MR) has been categorized into two main groups based on its etiology: degenerative MR, arising from primary valvular pathology, and functional MR (FMR), secondary to other cardiac conditions that lead to mitral valve dysfunction. For degenerative MR, surgical correction has generally yielded a favorable prognosis, with mitral valve repair being superior to replacement. However, the high recurrence rate of MR following repair in FMR patients—particularly among poorly selected cases—has led to considering mitral valve replacement as a more durable surgical option. Nonetheless, the optimal management strategy for FMR patients remains uncertain, with this patient population often experiencing less favorable outcomes.

Notably, FMR patients with reduced ejection fraction (EF) exhibit poorer outcomes and prognoses compared to those with preserved EF. FMR with reduced ventricular function is often associated with ventricular pathology (ventricular FMR, VFMR), wherein ventricular dilation leads to annular dilation and/or posterior leaflet tethering. In contrast, FMR with preserved EF may be linked to atrial pathology, designated as atrial FMR (AFMR), which typically involves left atrial (LA) remodeling and enlargement, resulting in isolated mitral annular dilation and subsequent MR. Emerging research supports that these FMR types should be regarded as distinct conditions, with differing surgical approaches and outcomes. In terms of the preferred surgical intervention for AFMR, debate persists, and the prognosis remains incompletely understood.

Accordingly, data from all patients undergoing mitral valve repair due to MR at Michigan Hospital between 2000 and 2020 were reviewed. Patients with degenerative/myxomatous disease, EF < 50% (VFMR), and diverse etiologies such as endocarditis and rheumatic disease were excluded to isolate a "pure" AFMR patient population. Out of 2,697 patients undergoing mitral repair, 123 were identified as AFMR cases. Among these, the mean preoperative LA diameter was elevated to 4.9 cm (95% CI, 4.7-5.0 cm), while the mean preoperative left ventricular diastolic diameter remained near normal at 5.0 cm (95% CI, 4.9-5.2 cm). Preoperative atrial fibrillation (AF) was observed in 61% (74/123). Echocardiograms were performed in 58% (71/123) of patients after a median of 569 days (interquartile range, 75-1782 days) post-surgery. Of these, 72% (51/71) exhibited trivial or no MR, 22% (16/71) had mild MR, and only 6% (4/71) had moderate or greater MR. Only 1.6% (2/123) required mitral valve reoperation. The estimated 5-year survival was 74%.

The authors conclude that AFMR shows favorable outcomes following mitral valve repair with ring annuloplasty, marked by low rates of reoperation, mortality, and MR recurrence. Mitral annuloplasty should be considered the surgical treatment of choice for AFMR.

COMMENTARY:

The study presented today sheds light on an aspect many surgeons may not have previously regarded with sufficient seriousness when addressing FMR. This study underscores that not all FMR cases are equivalent; in some cases, the mechanism of mitral regurgitation results from atrial dilation rather than ventricular dilation or leaflet tethering due to prior infarctions. Thus, if we were to summarize the two most practical and significant findings from this study, they would be:

1. It is crucial to consider the possibility of AFMR in any FMR patient with preserved ventricular function, especially in the absence of underlying coronary disease.

2. Although current guidelines do not yet reflect this, restrictive annuloplasty appears to emerge as the preferred and reference technique for treating AFMR, given its favorable clinical and echocardiographic outcomes.

AFMR is a FMR subtype characterized by left atrial and mitral annular dilation and is frequently associated with AF and heart failure (HF) with preserved ventricular function. Given the rising incidence of AF and HF with preserved ventricular function—largely due to population aging—this FMR subtype has begun gaining recognition among HF specialists. However, current clinical guidelines, often lagging behind recent evidence, do not yet clearly differentiate AFMR from FMR caused by ventricular dysfunction, typically associated with ischemic cardiomyopathy and reduced EF.

In this article, Wagner et al. have significantly expanded our understanding of AFMR, thanks to the high patient volume at Michigan Hospital. They present outcomes of ring annuloplasty in this patient cohort. After excluding 2,574 patients undergoing mitral repair over two decades—of whom 75% underwent repairs for degenerative MR or concomitant coronary surgery—123 patients were identified with a clear "pure" AFMR diagnosis. This leads to the primary deduction that AFMR is an uncommon entity, accounting for only 4.5% of all mitral repairs.

From a surgical standpoint, it is noteworthy that most cases involved restrictive annuloplasty with a complete, rigid ring, though no further information is provided. Additionally, a tricuspid annuloplasty was performed in cases of moderate or severe tricuspid insufficiency and/or annular dilation exceeding 4.0 cm (50%). Furthermore, an ablation procedure was performed in all preoperative AF cases (61%), despite preoperative AF not always warranting this procedure. This lack of selection may have increased surgical time and intervention risk without evident clinical benefit.

Interestingly, approximately 40% of AFMR patients did not present with preoperative AF. This suggests that AF may have gone undiagnosed (paroxysmal AF) or that another cause, such as hypertension, contributed to LA dilation in these patients. Hence, AFMR should not always be linked with AF, marking a shift from previous understanding. Moreover, the potential presence of undiagnosed underlying AF raises new questions about systematically closing the left atrial appendage in these patients with atrial dilation, even without documented arrhythmia.

Regarding follow-up and results, it is important to highlight that only slightly more than half of the cohort (58%) had subsequent echocardiographic follow-up, with a mean duration of 569 days. Of this group, only 6% had MR equal to or greater than moderate, and only 1.6% required reintervention, which demonstrates exceptional results. On the other hand, it is relevant to highlight that, although the incidence of AF after surgery was 34%, in the long-term follow-up, 72% of patients maintained sinus rhythm, including 61% of those who underwent the ablation procedure. This indirectly reflects the effectiveness of mitral repair. The perioperative mortality rate was 1.6%, and 5-year survival reached 74%, which are data consistently higher than any series of VFMR and which determine the different prognosis that both forms of FMR have, so they can no longer be considered as the same disease.

It should not be overlooked that this study has some obvious limitations. It is a retrospective case series, with no comparison groups and with 42% of patients missing follow-up, which could, in principle, undermine any meaningful conclusions. Despite

these limitations, the cases that did have follow-up show outstanding results. It should be emphasized that this study is based on interventions performed over a 20-year period, which partly explains the high rate of loss to follow-up of patients, especially those operated on during the first decade. Furthermore, since this hospital is a referral center for mitral surgery and serves patients from remote areas, follow-up is naturally difficult. Although this may detract from the conclusions, it should be emphasized that the competence of mitral repair was confirmed in virtually 100% of cases by postoperative echocardiography. Furthermore, among the patients with follow-up (60%), almost unbeatable results were obtained. Therefore, with a high degree of confidence, it can be stated that restrictive annuloplasty in the treatment of MIFA proves to be durable and effective.

Regarding the methodology used for patient exclusion, 2,027 patients with both degenerative/myxomatous MR and those who underwent concomitant coronary surgery were excluded in the same exclusion category, without making a distinction between them. This means that we do not have the capacity to determine the real percentage of cases of VFMR vs. degenerative MR in this population. It should be noted that AFMR is more frequent in older patients than in younger patients, therefore, with a greater possibility of presenting concomitant coronary disease. The fact of having excluded all mitral repairs with coronary surgery may have left out of the analysis many patients with AFMR with coronary surgery, only as a consequence of the finding of coronary disease, but without repercussion on ventricular dimensions or function. In contrast, some patients with coronary artery disease and normal EF, who did not undergo CABG for various reasons, could have been included in the “pure” AFMR group. In summary, for a more complete understanding of MI-related outcomes and more accurate patient selection, additional information such as history of myocardial infarction and preoperative catheterization findings are lacking in the study.

It is obvious that the approach to any secondary MR begins with appropriate medical management following established guidelines. Furthermore, according to the results of this study, rhythm control together with restrictive mitral annuloplasty in AFMR appears to offer a long-lasting benefit in these patients. This opens the door for future research that can further explore the impact of this approach on disease progression.

All in all, the findings of this study have significant clinical implications and motivate us to consider FMR from a broader perspective. When a possible diagnosis of AFMR is presented, we now know that restrictive annuloplasty is not only feasible, but has a high potential for success backed by some additional evidence that encourages us to consider it as a treatment option.

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Rafael Hernández Estefanía

Restrictive Annuloplasty and Remodeling in Patients with Functional Mitral Regurgitation: The Ongoing Debate

This study examines patients with ischemic heart disease and functional mitral regurgitation (FMR) undergoing coronary artery bypass grafting (CABG) with restrictive mitral annuloplasty (RMA), assessing the effects on left ventricular (LV) volume reduction one year post-surgery.

FMR in patients with ischemic cardiomyopathy is associated with increased morbidity and mortality. Clinical guidelines recommend RMA or mitral valve replacement (MVR) in patients with severe FMR undergoing CABG. However, in cases of moderate FMR, the decision to address the mitral valve concomitantly with coronary intervention remains controversial. Some authors propose that revascularization alone promotes LV remodeling and improves mitral regurgitation (MR), while others advocate for annuloplasty or valve replacement with a prosthesis. Numerous studies supporting these theories continue to fuel the open debate.

This article evaluates the reduction in LV end-systolic volume (LVESV) in patients diagnosed with FMR and undergoing CABG with RMA. The outcomes were assessed via transthoracic echocardiography (TTE) one year after the procedure. This retrospective study includes a total of 157 patients with ischemic LV dilation, treated over a 10-year period (1995-2015). Of the total study group, 84 patients (54%) had FMR (8% mild, 58% moderate, and 33% severe) and underwent concurrent RMA with CABG (regardless of regurgitation severity), while 73 patients were treated with CABG alone. In all cases, the decision to proceed with revascularization was made by the surgeon (with or without cardiopulmonary bypass, graft type and number, etc.).

At one year post-surgery, TTE was performed to evaluate the reduction in LV end-systolic volume. A significant reduction was observed in the group of patients who underwent CABG+RMA compared to those who underwent only CABG (from 32 to 15 mL/m² and from 37 to 21 mL/m², respectively). Improvement in ejection fraction (EF) was more pronounced in the CABG+RMA group compared to the "CABG only" group, although the results were not statistically significant (44% vs. 39% in the CABG+RMA group and "CABG only" group, respectively). No differences in survival were observed between the two groups.

The authors conclude that patients undergoing CABG+RMA experience a significant reduction in LV end-systolic volume compared to those treated with CABG alone, recommending this surgical approach while acknowledging the need for further studies to determine the impact of RMA on patient survival.

COMMENTARY:

The controversy surrounding the optimal surgical approach for patients with coronary artery disease and moderate FMR has existed since I began my residency in cardiac surgery. Despite many years, the debate remains unresolved, with decision-making varying by institution and often based on studies from experienced centers or older trends referenced in classical surgical texts. In my view, the study by Misumi et al. fails to categorically clarify any uncertainties on the matter.

In the present article, the authors conclude that for patients with FMR and ischemic heart disease indicated for coronary surgery, restrictive annuloplasty should be performed, as one year post-intervention shows significant LV reverse remodeling. However, the study design has notable gaps and raises many questions. First, this is a non-randomized

study, and the groups seem non-comparable, as patients with preoperative FMR have higher morbidity and a higher EuroSCORE II compared to the "CABG only" group. Nonetheless, this did not correlate with poorer mortality outcomes.

The criteria for performing annuloplasty remain unclear. Notably, seven patients (8%) in the CABG+RMA group with mild preoperative MR underwent reductive annuloplasty. The author justifies this as these patients had a “history of prior hospitalizations and exacerbations of their MR,” a somewhat unconvincing rationale. Was a mitral valve procedure really necessary, or could they have improved with CABG alone? Indeed, it is notable that CABG alone led to a reduction in LV end-systolic volume. This effect warrants consideration of the isolated impact of revascularization or optimized medical therapy (diuretics, neurohormonal agents) post-surgery.

Regarding the mitral valve (MV) technique employed, the author notes that “undersizing of the valve was left to the surgeon’s discretion,” acknowledging that “the most commonly used technique was a two-size ring reduction.” Additionally, “up to 8% underwent papillary muscle approximation also based on the surgeon’s criteria.” While the outcomes are commendable (only 10% residual MR at any degree one year post-procedure is reported in the results section), the study conveys a sense of case heterogeneity and high surgical variability. It is also noteworthy that many patients underwent additional concurrent procedures, such as tricuspid annuloplasty (52%) and atrial fibrillation surgery (14.2%), which could impact overall results. Furthermore, there is a lack of information on surgical times. It would be of interest to evaluate whether the aortic cross-clamp time added by addressing the mitral valve is offset by improved functional class and/or patient survival, particularly in those with moderate FMR.

While the authors demonstrate the effectiveness of RMA in reducing LV volumes one year post-surgery, the improvement in LVEF was not significant in the annuloplasty group, nor did it appear to impact survival. Does this justify a mitral procedure if the MR is moderate? As noted in the discussion section, previous randomized studies have shown mixed results in this regard. So, what should we do?

Misumi et al. define a significant LV end-systolic volume index (LVESVI) reduction as equal to or greater than 27%. Among the groups, reverse remodeling was achieved in 68% of the CABG+RMA group and 38% of the "CABG only" group. For the subgroup of patients with moderate FMR (49 patients), 63.2% achieved significant reverse remodeling, a noteworthy finding despite its limited impact on clinical variables. Why was significant reverse remodeling not achieved in the remaining cases? Was the surgical effort worthwhile? For those with severe MR, might some of these patients be better suited for mitral valve replacement? Will these results hold over time?

The authors openly acknowledge the limitations of their study, an honesty we appreciate. They consider the sample size small and note the need for a prospective, randomized study. It is unfortunate that LV volumes were not evaluated with additional imaging modalities, such as cardiac MRI, one year post-procedure. Misumi et al. leave many questions unanswered, and I fear the debate remains open.

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Gonzalo López Peña

What does closing the left atrial appendage during mitral repair offer in patients without atrial fibrillation?

This single-center, retrospective study compares the utility of left atrial appendage (LAA) closure in patients undergoing mitral valve repair without atrial fibrillation (AF).

Postoperative AF incidence following mitral repair exceeds 30%, with an annual stroke rate reaching up to 1%. In non-valvular AF cases, 90% of left atrial thrombi were located in the LAA, compared to 57% in valvular AF. The LAAOS III trial, published in 2021, demonstrated a statistically significant reduction in ischemic stroke and systemic embolism with LAA closure in patients with pre-existing AF and a CHADS2-VASc score >2, compared to those without closure.

The present study addresses the potential benefits of LAA closure in patients without AF or recent AF episodes.

A cohort of 1036 patients undergoing robotic mitral repair through right thoracotomy between 2005 and 2020 at a single institution was selected. Exclusion criteria included AF episodes within 30 days preoperatively, presence of a transcatheter LAA closure device, prior embolic events, and active endocarditis, resulting in a sample size of n=764. LAA closure was achieved through double-layer continuous sutures via left atriotomy post-mitral valve repair. Postoperative anticoagulation was not standard except for indications or persistent AF. Data on post-discharge embolic events and AF episodes were collected using California State emergency and hospitalization records.

The primary objective of this study was to compare long-term stroke/transient ischemic attack (TIA) risk in mitral repair patients based on whether or not LAA was closed.

A change in surgical practice occurred in the center after 2014, with LAA closure becoming routine in mitral repair patients without AF indications. Consequently, LAA was closed in 15 out of 284 patients (5.3%) before 2014 and in 416 out of 480 (86.7%) afterward. Both groups shared similar baseline surgical indications; however, the LAA closure group included older patients. Preoperative variables, such as age, gender, and comorbidities, showed no significant differences.

Clamp and pump times were shorter in the LAA closure group ($p<.0001$), as were reoperations for bleeding ($p=.02$). This may be attributed to greater surgical experience with robotic mitral repair post-2014.

Despite higher postoperative AF incidence in the LAA closure group (31.8% vs. 25.2%; $p=.047$), patients on warfarin at discharge (7.4% vs. 3.6%; $p=.02$), and those on antiarrhythmics (not beta-blockers) (32.9% vs. 18%; $p<.001$), the LAA closure group showed lower postoperative stroke/TIA incidence (2 vs. 7 cases). The cumulative 8-year stroke/TIA incidence was 2% in the LAA closure group compared to 6.3% in controls (HR, 0.26; 95% CI 0.09-0.78; $p=.02$).

This study suggests that routine LAA closure is safe in patients without prior AF episodes and may reduce late stroke/TIA incidence, as indicated by the LAAOS III trial (in anticoagulated patients with established AF).

COMMENTARY:

Postoperative AF following mitral repair, observed in 31.8% of the LAA closure group, is a common issue in ICUs and cardiac surgery units. Thus, it is logical to consider

addressing the ultimate risk posed by AF—embolisms. Indeed, a previous blog entry discussed the synergistic protective effect of LAA closure.

There is no doubt that anticoagulation in high-risk patients is first-line treatment, as emphasized in the LAAOS III trial, which clarifies that LAA closure offers additional embolic protection when a patient is correctly anticoagulated. In the LAAOS III subgroup analysis, results were not significant in non-AF patients (HR, 0.76; 95% CI 0.5-1.1), motivating the authors to conduct this study.

One major limitation of this study was tracking new AF episodes in discharged patients, as incidence might be underestimated due to lack of monitoring. Only emergency or hospitalization data were recorded. Additionally, anticoagulation duration was not documented, an essential factor in interpreting these results.

Another limitation involves LAA closure technique; only continuous double sutures were used, excluding clip or amputation methods. Postoperative echocardiography did not confirm complete LAA closure, despite literature questioning the full efficacy of the double-suture method, with incomplete closure rates of up to 30%.

A notable finding is the statistically significant association between double-suture LAA closure and increased postoperative AF episodes. Consequently, the reduced stroke incidence in this subgroup may reflect increased use of antiarrhythmics and anticoagulation at discharge.

The authors suggest that the shorter pump and clamp times may contribute to better outcomes in the LAA closure group. However, this impact is unlikely, as LAA closure success depends on complete occlusion, irrespective of time.

The question arises: could prophylactic LAA closure increase postoperative AF risk? If so, which technique is the least arrhythmogenic?

In conclusion, AF is common (up to 30%) post-mitral repair. Studies show that LAA closure, in anticoagulated patients with established AF, significantly reduces embolic events. In patients undergoing mitral repair without prior AF episodes, LAA closure has proven safe and may reduce stroke/TIA incidence.

Given this study's limitations, a prospective, multicenter, randomized study that includes various LAA closure techniques would be ideal for assessing efficacy in reducing potential post-AF stroke/TIA risks.

This article raises critical questions about “preventing” risks via surgical procedures when this is not the primary indication. The most notable question from this study’s results: are we inducing AF by closing the LAA in previously AF-free patients? Is there a less arrhythmogenic method?

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María Alejandra Giraldo Molano

Mitral prosthesis: mechanical or biological?

Comparison of readmission rates and outcomes in patients after biological vs mechanical mitral valve prosthesis implantation in a multicenter American registry.

Today, valve repair is the preferred surgical intervention for mitral valve disease. However, a significant number of patients present with irreparable valvular disease upon arrival in the operating room, leading many to undergo mitral valve replacement with either mechanical or biological prostheses. The choice of prosthesis for each patient is often unclear, presenting surgeons with the challenge of balancing risks, such as prosthetic deterioration and reoperation, against the need for lifelong anticoagulation, thus requiring a tailored approach for each patient.

Current European and American guidelines recommend mechanical prostheses for patients under 65 years and biological prostheses for those over 70 years in the mitral position. Nonetheless, additional factors must be considered when making a final decision, which may allow for the use of either prosthesis type in patients, particularly those aged 65 to 70 years. Important factors include not only the patient's life expectancy but also lifestyle aspects, profession, comorbidities that increase the risk of hemorrhagic and thromboembolic complications, adherence to treatment, risk of reoperation, and patient preference. The difference in readmission rates between patients with mechanical or biological prostheses is also crucial for patients, surgeons, and the National Health System.

The present study aims to compare patient outcomes and readmission rates after mitral valve replacement with mechanical vs biological prostheses. This is a retrospective multicenter study across 28 U.S. states, using the Nationwide Readmissions Database (NRD). All isolated mitral valve replacements in patients aged 18 and older between January 1, 2016, and December 31, 2018, were included, totaling 31474 procedures. Patients were divided into two groups based on prosthesis type. To minimize bias, propensity score matching was conducted to balance confounding factors between groups.

The authors concluded that patients with mechanical prostheses had a higher overall readmission rate at 30 and 90 days. The most common reasons for readmission were heart failure, arrhythmias, infection, and bleeding or coagulopathy. Heart failure decompensation was more frequent among those with biological prostheses, whereas bleeding or coagulopathy was more common in patients with mechanical prostheses. There were no differences in infection or arrhythmias between the two groups.

COMMENTARY:

There is a growing preference for using bioprostheses over mechanical prostheses in the aortic and mitral positions. In the cohort studied in this article, bioprostheses were used three times more frequently than mechanical prostheses. Currently, more elderly patients with increased comorbidities and greater overall frailty are undergoing intervention. This population is precisely the group at increased risk for complications related to chronic anticoagulation with vitamin K antagonists, which is necessary for patients with mechanical prostheses.

Given these considerations, we pose the question: is it worth justifying the use of mechanical prostheses over biological ones due to the risk of degeneration and subsequent reoperation? Decision-making should consider new available options. For

instance, recently developed biological prostheses specifically for the mitral position, such as those with the innovative Resilia® tissue technology by Edwards Lifesciences® (Edwards Mitris Resilia® prosthesis), potentially offer greater durability than conventional options. Furthermore, transcatheter valve implantation (TAVI) procedures in the mitral position, achievable through various approaches (transseptal or transapical), have demonstrated favorable outcomes in experienced centers.

In conclusion, selecting the appropriate prosthesis type for a patient requires an individualized decision that takes into account factors such as age, comorbidities, treatment adherence, INR monitoring capability, profession, and patient preference. The reviewed article suggests that, in the intermediate age group (55-65 years) with a moderate comorbidity burden, where mechanical prostheses are typically used, biological prostheses offer a similar safety profile and outcomes with fewer readmissions over a one-year follow-up period. However, given that this is a retrospective study based on a national database, important factors such as race, preoperative risk, and pre- or postoperative medications were not analyzed, which are critical for robust statistical analysis and clinical extrapolation.

Equally important, it is essential to remember that reducing readmissions among our patients depends on early identification and close follow-up, especially to mitigate hemorrhagic or thromboembolic complications associated with mechanical mitral prostheses.

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José Manuel Martínez Comendador

Management of Severe Mitral Annular Calcification with Transcatheter Balloon-Expandable Prostheses via Transatrial Access: A Step Towards Definitive Resolution

A multicenter registry evaluating the largest series to date regarding the outcomes of transcatheter valve implantation in the mitral position in massive annular calcification (ViMAC) using a transatrial approach during cardiac surgery with cardiopulmonary bypass.

Implantation of a transcatheter valve in massive mitral annular calcification (ViMAC) has emerged as an alternative to traditional surgical mitral valve (MV) replacement, as highlighted last year when we reviewed the study by Smith et al. Furthermore, this blog has thoroughly reviewed the evidence and use of transcatheter prostheses in mitral valve disease across all possible scenarios, including specific cases such as valve-in-valve/ring mitral (ViVM) in failed bioprosthetic or annuloplasty repairs. Most studies evaluating ViMAC are impractical due to grouping the transeptal, transapical, and transatrial forms of the procedure, creating uncertainty by preventing individualized analysis of the advantages and disadvantages of each technique. This study aims to evaluate clinical outcomes specifically for transatrial ViMAC using the most extensive multicenter registry to date.

For this purpose, patients with symptomatic MV dysfunction and severe mitral annular calcification (MAC) were included in a ViMAC study conducted in 12 centers across the United States and Europe. Clinical characteristics, procedural details, and clinical outcomes were extracted from electronic medical records. The primary endpoint was all-cause mortality. We analyzed 126 patients who underwent ViMAC, with a median age of 76 years (interquartile range [IQR] 70-82 years), 28.6% of whom were female. The median score on the Society of Thoracic Surgeons (STS) risk scale was 6.8% (IQR 4.0%-11.4%), with a mean follow-up of 89 days (IQR 16-383.5 days). Of these patients, 61 (48.4%) presented isolated mitral stenosis, 25 (19.8%) had isolated mitral regurgitation (MR), and 40 (31.7%) presented mixed MV disease. Technical success was achieved in 119 (94.4%) patients. Thirty (23.8%) patients underwent concomitant septal myectomy, and 8 (6.3%) experienced left ventricular outflow tract obstruction (7 of 8 did not undergo myectomy). Five (4.2%) of the 118 patients with postprocedural echocardiographic data presented more than mild paravalvular leakage. All-cause mortality at 30 days and one year occurred in 14 (11.1%) and 33 (26.2%) patients, respectively. In multivariable models, moderate or greater MR in early postprocedural phases was associated with increased risk of one-year mortality (hazard ratio 2.31; 95% confidence interval 1.07-4.99; $p = .03$).

The authors conclude that transatrial ViMAC is safe and feasible in this selected, predominantly male cohort. Moreover, they suggest that patients with significant MR may derive less benefit from ViMAC compared to those with isolated mitral stenosis.

COMMENTARY:

The results of this study position the ViMAC alternative as a significant shift in MAC treatment, highlighting an innovative approach that promises to transform future practices in cardiovascular surgery with promising, comparable, and sometimes superior results to traditional surgical methods.

The article reviewed today highlights the evolution and clear trend towards adopting less invasive techniques in MAC cases. Brener et al. present a study on 126 patients treated

with the ViMAC technique over seven years, demonstrating significant advancement in this field. In comparison, last year, we reviewed the study by Smith et al., then the largest published, with 51 patients undergoing open surgical implantation of balloon-expandable transcatheter prostheses in MAC scenarios. That study reported 30-day and one-year mortality rates of 13.7% and 33.3%, comparable to the current study, with 30-day and one-year mortality rates of 11.1% and 26.2%, respectively. This indicates that in the two largest documented series to date, 30-day mortality slightly exceeds 10%, reaffirming the technique's reproducibility and favorable outcomes. Other results obtained are frankly positive and comparable to those expected in conventional mitral surgery in similar high-severity and complex cases, showing a technical success rate of 95% and a paravalvular leakage rate of 4.2%.

The study authors employ a technique similar to the one we detailed last year. This approach offers the main advantage of allowing anterior leaflet resection while minimizing posterior mitral annular manipulation. It enables sutures at various annular positions using Teflon pledgets on the atrial surface, adapting to the anatomy to secure them to the prosthetic cuff and reduce periprosthetic leaks. It also facilitates myectomy when the predicted left ventricular outflow tract area (LVOT) is less than 200 mm^2. In this study, myectomy was performed in 1 out of 4 patients, of whom only 3.3% experienced LVOT obstruction. Conversely, among patients who did not undergo concomitant myectomy, LVOT obstruction was observed in 7.3%. Therefore, the incidence of LVOT obstruction in this series was low, thanks to both anterior leaflet resection and myectomy, showing significant improvement in LVOT free space not observed in strictly transcatheter procedures (percutaneous transeptal or transapical). This improvement represents one of the main advantages and findings in using balloon-expandable prostheses in MAC patients. Alongside preventing atrioventricular groove rupture, by avoiding annular calcification resection, the optimization of LVOT space with these prostheses stands as one of the major benefits of this technique.

These results underscore the efficacy of transcatheter prostheses when applied via a surgical approach, showing very good outcomes in cases where prognosis with traditional surgical techniques was unfavorable. On the other hand, the effectiveness of these same prostheses fully implanted by transcatheter routes, especially in contexts less complicated than those associated with MAC, has yet to be determined. Numerous clinical trials are currently underway to evaluate the outcomes of purely transcatheter mitral valve replacement (TMVR), employing transapical or transeptal approaches, with or without complementary techniques such as the LAMPOON (laceration of the anterior mitral leaflet) procedure and/or alcohol septal ablation. To date, no device has replicated all the advantages observed with the transatrial approach, which include complete anterior leaflet excision, myectomy when necessary, prosthesis placement and orientation under direct vision, and sutures to prevent perivalvular leaks. It is likely that with new devices, where the implant position of the balloon-expandable transcatheter prosthesis is more predictable, the commissural alignment relative to the LVOT will further improve obstruction outcomes and reduce the need for associated myectomy.

Although this surgical technique can be considered successful, confronting MAC represents one of the greatest challenges for any surgeon, and patient prognosis, regardless of the intervention performed, seems intrinsically unfavorable in the medium term. This fact is evidenced in the mentioned study, where one-year mortality was 35.4%, comparable to the 38.5% observed in the transatrial subgroup of the MITRAL study. A recent meta-analysis comparing TMVR outcomes in MAC patients using different techniques revealed a one-year mortality rate of 16% for conventional surgery and 43% for prostheses implanted exclusively percutaneously through transapical or transeptal access. This emphasizes the gap towards achieving optimal outcomes with

percutaneous techniques in treating this pathology, likely attributed more to high comorbidity and fragility in these patients than to the implant technique per se.

This study represents a valuable addition to the existing literature but is not without significant limitations, the main one being its retrospective nature. The lack of prospective data collection is especially relevant concerning critical variables such as preoperative LVOT gradients, right-sided hemodynamic pressures, or frailty criteria, for which detailed information is unavailable. The study began in 2014, a period before the adoption of a standardized MAC definition based on CT imaging criteria, limiting comparability with subsequent research. Additionally, the criteria followed by surgeons to decide on myectomy remain unknown, introducing potential selection bias.

The introduction of transcatheter prosthesis implantation via transatrial approach in TMVR in MAC cases has marked a revolutionary shift in managing these situations, presenting itself as an innovative treatment alternative that has surprisingly emerged to establish itself permanently. Although it remains an off-label use of this type of prosthesis, the article presenting the largest-ever published series of patients treated in this manner is evidence of this advancement, delivering results deserving recognition. The application of these prostheses could pave the way for their use in scenarios beyond MAC, such as in mitral stenosis cases accompanied by other surgeries extending the procedure duration, reoperations for dysfunctional prostheses, or in complex exposure situations, to name a few examples. Although it is currently premature to even consider these possibilities, some discoveries prompt us to explore doors yet unopened, revealing opportunities that have always been before us.

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Ariadna Nicol Jiménez Ortiz

Mitral valve replacement: is age a key factor in prosthesis selection?

This is a retrospective, multicenter observational study comparing long-term outcomes in terms of 10-year survival and freedom from reintervention following isolated mitral valve replacement with mechanical versus bioprosthetic valves, across different age groups.

The appropriate selection of prosthesis type—mechanical versus bioprosthetic—for mitral valve replacement has been largely based on long-term durability. It is well-known that younger patients are typically assigned mechanical prostheses to reduce the need for repeat surgeries, while older patients are often assigned bioprostheses to avoid prolonged anticoagulation therapy, at least with vitamin K antagonists. However, this approach has led to an increased use of mitral bioprostheses in younger patients, driven by the development of transcatheter “valve-in-valve” techniques, which may mitigate the risk of reintervention due to prosthetic degeneration.

Existing studies have compared mitral valve replacement outcomes between mechanical and bioprosthetic valves, often including patients undergoing concomitant cardiac procedures, mainly coronary artery bypass surgery and tricuspid and/or aortic valve replacement. To balance variations in morbidity associated with different age groups and prosthesis choices, studies like the present one, which focuses solely on isolated mitral valve replacement in propensity-matched populations, are essential for evaluating both early and long-term outcomes.

This study stratified patients into two age groups: under 65 and between 65 and 75 years. Initially, 1,536 patients who underwent isolated mitral valve replacement between 2000 and 2017 were included, of which 806 received mechanical prostheses and 730 bioprostheses. Propensity score matching was then performed based on 32 baseline variables, including demographics, sex, age at surgery, and comorbidities. For variables with missing data, such as ejection fraction or serum creatinine, multiple imputations assuming a multivariate normal distribution were used to estimate the missing values. The mean observational follow-up was 9.4 ± 5.8 years, during which postoperative complications, early and late morbidity, and both in-hospital and out-of-hospital mortality were evaluated. Additionally, logistic regression was employed to assess short-term outcomes, including in-hospital postoperative complications like stroke, gastrointestinal bleeding, and permanent pacemaker implantation. Cox proportional hazards model was used for long-term outcomes, which included 10-year mortality and the necessity for surgical or transcatheter reintervention. Inverse probability weighting was also applied to the results for comparative analysis.

The study successfully matched 226 patient pairs under 65 years and 171 pairs between 65 and 75 years, resulting in a total of 794 patients included in the final analysis. The findings from the propensity-matched cohorts indicated a higher stroke rate among patients with mechanical mitral valve replacement compared to those with bioprostheses, in both age groups. However, these differences were not statistically significant. Additionally, postoperative gastrointestinal bleeding rates were similar in both age groups. Regarding permanent pacemaker insertion, younger patients under 65 had a higher rate with mechanical valves, whereas among those over 65, the rate was higher with bioprostheses. Acute kidney injury requiring dialysis was significantly more common in patients under 65 with bioprosthetic valves (p = .011).

Long-term results revealed greater 10-year survival in patients under 65 with mechanical valves. Likewise, mechanical valves in younger patients were associated with a reduced reintervention rate compared to bioprostheses. However, this advantage did not extend

to patients between 65 and 75 years, in whom reintervention rates were comparable between both valve types. Thus, the survival advantage of bioprostheses was more significant in patients aged 65 to 75.

COMMENTARY:

As supported by similar studies, the preference for mechanical mitral prostheses in patients under 65 stems from their durability and reduced need for reintervention. However, most of these studies include concomitant procedures that may affect overall outcomes. This study's unique contribution lies in analyzing only isolated mitral valve replacements, thereby minimizing confounding factors and employing propensity matching across two age groups, reducing bias. However, the prosthesis selection based on biological age or expected survival may have influenced the better survival outcomes seen in younger patients with mechanical valves, which could reflect a cohort with a better preoperative condition not entirely controlled for by propensity analysis.

Although evidence seems robust, future studies should also consider long-term mortality and adverse events in patients with isolated mitral valve replacement with bioprostheses who cannot undergo prolonged anticoagulation, particularly among those under 65. Encouraging further research will help determine the individual impact of different prosthesis types and anticoagulation approaches associated with them, while considering that factors other than the prosthesis may dictate the need, type (vitamin K antagonists or direct oral anticoagulants), and intensity of anticoagulation therapy. It's important to remember that the presence of an indication for oral anticoagulation due to valve disease should not dictate the choice of mechanical prosthesis (Class IIb recommendation in current clinical guidelines).

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Adrián Muinelo Paúl

Mitral valve replacement: mechanical versus biological: long-term experience

Long-term follow-up after mitral valve replacement focusing on the impact of biological versus mechanical prostheses on survival and reoperation rates in over 2,000 patients, adjusted using propensity score matching.

Patients with symptomatic mitral valve disease who are not candidates for surgical mitral valve repair can be effectively treated through replacement with either a biological (bMVR) or mechanical prosthesis (mMVR).

This study retrospectively analyzes patients who underwent mitral valve replacement (MVR) at the Department of Cardiovascular Surgery at the German Heart Center in Munich, Germany, between 2001 and 2020. Propensity score matching was used to compare survival and reoperation incidence between patients receiving a biological versus a mechanical prosthesis in the mitral position. A total of 2,027 patients were included, with 1,658 in the bMVR group and 369 in the mMVR group. The mean age at surgery was 65.9 ± 12.9 years. The median follow-up duration was 6.83 years (interquartile range 1.11–10.61 years). Concomitant procedures were performed in 1,467 cases (72.4%).

The authors concluded that both groups demonstrated comparable survival. Indeed, survival following bMVR and mMVR remained similar throughout the follow-up period, reaching up to 20 years. However, patients with mMVR exhibited a significantly lower incidence of reoperation (20-year: 15% vs. 59%, $p < .001$).

COMMENTARY:

The choice between a biological or mechanical prosthesis can present a considerable clinical challenge. Anticoagulation or reoperation? That is the question.

The current European clinical guidelines recommend mMVR for patients aged 65 years or younger, while American guidelines set this threshold at 70 years. However, the progressive aging of the population increasingly leads to prosthetic degeneration at ages when reoperation involves a high risk of morbidity and mortality. On the other hand, the durability of mechanical prostheses necessitates lifelong anticoagulation, carrying associated bleeding risks. It is also crucial to consider the subgroup of younger female patients with reproductive aspirations, where a biological prosthesis is preferred. This study provides data that can be useful for decision-making in this frequent clinical dilemma encountered by cardiac surgeons.

The authors conclude that patients who received mechanical mitral valve replacement had significantly fewer reoperations, while survival was comparable between the mechanical and biological prosthesis groups.

Within the analyzed cohort, the age groups of 46–55 and 56–65 years showed no survival differences between prosthesis types. These results contrast with recent literature, which suggests higher survival with mMVR for patients aged 50–69. Notably, survival was also higher in the mMVR group prior to propensity score matching. Although propensity score matching is a valuable statistical tool for comparing techniques that often involve dissimilar patient profiles, such as mMVR and bMVR, it is crucial not to overlook the inherent biases associated with its use.

Although this study's selection of variables is comprehensive, an analysis of mortality in patients requiring reoperation during follow-up is absent. Additionally, specifying the

indications for reintervention, particularly in the mMVR group, would be insightful. These data could be especially useful for personalizing clinical treatment.

Information on anticoagulation-related complications during follow-up in the mMVR group would also be pertinent, given their impact on both quality of life and survival. The current trend is to implant biological prostheses in increasingly younger patients, grounded in numerous studies showing a higher bleeding risk after mMVR and increased durability of contemporary biological prostheses.

Finally, the potential of transcatheter therapies in mitral valve reoperation should not be overlooked, as this could represent a paradigm shift similar to the TAVI valve-in-prosthesis approach in aortic valve disease over the last decade. However, for mitral valve pathology, the risk of left ventricular outflow tract obstruction remains a significant challenge to further advancing structural interventions in this area. More research and experience in percutaneous mitral valve treatment are needed to potentially offer a viable alternative to surgical reoperation.

In conclusion, this study provides valuable information for decision-making in the surgical treatment of mitral valve disease. These findings can guide cardiac surgeons in individualizing treatment, taking into account not only the comparable survival between both types of prostheses and the reduced reoperation risk with mMVR but also the quality of life considerations associated with long-term anticoagulation.

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José Donoso

Degenerative mitral regurgitation surgery: presentation and outcomes by sex

A retrospective single-center analysis of preoperative status and surgical outcomes in men versus women for all patients undergoing surgery for degenerative mitral regurgitation over 9 years.

Degenerative mitral regurgitation is the second most frequent valvular heart disease in Europe. In Western countries, the degenerative etiology is predominant, while in developing countries, rheumatic causes remain prevalent. According to the guidelines developed by the European Society of Cardiology (ESC) and the European Association for Cardio-Thoracic Surgery (EACTS), surgery is indicated in patients with severe symptomatic primary mitral regurgitation and acceptable surgical risk, in asymptomatic patients with left ventricular dysfunction (left ventricular end-systolic diameter or LVESD > 40 mm, left ventricular ejection fraction or LVEF ≤ 60%), and it should be considered in asymptomatic patients with preserved left ventricular function (LVESD < 40 mm and LVEF > 60%) who present with atrial fibrillation secondary to mitral regurgitation or pulmonary hypertension at rest.

Degenerative mitral regurgitation is associated with heart failure, arrhythmias, and poor long-term outcomes. When surgically treated in a timely manner, normal life expectancy may be restored. Previous studies report that, despite its higher prevalence, women may be referred for surgery less frequently and at a more advanced stage of disease, potentially impacting surgical and prognostic outcomes. This study aims to compare the clinical and echocardiographic differences between men and women to assess the need for adjustments in surgical indications, with the goal of improving postoperative recovery times and long-term outcomes.

The study was conducted at Massachusetts General Hospital, reviewing electronic medical records of all patients undergoing mitral valve surgery from January 2013 to December 2021. The study included patients with severe mitral regurgitation due to Carpentier type II mechanisms and excluded reoperations. Perioperative mortality and early postoperative complications (including mechanical circulatory support requirement, mechanical ventilation > 24 hours, postoperative stroke, and in-hospital death) were evaluated, along with long-term freedom from reoperation and death.

A total of 963 patients with degenerative mitral regurgitation were included. At the time of surgical referral, women were older than men. Men had significantly higher rates of arterial hypertension, coronary artery disease, and body mass index, whereas women had higher NT-proBNP levels, mitral annular calcification, and predicted mortality risk based on the STS-PROM (Society of Thoracic Surgeons - Predicted Risk of Mortality) score. Although absolute left ventricular dimensions were greater in men, these differences reversed when indexed to body surface area. Beyond conventional echocardiographic measurements, the study employed additional techniques, such as atrial strain analysis, finding lower peak values in women for left atrial strain parameters, which, along with other findings, suggest higher degrees of left ventricular overload and damage in women, associated with decreased survival. Women required mechanical circulatory support more frequently, all due to severe biventricular dysfunction after weaning from cardiopulmonary bypass despite high inotropic support. They also required longer mechanical ventilation, spent more time in intensive care units, needed more transfusions, and had prolonged hospital stays. No differences were observed in other postoperative complications.

Based on these findings, the authors concluded that women present for surgery at a more advanced stage of the disease and experience more perioperative complications, highlighting the potential benefit of earlier interventions.

COMMENTARY:

This study's primary finding is the apparent clinical differences between men and women at the time of deciding on mitral valve surgery. These differences significantly influence the likelihood of perioperative complications and prognosis. But how should this be interpreted?

Although absolute left ventricular dimensions were greater in men, these differences equalized or reversed when indexed to body surface area. It is likely that the LVESD > 40 mm threshold in asymptomatic patients, as outlined in clinical practice guidelines, is based on studies conducted predominantly in male populations. A large international study suggested considering LVESD/BSA > 21 mm/m² as a better decision-making threshold.

Based on the analyses performed in this study, it may be beneficial to include indexed parameters and strain, which are relatively easy to obtain, in standard echocardiographic evaluations. This would provide more comprehensive information and could influence earlier intervention in women, improving short- and long-term outcomes.

While this analysis focuses on body surface area and especially echocardiographic parameters, other studies suggest incorporating magnetic resonance imaging into preoperative assessments. MRI can evaluate left ventricular dimensions as well as structural abnormalities such as fibrosis, which are predictors of advanced disease and certain complications. Including these findings in routine evaluations could enhance the quality of evidence.

Although short- and long-term mortality were comparable between men and women in this analysis, the observed differences in perioperative complications seem significant. Even though this was a retrospective analysis of a relatively small, single-center cohort with the inherent limitations in evidence level, it is evident that the sex-based disparities in outcomes warrant further, larger studies designed to produce more valid results. Such studies would enable objective evaluation and focus on strategies to equalize perioperative and prognostic outcomes. It is also clear that we must continuously review and promote updates in the guidelines that guide decision-making in our clinical practice.

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José Manuel Martínez Comendador

Reintervention after MitraClip® implantation: a new MitraClip® or mitral surgery?

A prospective review of a national US database evaluates outcomes for patients undergoing reintervention following initial transcatheter edge-to-edge repair (TEER).

Mitral regurgitation (MR) is the most prevalent valve disease in Europe and America, affecting 13% of people over the age of 75. In Spain, by 2040, around 16% of the population is expected to be over 65, indicating approximately 2 million people with significant valvular disease. Given this scenario, it is essential for practitioners addressing this pathology to be prepared to meet this challenge.

Over the past decade, TEER has revolutionized MR treatment. FDA approved TEER in 2013, recommending it for severe symptomatic primary MR in patients at high or prohibitive surgical risk (class IIa recommendation in American guidelines, IIb in European). Furthermore, based on promising results from secondary MR clinical trials, TEER now has a class IIb recommendation in European guidelines for inoperable patients with secondary MR and suitable anatomy. Despite encouraging results post-initial TEER, the increase in cases has led to a rise in reinterventions via repeat TEER or mitral valve surgery (MVS). Reintervention rates range from 8% to 21%, with a high 30-day mortality rate averaging between 9% and 10%. However, these data are primarily from case series and limited studies. With the anticipated rise in patients needing reintervention, it is critical to understand risk factors and outcomes in a more real-world representative context.

In response, the University of Michigan examined the incidence, characteristics, and outcomes of reinterventions following initial TEER using a nationally representative study (US) based on Medicare® beneficiary data. Data from 11,396 patients who underwent initial TEER between July 2013 and November 2017 were reviewed. These patients were prospectively tracked, identifying those requiring repeat TEER or MVS. Primary outcomes included 30-day mortality, 30-day readmission, 30-day composite morbidity (pneumonia, transfusion requirement, stroke, acute renal failure, or cardiac arrest), and cumulative survival. Of the 11,396 TEER patients, 548 (4.8%) required reintervention after an average interval of 4.5 months. Overall, 30-day mortality was 8.6%, readmission was 20.9%, and composite morbidity was 48.2%. By type of reintervention, 294 (53.7%) underwent repeat TEER, and 254 (46.3%) underwent MVS. Patients undergoing MVS were more likely to be younger and female but had a similar comorbidity burden compared with the repeat TEER cohort. After adjusting data, no differences in 30-day mortality (adjusted odds ratio [AOR]: 1.26) or 30-day readmission (AOR: 1.14) were found. MVS was associated with greater 30-day morbidity (AOR: 4.76) compared to repeat TEER. The need for reintervention was an independent risk factor for long-term mortality in a Cox proportional hazards model (hazard ratio: 3.26).

The authors conclude that reintervention after initial TEER is a high-risk procedure with significant mortality, underscoring the importance of ensuring initial TEER procedural success to avoid the overall morbidity of reintervention.

COMMENTARY:

Approximately 150,000 MitraClip® by Abbott® implants have been performed worldwide to date. In this pioneering national study led by Kaneko et al., 11,396 initial TEER implants were analyzed, with long-term follow-up for both cohorts—those who did not require reintervention and those who did (either via repeat TEER or mitral valve surgery).

Among these patients, 548 (4.8%) required reintervention, including 254 who needed surgery. Key findings from this research include:

1. The reintervention rate after the initial TEER procedure was lower than in previous studies, with most occurring within the first year.

2. The 30-day mortality rate for reinterventions (either repeat TEER or surgery) in MitraClip® patients was 8.6%, confirming the high risk associated with these procedures.

3. Short-term morbidity was common in nearly half of the patients, but significantly higher in those requiring surgery compared to those undergoing repeat TEER, with an almost fivefold increased risk.

The reintervention rate in this study was 4.8%, considerably lower than in relevant studies like EVEREST II (21%) and European registries (8-10%), but similar to American registries that used national readmission data (3.6%). This lower incidence of reintervention could be due to several factors: 1) Selection bias, where many patients, despite being eligible for reintervention, were not candidates due to their very high risk. This is supported by the fact that the non-reintervened group was older and had higher comorbidity than the reintervened group. 2) A lower incidence of severe residual MR after TEER due to growing experience among centers and professionals, which potentially reduced the need for reinterventions.

The need for reintervention in MitraClip patients was an independent risk factor for mortality. Most reinterventions occurred within the first year, with approximately 25% performed under urgent conditions. These findings are consistent with the EVEREST II study results. Short-term outcomes for reintervention via surgery and TEER showed minimal differences, with 30-day mortality rates of 8.6% and 30-day readmission rates of 21%, reflecting the high risk associated with these procedures. These figures align with previous studies, though they are better than those reported in smaller studies. Composite morbidity was 66% for surgery and 32% for TEER, as expected given the patient profile, which was predominantly elderly and frail. High mortality in surgery is likely due to patient comorbidity, age, and frailty rather than technical difficulties associated with reintervention in MitraClip patients. This contrasts with the situation in patients requiring reintervention after prior TAVI, where many undergo surgery on the aortic root, presenting a different set of technical challenges that increase mortality, as discussed in previous commentaries on this blog.

In contrast, long-term mortality in this study was better among patients who underwent surgery compared to those who received a new MitraClip. This could be explained by the selection of younger patients with a more favorable risk profile for surgery, naturally leading to better survival rates. Additionally, it is essential to remember that mitral valve replacement surgery practically eliminates residual MR, unlike repeat TEER, thus improving surgical survival rates.

Therefore, for high-risk surgical patients with a failed MitraClip®, surgery does not appear to be the best option for most. A repeat TEER, while not guaranteed to resolve the issue, represents a realistic alternative when no other options are available. Other options currently under study include transcatheter mitral valve replacement, even with a previously implanted MitraClip® (e.g., devices like AltaValve®). Another option is the use of the ELASTA-Clip, which involves electrocautery laceration of the clip to allow implantation of a percutaneous prosthesis. It is important to note that the patients in this study were treated between 2013 and 2017 with devices that were not up to date.

Currently, newer devices like the 3rd generation MitraClip® (NTR/XTR) and the latest G4 release system (Abbott®) have significantly improved outcomes compared to earlier versions.

FDA approval for TEER in cases of degenerative MR is limited to high-risk surgical situations, including frailty and contraindications for surgery. In this patient group, whether for a first TEER or reintervention, the essential goal is to prevent strokes and improve quality of life, even if it entails a high risk of residual MR. However, it is important to remember that in degenerative MR, repair is the standard treatment (class I), rather than replacement. Repair offers benefits like better short- and long-term survival, reduced complication risks, and no long-term anticoagulation requirement. Although technically challenging, its success depends on the surgeon's experience, and its use has increased, reaching up to 80% in some countries.

In this study, only 4% of mitral reinterventions were repairs, which is consistent with previous findings indicating that over a quarter of patients needing reinterventions have damage to the mitral leaflets, severely complicating the possibility of a successful repair. Additionally, in such cases, it is understandable that surgeons opt for mitral valve replacement, considered a safer and more effective option. Therefore, if this reintervention on MitraClip® patients were to be performed on low-risk patients, even if it entailed a reduced risk of mortality, a successful mitral repair would be unlikely. This would mean missing a valuable opportunity for a nearly guaranteed repair in a first intervention. One of the key messages I would like to convey is that it is essential not to succumb to industry pressure or patient preferences for a less invasive technique, given that TEER has neither been investigated nor authorized for use in low-risk patients with primary MR. Mitral repair outcomes are highly effective and challenging to match.

Data from this study, derived from the Medicare® database with a 5% reintervention rate, may be outdated and possibly not reflective of the current situation. As TEER is increasingly performed on younger, lower-risk patients, an imminent increase in surgical reintervention in this group is likely. Therefore, studies like this one provide invaluable information for understanding and effectively addressing a pathology that is set to become common in clinical practice.

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José Manuel Martínez Comendador

MitraClip® vs. mitral surgery in severe mitral regurgitation: French national registry

This study analyzes a longitudinal cohort using the French national hospitalization database to compare medium-term outcomes between percutaneous edge-to-edge therapy and isolated mitral surgery in patients with severe mitral regurgitation.

Mitral regurgitation (MR) is the most common acquired valvular disease globally, with a rising prevalence with age. For primary/degenerative MR, mitral surgery—whether replacement or repair—remains the first-line choice for surgically eligible patients. However, surgical techniques, especially restrictive annuloplasty in secondary or functional MR, have not achieved the same success. In this context, structural intervention, particularly transcatheter edge-to-edge repair (TEER), has emerged as a valid, less invasive option for severe MR patients using devices such as Abbott® MitraClip® and Edwards® Pascal®. Although initially targeted at primary MR, studies have demonstrated the safety and efficacy of TEER in secondary MR compared to optimal medical therapy, as shown in two large randomized trials.

Despite the progressive increase in TEER usage in daily clinical practice across industrialized countries, the current incidence of its use, indications, and comparative evolution with mitral surgery remains undefined. Addressing this, the article under review today leverages data from the national hospitalized patient database in France to provide a global and comparative view of all patients undergoing percutaneous and surgical interventions. The study included 57,030 patients with severe MR, who consecutively underwent one of the two procedures (52,289 surgery vs. 4,741 TEER) between 2012 and 2022. After propensity score matching, 2,160 patients were analyzed in each group. The average patient age was 76 years, with 58% men and an average EuroSCORE II of 3.9. At a 3-year follow-up (average follow-up of 1 year), TEER was associated with significantly lower incidences of cardiovascular death (HR 0.68; $p = .001$), pacemaker implantation (HR 0.68; $p = .00002$), and stroke (HR 0.65; $p = .03$). Non-cardiovascular mortality (HR 1.56; $p = .0002$), recurrent pulmonary edema, and cardiac arrest were more frequent in the TEER group. No differences were observed between the two groups in all-cause mortality, endocarditis, major bleeding, atrial fibrillation, or myocardial infarction (MI). A significant interaction was noted between age >75 years and EuroSCORE II ≥ 4% in the reduction of cardiovascular and all-cause mortality following TEER compared to surgery.

The authors conclude that these results suggest that TEER was associated with lower cardiovascular mortality compared to mitral surgery during long-term follow-up.

COMMENTARY:

The percutaneous MitraClip® treatment was approved in Europe for primary MR in 2008 (introduced in France in 2010) and in the U.S. in 2013. Since then, its indications have expanded to include functional MR, mainly following the positive outcomes of the COAPT clinical trial. The five-year COAPT study demonstrated benefits of TEER over medical treatment in patients with an LVEF of 20-50% and an LVEDD < 70 mm, as discussed in previous blog entries. However, these findings were not mirrored in the MITRA-FR trial (LVEF 15-40%), which included patients with more significant ventricular dilation.

Current clinical guidelines assign a class I recommendation for mitral surgery in patients with primary MR. However, there is consensus among experts in both the U.S. and Europe that TEER may be considered in non-surgical candidates due to high surgical risk. Regarding functional MR, American guidelines recommend it as class IIa for patients

with favorable anatomy and persistent symptoms despite optimal medical treatment. Meanwhile, in European guidelines, based on the COAPT study results, TEER also holds a class IIa recommendation for patients who do not respond to medical treatment and present excessively high surgical risk.

This analysis, led by Deharo et al., is noteworthy primarily for providing an overview of clinical practice in managing severe MR in France rather than for the comparative outcomes between MitraClip® and surgery, which are anecdotal and somewhat biased, as we'll discuss further.

From my perspective, the two key takeaways are:

1. Over a 10-year period, 8.3% of all MR cases treated in France were managed with percutaneous MitraClip® treatment. This transcatheter approach has continued to grow annually without decreasing the number of mitral surgeries performed, thereby consolidating itself as a genuine alternative in a significant percentage of severe MR cases.

2. Comparing patients undergoing surgery with those treated with MitraClip® reveals that the benefits of the latter are more pronounced in older patients with higher baseline surgical risk, confirming previous suspicions.

Everything else, including this last statement, should be approached with great caution, as this study has considerable limitations. The most significant limitation is the lack of distinction between mitral repair and replacement and between primary/degenerative and functional MR. This omission alone makes any attempt to match groups difficult to justify and reduces credibility.

The raw data from this study, reflecting the reality of MR treatment in France, are valuable and undoubtedly represent its most significant contribution. It's clear that patients treated with MitraClip® were older and had more comorbidities. This patient profile theoretically benefits most from MitraClip, a fact now confirmed by a national database.

After a propensity score analysis with 2,160 patients in each group, in which higher-risk surgical patients were selected, and with an average follow-up of 1 year, it was observed that patients over 75 years and those with EuroSCORE II ≥ 4 (intermediate and high risk) treated with MitraClip showed improvement in all-cause and cardiovascular mortality, which aligns with expectations.

Furthermore, by further scrutinizing the data, an attempt was made to differentiate primary and functional MR by classifying as primary those patients without a history of ischemic/dilated cardiomyopathy, coronary artery disease, MI, or revascularization surgery, which, in my opinion, is a stretch. When analyzing functional MR cases, lower all-cause mortality after TEER compared to surgery was observed.

If we delve deeper into the results from Deharo et al., the first thing that stands out is that unmatched percutaneously treated patients exhibited greater frailty and comorbidities compared to those undergoing surgery. In a direct comparison, cardiovascular mortality was 8.75% with TEER versus 3.6% with surgery (figures that could be compared to STS 2020 data, where mortality was 1.2% in mitral repair and 4.5% in mitral replacement). However, after adjustment, cardiovascular mortality became 7.96% with TEER versus 11.4% with surgery, reflecting a higher baseline risk in the surgical group to match the TEER group, illustrating the complexity of matching both groups. Therefore, after

analyzing matched subgroups, one could conclude that as surgical risk increases, the comparative outcomes of TEER improve in terms of mortality.

Regarding the observed benefit in functional MR, American guidelines currently favor TEER over surgery, assigning only a class IIb recommendation to the latter (except in cases of concomitant revascularization, where surgery is class I recommended if LVEF >30% and class IIa if <30%). Within this context, if we consider the study results valid, they would support the current recommendation of TEER over surgery for functional MR patients.

In primary MR, where surgery is considered superior to TEER, we await clinical trials to provide further insights. The REPAIR MR study is comparing MitraClip® TEER with surgical mitral repair in patients with severe MR and moderate risk, while the PRIMARY study makes the same comparison in low-risk patients.

Another significant point is the lack of information on technical success rates for the percutaneous intervention in this study. Limited comparative experiences between mitral valve repair surgery and edge-to-edge therapy in functional MR, based on real-world data, such as Okuno et al.'s work previously discussed in this blog, highlight an incidence of mild or no residual MR post-intervention of 72% for percutaneous therapy, far below the 96-98% success rates reported in COAPT and MITRA-FR studies, respectively. This discrepancy could stem from defining "procedure success" as merely a one-grade reduction in MR. Additionally, several studies have shown that residual MR after surgery has significant long-term prognostic implications. In this study, follow-up only extended to 1 year, and no information on residual MR is available, likely not an insignificant factor.

This study does not challenge the excellent and durable outcomes of mitral surgery in younger patients with lower surgical risk but rather evaluates the real-world practice of severe MR treatment in France over the past 10 years. If we consider the propensity analysis valid, it could be inferred that in patients over 75 years and with high surgical risk with severe MR (likely mostly functional), the use of MitraClip® fulfills its intended purpose, confirming what was already known.

Nevertheless, the results from matched groups do not allow for reliable conclusions, as the surgical group is highly heterogeneous regarding MR type and surgery type, invalidating the conclusions for practical purposes. While initial results suggest the validity and efficacy of MitraClip® in high-risk patients in terms of mortality, it is neither fair nor accurate to conclude, as the authors misleadingly suggest, that MitraClip® use in severe MR compared to surgery is associated with lower long-term cardiovascular mortality. Firstly, it isn't even mentioned that these results were obtained after a propensity subgroup analysis where dissimilar cases are grouped; secondly, if valid, it applies only to certain high-risk patients; and lastly, calling a one-year follow-up "long-term" is inappropriate.

Striking the right balance between the honesty of results and their presentation, considering the economic interests of companies promoting their products, is challenging. Studies like this offer valuable insights, such as a realistic description of clinical practice in the national management of severe MR. However, attempting to draw other conclusions and presenting them in a skewed way through propensity group analysis where anything fits may be a mistake and, above all, unfair.

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Begoña Bernal Gallego

Valve-in-valve mitral: goodbye to conventional reoperation?

A multicenter German registry compares short- and mid-term outcomes of transcatheter mitral valve implantation versus surgical reoperation for cases of bioprosthetic degeneration or failed repairs involving annuloplasty.

Mitral valve repair and bioprosthetic implantation are the most frequently performed procedures in adult patients requiring mitral valve surgery. These procedures avoid permanent anticoagulation therapy and improve patients' quality of life. However, with extended life expectancy, prosthetic degeneration and the need for subsequent invasive procedures have become increasingly common. Conventional surgical reoperation remains the most widely employed technique, though it carries perioperative risks associated with both technical aspects and additional morbidities compared to the original procedure. Recently, compassionate use of transcatheter valves in the mitral position (known as "valve-in-valve" or "valve-in-ring") has emerged as a less invasive option, as analyzed in a meta-analysis published last year on our blog. Additionally, we examined the current status of transcatheter mitral prostheses in a review from 2023.

Ten German centers participated in this multicenter registry, providing data from 273 patients with prosthetic or annuloplasty repair degeneration treated with mitral valve-in-valve/ring (ViVM, 79 patients) or conventional reoperation (redo-mitral, 194 patients) between 2014 and 2019. Patients with prosthetic endocarditis and dysfunctional mechanical prostheses were excluded. Data were retrospectively analyzed with propensity score matching. The primary endpoint was mortality at 30 days and midterm, with perioperative outcomes evaluated according to Mitral Valve Academic Research Consortium (VARC) criteria. Additionally, the influence of moderate or greater tricuspid regurgitation (TR) on mortality at 30 days and midterm was analyzed.

The results showed no significant mortality differences between the ViVM and redo-mitral groups. However, baseline characteristics differed, such as age and the presence of atrial fibrillation and moderate or greater TR. ViVM was associated with shorter procedural times and ICU stays. Redo-mitral allowed for larger prosthesis sizes (average 2 mm increase) and addressed concomitant lesions (30 concomitant procedures were reported). In both groups, moderate or greater TR was an independent predictor of mortality at 30 days and midterm.

The study concludes that while prosthetic replacement surgery remains the treatment of choice, ViVM may be an attractive alternative for high-risk surgical patients.

COMMENTARY:

This is the first German registry presenting and comparing outcomes of ViVM implantation versus reoperation to treat degenerative mitral valve bioprostheses/annuloplasty repairs. However, this study is not without limitations. It is a multicenter, retrospective study, carrying inherent biases and data collection and analysis limitations. Selection bias is evident regarding treatment group allocation; nonetheless, it is emphasized that therapeutic decisions were made following individual, multidisciplinary assessments by the Heart Team of each participating center. Additionally, the inability to present uniform echocardiographic data due to the multicenter nature of the study is acknowledged.

A noteworthy finding of this registry is that moderate or greater TR was an independent mortality predictor in both groups, a finding extensively corroborated in other studies. The group led by Szlapka et al. advocates that while it cannot address all coexisting

comorbidities, transcatheter therapy focusing solely on the mitral prosthesis offers a benefit due to its limited invasiveness. Future studies on larger populations with extended follow-up are necessary to clarify therapeutic options for this patient subgroup.

Undoubtedly, the revolution brought by the advent and consolidation of TAVI will extend to the mitral valve. ViVM presents a promising, disruptive alternative for managing patients with mitral pathology, which is just around the corner. However, its implantation poses unique challenges, making it more complex and less reproducible than TAVI. On one hand, it requires a transseptal access route, which is complex and not always feasible, thus renewing the importance of transapical access. The risk of left ventricular outflow tract obstruction remains the Achilles' heel of this technique, although the presence of a similarly-sized prosthesis mitigates this risk compared to implantation in native valves. Prosthesis migration occurs more frequently due to the higher closing pressure of the mitral valve than those observed in the other three valvular positions. Overall, with appropriate planning, this procedure offers a real, less complex alternative to conventional surgery, with hemodynamic outcomes comparable to those of a surgical prosthesis in terms of gradients and residual leakage. Therefore, it should be considered a viable and safe alternative to include in our therapeutic arsenal.

Current results support the effectiveness of the percutaneous approach, especially for high-risk surgical patients. However, it is also essential to maintain a realistic perspective on the future of mitral reoperations. While advances in percutaneous procedures offer new therapeutic options, there will still be cases where conventional surgery remains necessary and irreplaceable: endocarditis, prosthetic thrombosis, small prostheses, mechanical prostheses, etc. Nonetheless, we must keep in mind that in this era of transcatheter therapy, percutaneous mitral valve treatment is on the rise, and it is crucial to be prepared to adapt to these advances and harness their potential to provide the best therapeutic option tailored to each patient type.

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Miguel Sánchez Sánchez

The management of secondary mitral regurgitation. A paradigm shift

This commentary addresses a comprehensive review on the current management of secondary mitral regurgitation (sMR).

Severe secondary mitral regurgitation (sMR) is a prevalent condition that negatively impacts the prognosis of patients with heart failure, with a mortality rate of 20% within the first year of diagnosis. The high burden of comorbidities, advanced age, and impaired ventricular function render these patients suboptimal for conventional surgical management. Fortunately, advancements in heart failure management and the development of percutaneous techniques offer new therapeutic avenues. Consequently, the authors of this article summarize the available evidence and propose an algorithm based on it to guide clinical decision-making.

Secondary mitral regurgitation is defined as MR caused by alterations in supporting structures—namely, the left ventricle, left atrium, or mitral annulus—in contrast to primary MR, where the defect lies in the valve itself. Thus, addressing the underlying cause is crucial in sMR management, which involves:

1. Quadruple therapy for heart failure (HF).
2. Rhythm control strategies in atrial fibrillation (AF).
3. Cardiac resynchronization therapy (CRT), when indicated.
4. Direct intervention on the mitral valve, either percutaneously or surgically.

Breaking down the authors' review, sMR has seen significant advances over the past decade. The first major step in HF treatment was the introduction of sacubitril/valsartan (ARNI), which, since the PARADIGM-HF trial, has shown a significant reduction in ventricular volumes and improved ejection fraction, indirectly suggesting enhanced ventricular hemodynamics and reduced sMR, as later studies like PROVE-HF indicate, except in severely deteriorated ventricles. Additional milestones include the use of sodium-glucose cotransporter-2 inhibitors (iSGLT-2) and vericiguat, although their evidence is less robust in this context. STRONG-HF emphasizes the importance of rapid titration to optimal doses of HF medication, despite methodological discrepancies like the omission of iSGLT-2s from the therapy or the inclusion of few patients with de novo HF, underscoring improved prognosis with optimal medical therapy.

Rhythm control holds significant prognostic value in HF, especially through AF ablation, now a class IB recommendation in the 2023 guidelines for AF management. Studies by Gertz et al. demonstrated reduced MR with rhythm control, implicating mechanisms like improved atrioventricular synchrony and beat regularization. CRT also improves MR in patients with intraventricular conduction delay (wide QRS, particularly with left bundle branch block), as evidenced in studies such as MIRACLE and secondary analyses from SCD-HEFT, highlighting ventricular synchrony as essential for optimal mitral subvalvular function. Although outcomes with left bundle or His-bundle pacing remain unexplored, physiopathological knowledge suggests they may enhance ventricular synchronization over conventional right ventricular apex pacing.

Through these measures, approximately 40-50% of severe sMR cases can regress. Although significant, a substantial group of patients may still require additional therapy.

A notable advancement here is MitraClip®, a device replicating the Alfieri technique percutaneously, presenting another dilemma reflected in MITRA-FR and COAPT: who benefits? Despite both studies assessing efficacy, significant discrepancies existed. MITRA-FR included patients with greater ventricular dysfunction, while COAPT selected patients with less impaired ventricles (e.g., DTDVI <70mm, operability criteria for the technique, absence of right ventricular dysfunction, etc.). This analysis introduces the concept of proportional or disproportionate sMR, suggesting that severe MR in a moderately dilated or impaired ventricle is more likely to benefit from this technique than the opposite. Grayburn et al. illustrated this concept by mapping the patient selection in both studies, with recent studies delving deeper into this phenomenon, as noted in the work of Soltz et al., where sMR staging based on ventricular and atrial involvement correlates with prognosis, advocating early referral to ensure favorable outcomes.

Despite current knowledge, much remains unexplored. Further evidence is needed for other devices like PASCAL® and for other percutaneous systems such as Carrillon® and Cardioband® (both annuloplasty-based) or valve replacement devices like Tendyne®.

The authors conclude with the following recommendations:

1. Rapid titration of HF medical therapy to optimal doses within the first three months (based on STRONG-HF findings).

2. Consider rhythm control in AF or CRT where indicated, alongside therapeutic optimization.

3. If symptoms persist (NYHA ≥ II) and MR remains moderate to severe despite previous measures, a multidisciplinary Heart Team should assess eligibility for percutaneous intervention (preferable in most patients) or surgery, especially for those undergoing concurrent surgery or being considered for advanced therapies.

COMMENTARY:

Based on current evidence, the authors propose a straightforward therapeutic algorithm to assist clinical cardiologists in navigating available treatment options, prioritizing them based on evidence. The algorithm underscores the essential role of optimal HF medical therapy in managing and reversing sMR, often a clinical Achilles' heel due to therapeutic inertia or follow-up challenges, leaving many patients without optimized therapy and with adverse prognostic implications. Nonetheless, intervention holds promise, and the scope of endovascular treatment for sMR will likely expand to include currently suboptimal or inoperable patients.

While generally appropriate and widely accepted, this algorithm could, in my opinion, benefit from a particular focus on the frailest patients, who represent an increasing portion of daily practice. Rapid titration therapies may lead to hypotension and adverse effects not seen in younger groups. Additionally, incorporating frailty scales can help guide more or less invasive approaches in selected patients. It is important to mention when to consider palliative care if therapeutic measures pose significant risk or limited benefit given the patient's condition.

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Víctor M. Juárez Olmos

Percutaneous mitral repair vs. surgery in secondary mitral regurgitation

Analysis of the MATTERHORN trial on the efficacy and safety of two therapeutic approaches for treating secondary mitral regurgitation in patients with heart failure and optimal medical therapy: transcatheter edge-to-edge repair and mitral valve surgery (repair or replacement).

Secondary or functional mitral regurgitation is a common complication in patients with cardiomyopathy, fostering the onset of heart failure and associating with greater mid- and long-term morbidity and mortality.

Current treatment options include transcatheter edge-to-edge repair and mitral valve surgery, but we lack randomized clinical trials directly comparing these two strategies. In fact, clinical practice guidelines vary between regions. The European Society of Cardiology recommends percutaneous repair for patients unsuitable for surgery, while American guidelines favor percutaneous repair as the standard treatment except in patients with unfavorable anatomy. The MATTERHORN study aims to compare the effectiveness and safety of both approaches.

MATTERHORN is a multicenter, open-label, randomized non-inferiority trial conducted in Germany. It included 210 patients with heart failure and severe secondary mitral regurgitation who continued to exhibit symptoms despite optimal medical therapy. The primary efficacy endpoint was a composite of death from any cause, hospitalization for heart failure, mitral valve reintervention, implantation of a left ventricular assist device, or stroke within the first year after the procedure. The primary safety endpoint was a composite of major adverse events occurring within 30 days post-procedure. Secondary objectives included recurrence of significant mitral regurgitation (grade 3+ or 4+), one-year safety, and hospitalization duration as key parameters.

Of the 210 randomized patients, noteworthy characteristics included: mean age of 70.5 years, median STS-PROM risk score of 2%, EuroSCORE II median of 3%, mean left ventricular ejection fraction of 41%, and a surgical strategy consisting of 72% mitral repairs and 28% valve replacements.

At 12 months, 16.7% of patients in the transcatheter repair group and 22.5% in the surgery group experienced one or more events in the primary efficacy endpoint (95% CI, -17% to 6%; $p < .001$ for non-inferiority). The non-inferiority limit was set at 17.5%, which was met as the upper interval was at 6%. This result indicates that transcatheter repair was non-inferior to surgery regarding efficacy, reflected in a similar reduction in death, hospitalization, and other severe events.

In terms of safety, within 30 days post-procedure, 14.9% of patients in the transcatheter repair group presented major adverse events, compared to 54.8% in the surgery group (estimated difference of -40%; 95% CI, -51% to -27%; $p < .001$). The most common adverse events in the surgical group were major bleeding and the onset of atrial fibrillation.

Procedure success was high in both groups. In the transcatheter group, three incidents occurred: one partial clip detachment without embolization and two chordal ruptures requiring valve replacement (one immediate and one delayed). In the surgical group, eight patients required reintervention: two for valve replacement (failed repair) and the rest for bleeding or surgical wound infection.

For the one-year safety objective, results were similar to those at 30 days: an absolute reduction of 39% in events in the percutaneous group (95% CI, -51% to -25%).

Recurrence of grade 3+ or 4+ mitral regurgitation was higher in the transcatheter group (8.9%) than in the surgery group (1.5%). Nevertheless, both groups showed significant improvements in functional class and quality of life as assessed by questionnaires. The average hospital and ICU stays were significantly longer in the surgery group (4 vs. 12 days, and 1 vs. 3 days, respectively).

COMMENTARY:

Historically, secondary mitral regurgitation has been a condition with limited surgical intervention. Clinical benefits are harder to achieve when treating the end-stage consequence of cardiomyopathy rather than the primary cause, as with primary mitral regurgitation.

This trend began to shift with the advent of percutaneous devices and clinical trials like COAPT, MITRA-FR, and recently, RESHAPE-HF 2. All these trials randomized optimal medical therapy alone against an added benefit of correcting secondary mitral regurgitation. The MATTERHORN trial goes a step further, comparing percutaneous repair's non-inferiority against surgery in a low-surgical-risk population (STS-PROM 2%, EuroSCORE II 3%).

MATTERHORN results demonstrate that transcatheter mitral repair is comparable (non-inferior) to surgery in terms of a composite of clinical events, reducing complications inherent to major heart surgery. Hospital stay durations are significantly reduced with percutaneous repair, and efficacy remains high and similar across both groups (>95%).

Transcatheter repair offers a less invasive alternative for patients with secondary mitral regurgitation who do not require heart surgery for other reasons, regardless of surgical risk. Ultimately, the choice of technique should be a collaborative decision involving the multidisciplinary team and the patient, factoring in feasibility for percutaneous repair, comorbidities and surgical risk, necessity for additional interventions, and center experience/results.

In concluding this blog entry, I'd like to highlight some limitations of the study:

- Follow-up duration: Follow-up was limited to one year, leaving long-term outcomes—especially in terms of durability of transcatheter repair and heart failure progression—uncertain.

- Technological advancements: The trial spanned over seven years, meaning not all patients benefited from the latest transcatheter devices (most used 2nd and 3rd generation devices rather than 4th).

- Specialized centers: Participating centers had extensive experience in mitral repair, which may limit external validity.

- Bias: Being an open-label trial, the possibility of bias is greater.

In summary, the study suggests that transcatheter repair is an effective and safer therapeutic option for patients with heart failure and secondary mitral regurgitation. Additional studies and extended follow-up are necessary to evaluate long-term outcomes.

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Alejandro Lara García

Percutaneous repair to treat functional mitral regurgitation: edge-to-edge therapies are here to stay

A meta-analysis summarizing current evidence from the three main studies on the use of edge-to-edge therapies to treat moderate-to-severe functional mitral regurgitation in patients with symptomatic heart failure.

The onset of functional (or secondary) mitral regurgitation (MR), a common complication associated with left ventricular remodeling and left atrial dilation during the progression of heart failure (HF), significantly worsens the prognosis of affected patients.

Current therapies for treating functional MR include mitral valve surgery and transcatheter edge-to-edge repair (TEER). In recent years, the percutaneous option has gained prominence due to evidence from clinical trials such as COAPT, MITRA-FR, and the newly published RESHAPE-HF2 study in 2024.

This year, a meta-analysis was published in *JACC* analyzing the comprehensive evidence provided by these three studies on percutaneous repair of functional MR in patients with heart failure receiving optimal medical therapy.

Firstly, this meta-analysis evaluated a total population of 1,423 patients comparing percutaneous mitral regurgitation repair using the Abbott MitraClip® device plus optimal medical therapy against optimal medical therapy alone. The common endpoints assessed across these trials over two years of follow-up included HF hospitalizations, recurrent rehospitalization events or all-cause death, all-cause mortality, cardiovascular mortality, and changes in the six-minute walk test (6MWT) after one year.

Baseline patient characteristics represented a broad spectrum of moderate-to-severe functional MR. The median age ranged between 70 and 72 years, with all patients exhibiting left ventricular systolic dysfunction and an ejection fraction around 31–33%. Comorbidities associated with heart failure were similarly distributed. The severity of MR, measured by effective regurgitant orifice area (EROA), ranged from 0.25 to 0.40 cm^2. Similarly, HF progression, estimated by left ventricular end-diastolic volume index (LVEDVI), ranged from 192 to 252 mL.

The results showed statistically significant benefits for the Abbott MitraClip® in HF hospitalizations (HR = 0.69; $p = .0324$), recurrent rehospitalization events or all-cause death (HR = 0.71; $p = .0486$), and the change in the six-minute walk test at one year. However, while a positive trend was observed, differences in all-cause and cardiovascular mortality were not statistically significant. It is worth mentioning that this meta-analysis did not include safety outcomes, but the safety profile reported across the studies was excellent, with a low proportion of procedural failures or related complications.

In conclusion, this meta-analysis suggests that percutaneous repair of moderate-to-severe functional MR combined with optimal medical therapy is beneficial for patients with symptomatic heart failure.

COMMENTARY:

The natural history of heart failure represents a feedback cycle leading to left chamber dilation and subsequent functional mitral regurgitation, which, in turn, exacerbates heart failure. For this reason, achieving benefits from addressing a valvular disease secondary to the natural progression of another condition has been historically challenging.

The COAPT and MITRA-FR clinical trials recruited opposing patient populations but shared moderate-to-severe mitral regurgitation as a common feature. These studies laid the foundation at the end of the last decade to define criteria selecting MR cases disproportionately more severe than ventricular dilation, which predicted the benefit of repair. These findings were reflected in European and American guidelines, granting edge-to-edge therapies a class IIa recommendation and establishing an international EROA threshold of 0.30 cm^2 for intervention consideration.

In this context, the 2024 RESHAPE-HF2 study provides evidence defining a broader range of patients benefiting from this therapy, encompassing MR grades as low as 0.25 cm^2 EROA and ventricular dilation up to 211 mL. This is particularly important as prior evidence suggested no clinical benefit from treating moderate MR, such as findings from a trial on ischemic MR repair with mitral annuloplasty in patients undergoing coronary bypass surgery.

However, one major limitation of the meta-analysis is the significant heterogeneity in patient populations, especially regarding optimal medical therapy. For example, RESHAPE-HF2 patients received superior medical treatment, with a higher proportion using beta-blockers, angiotensin receptor blockers, and neprilysin inhibitors. Notably, 80% of these patients were treated with mineralocorticoid receptor antagonists, compared to only 50% in the other two studies.

Another pertinent critique is the lack of surgical risk assessment across studies, except for COAPT, where 42% of patients had an STS score ≥8%, indicating high surgical risk. This omission precludes evaluating whether mitral valve surgery might have been feasible in low-risk surgical cases.

Looking forward, given the heterogeneity of both the studies and secondary mitral regurgitation itself—with phenotypes exhibiting distinct responses to medical and interventional treatments—future trials may benefit from focusing on "patient type" rather than "mitral regurgitation grade" to identify the most representative and benefitting patient groups.

Overall, there seems to be sufficient evidence to recommend transcatheter repair for patients with symptomatic heart failure and moderate-to-severe secondary mitral regurgitation. Nevertheless, further studies specifically designed for moderate MR are needed to establish robust recommendations in this scenario.

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José Manuel Martínez Comendador

Commando procedure in non-endocarditis contexts: Cleveland Clinic experience

This retrospective analysis spans ten years of single-center interventions, evaluating the Commando procedure in non-infectious mitral-aortic involvement cases.

Beyond endocarditis, other causes can lead to severe damage to the mitral-aortic junction, making conventional prosthesis implantation techniques unsuitable. Among the most frequent causes, besides endocarditis, are severe anterior annulus calcification or its destruction during repeat cardiac surgeries. The Commando procedure, which includes reconstruction of the mitral-aortic junction/curtain, was introduced over three decades ago and is primarily used in cases of severe mitral-aortic curtain destruction due to endocarditis, allowing double-valve replacement (DVR). Over the years and with accumulated experience, the indications for this procedure have broadened. This study examines these indications and patient follow-up through Cleveland Clinic's results for patients with mitral-aortic junction destruction, excluding endocarditis cases.

From January 2011 to January 2022, 129 Commando procedures and 1,191 mitral and aortic DVRs were performed, excluding endocarditis cases. The primary reasons for the Commando procedure were severe calcification (67 patients with prior radiation exposure and 43 patients without prior radiation) and other causes in 19 patients. Commando procedures were compared to a balanced subset of DVRs using score-matching (109 pairs).

Between balanced groups, Commando versus DVR procedures showed higher total calcium scores (median 6140 vs 2680 HU; $p = .03$). Hospital outcomes were similar, including operative mortality (12/11% vs 8/7.3%; $p = .35$) and reoperation for bleeding (9/8.3% vs 5/4.6%; $p = .28$). Five-year survival and freedom from reoperation rates were 54% vs 67% ($p = .33$) and 87% vs 100% ($p = .04$), respectively. Higher calcium scores were associated with lower survival after DVR but not after Commando. The Commando procedure showed lower mean aortic valve gradients at 4 years (9.4 vs 11 mm Hg; $p = .04$). For Commando procedures due to calcification, five-year survival was 60% and 59% with and without prior radiation exposure, respectively ($p = .47$).

The authors concluded that the Commando procedure, with mitral-aortic reconstruction due to mitral annular calcification, radiation, or prior surgery, shows acceptable outcomes similar to standard DVR.

COMMENTARY:

A preliminary reflection on the study by Kakavand et al. is that for patients with similar risk profiles and no endocarditis, performing a Commando procedure with DVR poses a comparable risk to conventional DVR. In other words, the Commando procedure, in the absence of endocarditis and with a similar predicted risk, generally in non-emergency settings, does not pose greater risk than conventional DVR. This notion is plausible but needs further refinement for more precise interpretation.

Conventional aortic and mitral DVR has historically been associated with in-hospital mortality rates of 5–15%. Calcification of the anterior and posterior mitral annulus presents a significant challenge, particularly when paired with a small mitral annulus and mitral-aortic curtain involvement. The Commando procedure circumvents the need for suturing through the calcium-laden anterior annulus and mitral-aortic curtain, additionally facilitating the implantation of a larger prosthesis. Indeed, this is the only procedure that enables, through complete debridement and patch enlargement of the mitral annulus, the implantation of a larger mitral prosthesis. Initially, this procedure was deemed

complex, especially given the extensive reconstruction with patching, posing a considerable geometric challenge and with early series reporting operative mortality of 7–28%. However, it remains uncertain whether this high mortality rate was largely due to procedural factors or to complications such as endocarditis.

This series can only be compared to the largest series published to date by Tirone David (reviewed on our blog in 2022), involving 182 Commando procedures over 35 years at Toronto Hospital (only 13% involved endocarditis). Their operative mortality was 13%, with one-, five-, and ten-year survival rates of 82%, 69%, and 51%, respectively. In the present study, operative mortality was 11%, similar to David's, and five-year survival was 53%, an improvement over David's series.

In this study, there were no significant differences in ischemic and extracorporeal circulation times or in postoperative complications between the Commando and conventional DVR procedures. However, a higher reoperation rate was noted at five years in the Commando group, suggesting increased bioprosthetic dysfunction among these patients. In Toronto's study by Tirone David, mitral-aortic curtain reconstruction was performed in two-thirds of cases with bovine pericardium and in one-third with a shaped Dacron conduit. Late calcification was associated with bovine pericardium use, being a cause of late paravalvular leakage. Therefore, in the last decade, the trend has been to use Dacron patches instead of pericardium for this technique. The study by Kakavand et al. under review here does not provide information on this, so we cannot ascertain if the higher reoperation rate in the Commando group is partially due to pericardium patch use.

The association between annular calcification and valvular dysfunction is increasingly recognized in industrialized countries, along with its relation to poorer prognosis. Quantification and grading of this calcification by echocardiography and CT are essential. Detailed calcium assessment is crucial for surgical risk evaluation in mitral surgery, guiding eligibility and surgical choice. However, in this study, severe mitral annular calcification did not negatively impact survival after Commando surgery; conversely, in conventional DVR patients, higher calcium scores in the mitral-aortic curtain correlated with poorer outcomes. Based on this reasoning, the Commando procedure appears optimal for treating severe mitral-aortic curtain calcification, offering superior exposure for calcium debridement.

In this study, indications for the Commando procedure, excluding endocarditis cases, were severe mitral-aortic curtain calcification and/or its destruction following debridement, as well as in repeat mitral or DVR surgeries. For certain patients considered inoperable, the Commando procedure provided a new option. Moreover, for patients with extremely fragile tissues, such as those with previous radiation exposure or small hearts, this intervention reduced the likelihood of periprosthetic leakage. Lastly, this technique affords better exposure during DVR, which may explain the slight difference in surgical times compared to conventional surgery. In patients with small mitral annuli, the Commando technique allows for the implantation of an appropriately sized prosthesis, although in this study, there were no significant differences in mitral prosthesis size between the Commando and conventional DVR groups. Notably, we lack data on preoperative annulus sizes, which are challenging to measure with extensive calcifications.

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Section V C:

Tricuspid valve disease

Mónica García Bouza

Should Routine Implantation of a Permanent Epicardial Pacemaker Be Considered in Cases of Tricuspid Valve Replacement?

This paper examines the outcomes and implications of implanting permanent epicardial pacing systems in patients undergoing tricuspid valve replacement (TVR).

Tricuspid valve replacement (TVR) is one of the least common procedures in cardiac surgery, posing challenges not only due to its rarity but also because of certain procedural difficulties. Traditionally, it has been reserved for patients with high surgical risk, a topic previously discussed in other blog posts. Additionally, TVR is associated with a high incidence of conduction disorders, carrying a considerable risk of requiring permanent postoperative pacemaker implantation, estimated between 22-32%. This raises the question of whether a preventive, simultaneous pacemaker implantation could be beneficial, thus proactively addressing conduction complications.

A recent article by a French team from Bichat Claude Bernard Hospital in Paris discusses the prophylactic implantation of a permanent epicardial pacemaker in TVR cases. At this center, routine use of this approach was adopted due to the high incidence of conduction disorders requiring stimulation, not only in the immediate postoperative period but also in the long term. Their objective was to assess the risks and benefits of this practice, as well as identify factors associated with conduction disorders following TVR. A total of 80 patients who underwent TVR with bioprostheses from March 2014 to December 2018 were retrospectively included. Patients with previous pacemaker or ICD implantation were excluded. Electrodes were implanted on the diaphragmatic surface of the right ventricle, with the generator placed in a subcostal epigastric position. The mean age was 57±16 years; 70% were women. Thirty-five cases (44%) were reoperations, of which 19 (24%) involved left-sided valvular disease, and 24% had associated moderate or severe right ventricular dysfunction. Isolated TVR was performed in 28 patients (35%), while it was combined with mitral valve replacement in 29 patients (36%), aortic valve replacement in 11 patients (14%), and other combinations in 12 patients (15%). Single-lead electrodes were used in 41 patients (51%), and two leads in the remainder. Postoperatively, 11 patients (14%) died, and 10 (12.5%) were lost to follow-up, leaving a total of 59 patients for analysis. The mean follow-up period was 36 months. Cardiac pacing was required in nearly half (46%) of patients, although the need for pacing decreased to 5% after the first year. An additional 9 patients died during follow-up. Severe device-related complications occurred in 2 patients (2.5%), including one case of cardiac arrest secondary to inappropriate pacing and another case involving an infection at the generator pocket site, requiring device removal. Other complications included lead dysfunction in 3 patients and an upgrade to resynchronization therapy in 4 patients. No cases of premature battery depletion were reported.

The primary limitation of the study is that it is a single-center, retrospective study not exclusively focused on the tricuspid valve, so caution should be exercised when extrapolating the results. Nevertheless, the authors conclude that following TVR, the need for permanent cardiac pacing arose in nearly half of the patients due to postoperative atrioventricular conduction disorders. This high incidence, combined with an acceptable safety profile, could support a strategy of prophylactic epicardial pacing for patients undergoing TVR.

COMMENTARY:

Following TVR, one of the consequences of annular suturing may be dysfunction resulting from permanent damage or temporary inflammation/tension of the

atrioventricular node, located at the apex of Koch's triangle, adjacent to the septal leaflet. Techniques to minimize this phenomenon include anchoring the suture in this area to the leaflet itself with different reinforcements, such as pericardium or Teflon, or ventralizing this annular segment by placing the prosthesis at the atrial level outside this segment. Nonetheless, the subsequent need for pacemaker implantation remains high. Additionally, the presence of a prosthesis in the tricuspid position contraindicates the passage of an electrode through it due to dysfunction and high risk of future endocarditis. Consequently, the intraoperative implantation of a pacemaker lead, given the high incidence and traditional use of epicardial systems, aims to prevent a secondary procedure requiring general anesthesia by performing the implant at the same time.

Although this study's experience reports higher rates of cardiac pacing requirements compared to other series, it is important to note that many concomitant procedures are performed, with the associated increased risk of conduction system injury/dysfunction. However, as shown, permanent pacemaker implantation is not without complications, making prophylactic implantation an imperfect solution despite the authors suggesting an "acceptable" risk/benefit profile. In reality, adding an additional surgical procedure increases the likelihood of complications simply due to the inclusion of an extraordinary procedure. Therefore, the best approach should involve reserving each procedure as needed and considering alternative strategies.

In this regard, several pacing options could be considered. Some include placing the pacemaker leads paravalvularly at the time of valve implantation, leadless pacemakers (also previously discussed in the blog), and electrodes in the coronary sinus. Each of these alternatives has its own risk-benefit balance. Paravalvular endocardial systems implanted during the surgical procedure are the least common, as they entail trapping the lead, preventing its removal in case of dysfunction, and potentially resulting in endocarditis. However, they do not interfere with the prosthesis and allow for dual-chamber pacing if the patient has sinus rhythm. Leadless pacemaker implantation is still under development, with limited experience. They could be placed in the ventricle, but their postoperative implantation would require transprosthetic manipulation with catheters, which is impossible in mechanical prostheses and complex with bioprostheses. Experience with dual-chamber systems of this type is even more limited. Coronary sinus electrodes, as the most suitable endocardial solution, enable dual-chamber systems but tend to have poor long-term stability and initially stimulate the left side.

If the epicardial approach is chosen, implanting the leads without connecting them to the generator and placing them in an epigastric/subcostal position until the need for permanent pacing is confirmed appears to be a prudent solution. This second surgical step could be performed under local anesthesia if permanent pacing is indicated, with the only drawback being the implantation of epicardial leads that may not be used. A notable disadvantage of the epicardial approach includes higher pacing thresholds than endocardial systems and more frequent generator replacements. Additionally, we must consider current trends toward minimally invasive surgery, percutaneous approaches, and hybrid solutions, which could provide more appropriate responses to these issues by changing the paradigm of how future patients will be managed.

Another noteworthy point is the high percentage of patients without long-term pacing needs, reinforcing the notion that early postoperative pacemaker implantation does not often yield optimal outcomes. In this study, early intervention was marked by prophylactic implantation from the beginning of the postoperative period. However, a substantial number of patients undergoing various procedures (arrhythmia ablations, valve surgeries, sutureless valve implants) experience spontaneous recovery within a period of up to two weeks postoperatively.

As surgeons, we should perform TVR only when repair is not feasible, strive to minimize conduction tissue damage, and establish a collaborative strategy with cardiology teams to address atrioventricular block complications according to each unit's practices. Nevertheless, it still seems prudent to reserve any intervention for when a clear indication is present, regardless of its perceived simplicity.

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Bunty Ramchandani

Should We Repair Mild or Moderate Tricuspid Regurgitation During Degenerative Mitral Surgery?

A retrospective study at Mayo Clinic analyzed outcomes of mild or moderate tricuspid repair among 1,588 patients with degenerative mitral valve disease.

The right ventricle and tricuspid valve are no longer viewed as neglected cardiac structures. In recent years, an influx of literature, largely driven by interventional cardiology colleagues, has aimed to elucidate the complex function of this structure. Anatomically, the tricuspid valve comprises three leaflets—anterior, posterior, and septal—attached by chordae tendineae to two papillary muscles. The anterior leaflet is the largest, the posterior leaflet can exhibit multiple scallops, and the septal leaflet is typically the smallest. Accessory chordae often anchor to the free wall of the right ventricle and the moderator band, especially around the septal leaflet and adjacent septo-anterior and septo-posterior commissures. Unlike the horseshoe shape of the mitral annulus, the tricuspid annulus has a three-dimensional structure, with the septo-anterior and antero-posterior commissures at the highest points and the septo-posterior commissure at the lowest point. Thanks to the study by Dreyfus et al. in 2005, we learned that annular dilation occurs along the antero-posterior commissure with right ventricular remodeling. Additionally, with the new tricuspid regurgitation (TR) classification, we know TR can be primary or organic, related to intracavitary pacing devices, and secondary or functional. Functional TR is subcategorized based on the primary chamber causing regurgitation: either due to atrial dilation from atrial fibrillation, stretching the annulus, or right ventricular dysfunction impairing leaflet coaptation through tethering forces. The etiology of TR is crucial as it impacts the prognosis of tricuspid valve interventions.

According to 2020 American and 2021 European guidelines, it is valid to repair a dilated tricuspid valve with an annular diameter >4 cm (septal-anterior distance) or in patients with symptoms of right heart failure, with a Class IIa indication. Uncertainty arises when regurgitation is less severe and right heart failure symptoms are absent. The Mayo Clinic study aims to evaluate long-term outcomes for 1,588 patients with mitral valve disease and mild or moderate TR, comparing outcomes between those who received a surgical intervention and those who did not.

Data collection included all patients from 2001 to 2018 who underwent mitral valve surgery with or without concomitant tricuspid valve surgery, assessing pre- and postoperative echocardiograms for TR severity and annular size. Patients with endocarditis, rheumatic or ischemic mitral disease, primary cardiomyopathy, congenital malformations, under 18 years of age, procedures involving MitraClip, reoperations on the mitral and/or tricuspid valve, and concomitant aortic valve procedures were excluded.

Concomitant tricuspid valve surgery was performed in 235 patients (14.8%). During the study period, the rate of tricuspid valve repair in this context rose from 7% to 20% in the final year. The intervention improved the TR grade independently of the preoperative severity, with these postoperative improvements sustained over time. The annular size did not affect the risk of progression to severe TR ($p = .226$). The atrioventricular block rate was three times higher (3%) compared to isolated mitral surgery. After adjusting for baseline characteristics and with a median follow-up of 6.5 years, survival was similar between groups. There were 22 late tricuspid valve reoperations (5-year cumulative risk of 1.5%), with severe TR as the primary indication in only 6 patients. Preoperative TR grade and concomitant tricuspid surgery were not associated with reoperation incidence.

The authors concluded that concomitant tricuspid valve surgery reduces postoperative regurgitation without influencing survival or reoperation incidence. In patients with less-than-severe TR, tricuspid annular diameter was not associated with progression to severe regurgitation.

COMMENTARY:

Since the CTSN trial (Cardiothoracic Surgical Trials Network), specifically the CTCR-MVS study (Concomitant Tricuspid Valve Repair + Mitral Valve Surgery vs. Mitral Valve Surgery Alone), tricuspid valve repair in degenerative mitral surgery has been performed more liberally. The CTCR-MVS study recruited 401 patients with mitral valve replacement (repairs were not included) and mild/moderate TR, comparing concomitant surgery to isolated mitral surgery. Results showed less TR progression to severe in the concomitant surgery group (0.6% vs. 5.6%; $p < .05$), with a trade-off of higher postoperative atrioventricular block rates (14.1% vs. 2.5%; $p < .05$) and increased cerebral ischemic events (4.5% vs. 1.5%; $p < .05$), without improved rehospitalization rates or quality of life. Notably, follow-up was only 2 years, and one-third of the patients had moderate TR, with the rest included due to annular dilation. Five-year results from this study, expected this year, will assess mid-term survival differences.

Each etiology of mitral valve disease with TR has a unique natural history. This was elegantly illustrated in a 2011 Mayo Clinic publication by Yilmaz et al., showing that TR associated with organic mitral disease typically improves following mitral valve treatment. However, in rheumatic mitral disease, TR often worsens, with up to 60% progressing to grade III/IV within 5 years. Patients with ischemic cardiomyopathy experience the fastest TR progression, likely due to biventricular dysfunction.

Right heart echocardiographic evaluation is more complex than left-sided assessments. For example, magnetic resonance imaging has a shorter learning curve for right-sided evaluation compared to echocardiography. Preload and afterload dependency of the tricuspid valve and right ventricle often lead to discrepancies, such as moderate TR in consultations not appearing on intraoperative transesophageal echocardiography. Dreyfus' 2005 study systematically measured the septo-anterior to antero-posterior commissure length intraoperatively, establishing a cut-off of 7 cm, distinct from the 4 cm echocardiographic measurement. Variability in preoperative study types and timing complicates results comparison in the literature.

Today's study, as a single-center retrospective study, inherently has limitations. Follow-up was not standardized, depending on symptoms or cardiologist discretion, and lacks data on right ventricular function, size, and exercise capacity. Consequently, we do not know if functional improvement justifies concomitant TR procedures despite no survival benefit.

In conclusion, each additional step in surgery increases morbidity and mortality, warranting careful risk-benefit assessment. For mild/moderate TR with degenerative mitral disease, treating the mitral valve alone generally suffices. Surgical risk, complexity, mitral disease etiology, and progression factors like right ventricular dilation, potential pulmonary hypertension reversibility from left-side repair, or atrial fibrillation presence should inform decisions. As Hippocrates advised, "primum non nocere."

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Mónica García Bouza

New tools for the surgical treatment of complex tricuspid regurgitation

Review emphasizing the experience of San Raffaele Hospital in the surgical management of tricuspid regurgitation when annuloplasty alone is insufficient, using clover and edge-to-edge repair techniques.

Moderate or severe tricuspid regurgitation (TR) is observed in 0.55% of the general population, with its prevalence increasing with age, affecting approximately 4% of patients aged 75 years or older. Secondary TR is more common (>90%) than primary TR.

The management of TR has not historically been a primary focus for cardiac surgeons, often being underestimated due to the belief that addressing left-sided heart conditions would resolve secondary TR or that medical treatment would suffice. However, severe TR has been shown to be a strong predictor of prognosis across various disease states, particularly when compensatory mechanisms of the right ventricle (RV) develop. Over time, these mechanisms lead to changes in RV geometry, resulting in papillary muscle displacement, leaflet tethering, and/or coaptation deficit. Despite its high prevalence and poor prognosis, most patients (>90%) are undertreated, and management remains controversial due to variable surgical outcomes, sometimes failing to account for the anatomical complexity of the tricuspid valve.

Tricuspid valve repair remains the preferred technique for patients requiring surgery and is primarily focused on annuloplasty using sutures or rings. The goal is to reduce the annular diameter. Numerous clinical, anatomical, and surgical predictors of annuloplasty failure have been identified, often related to anatomical changes in the leaflets. In these cases, annuloplasty alone may not suffice, necessitating consideration of additional techniques to restore valve competence.

In December 2024, *The Annals of Thoracic Surgery* published an article on the long-term outcomes of clover repair (centralizing the free edges of all three leaflets) and edge-to-edge repair (resulting in a double-orifice valve) for addressing complex tricuspid regurgitation. This observational study, conducted at San Raffaele University Hospital in Milan by Dr. Maisano and Dr. De Bonis, demonstrated favorable outcomes for these techniques in the surgical treatment of complex tricuspid valve insufficiencies.

The study recruited patients from 2001 to 2019. All preoperative, intraoperative, postoperative, and follow-up data were prospectively entered into a dedicated database and retrospectively analyzed. In addition to conventional statistical analysis, a competing risks proportional hazards regression model was employed. This model accounted for competing risks, defined as events that alter or prevent the occurrence of the primary event of interest. The Fine and Gray model was used to evaluate time to TR ≥2+ while considering death as a competing risk, as well as time to cardiac death with non-cardiac death as a competing risk. Hazards were reported as hazard ratios (HR) with 95% confidence intervals (95% CI). A p value < .05 was considered significant. Graphs were truncated at 16 years to ensure an adequate number of patients at risk.

The study included 145 consecutive patients (57% female) with severe or moderately severe TR secondary to leaflet prolapse or flail in 115 patients (79%), tethering in 27 patients (19%), or mixed lesions in 3 patients (2%). The origin of TR was degenerative in 75% of cases, post-traumatic in 8%, and secondary to dilated cardiomyopathy in 17%. Previous cardiac surgery had been performed in 17% of the patients.

The surgical technique employed was clover repair in 110 patients (76%) and edge-to-edge repair in 35 patients (24%), combined with annuloplasty in 95% of cases. A prosthetic ring was used in 64% of these cases, while sutures were used in 31%. The mean prosthetic ring size was 32 ± 2.7 mm. Concomitant procedures, primarily mitral surgery, were performed in 80% of cases.

The in-hospital mortality rate was 5.5% (8 out of 145 patients). Follow-up was 98% complete, with a median follow-up duration of 15 years (interquartile range: 14–17 years), and the longest follow-up extending to 21 years. Overall survival at 16 years was 56% ± 5%. Previous cardiac surgery (HR = 2.83; 95% CI: 1.15–6.93; p = .023) and right ventricular dysfunction (HR = 2.24; 95% CI: 1.01–4.95; p = .046) were identified as significant predictors of mortality.

The 16-year cumulative incidence of cardiac death, with non-cardiac death considered a competing risk, was 19.6%. Previous cardiac surgery (HR = 3.44; 95% CI: 1.23–9.65; p = .019) was the only predictor of this event. At the last follow-up, New York Heart Association (NYHA) functional class III or IV was reported in 14% of patients, compared to 51% at baseline (p < .0001).

Regarding echocardiographic findings, 103 out of 134 patients (77%) had no or mild TR at the last follow-up. Moderate TR was observed in 20% of patients, and severe TR was present in 3% of patients, two of whom required reintervention. No significant tricuspid stenosis was detected. At 16 years, the cumulative incidence of TR ≥2+ with death as a competing risk was 23.8%. Previous cardiac surgery (HR = 2.30; 95% CI: 1.06–5.01; p = .04) emerged as the sole predictor of this event.

COMMENTARY:

The incidence of residual tricuspid regurgitation (TR) following tricuspid valve surgery varies between 10% and 30%, depending on baseline patient characteristics and the surgical approach, among other factors. Annular dilation is recognized as a preoperative predictor of residual TR. However, there is no consensus on other potential predictors, such as right heart failure, pulmonary hypertension, increased atrial volume, atrial fibrillation, rheumatic mitral valve disease, marked right ventricular (RV) remodeling or dysfunction, or a history of ischemic heart disease. Accurate identification of the mechanisms underlying TR through echocardiographic data is essential, requiring more focused attention comparable to that given to other valves.

A study published in 2022 developed an algorithm for selecting the optimal surgical technique for tricuspid valve treatment based on specific characteristics. This study concluded that applying the algorithm resulted in lower rates of residual postoperative TR compared to other series.

The principal finding of the current study, which motivated this commentary, was that the use of varied tools to address complex TR is both effective and durable, achieving a low recurrence rate of significant TR 15 years post-surgery. This group favors simplifying repair through clover or edge-to-edge techniques rather than more complex methods, such as leaflet resection or neochordae implantation, when annuloplasty alone is insufficient. These techniques provide an efficient and straightforward solution to restore valve coaptation. Furthermore, they suggest adding a small Teflon patch to the clover or edge-to-edge sutures in cases of particularly fragile tissue.

It is worth noting the increasing competition from percutaneous approaches. Transcatheter methods have also extended to the tricuspid valve, with devices currently gaining popularity. However, the absence of concomitant annuloplasty may explain the suboptimal outcomes currently observed with transcatheter edge-to-edge tricuspid repair

(TEER). Immediate results remain less satisfactory, with over 20% of patients showing severe or torrential TR post-procedure in recent series.

In conclusion, when tricuspid regurgitation cannot be managed with annuloplasty alone, concomitant leaflet repair using clover or edge-to-edge techniques effectively restores valve competence and provides durable long-term results. When applied correctly, this approach can significantly enhance the surgical armamentarium of cardiac surgeons. It may also increase the repair rate, reduce the incidence of suboptimal early and late outcomes, and ultimately improve patient prognosis.

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Section VI:

Miscellaneous

Marina Pérez Fernández

Are leadless pacemakers a safe alternative following cardiac surgery or percutaneous valve interventions?

This single-center retrospective study analyzes the clinical and safety outcomes of leadless pacemakers in patients requiring permanent pacing after cardiac surgery or transcatheter valve intervention.

Conduction system disturbances necessitating permanent pacemaker implantation are common following cardiac surgery and transcatheter valve interventions. Conventional pacemakers in such patients have been associated with infectious complications, including endocarditis and pocket infections, as well as with the onset or worsening of tricuspid regurgitation. Leadless pacemakers have emerged in recent years as an alternative to conventional pacemakers to mitigate these complications. However, despite their proven safety and efficacy, leadless pacemakers also present certain limitations. There are two generations of these devices: the first generation (Micra-VR) and the second (Micra-AV), both of which provide pacing solely in the right ventricle, resulting in loss of interventricular synchrony. Neither Micra-VR nor Micra-AV can stimulate the atrium. However, the Micra-AV is capable of maintaining atrioventricular synchrony in patients with normal sinus node function due to its ability to sense atrial activity. Therefore, patients with sinus node dysfunction, which is common following these types of interventions, would not be suitable candidates for leadless pacemaker therapy. Additionally, leadless pacemakers may increase the prevalence of pacemaker-induced cardiomyopathy due to their inability to provide physiological pacing.

This study conducted a single-center retrospective analysis involving 78 patients, 50 of whom underwent cardiac surgery and 28 transcatheter valve interventions. Forty of these patients received the Micra-VR and 38 the Micra-AV. Patients included had cardiovascular risk factors and comorbidities such as renal disease, coronary artery disease, atrial fibrillation, and heart failure. The average age was 65.9 years, with 52% male. Follow-up was conducted over 1.3 years in the Micra-VR group and 0.8 years in the Micra-AV group. There was only one implant-related complication: a femoral access site hematoma requiring evacuation. During follow-up, there was an increase in the pacing threshold and a decrease in impedance, both clinically insignificant. Sensing parameters remained stable. Pacing burden varied among patients, though overall pacing burden decreased. There was a significant reduction in left ventricular ejection fraction (LVEF), primarily among patients with reduced baseline LVEF. In subgroup analysis, this decline was observed in the Micra-VR group, with no significant change in the Micra-AV group. Six patients required conventional pacemaker implantation during follow-up—four due to LVEF decline and two due to sinus node dysfunction.

The authors conclude that leadless pacemakers may serve as a viable alternative to conventional pacemakers in carefully selected patients following these interventions, provided the limitations of these devices are considered, and close follow-up is conducted to monitor the potential need for an upgrade.

COMMENTARY:

Leadless pacemakers represent a significant advancement in cardiac pacing. These devices operate similarly to traditional pacemakers but eliminate the need for leads connecting the device to the heart, potentially reducing some associated complications and risks. Generally, leadless pacemakers offer several potential advantages, such as reduced infection risk, decreased need for surgical reintervention for replacements, and lower tricuspid regurgitation rates. However, as with any medical innovation, leadless

pacemakers also pose certain challenges and limitations. They may not be suitable for all patients, as they are only capable of pacing the right ventricle, resulting in loss of interventricular synchrony and making them unsuitable for specific pathologies like sinus node dysfunction. In fact, lead systems capable of stimulating the left bundle branch of the His bundle are currently being implanted, allowing narrow QRS ventricular pacing and intraventricular synchrony, counteracting the effects of left bundle branch block induced by pacing, particularly significant in patients with reduced LVEF and avoiding the need for an “upgrade” to resynchronization therapy. Another limitation is the inability to replace the battery at the end of its lifespan, necessitating the implantation of a new system (leadless or with leads) while leaving the old device in the ventricular cavity. In young patients, repeated replacements could theoretically limit right ventricular cavity space. Furthermore, as a relatively new technology, continued research and long-term data collection on their safety and efficacy are essential.

The MICRA CED (Micra Clinical Evaluation) study is an observational study designed to evaluate the safety and efficacy of leadless pacemakers compared to conventional single-chamber VVI pacemakers. This study reported a higher rate of perforation and pericardial effusion in the leadless pacemaker group, though this rate was less than 1% and remained higher than in the conventional pacemaker group. Additionally, device-related complications and six-month complication rates were higher in the conventional pacemaker group.

The present study assessed the safety and efficacy of leadless pacemakers after cardiac surgery or transcatheter valve interventions. In my opinion, the study has some limitations. It is a retrospective study with a small sample size and short follow-up period, potentially limiting its ability to capture long-term events and adequately compare outcomes across groups. Furthermore, there was no control group. A direct comparison between leadless and conventional pacemakers would have provided a more comprehensive assessment of the effectiveness and safety of leadless pacemakers in this specific clinical context.

In conclusion, leadless pacemakers represent a safe and effective alternative for treating highly selected patients requiring cardiac pacing after cardiac surgery or structural valve interventions by catheterization. Their ability to prevent complications associated with conventional pacemakers makes them attractive in specific clinical scenarios. However, given the limited long-term evidence, ongoing evaluation of outcomes and complications as more clinical experience with these devices accumulates is essential. Careful patient selection and continuous monitoring are crucial to ensuring the long-term safety and efficacy of leadless pacemakers in clinical practice.

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Encarnación Gutiérrez Carretero

Mortality and Cost of Cardiac Stimulation Device Infections According to the Applied Treatment: Expert Commentary

Dr. Encarnación Gutiérrez's review discusses the current state of managing infections associated with cardiac stimulation devices (CSDs), addressing the increase in associated costs due to three primary factors.

Currently, the implantation of cardiac stimulation devices (CSDs) is associated with increased costs for three reasons:

1. Demographic Changes: An aging, more fragile population with increased comorbidities and expanding device indications has led to a rise in both primary and replacement CSD implants.

2. Device Complexity: The growing intricacy of devices, with multiple leads and therapies, has resulted in higher initial implant and replacement costs.

3. Infection Rates: An unexplained increase in infections, currently ranging from 3–7%, possibly linked to the above reasons. Additionally, the increase in implanting centers, some with limited experience or in a learning curve, may also be a factor. These infections are invariably associated with increased patient morbidity and mortality, leading to substantial healthcare costs due to prolonged hospital stays (often extended for systemic infections), antibiotic treatment, and the expense of materials used for both device removal and reimplantation.

CSD infections (CSDIs) can be categorized based on clinical manifestations into two types:

- Local Infections: Characterized by the absence of systemic symptoms (fever, shock, emboli, vegetations, or distant complications) and negative blood cultures. Symptoms are localized to the generator pocket, such as pain, inflammation, continuous discharge in the form of a fistula, or even generator and/or lead extrusion.

- Systemic Infections: Defined by the presence of systemic signs (fever, shock, emboli, distant complications like spondylitis), consistently positive blood cultures, and often (in approximately 70% of cases) vegetations on leads or right-sided cardiac chambers visualized via transesophageal echocardiography.

Therapeutic Approaches:

The therapeutic strategies currently used for managing CSDIs are primarily threefold:

1. Antibiotic Therapy Only

2. Local Surgery: Including pocket debridement, generator replacement in the same or contralateral pocket while maintaining the old leads.

3. Complete System Extraction: Typically preferred through transvenous lead extraction (TLE) as the first choice or open-heart surgery if TLE fails.

Currently, the preferred treatment for CSDIs is the complete system removal via TLE, using self-rotating mechanical sheaths or lasers. In experienced hands, TLE is a safe technique, but it can still have serious complications in up to 2–4% of cases, including tricuspid valve rupture, right ventricular rupture with cardiac tamponade, and even superior vena cava tears, which may require open-heart surgery (sternotomy) and even cardiopulmonary bypass (CPB). Therefore, it is essential that these procedures are performed in an environment equipped with comprehensive safety measures.

For systemic infections, the best treatment appears to be the removal of electrodes from the circulatory stream via TLE. In cases of very old leads and very fragile patients, a chronic suppressive treatment may be attempted.

In local infections, which are generally less aggressive without systemic repercussions, localized approaches, such as pocket debridement and generator replacement while maintaining the old leads, are frequently used. This approach is common in centers lacking TLE capability and even in those with TLE capability but limited experience. However, this can lead to an unacceptable rate of clinical failures and subsequent complications, resulting in increased patient mortality and healthcare costs.

Our conclusions are based on a study of 380 CSDIs, of which 233 were local infections (61.3%) and 147 systemic (38.7%), with costs analyzed based on the treatment strategy and patient mortality, both in-hospital and during follow-up. Notably, 126 (33.2%) cases were referred from other centers, where multiple failed local approaches were frequently attempted.

In patients treated with TLE for local infections, mortality was 2.5% (6 cases, with 4 related to TLE: 2 superior vena cava ruptures, 1 cardiac tamponade, and 1 ventricular arrhythmia). For systemic infections, mortality was higher, reaching 10.8%, primarily due to sepsis. Regarding costs, we found them to be very high, averaging €21,790 for local infections and €34,086 for systemic infections, with 46% of local and 74% of systemic infection costs stemming from hospital stays.

Comparing these figures with those from patients with local infections treated using other strategies, we found that:

The failure rate was 58.3% for antibiotic therapy alone and 74.6% for local pocket surgery. Among all untreated local infections, 48.5% developed into systemic infections, which later required TLE or even open-heart surgery when TLE failed. The mortality rate in this patient group was 3.1% (3 cases related to TLE).

The average cost of local approaches was €42,978 due to repeated procedures (re-implantations with new generators), which almost always resulted in a final TLE or even open-heart surgery once the infection evolved to a systemic level, making TLE impractical due to prior lead manipulation.

Conversely, initial TLE yielded a higher cure rate (83.7%) and a lower cost (€24,699).

For initial systemic infections, results were as follows:

High mortality (19.2%) with a cure rate of only 7.6% for those treated solely with antibiotics, contrasting with a cure rate of 86.6% and mortality of 7.7% in those treated with TLE, with no deaths related to the procedure.

Again, when comparing antibiotic-only therapy with TLE, the latter was associated with lower costs (€37,545 vs. €39,525).

Based on these findings, we affirm that TLE is the most effective and safest treatment for patients with CSDIs, whether local or systemic, with lower associated costs.

Another aspect we analyzed in this CSDI patient group was the costs and morbidity-mortality of reimplantation after extraction, performed either in a single-stage surgery (extraction and reimplantation in the same procedure) or in a two-stage surgery (reimplantation on a different day). In single-stage surgery, performed in 74% of cases, we found:

- Lower reinfection rates, all of which were local infections, with reinfection understood as infection of the new device by a different microorganism during the first year of follow-up (4% vs. 7%).
- Shorter hospital stays (11 vs. 28 days).
- Lower cost (€25,600 vs. €44,797).

There was no significant difference in late mortality concerning reimplantation timing.

In local infections, there were no significant differences between single- and two-stage surgeries. However, for systemic infections, single-stage surgery was significantly better in three analyzed parameters:

- Fewer hospitalization days (22 vs. 32 days).
- Fewer relapses, defined as infection by the same microorganism (1.3% vs. 3.5%).
- Fewer reinfections, where the infection is caused by a different microorganism (2.6% vs. 14.2%).

These results support the practice of single-stage extraction and replacement, which not only reduces hospital stay and patient discomfort (double operating room visits) but is also associated with (contrary to theoretical expectations) fewer reinfections or relapses in the new implant.

Finally, when analyzing patient age, we found that even in octogenarians, initial aggressive TLE approaches yielded excellent results, leading us to believe that age should not be an absolute contraindication for TLE.

In conclusion, our multidisciplinary team believes that:

- CSDIs are associated with increased patient morbidity and mortality and pose a significant financial burden on the healthcare system.
- Local infections, far from being a minor problem often addressed with local surgery (generator excision and reimplantation), frequently precede systemic infections, warranting aggressive initial treatment with complete system removal by TLE, proven as the most cost-effective and safest strategy, even for frail patients.

- Therefore, specialized reference centers in our country are desirable for managing this low-prevalence yet highly complex, multidisciplinary condition. Including this aspect within the National Health System's Reference Centers, Services, and Units Network (CSUR) is an advancement that will facilitate easier referral of complex cases to reference centers for appropriate management. This will help concentrate high-level expertise in specific centers, ensuring quality, safe, and efficient healthcare, while providing equitable access to specialized services for all citizens when needed.

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Adrián Muinelo Paúl

Comparison of outcomes and required tools for transvenous lead extraction: insights from a high-volume center

This study compares the safety and efficacy of transvenous lead extraction (TLE) for implantable cardioverter defibrillators (ICDs) and pacemakers (PMs), analyzing procedural differences based on a large-scale prospective registry from Cleveland Clinic over a decade.

Studies comparing TLE outcomes for ICD and PM leads are outdated and limited. This research aimed to evaluate the safety, efficacy, and characteristics of TLE in ICDs and PMs while assessing the impact of lead age.

The cohort included all consecutive patients undergoing TLE for ICD and PM leads in the Cleveland Clinic Prospective TLE Registry from 2013 to 2022. Definitions of extraction success, complications, and failures followed the 2017 Heart Rhythm Society (HRS) guidelines for TLE.

A total of 885 ICD leads with a median implant duration of 8 years (IQR: 5−11 years) in 810 patients and 1352 PM leads with a median of 7 years (IQR: 3−13 years) in 807 patients were included. Procedural success rates were higher for ICD patients compared to PM patients for leads older than 20 years, but similar for leads ≤20 years. In the PM group, complete success rates decreased significantly with increasing lead age, a trend not observed in the ICD group. ICD TLE required more extraction tools than PM TLE, but older leads in both groups often necessitated non-laser extraction tools. The most common injury sites differed between ICD and PM complications, though major complication rates were not significantly different (2.7% vs. 1.6%, p = .12).

Procedural success rates for TLE were higher in ICD patients than in PM patients for leads older than 20 years, although more extraction tools were required. Common sites of vascular complications, as well as the influence of lead age on outcomes and required tools, varied between ICD and PM TLE.

COMMENTARY:

In Spain, the implantation of endovascular cardiac devices remains a cornerstone in treating cardiovascular diseases, reflecting both technological advancements and the needs of an aging population. In 2022, 41,082 conventional pacemakers were implanted, equating to 866 units per million inhabitants. Additionally, 7,693 ICDs were implanted, marking a 2.6% increase from the previous year and the highest figure in historical records.

Regarding TLE, a critical procedure in cases of infection, malfunction, or device replacement, advances in tools such as laser sheaths have improved success rates and reduced complications. Cleveland Clinic's previously published experience from 1996 to 2012, which included 5,973 leads extracted from 3,258 patients, identified leads older than five years as a significant risk factor for complications, establishing a reference for endovascular device extraction.

The current Cleveland Clinic cohort, spanning 2013−2022, provides a comprehensive view of TLE challenges, encompassing 1,617 patients (810 with ICDs and 807 with PMs). Tools employed included simple and locking stylets, telescoping extraction sheaths, mechanical or powered (rotational or laser) sheaths, and additional materials such as mechanical sheaths and endovascular snares.

ICD TLE required more tools than PM TLE, regardless of lead age. In the PM group, leads ≤5 years old were extracted without advanced tools in nearly two-thirds of cases.

However, in both groups, the number of required tools increased with lead age. Fibrotic tissue and calcifications around leads are major barriers, particularly for devices implanted for over 15 years. These phenomena occur in both ICD and PM leads, although ICD leads more frequently exhibit adhesions due to their robust, larger-diameter design.

Dual-coil leads in ICDs predicted adhesions in the innominate vein and superior vena cava, while passive fixation mechanisms—becoming less common in modern practice—were associated with adhesions in the heart. Larger-diameter leads provide stronger support for extraction tools and can withstand greater traction forces without losing structural integrity. ICD leads, with their larger size and higher conductor count, demonstrate greater tensile strength compared to the more fragile PM leads.

Partial lead extraction rates were significantly discordant, being 3.5 times higher in the PM group (2.8% in PMs vs. 0.8% in ICDs). This disparity reflects the thinner, less robust design of PM leads. These findings align with data from the 2017 ELECTRa registry, which reported a 1.7% major complication rate across 3,555 patients.

From a clinical outcomes perspective, procedural success rates were higher in ICD patients (97.3% complete success and 98.1% clinical success) compared to PM patients (93.8% and 96.8%, respectively; $p = .001$). Among leads older than 20 years, complete success rates were significantly higher for ICDs ($p = .005$), while no differences were observed for leads ≤20 years old. Multivariate analysis identified lead age, passive fixation, and manufacturer as predictors of incomplete lead removal.

In terms of complications, major events—defined as requiring emergent surgical or endovascular intervention—did not differ significantly between groups (2.7% in ICDs vs. 1.6% in PMs; $p = .12$). However, injury locations varied: superior vena cava injuries were most common in ICDs (50%), whereas right atrium injuries were predominant in PMs (33%).

Preoperative imaging (CT or venography) was not included in this study but could help identify high-risk adhesion sites. At CHUAC, findings presented at the SECCE Congress in June 2024 identified preoperative venographic abnormalities as a risk factor for major complications in TLE using laser sheaths.

Although major complication rates remain low, these events are severe. To ensure rapid and effective rescue, high-risk lead extractions should be conducted in cardiac surgery operating rooms under general anesthesia with extracorporeal circulation support and skilled surgeons ready to address potential complications.

In conclusion, while TLE for ICD leads often requires more tools and presents greater technical challenges, success rates generally surpass those for PM leads, especially for devices implanted for over 20 years. These observations underscore the need for specialized protocols and advanced equipment at reference centers to optimize outcomes and minimize risks.

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José Manuel Martínez Comendador

Isolated Surgical Closure of the Left Atrial Appendage with Automated Devices: Incidence of Acute Thrombosis

This retrospective single-center study examines the incidence of acute thrombosis at the stump line of the left atrial appendage (LAA) and its prognosis following isolated surgical closure with automated devices.

The closure of the LAA has been established as an alternative to anticoagulation in the prevention of thromboembolism for patients with atrial fibrillation (AF). Existing percutaneous endovascular devices, notably the WATCHMAN™ (Boston Scientific), have shown a risk of thrombosis, negatively impacting patient prognosis. Recent studies, including that of Dukkipati et al., estimate an annual thrombosis incidence of 7.2% with percutaneous LAA closure devices, and an increased stroke rate associated with this complication.

However, isolated surgical closure or resection of the LAA using devices such as vascular staplers or exclusion systems like the AtriClip™ (AtriCure™) has not clearly demonstrated this complication. This may be attributed to the epicardial application of these devices, meaning they lack direct contact with blood flow. Another potential reason for the absence of this association between epicardially applied devices and thrombosis could be the scarcity of rigorous studies that employ imaging follow-up.

This study sought to determine the actual incidence, prognosis, and factors associated with thrombogenesis following surgical LAA occlusion. Patient data were analyzed for those who underwent two types of isolated LAA surgical closure (either resection using the Powered ECHELON™ vascular stapler, Ethicon ENDOSurger™, or exclusion using the AtriClip™ system, AtriCure™) between July 2014 and March 2020 at a single center. A total of 239 consecutive AF patients underwent minimally invasive surgical LAA occlusion (184 resection cases and 55 clipping cases). On postoperative day 2, electrocardiogram-synchronized contrast-enhanced computed tomography (CT) was performed in 223 cases (93.3%), while transesophageal echocardiography (TEE) follow-up was conducted in 16 cases where CT was contraindicated. Acute postoperative thrombus was detected on the closed stump in 35 cases (14.7%): 29 cases (15.8%) in the resection group and 6 cases (10.9%) in the clipping group. No significant difference was found between the groups, nor were significant predictors of acute-phase thrombosis identified. Thromboembolism occurred in 4 patients before the postoperative imaging follow-up, but no thrombi were found in these patients on postoperative day 2 CT. Three months after the initial CT, thrombi were no longer detected in 34 of 35 patients (97.1%).

The authors conclude that thrombosis can occur following surgical LAA occlusion. Although its clinical significance remains unclear, it may be reasonable to continue anticoagulation therapy until the absence of thrombosis is confirmed, barring any contraindications.

COMMENTARY:

Before delving deeper into this study, I would like to clarify some concepts to better understand our current position. AF is believed to be responsible for at least one-third of ischemic strokes. Most of these events are thromboembolic in origin, arising from the LAA. Although oral anticoagulation has proven effective and safe in preventing these events, it has limitations, including bleeding risk and lack of adherence, especially among patients treated with vitamin K antagonists (VKAs). Thanks to the LAAOS III (The Left

Atrial Appendage Occlusion Study), published in 2021, we know that surgical LAA closure provides protection against ischemic strokes and systemic embolism in AF patients. Since thromboembolic risk is also elevated in patients undergoing scheduled cardiac surgery, it is incumbent upon us to close the LAA during cardiac surgery procedures using various techniques, such as the traditional continuous suture or automated devices like staplers and exclusion systems like AtriClip™. Recent studies suggest better outcomes with the AtriClip™ system, achieving a closure success rate of 96%, defined as a residual stump less than 1 cm and no contrast beyond the occlusion device on CT 12 months post-LAA closure.

Additionally, other studies suggest discontinuing anticoagulation once effective LAA closure is confirmed, though this should particularly apply to younger patients meeting the CHA2DS2-VASc < 2 score criterion. LAAOS III study patients with a CHA2DS2-VASc score > 4 are recommended class IB anticoagulation, regardless of LAA status. Therefore, discontinuing anticoagulation is a complex issue that cannot be adequately summarized here.

For years, interventional cardiologists have used percutaneous devices like the WATCHMAN™ (Boston Scientific™) in AF patients with contraindications or poor anticoagulation control as a stroke prevention method. The problem is that these percutaneous devices have shown a thrombosis rate close to 10% annually, likely due to their endovascular design, which maintains constant blood contact in atria lacking effective transport function, favoring thrombogenesis.

Similarly, as an alternative to these endovascular devices, cardiac surgeons are gaining experience with AF surgery through minimally invasive procedures, allowing for isolated LAA closure using the aforementioned automatic closure devices. Moreover, through a relatively simple thoracoscopic approach, we can achieve LAA closure with automatic devices like the AtriClip™, simplifying the surgical procedure. This option presents itself as an alternative to the percutaneous endovascular devices used by interventionists, which are associated with a higher thrombosis rate and thus an increased stroke risk.

The most relevant findings from Inoue et al., evaluating over 6 years of isolated surgical LAA resection outcomes, include:

- Acute-phase thrombus formation with epicardial closure or exclusion devices is higher than expected, approximately 15%.

- The positive news is that maintaining good anticoagulation during the first 3 months led to the disappearance of these thrombi, with no patient experiencing a stroke.

Although the risk of thrombus formation was thought to be low due to the absence of a residual foreign body in the bloodstream, in comparison with percutaneous devices, the frequency of acute-phase thrombosis was unexpectedly high. These results contrast with other publications where neither CT nor TEE detected thrombosis at the AtriClip™ closure level. One possibility is that in those studies, the imaging protocol was not as rigorous as in this study, which may have allowed thrombosis cases to go undetected.

Effective LAA exclusion requires no residual pocket at the base or closure line. This has been identified as one of the most common mechanisms of failure after automatic stapler excision. Ensuring that the LAA is well closed requires multi-view TEE, which is challenging and requires experience. Additionally, the anatomical variability of the LAA is well-documented, with trabeculations and lobes posing significant challenges. However, this issue primarily affects interventional devices with components that must

adapt to LAA morphology. Surgical devices, acting on the antral line connecting the LAA to the left atrium, are less sensitive to morphological variations in achieving technical success. Untreated AF is a hypercoagulable state, and a residual LAA stump poses a thromboembolic risk, leaving the patient vulnerable. Therefore, evidence of thrombus formation on the closure line in at least 1 in 10 patients should alert us to the importance of identifying these patients through meticulous echocardiographic imaging review. If thrombi are detected, proper follow-up and confirmation of adequate anticoagulation are crucial.

No significant difference in thrombosis rate was observed between the two LAA surgical closure techniques, although a trend toward a slightly higher thrombus formation rate was noted in the automatic stapler resection group. This may be due to exclusion systems like the Atriclip™ not affecting the endocardium as they do not damage the layers of the atrial wall, while resection may cause some damage when the stapler blade penetrates the atrial wall.

The main limitation of this study is its retrospective nature, based on single-institution cases. Future studies should include multiple institutions and established protocols for prospective surgeries, including investigations to determine optimal postoperative anticoagulation.

In light of these excellent results, I would like to take this opportunity to encourage and motivate cardiac surgeons to initiate programs for isolated LAA closure surgery using thoracoscopic approaches with automatic devices like the AtriClip™ at their hospitals. This epicardial LAA closure technique is beginning to demonstrate more favorable outcomes than percutaneous endovascular closure in terms of short- and especially long-term thrombosis rates. The procedure is technically simple, with an extremely low complication rate, and in the event of bleeding, surgeons themselves can resolve it. Many AF patients struggling to maintain anticoagulation could benefit from this technique. All that remains is for hospitals to offer this option and, above all, for cardiologists to become aware of this emerging alternative.

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José Manuel Martínez Comendador

Thoracoscopic Closure of the Left Atrial Appendage: AtriClip® or Stapler?

This study compares outcomes of thoracoscopic left atrial appendage (LAA) closure using the AtriClip® or an automatic stapler.

The LAA is the primary site of thrombus formation in patients with atrial fibrillation (AF), contributing to over 90% of embolic strokes in this population. LAA closure has emerged as a valuable therapeutic alternative for selected AF patients. Percutaneous devices such as the WATCHMAN™ (Boston Scientific™) allow for percutaneous LAA occlusion; however, various studies estimate a high thrombosis rate (7.2% annually), resulting in an increased stroke rate.

Consequently, with the advent of other devices, including automatic staplers and clipping systems like the AtriClip™ (AtriCure™), which exhibit lower thrombosis rates than endovascular devices (although not exempt from it, as discussed in previous entries on this blog), attention has shifted not only to LAA closure during conventional cardiac surgeries but also to thoracoscopic procedures with or without AF ablation. Some studies place the AtriClip™ system in a favorable position regarding effective closure results and a lower tendency to develop thrombosis, as it avoids endocardial damage by not piercing the atrial wall, unlike automatic staplers, and does not contact blood continuously as endovascular devices like the WATCHMAN™. With this context and recognizing that the critical point for effective thromboembolic prevention is complete LAA closure, this study aimed to compare the AtriClip™ with an automatic stapler system to shed light on this question.

To this end, the study included 333 patients who underwent thoracoscopic AF ablation and LAA closure from February 2012 to October 2020. Propensity score matching in a 4:1 ratio paired 90 patients with LAA clipping (AtriClip™) with 206 patients with stapled resection (Endo GIA™, Tyco Healthcare Group™). The primary objective was complete LAA closure, defined as a residual LAA depth of less than 1 cm in CT images obtained one year postoperatively.

No deaths occurred within 30 days. Complete LAA closure was achieved in 85.9% (286 of 333) of patients. After propensity score matching, the AtriClip™ group demonstrated a significantly higher rate of complete LAA closure compared to the stapler resection group (95.6% vs. 83.0%; $p = .003$), as well as a lower residual LAA stump depth (2.9 vs. 5.3 mm; $p = .001$).

After 4 years of clinical follow-up, the stroke incidence was 0.76% per year in the stapler group and 0.97% per year in the AtriClip™ group. A residual LAA stump was found in 2 patients who developed strokes. Long-term follow-up indicated that 82% of patients could discontinue oral anticoagulants.

The authors concluded that the AtriClip™ group demonstrated a higher rate of complete LAA closure compared to the stapler resection group. Close monitoring of patients with residual LAA stumps is essential. Further research with larger cohorts is needed to elucidate the impact of the residual LAA stump on thromboembolic events.

COMMENTARY:

The clinical benefits of LAA closure are increasingly clear, despite recent uncertainties. Since 2017, the Society of Thoracic Surgeons (STS) clinical practice guidelines have recommended (class IIa) LAA closure for thromboembolic prevention. However, it was not until 2021, with the publication of the LAAOS III study (The Left Atrial Appendage Occlusion Study), that surgical LAA closure was demonstrated to provide protection

against ischemic strokes and systemic embolism in AF patients. The absence of clear evidence prior to this study may be partly due to the use of various LAA closure techniques. Thanks to the LAAOS III study, the 2023 ACC/AHA/ACCP/HRS guidelines currently recommend class I LAA closure during cardiac surgery for patients with a CHA2DS2-VASc score ≥2 and class IIa for percutaneous closure in patients contraindicated for anticoagulation.

The ideal technique for effective LAA closure remains a topic of debate. Our traditional internal suture technique, the most commonly employed method, has proven ineffective in a significant percentage of cases (up to 24%). Other techniques, such as staplers that resect the LAA tissue, prevent recanalization and increase closure success rates. However, they may leave a suboptimal residual stump. Lastly, the latest system, which excludes the LAA through clipping, such as the AtriClip™, appears to demonstrate a higher rate of effective closures. In this vein, the present study provides two key takeaways:

1. This study is the first to clearly and significantly demonstrate a higher rate of effective closure with the AtriClip™ compared to automatic staplers, with a smaller residual stump.

2. Oral anticoagulation was discontinued in 82% of patients in the long-term follow-up.

In my opinion, the higher success rate with the AtriClip™ may be associated with several factors:

- Reduced Endocardial Damage: As noted in the introduction, the AtriClip™ system does not damage the endocardium by avoiding wall penetration, which results in reduced thrombosis formation.

- Design and Versatility: The AtriClip™ port is smaller, and its release system offers greater maneuverability compared to automatic staplers, enabling better positioning and release at the LAA base.

Residual flow from the left atrium into the LAA after incomplete closure, along with a residual stump larger than 1 cm, has been associated with an increased risk of thrombosis, even greater than if no procedure were performed. In this study, the absence of a significant stump and an individualized low CHA2DS2-VASc score were the criteria used for discontinuing anticoagulation. Specifically, 82% of patients maintained no anticoagulation with a very low stroke rate.

Aside from being a single-center retrospective study with a relatively small sample size, there are additional limitations to consider. These include the lack of information on LAA morphology, which is crucial for determining closure difficulty. Moreover, the limited experience in analyzing stapler results, as staplers were predominantly used in the first five years, also constitutes an important limitation. Since 2017, the use of AtriClip™ has been predominant, which may also have influenced the results.

In conclusion, I would like to send two last messages:

- The new class I recommendation for LAA closure during cardiac surgery in AF patients with a CHA2DS2-VASc score ≥2 requires us, as surgeons, to perform LAA closure, either through direct suture or with percutaneous

devices. Based on the available evidence, which I have summarized here, I would undoubtedly choose the AtriClip™ system.

- Furthermore, in a specialty like ours, which has undergone significant changes in recent years and faces constant competition from interventional cardiology, it is crucial to stay current with the latest scientific evidence and be innovative in adopting new minimally invasive techniques that simplify and enhance procedures. We cannot make excuses for not adopting techniques such as thoracoscopic surgery and other emerging innovations when new devices and expanded surgical indications arise. We must embrace all new technologies available to benefit our patients, for "he who does not know what he wants ends up where he does not want to be."

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Raquel Vázquez García

Pocket Summary of the 2024 Atrial Fibrillation Guidelines

Summary of the new 2024 European Society of Cardiology guidelines on atrial fibrillation.

The 2024 European Society of Cardiology (ESC) guidelines on managing atrial fibrillation (AF) provide new insights into patient care. Similar to previous ESC guidelines, these guidelines reinforce a stepwise comprehensive approach. They offer recommendations not only on treating tachyarrhythmia, prioritizing rhythm control, but also stress the importance of identifying and managing cardiovascular risk factors (CVRF) as essential components of comprehensive AF management. Throughout the guidelines, patients remain the focal point of AF management, highlighting the need to educate patients and caregivers to optimize decision-making and facilitate therapeutic approaches, recommending multidisciplinary teams and telemedicine for these purposes.

This guideline summary shares the main changes in clinical practice recommendations for their prompt application in patient management.

The main updates compared to the 2020 ESC guidelines include the emphasis on comprehensive CVRF management, the importance of early rhythm control strategies, the change in CHA2DS2-VA score nomenclature with the removal of the gender criterion, and the use of catheter ablation as a first-line rhythm control strategy for patients with paroxysmal AF.

KEY MESSAGES:

Below are the key topics addressed in the guidelines, highlighting those expected to have the greatest impact on daily clinical practice due to new scientific evidence.

1. Unlike the 2023 American Heart Association (AHA) guidelines, which view AF as a continuum, these guidelines retain the classic classification based on duration (first diagnosis, paroxysmal, persistent, and permanent), emphasizing frequent reassessment due to the disease's variable nature. Nonetheless, the guidelines acknowledge the need for classification based on pathophysiology and its influence on individual AF management.

2. For diagnosis, confirmation of AF with a 12-lead electrocardiogram (ECG) is still required; if detected via a device, it should enable ECG tracing and require physician evaluation for confirmation.

3. A stepwise management of AF is recommended. The 2020 ESC guidelines previously referred to this as the ABC protocol, now updated to AF-CARE, encompassing "C" for comorbidity and CVRF management, "A" for anticoagulation to prevent strokes and embolisms, "R" for symptom reduction via heart rate and rhythm control, and "E" for dynamic process assessment.

4. **C**: Emphasis is placed on the identification and management of CVRF as an integral part of AF care, aimed at both preventing AF and reducing its progression or adverse effects. Detailed guidance is provided on blood pressure, glucose control, exercise, managing obstructive sleep apnea, reducing alcohol intake (<30g/week), and intensive weight management for overweight or obese patients, with a target of a 10% reduction in body weight.

Additionally, it is recommended that, in the absence of specific evidence for this subgroup, heart failure (HF) management in patients with reduced or preserved ejection fraction (EF) should follow standard HF treatment protocols. This includes achieving euvolemia and initiating SGLT2 inhibitors in symptomatic patients, regardless of EF.

5. **A**: Anticoagulation (AC) is still recommended for patients with high ischemic risk, defined by validated scales such as CHA2DS2-VA. A notable update in these guidelines is the removal of the gender criterion from the CHA2DS2-VA scale, as female sex is now considered a risk modifier rather than an independent risk factor. CHA2DS2-VA ≥ 2 indicates a high thromboembolic risk, while CHA2DS2-VA =1 can be regarded as a high-risk factor.

6. One of the main evidence gaps in AC remains the management of subclinical AF. Despite recent data from the NOAH and ARTESIA studies, the guidelines provide only a tentative recommendation for AC in this patient population. The initiation of direct oral anticoagulants (DOAC) may be considered (IIb) in patients with high ischemic risk but without major bleeding risk, although specific thresholds for duration or burden of subclinical AF are not yet defined.

7. For the type of anticoagulant, DOACs are prioritized over vitamin K antagonists (VKA), except in cases of moderate-to-severe mitral stenosis or mechanical heart valves. It is recommended that patients over 75 years and those on multiple medications with stable INR levels remain on VKAs rather than switching to DOACs, as the latter have been associated with increased major bleeding in this demographic.

8. A level IA recommendation is now given for surgical left atrial appendage (LAA) closure combined with AC in patients with AF undergoing cardiac surgery. This recommendation is based on the findings of the LAAOS III trial, which showed a 33% reduction in stroke or systemic embolism risk in anticoagulated AF patients with LAA closure. Evidence for LAA closure in hybrid ablation is still limited, but ongoing studies are investigating this application.

9. **R**: Similar to AHA guidelines, early rhythm control is advocated, prioritizing sinus rhythm maintenance and AF burden reduction.

10. In terms of acute management of AF patients, the only difference from previous guidelines is a shorter safety interval (reduced from 48 to 24 hours from AF onset) for performing cardioversion in patients without AC or imaging to rule out LAA thrombi.

11. Catheter ablation for patients with paroxysmal AF is now given a level IA recommendation (previously IIa) as first-line therapy for rhythm control, aiming to reduce symptoms, recurrence, and disease progression. This is supported by recent studies such as STOP-AF and EARLY-AF, which demonstrate the superiority of cryoablation over antiarrhythmic drugs. The evidence for catheter ablation in persistent AF is less conclusive, leading to a stronger emphasis on electrical cardioversion for evaluating the benefits of

sinus rhythm restoration, followed by medical management if necessary. For persistent AF, first-line catheter ablation has a recommendation level of IIa.

12. The IB recommendation for catheter ablation in HF patients with reduced EF and suspected tachycardia-induced cardiomyopathy remains.

13. Hybrid ablation is considered (IIa) for persistent AF refractory to medical treatment, focusing on symptom relief, recurrence reduction, and progression prevention. It is less strongly recommended for paroxysmal AF.

14. Surgical ablation is advised for patients with AF undergoing mitral surgery, with a lower recommendation level for non-mitral procedures. Posterior pericardiotomy may be considered for AF prevention in patients undergoing cardiac surgery.

15. **E**: Regular assessment and reassessment to detect structural and functional cardiac changes, as well as to evaluate comorbidity development, treatment adherence, improvement in functional capacity, and quality of life. Reassessment is recommended at 6 months post-event and annually or based on clinical presentation thereafter.

16. Finally, recommendations are provided for managing special cases such as pregnancy, acute coronary syndromes, and stroke.

With respect to ablation, these guidelines highlight its central role. Like previous AHA guidelines, they emphasize early rhythm control and ablation as first-line therapy to achieve this goal. Therefore, a summary of the evidence supporting these recommendations is presented below. The early rhythm control strategy is based on findings from the EAST-AFNET 4 study, which demonstrated better cardiovascular outcomes over 5 years with early rhythm control achieved through either medical therapy or ablation compared to conventional rate control. To determine the best approach for rhythm control, the EARLY-AF and STOP AF studies compared endocardial ablation with antiarrhythmic drugs, showing lower tachyarrhythmia recurrence and improved quality of life in paroxysmal AF patients undergoing ablation compared to medical therapy. Additionally, the CASTLE-AF and CASTLE-HTX studies support ablation as first-line therapy in HF patients with reduced EF, even in advanced stages, reducing morbidity and mortality. This evidence underscores the importance of ablation in selected patients. Hybrid ablation is primarily recommended for persistent AF refractory to medical therapy, aiming to decrease symptoms, recurrence, and progression to permanent AF.

As a final summary, a comparative table is provided for ablation recommendation levels according to the ESC 2020, AHA 2023, and ESC 2024 guidelines, offering a visual overview of the increased recommendation for ablation supported by recent evidence.

ESC 2020	AHA 2023	ESC 2024
Catheter Ablation for Paroxysmal AF	Catheter ablation may be considered as first-line rhythm control for symptom improvement in symptomatic patients (IIa)	In selected patients (young and with few comorbidities), catheter ablation is recommended to improve

		symptoms and reduce progression (IA)
Catheter Ablation for Persistent AF	Catheter ablation may be considered as first-line treatment in selected patients without AF recurrence risk factors as an alternative to antiarrhythmic drugs (IIb)	Catheter ablation may be considered as first-line treatment to improve symptoms (IIa)
Catheter Ablation in Heart Failure	Catheter ablation is recommended as first-line treatment for reversing left ventricular dysfunction in AF patients with suspected tachycardiomyopathy, regardless of symptoms (IB)	In patients with properly managed HF and reduced EF with AF, catheter ablation is recommended to improve symptoms, quality of life, ventricular function, and cardiovascular outcomes (IA)
Hybrid Ablation	Hybrid ablation may be considered in patients with persistent or paroxysmal AF refractory to antiarrhythmic drugs and failed prior percutaneous ablation for sinus rhythm maintenance (IIa)	Hybrid ablation may be reasonable in symptomatic patients with persistent AF refractory to treatment (IIb)

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Bunty Ramchandani

Anticoagulation following postoperative atrial fibrillation: what is the evidence?

Expert opinions review guideline evidence on anticoagulation after postoperative atrial fibrillation (POAF).

Postoperative atrial fibrillation (POAF) is a common complication, arising in approximately one in three cardiac surgery patients, typically between postoperative days 2 and 4. With pharmacological treatment, it generally resolves within 24 hours of onset, with 90% of patients discharged in sinus rhythm. In non-surgical settings, atrial fibrillation (AF) is managed by either rhythm or rate control and initiation of oral anticoagulation (OAC) to prevent thromboembolic events. Consequently, anticoagulation in an immediate postoperative context may pose an increased bleeding risk.

COMMENTARY:

This article aims to examine recommendations from various societies regarding POAF anticoagulation management. In 2014, the American College of Cardiology, the American Heart Association, and the Heart Rhythm Society advised managing POAF similarly to non-surgical AF cases (Class IIA recommendation, level of evidence B), based on findings from the PREVENT-IV trial, which assessed saphenous vein graft patency. In this trial, 25% of patients developed POAF, and anticoagulation was prescribed at discharge. However, without a control group, the significance of this finding remains uncertain. Throughout this article, we highlight the scarcity of trials focusing on POAF, resulting in a generally low evidence level for current recommendations. This is apparent in the 2019 guideline update by the aforementioned societies, which maintained the previous recommendations, albeit emphasizing “shared decision-making and individualized treatment” and adjusting the recommendation to Class IC.

This lack of consensus persists globally. The Society of Cardiovascular Anesthesiologists and the European Association of Cardiothoracic Anaesthetists issued a Class IIA recommendation with level of evidence B/C in 2019. In 2016, the European Society of Cardiology, the European Association for Cardio-Thoracic Surgery, and the European Heart Rhythm Association recommended OAC for POAF (Class IIA-B), later downgrading to Class IIB-B in 2020. Canadian guidelines also issued a weak recommendation, advising against OAC initiation within the first 72 hours postoperatively due to bleeding risks.

The primary rationale for anticoagulating AF is to reduce thromboembolic events. A meta-analysis of 55 studies, including 540,209 patients, found a 28.1% incidence of POAF, translating to one stroke for every 50 POAF patients. In coronary surgery patients, POAF incidence was 25.2%, resulting in a stroke in every 69 patients, while in valvular patients, POAF incidence increased to 49%, equating to a stroke in every 36 cases. Two conclusions are evident: first, one in 50 patients who undergo surgery and experience POAF will suffer a stroke; second, stroke risk doubles for valvular patients who develop POAF. However, long-term stroke risk post-POAF remains underexplored, leaving it unclear whether AF is a consequence of underlying morbidity or potentially surgery-related.

The benefits of OAC are also unclear, as demonstrated by three meta-analyses with conflicting findings. Two of these analyses concluded that OAC reduces thromboembolic events, with one reporting a reduction of 2 events per 1,000 patient-years and another showing a 0.6% decrease. However, both studies noted an increase in bleeding events of approximately 42 events per 1,000 patient-years. None of the meta-analyses demonstrated a significant reduction in mortality. The limitations of these analyses are

rooted in the varied study quality, clinical management approaches, and inconsistencies in OAC timing and discontinuation, which hinder result interpretation.

Registries further underscore the lack of consensus in POAF management. In the Swedish SWEDHEART registry, nearly 25,000 patients were followed longitudinally over eight years. POAF incidence reached 30%, leading to increased rates of stroke, thromboembolism, hospitalization, and heart failure (adjusted HR = 4.16), with no observed increase in all-cause mortality. OAC was associated with elevated bleeding risk (adjusted HR = 1.4). A Danish registry involving 10,500 patients observed only 8.2% of POAF cases receiving OAC, with lower thromboembolism rates than in nonvalvular AF, suggesting potential differences in pathology.

The Society of Thoracic Surgeons (STS) registry showed a POAF incidence of 25.7% among 167,000 patients. OAC rates varied between 17% and 30%, depending on CHA_2DS_2-VASc score, with no difference in 30-day stroke readmission rates between anticoagulated and non-anticoagulated groups. However, the OAC-treated group had higher mortality at 30 days (HR=1.2) and an elevated rate of bleeding-related readmissions (HR=4.3). Notably, 74% of non-anticoagulated patients were discharged with amiodarone alone, a practice not specified in guidelines, yet this group did not demonstrate increased 30-day mortality, stroke readmission, or bleeding.

A further STS registry analysis with propensity matching in 39,000 coronary patients found no difference in thromboembolism or stroke incidence between anticoagulated and non-anticoagulated patients. However, POAF patients discharged on OAC had higher short- and long-term mortality (HR = 1.16) and increased bleeding readmissions (HR = 1.6). These findings raise doubts regarding OAC benefits for coronary patients with POAF.

Finally, the study highlights that patients remain within therapeutic range only 64% of the time during OAC treatment, with lower rates in the initial 3–6 months. High-bleeding-risk patients (e.g., those with renal dysfunction, heart failure, or prior stroke) exhibit the lowest time in therapeutic range. An alternative is direct oral anticoagulants (DOACs), which do not require monitoring. A meta-analysis of five randomized trials and seven observational studies showed that DOACs reduced stroke risk by 37% (NNT = 204) and bleeding by 26% (NNT = 143) compared to warfarin, with no significant difference in mortality, suggesting DOACs may be preferable to vitamin K antagonists (VKAs).

POAF may represent a distinct entity from general AF, lacking consensus on its management due to insufficient evidence. Few studies consider POAF's duration, frequency, and occurrence at discharge. Additionally, the CHA_2DS_2-VASc score is not tailored to the postoperative setting and does not consider reoperations, cardiopulmonary bypass duration, or concurrent antiplatelet therapy. Optimal anticoagulation duration also remains unknown.

In conclusion, before issuing management recommendations for POAF, a comprehensive understanding of this complication is essential. Ongoing trials, such as the Anticoagulation for New-Onset Post-Operative Atrial Fibrillation After CABG (PACES), may provide guidance on optimal management strategies, potentially leading to further publications on this frequent complication.

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Ignacio Vázquez Alarcón de la Lastra

On-X® Aortic Prosthesis Carriers in Aortic Position: Is This the End of Anticoagulation Demonization?

This study confirms the findings of the PROACT trial on the safety profile of reducing oral anticoagulation in patients with an On-X® prosthetic valve in the aortic position.

The patient's perspective increasingly influences the choice of prosthesis, particularly considering the perceived quality of life associated with antiplatelet/anticoagulant medication. Added to this is the recent rise of percutaneous interventions as potential solutions for structural degeneration in bioprostheses, which has led to a significant decline in the recommendation for mechanical prostheses, even in younger populations.

However, mechanical aortic prostheses continue to hold a crucial role with well-defined indications for aortic stenosis treatment, with ongoing advancements in their technological development. This study aims to support the indication proposed in the PROACT (Prospective Randomized On-X Anticoagulation Clinical Trial) study, where a low INR in the context of an On-X® aortic valve implant could be considered safe for thromboembolic events, with a reduced risk of bleeding complications.

It is known that all mechanical aortic prostheses require lifelong oral anticoagulation with a vitamin K antagonist, and that other studies examining alternative antithrombotics (dual antiplatelet therapy, dabigatran, or apixaban) have not been considered safe for thromboembolic events.

Following the PROACT study, which confirmed the efficacy of a combination of low-dose warfarin (INR between 1.5 and 2) and low-dose aspirin (ASA) after the first three postoperative months in high thrombotic risk patients with home INR monitoring, the FDA required an additional study to confirm this hypothesis, enabling this indication for all patients with an On-X® prosthesis in the aortic position regardless of thrombotic risk or monitoring method.

The study analyzed here is a prospective, observational, multicenter study that followed a cohort of up to 510 patients over five years. They received low-dose warfarin combined with low-dose ASA (if no contraindications existed) after three months of standard-dose anticoagulation following the prosthetic implant. Patients included were over 18 years old with a life expectancy exceeding five years, excluding any patients with another prosthetic valve implant other than aortic. The control group was randomly selected from the PROACT study and included all patients who received standard-dose warfarin to maintain an INR between 2 and 3, along with low-dose ASA regardless of thrombotic risk. The primary variable studied was the incidence of thromboembolic events, valve thrombosis, or major bleeding, analyzed in four subgroups: home vs. clinic-based INR monitoring and high vs. low thrombotic risk. Secondary variables included the occurrence of these events individually, overall thrombotic events, death rate, reoperations, or prosthesis explants, as well as general bleeding (both major and minor). Follow-up consisted of two visits in the first postoperative year and an annual visit for the next four years. This article includes data up to the one-year follow-up for all patients, with final results expected in 2027. A 95% confidence interval was used, with primary variable incidence studied using Poisson regression and the Kaplan-Meier curve for the percentage of patients free from the composite primary endpoint.

Among the 510 patients studied, 128 (25.1%) were at high thrombotic risk, while 382 (74.9%) were at low risk. Of these, 70 (13.7%) had home INR monitoring, and 440 (86.2%) clinic-based. The median follow-up was 3.35 years (1,562.9 patient-years), with a median INR of 1.9.

For the primary endpoint, the total incidence of thromboembolism, valve thrombosis, or major bleeding was 2.3% per patient-year, significantly lower than the 5.4% per patient-year in the control group (95% CI 4.1-6.9%). In subgroup analysis, the primary endpoint incidence was 2.4% in home-monitored patients and 2.3% in clinic-monitored patients, notably lower than the 5.4% in the control group. For thrombotic risk categories, high-risk patients had a 2.5% incidence, and low-risk patients a 2.2%, compared to 5.8% and 4% in the control groups, respectively. Subgroup analysis showed statistically significant results for high-risk patients but not for low-risk patients. The Kaplan-Meier curve estimated that at least 89.7% of patients would be free of any primary event over five years, with statistical significance.

Secondary analyses revealed significantly fewer major bleeds in the study group than in the control group (0.6% per patient-year vs. 3.8% per patient-year). Incidences of thromboembolic events and valve thrombosis were low and similar between groups. The overall bleeding rate, including minor bleeds, was also significantly lower in the study group (1.9% vs. 7.1%).

COMMENTARY:

The article confirms, up to the current follow-up, the findings of the PROACT study, suggesting that a lower INR with low-dose ASA is safe for preventing thromboembolic events and reduces bleeding complications in patients with On-X® valves in the aortic position. The FDA requested this study to validate this hypothesis in real-world patients with these valves, regardless of monitoring method or thrombotic risk.

The results, which even improve upon those of the PROACT study, support the practice of reducing anticoagulation in On-X® aortic valve patients. However, therapeutic approaches should continue to be individualized.

Despite these findings, final results will be available in 2027 after five years of follow-up, as designed.

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Bunty Ramchandani

Generating More Evidence for DOACs in Cardiac Surgery

A bicentric, retrospective study based on registry data comparing the use of warfarin versus direct oral anticoagulants (DOACs) in the immediate postoperative period following cardiac surgery in patients with atrial fibrillation and a bioprosthetic valve implant.

Direct oral anticoagulants (DOACs) such as apixaban, dabigatran, rivaroxaban, and edoxaban have demonstrated a safe and effective profile in treating non-valvular atrial fibrillation (AF). Currently, they are considered the first-choice treatment for this patient profile. Non-valvular AF is an evolving concept, presently referring to AF in the absence of a mechanical heart prosthesis, rheumatic mitral stenosis, and/or moderate to severe mitral stenosis. DOACs have been widely discussed in previous blog entries, reviews, and recent meta-analyses. American guidelines on valvular diseases recommend warfarin over DOACs during the first three months following a bioprosthetic implant (II-A recommendation). After this period, DOACs may be used as an alternative. However, off-label use of DOACs within these first three months is becoming increasingly frequent, despite limited evidence on the use of these anticoagulants in the initial three months post-cardiac intervention.

Today's article aims to generate evidence by evaluating clinical practice in Alberta, Canada. To this end, data from all patients operated on in two hospitals from July 2014 to June 2021 were retrospectively collected. Patients under 18, with mechanical prostheses, transcatheter valves, those who died in the hospital, without discharge data, or missing anticoagulant dispensation information for the first 90 days post-intervention were excluded from the analysis. Data were accessed using Alberta's surgical registry, linking identifiable data to locate patients in Alberta's pharmaceutical dispensation database. The primary efficacy outcome was a composite measure of mortality, stroke, transient ischemic attack, and systemic embolism within the first three months post-intervention. The primary safety outcome included intracranial hemorrhage, cardiac tamponade, gastrointestinal bleeding, clinically relevant bleeding at other sites, or a 20 g/L decrease in hemoglobin. Secondary analysis included a detailed comparison of primary outcomes, temporal anticoagulation patterns, and 30-day readmission rates.

Information was collected on a total of 1,743 patients. Among the 570 patients receiving DOACs, 17 cases (2%) presented an efficacy event and 55 (10%) a safety event. Of the 1,173 patients treated with warfarin, 41 (3%) had an efficacy event and 114 (10%) a safety event. The secondary analysis did not reveal significant differences between the two regimens in terms of safety, efficacy, or 30-day readmissions.

The authors suggest that the use of DOACs within the first three months after valvular cardiac surgery involving repair or replacement with a bioprosthesis could be as safe and effective as warfarin. However, confirmation of these findings requires adequately powered randomized prospective studies.

COMMENTARY:

In the immediate postoperative period following cardiac surgery, we must choose an anticoagulant that does not increase bleeding rates and can be quickly reversed if necessary. Furthermore, it should achieve therapeutic ranges rapidly, as the first three months carry the highest embolism risk. Dicoumarin anticoagulants offer the advantage of extensive experience due to their presence in pharmacopoeias since the 1950s. However, the Achilles' heel of this medication is its interpatient variability, which meant that only a quarter of the study cohort was within therapeutic anticoagulation ranges.

DOACs, on the other hand, exhibit more predictable pharmacokinetics by selectively inhibiting specific coagulation factors. Their effect is immediate and requires no monitoring. The downside of these medications is the lack of validation of anticoagulant effect in this type of patient.

It is interesting to note that from 2019 to 2020, DOAC prescriptions doubled compared to warfarin, becoming the most commonly used anticoagulation regimen. This shift can be explained by the impact of the coronavirus pandemic, which restricted hospital access and overwhelmed laboratories. The most logical solution was to opt for anticoagulation regimens requiring less frequent monitoring.

DOACs have limited representation in the immediate postoperative period in major clinical trials. In the RIVER trial (Rivaroxaban in Patients with Atrial Fibrillation and Bioprosthetic Mitral Valve), events were evaluated one year post-intervention. Only 19% of patients underwent surgery within three months prior to inclusion, and the results for this subgroup were not reported. The ENAVLE trial (Efficacy and Safety of Edoxaban in Patients Early After Surgical Bioprosthetic Valve Implantation and Valve Repair), previously discussed in a blog entry, remains the largest study with 220 patients evaluating a DOAC in the immediate postoperative period, but only five patients in the study we analyzed were treated with edoxaban. We await results from the DANCE trial (Direct Oral Anticoagulation vs. Warfarin After Cardiac Surgery) with over 6,000 patients for robust data.

Finally, we must mention the study's limitations. Despite being the largest study investigating DOAC use in the context of atrial fibrillation in the immediate postoperative period, it still has the inherent limitations of a retrospective, registry-based study: coding gaps, incomplete data, prescription bias, or the absence of post-discharge clinical data. The study population included both aortic and mitral valve patients, which are distinct profiles with differing morbidity and mortality, requiring different anticoagulation regimens. The study was affected by the pandemic, where adequate patient follow-ups were not conducted. We must interpret these results cautiously, as they do not fully reflect routine practice.

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Bunty Ramchandani

Isolated mitral valve endocarditis: repair or replacement?

This retrospective, single-center study conducted by the Cleveland Clinic's endocarditis working group examines pathological, bacteriological characteristics and short- and long-term surgical outcomes of mitral valve repair versus replacement in isolated mitral endocarditis.

Survival after mitral valve surgery in the context of infective endocarditis (IE) is poorer compared to aortic valve cases. For extensive infections in aortic valve endocarditis, the aortic root may be replaced. For the mitral valve, aggressive debridement of abscesses is necessary, with the main limiting factor being the integrity of the atrioventricular groove. This approach reinforces and seals the area but consequently limits antimicrobial penetration, increasing the risk of reinfection and compromising patient survival. Clinical guidelines recommend mitral valve repair, as repair outcomes are generally better than replacement. However, studies advocating repair often include heterogeneous populations, mixing patients with active and cured endocarditis.

The Cleveland Clinic study investigates the clinical, pathological, bacteriological, and surgical characteristics of patients with isolated mitral endocarditis, analyzing short- and long-term outcomes of reinfection, reoperation, and mortality in patients undergoing repair versus replacement. A retrospective review from 2002 to 2020 identified 2,303 endocarditis surgeries, including 447 cases of isolated mitral valve endocarditis (429 patients). Primary endpoints included surgical complications, defined by the STS database: reinfection, reoperation for infectious or non-infectious mitral valve causes, mitral insufficiency during follow-up, and mortality.

Of the 447 isolated mitral endocarditis cases, 236 involved the native valve (NV) and 121 a mitral prosthesis (MP). Patients were categorized into three groups: untreated NV (n=282; 63%), repaired NV (RV, n=44; 9.8%), and MP (n=121; 27%). Staphylococcus aureus was the predominant infectious agent in all groups. Of the 326 NV patients with IE, 88 (27%) underwent standard repair, 43 (13%) extended repair, and 195 (60%) valve replacement. Patients receiving standard repair were younger with fewer comorbidities. Hospital mortality was 3.8%; none in the standard repair group, 3 patients in the extended repair, 8 patients in the previous mitral valve replacement (PM) group, and 6 in those requiring mitral valve replacement. With a median follow-up of 4.4 years, survival at 1, 5, and 10 years for any repair was 91%, 75%, and 62%, while for replacement, it was 86%, 62%, and 44%. Renal failure emerged as the primary mortality risk factor. Risk-adjusted results and survival were similar across all groups.

The authors concluded that surgical solutions should be tailored to each patient based on clinical status and risk factors. The apparent superiority of repair in the IE context relates more to patient characteristics than to surgical technique. Renal failure is the most significant mortality risk factor, and in cases of extensive destruction, replacement is preferable to complex repairs.

COMMENTARY:

Historically, the Cleveland Clinic has pioneered advancements in medicine. This article is no exception, presenting the largest report on the microbiological, pathological, and surgical outcomes of isolated mitral endocarditis. The core message is simple: endocarditis affects a diverse and highly heterogeneous population. Surgeons must choose the most appropriate technique based on the patient, perioperative conditions, and intraoperative findings. The more localized the infection, the more feasible valve repair becomes. The study also highlighted that extended repairs offered no benefits

over mitral valve replacement in terms of reoperation, reinfection, or survival. This reinforces the general approach in endocarditis surgery: perform the procedure efficiently and safely. If complex valve reconstruction, tissue deficits, or challenging repair are anticipated, it indicates advanced infection and suggests prosthesis implantation.

In addition to reporting impressive mortality figures (3.8% overall hospital mortality over 20 years, 0% in the standard repair group), the article discusses cardiorenal and cardiohepatic syndromes in the endocarditis context. Preoperative renal dysfunction was the most significant mortality risk factor, and hyperbilirubinemia emerged as a risk factor for infection recurrence. A "J"-shaped non-linear relationship between plasma conjugated bilirubin levels and adverse in-hospital outcomes likely reflects bilirubin's anti-inflammatory and antioxidant properties. These findings are essential for risk stratification and potential therapeutic interventions.

Finally, it is essential to note the study's limitations. Although the most extensive report on isolated mitral endocarditis, it remains a single-center, observational, retrospective study. The Cleveland Clinic is a national reference center that also treats international patients, so their patient cohort may not represent typical daily practice. Therefore, antimicrobial therapies varied in coverage and duration. Additionally, the surgeons involved had extensive mitral repair experience, with an annual case rate of 25 mitral repairs—a milestone few surgeons achieve, let alone maintain.

In conclusion, today's article talks about the importance of offering targeted and personalized surgery. Both repair and replacement have their place in these surgeries, the important thing is to choose which one will benefit our patient the most. Remembering the old surgical aphorism: "patients should be offered the surgery they need, not the one we would like to perform."

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Teresa González Vargas

Infective endocarditis as a primary focus... are we globally addressing the problem?

This multicenter study evaluates the impact of spondylodiscitis associated with infective endocarditis on recurrence and survival based on the treatment sequence employed.

Coinfection with infective endocarditis (IE) and spondylodiscitis (SD) has been inadequately studied, showing considerable variation across studies. It is estimated that up to 30% of patients with SD may have an IE coinfection. These differences arise from the simultaneous need for echocardiograms and spinal MRIs within a brief period, both essential for diagnosis. Access to these diagnostic tools depends on the protocols and department availability where the patient is admitted (Traumatology, Neurosurgery, Cardiology, Internal Medicine, Intensive Care, etc.).

A recent multicenter study, the largest to date, was published in the *European Journal of Cardio-Thoracic Surgery*. This study examines IE and concomitant SD cases, focusing on the impact of treatment sequence on mortality and survival outcomes. The authors compared treatment sequences to assess survival rates and identify risk factors for survival and recurrence. This multicenter study in Germany involved 150 patients with IE+SD. Among them, 76.6% received primary surgery for IE, while 23.3% underwent initial treatment for SD. A univariable and multivariable analysis was performed, with inverse probability weighting (IPW) applied to minimize bias.

Patients receiving initial SD surgery did so due to reasons such as neurological deficits, progressive painful spinal deformity, spinal instability, intraspinal empyema, or failed conservative treatment. In other cases, IE was addressed first, following recognized clinical guidelines.

The findings revealed that, out of 3,991 patients with IE, only 150 had concurrent SD. Risk factors for this coinfection included an average age of 70 years, male gender, hypertension, diabetes mellitus, and chronic renal failure. Of these, 115 received initial IE surgery, and 35 were first treated for SD. Only 31 patients who underwent primary IE surgery subsequently required SD surgery; the rest received conservative treatment. However, all patients initially treated for SD subsequently required surgical intervention for IE. Compared to primary IE treatment, primary SD surgery resulted in significantly higher 30-day mortality and a trend toward increased 1-year mortality (25.7% vs. 11.4% at 30 days; 34.3% vs. 21.1% at 1 year). However, primary IE treatment showed higher recurrence rates for IE and SD at 30 days and 1 year. Mortality predictors included diabetes mellitus and primary SD treatment, which increased 30-day mortality, preoperative hemodialysis, and a BMI >25 kg/m², both of which elevated 1-year mortality risk. Recurrence predictors included chronic kidney disease, thoracic SD, and primary IE treatment.

COMMENTARY:

In 25% of concurrent IE and SD cases, Enterococcus was isolated, in contrast to other pathogens commonly found in isolated IE cases. This observation aligns with other published series. The authors suggest spinal MRI for cases with Enterococcus, even with mild symptoms like controlled lumbar pain.

Another noteworthy aspect is that while 30-day mortality is higher when SD is treated first, 1-year prognosis aligns, as observed in other series. This result, however, depends on early SD diagnosis and proper, complete antibiotic therapy.

Recurrence rates of IE are significantly higher in patients first treated for IE, likely due to the conservative treatment of SD in most cases, leading to potential local relapse from inadequate infection control.

Lastly, the study authors acknowledge limitations due to the multicenter nature, differing imaging protocols, diagnosis, and antibiotic therapy. While statistical tools aimed to reduce selection bias, inherent limitations may impact findings (noting, from the outset, that the SD primary treatment group was notably smaller than the IE group, initially limiting comparability).

Despite the formerly mentioned, personally I thik we shoud focus on three ideas:

- The coinfection frequency of IE and SD is low (ranging from 5% to 30%, depending on series), yet it significantly elevates mortality. This should prompt reflection on routine clinical practices, especially in cases without a primary focus. Are we potentially underdiagnosing or undertreating? Should we, as the authors suggest, incorporate protocolized MRI in all Enterococcus IE cases?

- It appears safe to conclude that, in diagnosed cases, cardiac surgery for IE should be prioritized (per 2023 EACTS guidelines), but addressing the primary SD focus aggressively, if necessary, including surgery, remains equally critical.

- Finally, it is essential to emphasize the value of collecting national data. The authors highlight the difficulties in gathering data due to the scarcity of reported cases, reminding Spanish surgeons of the importance of national registry contributions (e.g., the comprehensive, user-friendly RECC registry). I believe this is not only a need but an obligation to ensure future patients receive evidence-based, optimal treatment options.

To conclude, my reflection today is (and hence the title used in this post); if we are limiting ourselves or focusing on treating the heart infection (what “kills the patient” in the short term and what we, as cardiovascular surgeons, control) and we are forgetting about the initial problem, in this case spondylodiscitis, which could be a primary focus like any other, even unknown, we would not be carrying out a complete treatment.

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Marta Hernández Meneses

Valvular surgery in infective endocarditis according to frailty risk scales: are data at the service of science or is science at the service of data?

A retrospective study using data from the U.S. National Inpatient Sample (NIS) to analyze patients diagnosed with infective endocarditis, evaluating the impact of valvular surgery according to frailty risk scores.

The lack of reliable risk assessment scales to stratify patients with infective endocarditis (IE) requiring surgery remains a challenge for multidisciplinary IE teams, especially in cardiac surgery settings. This study aims to address this need by analyzing data from the U.S. National Inpatient Sample (NIS) database. A retrospective analysis was conducted on over seven million annual hospitalizations from 2016 to 2019, including 53,275 adults with a primary diagnosis of IE. Frailty in this cohort was assessed using the Hospital Frailty Risk Score, categorizing patients as low, intermediate, and high risk. Valvular surgery was identified through ICD-10 procedure codes, and inverse probability of treatment weighting (IPTW) was applied to balance baseline differences between intervention groups (valvular surgery vs. non-surgical candidates). The analysis was stratified by frailty levels. The study focused on in-hospital mortality, with no follow-up data. Secondary outcomes included the need for renal replacement therapy (RRT), circulatory support, and/or permanent pacemaker placement.

From the 53,275 patients coded with IE, the mean age was 52 years (34–68), with 59% males. The Elixhauser Comorbidity Index was 5 (3–6), 9% of patients had a previous valvular prosthesis, and 39% were identified as intravenous drug users (IDUs). Valvular surgery was performed in 18.3% of cases, with surgical patients being younger, having longer hospital stays, and higher frailty scores. However, data on the proportion of the overall IE cohort that had surgical indications were not provided. Aortic valve surgery was performed in 55% of cases, mitral valve surgery in 46%, combined mitral-aortic surgery in 16%, and pulmonary valve surgery in 1%. Right-sided surgeries were performed in 12% of cases, and left-right surgeries in 4%.

In the overall cohort, 42.7% had low frailty risk, 53.1% intermediate risk, and 4.2% high risk. After IPTW adjustment, there were no statistically significant differences in in-hospital mortality between valvular and non-valvular surgery groups for the entire cohort (3.7% vs. 4.1%, $p = .483$), or for patients with low (1% vs. 0.9%, $p = .952$) or moderate (5.4% vs. 6%, $p = .548$) frailty risk. However, patients with high frailty risk showed significantly lower in-hospital mortality in the valvular surgery group (4.6% vs. 13.9%, $p = .016$). There was a higher incidence of septic shock, need for mechanical circulatory support, and pacemaker placement in the surgical group, particularly in patients with low and intermediate frailty risk.

The authors conclude that in IE patients at high frailty risk, "the decision to proceed with valvular surgery should be made cautiously," as a mortality reduction benefit has been observed despite the predicted risk. Furthermore, they conclude that surgery was associated with an increased need for pacemaker implantation and mechanical circulatory support, similarly across all frailty risk groups.

COMMENTARY:

IE is a complex disease with significant interindividual clinical variability, requiring a multidisciplinary approach for diagnosis and treatment. Although the study's objective is relevant, the analysis of retrospective administrative data from a large registry not designed specifically for IE, combined with a lack of follow-up, limits its precision.

Moreover, it may introduce biases in diagnosis coding, procedure interpretation, and results extraction.

First, this study does not enable adequate case definition. It does not account for Duke diagnostic criteria, so it is not possible to classify cases as definite, possible, or rejected IE. Secondly, not all relevant clinical information is provided. Microbiological data, which undoubtedly influence the disease's aggressiveness and impact surgical decision-making and mortality—as demonstrated with *S. aureus* IE in various international and multicenter registries—are unknown. Additionally, echocardiographic variables, structural complications, distant embolisms, heart failure, and cardiogenic shock are not considered. This, along with the lack of data on specific surgical indications, affects the interpretation of both primary and secondary study outcomes. Thirdly, it is crucial to know the percentage of patients in the cohort with surgical indication who underwent surgery versus those who did not, to properly evaluate the impact of frailty on surgical decision-making.

In contrast, the general cohort results differ from other recognized multicenter IE registries, such as the ICE (International Collaborative Endocarditis Prospective Cohort Study) enrolling patients from 2000 to 2012, or the EUROENDO study conducted from 2016 to 2018. This study describes a younger cohort with a notably lower surgery rate (18%) and lower mortality (4%) than reported in the literature. In the ICE and EUROENDO registries, respective surgery rates were 52% and 51%, with in-hospital mortality rates of 19% and 17%, reaching 22% at six months in ICE and 23% at one year in EUROENDO. The authors suggest these differences may be due to better representativeness of community-acquired IE in lower-risk patients, typically excluded from tertiary university hospital studies. This cohort also includes a high percentage of IDUs (39%), who are generally younger and present with right-sided IE, usually not referred for surgery.

In summary, frailty assessment is a key factor in IE management, helping to identify patients who may benefit from surgery despite high risk. Early-stage surgery, when indicated, has shown a positive impact on prognosis. Integrating frailty assessment into preoperative risk models could enhance outcome prediction accuracy and facilitate therapeutic decision-making. However, given the rarity of surgery in high-risk patients in this study, no robust evidence supports general recommendations.

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Elio Martín Gutiérrez

Spain, 17 countries in one… also in terms of infective endocarditis epidemiology

Epidemiological study on the prevalence and regional differences in etiologies, treatment, and outcomes of infective endocarditis in Spain.

Infective endocarditis is a silent epidemic. Its incidence has doubled in developed countries over the past two decades. Key contributing factors likely include population aging, increasingly aggressive medical interventions (both cardiac and non-cardiac), a criticized relaxation in infectious prophylaxis recommendations (highlighted in previous blog entries), and misuse of antibiotic therapy, leading to the emergence of multi-resistant organisms. In this context, our country is not an exception to this trend. As surgeons, we are—or should be—part of the so-called Endocarditis Team, responsible for decision-making in highly complex patients, where the possibility of performing surgery remains a differentiating factor in prognosis for these patients.

The study, published from the perspective of cardiologists and public health experts, provides a snapshot of the current situation in Spain, as reported in *Revista Española de Cardiología*. For data collection, they relied on the Spanish Minimum Basic Data Set (MBDS), identifying cases treated from 2016 to 2019 across institutions affiliated with the Spanish National Health System, which covers 98.4% of healthcare services. The MBDS enabled demographic data collection alongside secondary diagnoses coded according to ICD-10 criteria.

While the authors' effort is commendable, it is essential to note that such methodologies typically introduce significant biases that may distort final results. Episodes lacking identification of a causative pathogen were excluded, potentially omitting cases with reporting errors or those with negative cultures. This is crucial since some of the most aggressive forms of endocarditis caused by pathogens like *Coxiella*, *Mycobacterium* (e.g., *M. chimaera*), fungi, or *T. whipplei*, among others, often present with negative cultures. Additionally, cases where patients did not declare their status at discharge (due to administrative errors) and those under 18 years (though rare) were not considered. Given these limitations, it is anticipated that some degree of misclassification may exist for comorbidities captured in variables such as renal insufficiency, diabetes, cancer, malnutrition, parenteral drug use, pre-existing valvular disease, prior valve prosthesis, or implanted cardiac electronic devices; the Charlson index score; and in-hospital morbidity and mortality, including heart failure, cardiogenic shock, systemic embolism, stroke, septic shock, acute renal failure, and the need for cardiac surgery. Furthermore, statistical inference to compare groups (surgery vs. no surgery, inter-regional differences) was limited to age and sex adjustments.

The study ultimately identified 9,008 episodes of infective endocarditis over the four years. Based on the population receiving healthcare, an incidence rate of 5.7 cases per 100,000 inhabitants was estimated, being twice as high in men (8.7 cases/100,000) as in women (3.7 cases/100,000). This figure represents an upward trend, aligning with reports from other countries, with previous incidence set at 3.49 cases/100,000 inhabitants in a similar study from 2014. The mean age was 69.5 years, with a comorbidity rate commonly encountered in our practice, and a median Charlson index of 2. Prevalence of pre-existing conditions included 36.8% with prior valvular disease, 26.8% with a prosthetic valve, and 10.6% with an implanted cardiac electronic device. The most frequently isolated pathogens were *Staphylococcus* (33.3%, with 19% being *S. aureus* and 14.3% coagulase-negative staphylococci), followed by *Streptococcus* (20.8%) and *Enterococcus*(15.3%). Episodes of culture-negative endocarditis comprised over 20% of cases. During hospitalization, the most common complication was heart failure (38.6%), followed by acute renal failure (27.5%) and stroke

(11.1%). The average hospital stay was 26 days, a relatively short period, likely due to a low rate of surgical treatment (less than 20% across the series) and probable outpatient management of antibiotic therapy in many cases (length of stay ranging from 13 to 43 days). Overall in-hospital mortality reached 27.2%, contextualized by a low rate of operability and the severity of the disease.

As noted earlier, the multivariate models developed from the collected data lack full reliability. However, they reinforced established knowledge: patients with the worst prognosis presented with cardiogenic shock, septic shock, and/or cerebral embolism, while patients selected for surgery had a better prognosis than those who did not undergo surgery. This study's true value lies in exposing the considerable differences in cardiovascular health service quantity and quality across the various autonomous communities, each with its health service framework. The disparities affected multiple aspects highlighted below:

- Incidence: Lower in the central plateau (except Madrid) and the Levante region (except Catalonia), paradoxically, areas with a predominantly older population.

- In-hospital mortality: Adjusted by incidence, it was lowest in Galicia, Catalonia, Madrid, and the Balearic Islands, followed by Castile and Leon and the Basque Country.

- Cardiac surgery rates: Most communities had rates below 20%, with only Andalusia, Asturias, the Canary Islands, Cantabria, Extremadura, Madrid, Murcia, and the Basque Country surpassing this threshold.

- Referral to specialized centers: Only less than one-third of declared cases in each community were referred, with Andalusia, Aragon, Asturias, the Canary Islands, Cantabria, Valencia, Extremadura, Madrid, Murcia, and the Basque Country exceeding this threshold. The authors emphasize and corroborate with their analysis the benefits of being treated in hospitals that include cardiac surgery in their service portfolio, which allows for higher rates of pathogen identification (intraoperative culture samples).

- Microbiological profile: The different regions showed variations in the frequency with which agents caused episodes of endocarditis, with no clinically or ecologically relevant differences, other than some statistically significant but difficult-to-explain findings. Particularly notable were the following aspects:

    - Failure rates in identifying the causative pathogen in blood cultures: Especially high in Andalusia, the Canary Islands, Castile-La Mancha, Castile and Leon, and Extremadura. These regions tend to have high rurality rates, smaller hospitals, and likely difficulties in sending viable samples to reference laboratories or limited access to centers with cardiac surgery.

    - Prosthetic endocarditis rates: Showed a north-south gradient, being higher in northern communities (Castile and Leon, Galicia, the Basque Country, or Asturias, each exceeding 30% of cases).

- Endocarditis associated with intravenous drug use: Although not comparable to the epidemic levels in countries like the USA, it was concentrated in regions such as Catalonia, Valencia, Murcia, and Madrid, where it accounted for over 2% of cases.

COMMENTARY:

This work is very much appreciated and, despite potential inaccuracies, serves as an indictment of the social injustice represented by the disparity in healthcare across 17 different health systems within the same country. Some intriguing data relate to the demographic, economic, or geographic characteristics that we all recognize and that influence microbial etiology, referral possibilities to tertiary centers, and, most concerning, survival or surgical treatment rates. Sometimes, we feel inadequate comparing ourselves to other countries (especially in Europe) when working in or receiving care from our so-called "best healthcare system in the world." Yet what I find intolerable is that two people receiving care in the same country have different outcomes simply because they are in neighboring communities. No healthcare system is perfect, but decades of reassurance about having the best have led to a complacent acceptance of a situation that is increasingly unacceptable. Our healthcare system may indeed excel in some areas, like organ transplants, be among the most compassionate, and efficient (at the expense of healthcare professionals' salaries). However, in terms of quality and uniformity, we cannot settle for less, especially in the 21st century, when, against a probabilistic disease like endocarditis, some Spaniards still lack equal chances of overcoming it.

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Neyda Daniela Contreras Barrientos

Results Following Valve Surgery in Patients with Infective Endocarditis and Preoperative Septic Cerebral Embolism: Insights from the CAMPAIGN Registry

The German CAMPAIGN registry outcomes focused on comparing morbidity and mortality in patients with infective endocarditis (IE) complicated by septic cerebral embolism (SCE) versus those without it.

Infective endocarditis (IE) presents a significant public health challenge, with an estimated incidence of 13.8 cases per 100,000 individuals annually, leading to approximately 66,300 deaths globally due to its high morbidity and mortality rates. Septic embolic stroke is one of the most frequent and feared complications, affecting up to 50% of patients with IE and correlating with an increased mortality risk. However, the impact of preoperative septic cerebral embolism (SCE) on postoperative outcomes and long-term survival in IE patients requiring valve surgery remains underexplored.

This study aimed to evaluate the impact of preoperative SCE on both short- and long-term outcomes in IE patients undergoing valve surgery. This retrospective study utilized data from the Clinical Multicenter Project for Analysis of Infective Endocarditis in Germany (CAMPAIGN) registry, covering cases from 1994 to 2018 across six German centers, with follow-up until the first quarter of 2022.

The study analyzed demographic data, risk factors, medical history, clinical status, echocardiographic and microbiological findings, intraoperative and postoperative details, and complications. During the study period, a total of 4,917 patients underwent cardiac surgery due to IE. Among these, 3,909 patients (79.5%) did not present with preoperative SCE, while 1,008 patients (20.5%) did.

Among the patients with SCE, 71.6% were symptomatic, while 28.4% were asymptomatic. The SCE group showed a higher prevalence of cardiovascular risk factors, including smoking (21.3% vs. 17.1%; $p < .005$), myocardial infarction (8.8% vs. 6.7%; $p < .05$), hypertension (62.5% vs. 47.6%; $p < .05$), and peripheral artery disease (9.3% vs. 7.2%; $p < .001$). Additionally, EuroSCORE II was significantly elevated (11% vs. 10%; $p < .007$) in the SCE group.

The SCE group also demonstrated a significantly higher need for preoperative mechanical ventilation (18.1% vs. 7.2%; $p< .001$) and exhibited increased prevalence of mitral valve IE (44.1% vs. 33.0%; $p < .001$), presence of vegetations (87.8% vs. 57.9%; $p < .001$), large vegetations (>10 mm; 43.1% vs. 30.0%; $p < .001$), and Staphylococcus spp. as the causative microorganism (42.3% vs. 21.3%; $p < .001$).

Postoperative outcomes showed significantly longer mean durations of mechanical ventilation (25 h vs. 15 h; $p < .001$) and ICU stays (4 days vs. 3 days; $p < .001$) in the SCE group. Furthermore, the SCE group had a higher incidence of new-onset postoperative stroke (24.9% vs. 12.0%; $p < .001$).

Analysis of 30-day mortality (22.8% vs. 20.1%) and 5-year survival (49.1% vs. 47.8%) revealed no statistically significant differences.

The authors concluded that early mortality and 5-year survival are comparable between patients with and without preoperative SCE. However, a comprehensive evaluation of the patient's overall condition remains essential for informed decision-making.

COMMENTARY:

Septic cerebral embolism (SCE) is recognized as a common complication in infective endocarditis (IE). This article reaffirms the prevalence outlined in the 2023 ESC guidelines on IE (35%), with a 20.5% occurrence rate in the CAMPAIGN registry cohort. The study also supports existing literature linking IE with SCE, noting an increased prevalence of left-sided heart involvement, presence and size of vegetations, and Staphylococcus spp. infections.

While SCE did not influence 30-day mortality or 5-year survival, it was associated with an elevated baseline risk profile and delayed recovery. The study did not analyze specific tomographic characteristics, the extent of SCE, neurological manifestations, or neurological status pre- or post-surgery, limiting comprehensive outcome analysis.

A holistic view of SCE's impact is crucial, taking into account the patient's neurological state without letting SCE alone dictate morbidity or drive clinical decisions.

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Bunty Ramchandani

Papillary fibroelastoma: the most common primary cardiac tumor that also recurs

A retrospective single-center study from the Mayo Clinic reviewing and following 294 patients who underwent surgical excision of papillary fibroelastoma.

Contrary to previous understanding, the most common benign primary cardiac tumor is now believed to be the papillary fibroelastoma (PFE), not the myxoma. These tumors are found 90% of the time on cardiac valves, with a particular preference for the aortic valve, though they can appear on any endocardial surface. With an average size of approximately 20 mm, they have a stalk-like shape and were historically termed “giant Lambl’s excrescences.” Most patients are asymptomatic, and the diagnosis is often incidental. Symptoms, when present, are typically secondary to tumor embolisms, whether cerebral, cardiac, or pulmonary. Symptomatic patients are clearly indicated for surgical excision. However, the management of asymptomatic patients remains controversial.

This study aims to analyze Mayo Clinic’s experience with the surgical treatment of PFE and long-term outcomes. To this end, data from 1998 to 2020 was retrospectively reviewed, including any patient who underwent PFE surgery. The cohort was divided into primary PFE, where tumor excision was the surgical indication, and secondary PFE, where it was removed incidentally during another surgery.

Of the 294 patients analyzed, 60% were female, and the mean age of the entire cohort was 66 years. Half of the cases were primary PFE, and of these 136 patients, half presented with symptoms of cerebral embolism or transient ischemic attack before surgery. In secondary PFEs, over a third of cases had preoperative tumor identification. The tumor was located mainly on the aortic valve, with right-sided location being rare. When the PFE was on a normal valve, 96% of cases allowed for shaving the valve without functional impairment. In-hospital mortality was low, at 0% for primary cases and 2.5% for secondary cases, attributed to patient comorbidities rather than the tumor. The rate of immediate postoperative neurological events was 1.3%. With a median follow-up of 8.5 years, the 10-year recurrence rate was 16%, with most cases managed conservatively. However, three patients underwent reoperation for tumor recurrence in the same initial location. Ten-year survival was 78% for primary cases and 54% for secondary cases ($p = .003$).

The authors concluded that PFE excision can be performed safely, preserving the native valve and with a low risk of immediate postoperative neurological events. Long-term surgical outcomes are excellent, although recurrences are more frequent than previously thought.

COMMENTARY:

PFE was first described in the late 19th and early 20th centuries and has been known by various terms: papillary myxomas, papillary excrescences, and, as mentioned earlier, giant Lambl’s excrescences. There is even controversy as to whether PFEs are indeed Lambl’s excrescences. Lambl’s excrescences are thought to be reactive mechanical processes associated with normal valve function, typically located along the coaptation line. However, the etiology of both remains unknown, with minimal histological differences. Characteristics such as size, structural complexity, or location have been proposed to differentiate them, but these are arbitrary and artificial criteria. Some believe PFEs result from uncontrolled growth of Lambl’s excrescences.

What is undisputed is their high embolic risk, which justifies primary PFE surgery. Surgery is known to halve cerebrovascular events at five years compared to non-operated patients, which translates into increased long-term survival. With routine use of transthoracic and transesophageal echocardiography, PFE incidence has risen, making it now considered more common than myxoma. Echocardiographic studies have shown that PFEs grow by approximately 0.5 mm annually and, depending on their location, may present symptoms sooner or later. Right-sided tumors, for instance, tend to have a more indolent course, with symptoms appearing when tumors are large. It's essential to remember that less than 10% of PFEs may have multiple locations, so all suspected cases should include a thorough examination of all locations to avoid missing any.

The most significant finding of this study is the 16% recurrence rate at 10 years, much higher than the previously assumed 3%. This raises several questions: how frequently should these operated patients be followed up? What imaging modality should be used? Should a more aggressive approach be taken rather than merely shaving the valve? Regarding the latter, adding cryoablation to the resection bed could provide benefits, as it has shown not to damage the valve, although no solid data on long-term recurrence prevention exists. Some groups, however, perform this systematically.

To understand this article's findings in context, it's crucial to consider its limitations. This is a single-center retrospective study from a quaternary hospital, which may not reflect the caseload of a standard hospital. Data were not analyzed for patients with a PFE diagnosis who were not operated on. Long-term neurological event data and echocardiographic data were unavailable for nearly half of the cohort, so the recurrence rate could be underestimated (in addition to the consequences of the conservative approach taken in most cases).

In conclusion, despite these limitations, this study is one of the largest published on PFE and significantly contributes to potentially changing the surgical management of this rare pathology.

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María Alejandra Barreto

Malignant pericardial effusion: pericardiocentesis or pericardial window?

This single-center retrospective study evaluates clinical outcomes over 20 years, specifically focusing on the recurrence of pericardial effusion and mortality, comparing pericardiocentesis with pericardial window in the treatment of malignant pericardial effusion.

Pericardial effusion in cancer patients is associated with a poor prognosis. The treatment objectives should include symptom relief and minimizing recurrences that require further intervention. Current guidelines recommend pericardiocentesis as a Class I indication for these patients, yet some studies support pericardial window as a strategy with comparable clinical outcomes and lower recurrence, although evidence remains insufficient. This study aimed to compare clinical outcomes (recurrence and all-cause mortality) based on the selected drainage method (pericardiocentesis versus pericardial window) and over a 10-year interval to adjust results to advancements in chemotherapy treatments.

Malignant pericardial effusion in cancer patients usually arises from tumor invasion, though it can also be a secondary effect of treatment. Regardless of the cause, it is linked to poor prognosis, significant quality of life reduction, treatment interruption, and high recurrence rates. In severe cases or those compromising the patient's hemodynamic stability, evacuation is indicated. Techniques for this include percutaneous and surgical approaches, with various studies aiming to demonstrate superiority regarding mortality, recurrence, recovery, etc. The significant increase in cancer patient survival, along with the emergence of new drugs and therapies, emphasizes the need to prevent recurrence in patients with neoplastic pericardial effusion and review the strategies for achieving this.

This single-center retrospective cohort study included 874 cancer patients who underwent pericardial drainage between January 2003 and December 2022, excluding those undergoing concurrent cardiac surgery or those with effusion from unidentified causes. Patients were compared based on the drainage method used (pericardiocentesis versus pericardial window) over two time periods (2003–2012 and 2013–2022). The choice of procedure followed clinical judgment and clinical guideline recommendations. The analyzed outcomes were effusion recurrence (need for reintervention or reappearance of pericardial effusion with a separation of pericardial layers >20mm on follow-up echocardiogram) and all-cause mortality. Subgroups were created to analyze factors associated with recurrence. The log-rank test compared clinical outcomes between the two groups, and a multivariate model was constructed using clinical variables with $p < .100$ in univariate analysis and variables with established clinical significance from prior studies.

The mean follow-up was 91 days. There was no difference in all-cause mortality (death within the first 24 hours and at 30 days) between the two groups. Recurrence of pericardial effusion was significantly higher in the pericardiocentesis group (18%) than in the pericardial window group (6.3%, $p = .01$). Comparing outcomes by period, as expected, survival rates improved in the second period, with a trend toward less frequent pericardial window procedures. Although all-cause mortality did not differ between groups over time, 30-day mortality was higher in the pericardial window group ($p = .01$). Conversely, effusion recurrence was greater in the pericardiocentesis group than in the pericardial window group during the second period ($p = .005$). In univariate analysis, pericardial window was associated with lower effusion recurrence, while younger age

(<55 years), metastatic or relapsed cancer, and positive malignant cell cytology in pericardial fluid were risk factors for recurrence ($p = .001$).

COMMENTARY:

Malignant pericardial effusion significantly impacts cancer patients by reducing quality of life, survival, and necessitating interruptions in specific therapy. Despite the importance of recurrence prevention, the first-line intervention remains controversial. Some prior studies have shown positive results using open, percutaneous, and minimally invasive techniques (mediastinoscopy/videothoracoscopy) for preventing recurrence, but with a limited number of patients. Other retrospective studies have found similar outcomes when comparing pericardiocentesis and pericardial window regarding recurrence, associating the latter with higher complication and mortality rates. This study ultimately included 765 individuals, allowing for a more robust statistical analysis than in previous studies. Although mortality outcomes showed no differences, recurrence rates were lower in those who underwent a pericardial window (18% vs. 6.3%).

An additional contribution was the comparison of both techniques over two different time periods. The improvement and increased interest in new drugs and therapies for cancer patients are evident. The study also confirmed the advantage of pericardial window in the most recent period (2013–2022). Minimally invasive approaches, such as videothoracoscopy, seem better suited to the patient's condition, offering an alternative to pericardiocentesis by providing pleuropericardial communication and not merely draining the cavity, thus reducing the recurrence risk.

In terms of factors associated with recurrence, previous studies have shown that the primary cancer type, age, and chemotherapy response could be linked. This study found that younger age (<55 years), metastatic cancer, and positive malignant cell cytology in pericardial fluid are associated with higher recurrence, suggesting that cancer patients with these characteristics might initially benefit from a pericardial window as a drainage method, although randomized studies are needed to explore this new hypothesis.

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Victor Daniel Ortíz

When, who, and how to perform a pericardiectomy?

A review of the state-of-the-art approach to the clinical presentation, diagnosis, and treatment of constrictive pericarditis, assessing the most recommended surgical treatment for each case.

Pericardial diseases are uncommon and, consequently, are sometimes not diagnosed due to a lack of clinical suspicion. This results in missed opportunities for treatment. With recent advances in understanding the pathophysiology of pericardial diseases, alongside the development of multimodal imaging techniques for diagnosis and updated treatment strategies, an up-to-date overview is essential, particularly focusing on constrictive pericarditis (CP).

Given the intraoperative and postoperative risks of surgical procedures, the challenge for surgeons and the medical team is to determine the appropriate patient, timing, and treatment.

CP is a reversible cause of heart failure, yet it is difficult to diagnose and requires a high level of suspicion. CP can follow any pericardial pathology, with the primary etiologies being idiopathic or viral (42-61%); post-cardiac surgery (11-37%); post-radiotherapy, mainly in cases of Hodgkin's lymphoma and breast cancer (2-31%); connective tissue disease (3-7%); and post-infection, such as tuberculous pericarditis (3-15%). Other causes, including malignancy, sarcoidosis, uremic pericarditis, asbestosis, trauma, or drug-induced origins, are rare (<10%).

Patients with CP primarily exhibit symptoms of right heart failure, such as ascites, peripheral edema, and elevated jugular venous pressure, although dyspnea and pleural effusion may also occur.

Traditionally, cardiac catheterization has been the reference test for diagnosis. However, currently, multimodal imaging (echocardiography, computed tomography, magnetic resonance imaging, and PET-CT) provides equally valuable findings for both diagnosis and follow-up, constituting non-invasive alternatives. Indeed, classic signs, such as pericardial calcification, are no longer required to support the hemodynamic diagnosis, as it suffices to demonstrate inflammatory activity and/or significant thickening resulting from chronic inflammation.

The presentation of CP can range from simple pericardial inflammation, which typically resolves with anti-inflammatory agents, colchicine, and/or steroids (subacute or transient pericarditis), to chronic effusive, constrictive, or recurrent pericarditis, which may require pericardiectomy.

When? Since 2015, the European Society of Cardiology (ESC) Working Group on the Diagnosis and Management of Pericardial Diseases, endorsed by the European Association for Cardiothoracic Surgery (EACTS), has published the following recommendations:

- Pericardiectomy is recommended in patients with chronic CP and New York Heart Association (NYHA) functional class III or IV symptoms.

- Pericardiectomy may be considered in patients with refractory recurrent pericarditis (RP).

- Pericardiectomy is recommended in patients with partial pericardial agenesis resulting in cardiac herniation and hemodynamic compromise.

- Pericardiectomy is rarely performed in cases of recurrent pericardial effusions, even in the presence of loculated effusions, or when a biopsy is needed, due to advances in surgical pericardial window techniques, including minimally invasive approaches.

Who? Patient selection should include a risk assessment. While specific estimation systems are not available, commonly used scores such as STS-PROM and EuroSCORE II may be applied. However, integrating scales like the MELD-XI, which assesses both renal and hepatic dysfunction in relation to systemic congestion, is valuable. A careful evaluation of patients with end-stage renal disease and/or advanced liver disease, with a Child-Pugh score of B or C (>7 points) or MELD-XI score of 13.7-30.6, can help in identifying cases of futility or high surgical risk. In patients with "end-stage" CP who present with cachexia, malnutrition, hypoalbuminemia due to protein-losing enteropathy, cardiac cirrhosis, and low cardiac output, surgery is not indicated. This presentation is common in patients with post-radiation CP.

Regarding etiology, idiopathic pericarditis has the best prognosis, followed by post-surgical and post-radiation pericarditis. In a study involving 601 patients, the overall in-hospital mortality was 6%, with 1.1% in idiopathic cases, 9.7% in post-surgical cases, and 27% in post-radiation cases. The 5-, 10-, and 20-year survival rates were 87%, 73%, and 30%, respectively. Patients with idiopathic disease had a survival rate of over 80% at 5-7 years, while those with post-radiation CP showed survival rates of 53.4% and 32.1% at 5 and 10 years, respectively.

How? Radical pericardiectomy via median sternotomy is currently preferred. Traditionally, anterior pericardium resection from one phrenic nerve to the contralateral phrenic nerve was performed, also releasing the pericardial ring around the superior vena cava (SVC), ascending aorta, and pulmonary artery. However, leaving the pericardium over the left ventricle (LV), on the diaphragmatic surface, or on the posterior pericardium has been associated with cases of recurrent constrictive physiology, where hemodynamic analysis reveals a more "postcapillary" than "precapillary" profile. This has led to recommendations to extend resection to the lateral LV, diaphragmatic pericardium, and posterior pericardium whenever possible. In this way, complete resection avoids any residual pericardial band that could cause residual constriction, while carefully managing the phrenic nerve pedicles to prevent iatrogenic injury.

In some patients, pericardium removal alone may not be sufficient as the epicardium is thickened and fibrotic (epicarditis), contributing to constriction. In these cases, it is also essential to remove the epicardium (visceral pericardium) to relieve constriction. This represents a significant surgical challenge, as complete removal may not be feasible in all cases. However, a "chessboard" or "tortoise shell" technique, in which the fibrotic layer is divided into multiple areas to allow heart expansion, can be applied. This technique is mainly described for tuberculous pericarditis, where epicardial calcification infiltration is present.

Despite being far from a surgery without cardiopulmonary bypass (CPB), which must be kept on standby for potential bleeding complications, CPB is used in 40%-63% of cases in various series, and many specialized centers recommend its use to facilitate access to lateral pericardium areas that would not be accessible without CPB. Moreover, with the classic approach, it is even more critical to relieve the epicardial constriction on the ventricles rather than the atria alone. Cardiac arrest may be necessary to assist

dissection of the lateral LV surface when adhesions are firm, and the epicardial surface is fragile, or when concomitant procedures are required.

Evaluation of the mitral and tricuspid valves is essential. Surgical planning should account for the potential need for mitral and tricuspid repair. Even mild disease can progress after the removal of the “external annuloplasty” effect of the pericardium, as well as due to the hemodynamic changes resulting from the relief of constriction and recovery of cardiac output. This is particularly important in severe chronic CP, which can lead to annular dilation and worsening of valvular regurgitation postoperatively. Another mechanism of tricuspid regurgitation involves right ventricular (RV) dysfunction, which can stem from multifactorial causes such as surgical manipulation, hyperflow from the release of caval venous rings, and myocardial damage due to chronic inflammation. Worsening tricuspid regurgitation after pericardiectomy occurs in half of the cases and is associated with decreased survival. In fact, prophylactic annuloplasty should be considered in patients with moderate or greater preoperative tricuspid or mitral regurgitation.

The intraoperative and early postoperative management principles are “dry and tight,” meaning that positive fluid balances are kept to an absolute minimum, avoiding situations that lead to pulmonary hypertension (e.g., vasoconstrictors and desaturation), with enhanced diuretic therapy through sequential nephron blockade (loop diuretics, potassium-sparing agents, and SGLT2 inhibitors, with or without thiazide diuretics, especially chlorthalidone), avoiding bradycardia with temporary pacemaker support if necessary, considering dobutamine support according to RV response, and limiting volume expansion generally to blood products and albumin.

COMMENTARY:

There are currently no guidelines from the American College of Cardiology/American Heart Association for managing pericardial diseases. According to ESC recommendations, surgical treatment with pericardiectomy is the only definitive treatment for chronic CP.

The 2015 ESC/EACTS guidelines recommend resecting “as much as possible” of the pericardium while avoiding cardiopulmonary bypass, using it only in cases of uncontrollable bleeding. This guidance is somewhat subjective, as there is no consistent way to determine intraoperatively when “enough” pericardium has been resected. In fact, as previously noted, expert groups advocate for extended resection, including the use of CPB if necessary to achieve it.

Therefore, the current recommendation is to perform pericardiectomy via median sternotomy, considering the use of cardiopulmonary bypass for a more aggressive resection, as partial resections can lead to recurrence. The use of CPB has the drawback of a higher incidence of bleeding, which must be taken into account during the intervention. In cases of postoperative heart failure, early consideration for support with ECMO or oxy-RVAD may be warranted.

Ultimately, one of the limiting factors in decision-making is the stage of disease progression at the time of diagnosis, which may be late, resulting in missed treatment opportunities and compromised patient prognosis. Currently, we have non-invasive multimodal imaging methods that enable early diagnosis, changing prognosis and improving patients' quality of life.

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Miguel Ángel Parada Nogueiras

A review of myocardial protection in cardiac surgery: a retrospective since 2020

This literature review revisits the pathophysiological principles of ischemia, reperfusion, and myocardial ischemia tolerance, as well as the concepts of myocardial protection and the main evidence on outcomes among different cardioplegia solutions retrospectively since 2020.

The heart requires a continuous supply of oxygen and substrates to maintain contractile function. The interruption of blood flow is termed ischemia, while its resumption is called reperfusion, which itself induces a myocardial injury mechanism known as reperfusion injury. It is often challenging to distinguish this from ischemic damage, so the combined term ischemia/reperfusion injury is used. During myocardial ischemia, there is a period during which cardiac function can fully or partially recover, known as the ischemia tolerance period. Once this period is surpassed, irreversible myocardial damage will occur. In humans, this timeframe is approximately 20 minutes under normothermic conditions.

With the advent of cardiopulmonary bypass (CPB), the need to extend heart function exclusion times increased. The primary metabolic approach applied to extend myocardial ischemia tolerance was cooling to reduce oxygen consumption. Surgeons operated under the motto "operate as fast and as cold as possible." To improve myocardial protection (MP), inducing cardiac arrest by modifying cellular membrane potentials was also evaluated. This approach was termed "cardioplegia."

Cold cardioplegia (CP) is currently the most used technique in cardiac surgery (CS) worldwide. MP strategies have remained unchanged for decades, with the most recent being the Del Nido CP, dating back to the 1990s. Comparing the number of CS articles published in the 1990s and 2010s, scientific production tripled, while publications related to MP or CP halved.

Patient profiles have changed; they are older with more comorbidities, while CP solutions remain the same.

– Comparison of cardioplegic solutions and administration techniques:

CP types can be differentiated based on solvent (crystalloid or blood), mechanism to achieve asystole (extra- or intracellular ionic profile, hyperdepolarization), temperature (cold-warm-hot), administration route (antegrade, retrograde), or dose frequency (single, intermittent, continuous). This results in the elimination of the spontaneous generation and propagation of electrical impulses that trigger myocardial contraction.

The most commonly used crystalloid CP is Bretschneider (HTK or Custodiol®). Low sodium concentrations prevent rapid ion influx through the cell membrane, arresting the action potential in a hyperpolarized state. Solutions with high potassium concentrations are blood-based CPs that inhibit intracellular ion efflux during membrane repolarization, resulting in asystole in a depolarized state. Combining both is possible, as in Del Nido CP, which inhibits both mechanisms. In all cases, electrical excitation of the contractile apparatus is blocked, keeping the heart still and relaxed for easy manipulation.

[For previous articles on the use of Del Nido cardioplegia: https://secce.es/en/lights-and-shadows-in-the-use-of-del-nido-cardioplegia-in-cardiac-surgery/]

The main challenge in CP solution studies lies in the significant variability in conditions and protocol applications. Nonetheless, outcomes are surprisingly similar.

Studies comparing blood versus crystalloid CP found higher postoperative bleeding with crystalloid CP and greater inotropic use with blood CP, with no differences in other variables, primarily mortality. A meta-analysis reported lower low cardiac output syndrome (LCOS) and myocardial damage markers with blood CP, with similar mortality and myocardial infarction (MI) rates, while another study found no significant differences in study variables, including MI, LCOS, and mortality.

Another study comparing cold versus warm blood CP found no temperature impact on survival or perioperative mortality, though CK-MB levels were higher with cold CP. A meta-analysis reported increased biomarker release and lower cardiac index with cold CP, with no effect on morbidity and mortality.

In addition to myocardial damage markers and cardiac output indices, myocardial damage can also be assessed by cardiac edema, though it is challenging to measure. Mehlhorn et al. evaluated this in an animal model comparing blood versus crystalloid CP, finding no differences.

Regarding the administration route, a study comparing antegrade versus retrograde cold blood CP found no differences, while another with crystalloid CP reported higher troponin levels in the antegrade route.

A meta-analysis comparing single versus multidose administration found no significant differences in mortality or MI.

– Cardio-specific effects of cardioplegic solutions:

MP strategies extend myocardial ischemia tolerance, though this period may not be harmless. A study analyzing mortality with aortic cross-clamp time (TCA) reported a 2.2% mortality, identifying TCA as an independent predictor.

Another cardiac transplant study associated prolonged ischemia with higher 30-day mortality. A strong association between TCA and mortality was found in this systematic review. There is a notable difference in CP's ability to extend ischemia tolerance between young and older patients. Age is a key cofactor traditionally linked to increased postoperative morbidity, identified as an independent risk factor in most analyses. However, age's specific impact on TCA and outcomes has never been evaluated in the context of CP solutions.

Another CP-related factor is the need for CPB, which introduces additional trauma during cannulation and manipulation. Data from the PARTNER 3 study comparing low-risk surgical patients in conventional surgery versus transfemoral TAVI showed right ventricular dysfunction in most surgical patients, absent in TAVI. Further investigation is required, as despite this, long-term morbidity and mortality outcomes still favor conventional surgery.

– Extra-cardiac effects of cardioplegic solutions:

Significant volumes of CP solution enter the systemic circulation, potentially leading to adverse extra-cardiac effects.

Systemic vascular resistance (SVR) reduction is known in CPB CS. Characterized by hypotension, it is associated with higher morbidity and longer recovery times. Carrel et al. demonstrated that low SVR correlates with total CP volume. Certain CP types (crystalloids) result in more severe vasoplegia, necessitating higher vasopressor support. This effect can be significantly reduced by aspirating the solution from the coronary sinus during administration to prevent systemic entry.

Perioperative renal dysfunction is a dreaded complication associated with increased morbidity and mortality. The main risk factor for acute renal damage is pre-existing renal insufficiency, which can be exacerbated by hypotension, LCOS, inotropic/vasopressor support, or low perioperative hematocrit. Renal damage is often evaluated as a secondary outcome in studies, leading to statistical Type I error. Therefore, dedicated randomized trials are needed to investigate renal function parameters as primary outcomes.

CP administration may affect brain function due to electrolyte imbalance (hyponatremia) or hemodilution. Studies indicate higher cerebral infarction incidence with warm and retrograde CP, as well as greater postoperative delirium and seizures (in pediatric patients) and cerebral edema (animal models).

– Current innovations:

Research has continued, though rarely seen in the operating room. Dobson et al. tested a normokalemic hyperpolarizing solution, resulting in superior MP compared to St. Thomas solution.

The main innovation is Custodiol-N®, an improved version of classic Custodiol® with added iron chelator to reduce oxidative damage and L-arginine to enhance endothelial function, showing reduced postoperative CK-MB levels.

Another MP optimization method involves ischemia/reperfusion conditioning techniques, though evidence remains inconclusive.

These results suggest that current CP solutions are equally effective. However, the role of age, impact on other organs, and effects on short- and long-term left and right ventricular function must be evaluated to select the best MP strategy. Specifically, factors such as ischemia duration, impact on baseline cardiac function, and extra-cardiac CP effects require further detailed investigation.

COMMENTARY:

The emergence of new CP solutions or “miracle” strategies to improve MP seems unlikely. As reflected in the article, CS outcomes continue to improve over time, despite the absence of changes in MP in recent decades. Therefore, we can consider that CP fulfills its function, and the improvements observed are attributed to advances in perioperative care, surgical techniques, materials, and perfusion methods.

Each surgical team selects the CP they deem most suitable, and the similarity in results among different strategies highlights the lack of evidence favoring one over others. Each CP type has unique properties that should be considered in individualized selection based on comorbidities (diabetes, HTN, renal insufficiency), CS type (long, short, with circulatory arrest), and patient characteristics (hematocrit, body surface area), etc.

Crystalloid CPs cause more hemodilution, reducing hematocrit. Hyperpolarizing crystalloid CPs cause hyponatremia, and others containing glucose can lead to hyperglycemia, especially in diabetic patients. Single-dose CP administration must be accurate, as errors lead to insufficient MP with severe consequences, and there are no established protocols for redosing. Multidose strategies may extend CPB time. Solutions exist for all these side effects, such as diuretics, hemoconcentrators, sodium administration, insulin, CP redosing in single doses, or optimal administration timing in multidose strategies to minimize surgical interference.

Thus, even today, CP selection often remains a matter of “it works for me.”

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Miguel Ángel Parada Nogueiras

Conventional extracorporeal circulation versus minimally invasive extracorporeal circulation in cardiac surgery patients: a randomized controlled trial (COMICS)

This international, multicenter randomized controlled trial involved 1,039 adult patients. It compared outcomes in scheduled or urgent cardiac procedures—coronary artery bypass grafting (CABG), aortic valve replacement (AVR), or a combination of both—using either conventional extracorporeal circulation (CECC) or minimally invasive extracorporeal circulation (MiECC).

Advances in cardiac surgery continue with new techniques, as well as developments in extracorporeal circulation (ECC) technology aimed at minimizing procedural invasiveness. These innovations in ECC seek to mitigate adverse effects arising from blood contact with artificial surfaces, coagulation activation, hemodilution, and hypoperfusion, which lead to microcirculatory dysfunction. MiECC represents a more physiological approach to intraoperative perfusion, designed as a closed system that better preserves microcirculation and coagulation integrity, and improves organ perfusion.

In this study, the authors performed a multicenter, randomized, controlled trial comparing MiECC with CECC in all patients undergoing elective or urgent cardiac surgery without circulatory arrest. Procedures included CABG, AVR, or a combined operation. The MiECC system adhered to the specifications required in the European Community and employed Type II, III, and IV systems as described by Anastasiadis et al. in 2015.

The initially estimated sample size was 3,500 patients. However, due to COVID-19, the steering committee recommended early termination of the trial, resulting in data collection from 1,039 patients, with 522 in the CECC group and 517 in the MiECC group. The hypothesis was that MiECC would reduce the proportion of patients experiencing serious adverse events (SAEs) compared to CECC.

Preoperative characteristics were similar between groups, with an average age of 66 years, and 83% of participants were male. Most had a left ventricular ejection fraction (LVEF) >50% (71%), were classified as <III on the CCS scale (79%), and scored I or II on the NYHA scale (78%). The median EuroScore II was 1.24 (IQR 0.83–2.05). Of the total participants, 84% underwent CABG, 9% AVR, and 6% combined procedures. Elective surgeries comprised 87.1%, urgent surgeries 11.9%, and emergency surgeries 1%. Cardioplegia techniques were comparable across groups (blood cardioplegia in 80.9%, warm cardioplegia in 64.6%, antegrade in 88.7%, and intermittent in 98.2%). Average times for cardiopulmonary bypass and aortic cross-clamping were 88 and 57 minutes, respectively.

Primary SAEs included mortality, myocardial infarction, stroke, intestinal infarction, postoperative renal failure (AKIN III) and/or need for renal replacement therapy, reintubation, tracheostomy, mechanical ventilation >48h, reoperation, percutaneous intervention, sternal wound infection with dehiscence, and sepsis, assessed up to 30 days post-surgery. In the CECC group, 13.2% of patients experienced one or more SAEs, compared to 9.7% in the MiECC group. After adjusting for center stratification, the risk ratio (RR) was 0.73 (95% CI, 0.56–0.96; p = .025). The most frequent SAEs included reintubation (CECC 5% vs. MiECC 2.5%), reoperation (CECC 4% vs. MiECC 3.3%), mechanical ventilation >48h (CECC 2.7% vs. MiECC 2.5%), and AKIN stage III renal failure (CECC 1.9% vs. MiECC 2.5%). Mortality rates were 1.9% in CECC and 1.5% in MiECC (RR = 0.80; 95% CI, 0.36–1.74; p = .568).

Secondary outcomes assessed up to 30 days post-surgery included all-cause mortality, other SAEs (with 20 defined as secondary outcomes, most frequently cardiac arrest (1.3%), supraventricular tachycardia/atrial fibrillation requiring treatment (1.1%), inotropic support (1.4%), and vasodilator therapy (1.1%)), blood transfusions, ICU and hospital stays, and health-related quality of life (HRQoL) measured by the EQ-5D-5L survey, which includes a visual analog scale (VAS). These events occurred in 13.4% of the CECC group vs. 10.5% of the MiECC group (RR = 0.79; 95% CI, 0.53–1.18; $p = .25$). Red blood cell transfusions were required in 38.6% of CECC patients compared to 32.4% of MiECC patients (RR = 0.84; 95% CI, 0.7–1.01; $p = .067$), while other blood component transfusions occurred in 10.6% of CECC patients vs. 11.2% in MiECC (RR = 1.07; 95% CI, 0.81–1.41; $p = .65$). ICU (median 24 hours) and hospital stays (median 7 days) did not differ significantly between groups. Minor differences were observed in EQ-5D-5L descriptive system medians (0.80 for MiECC and 0.77 for CECC), with no significant differences in VAS scores. Average VAS scores were higher in MiECC (76.6 and 84.1 at 30 and 90 days, respectively) than CECC (73.3 and 81.9), with a significant difference ($p < .001$), indicating a higher perceived health status in the MiECC group.

These findings suggest that MiECC significantly reduces primary SAEs but does not significantly impact mortality, non-primary SAEs, hospital stays, or transfusion rates. However, MiECC had favorable treatment effects for nearly all outcomes, including perceived HRQoL. Due to sample size limitations from early trial termination, the study could not individually assess primary outcomes, although MiECC had lower event rates for all outcomes except AKIN III renal failure. This trial also showed a significant improvement in MiECC group HRQoL based on the EQ-5D-5L VAS.

This pragmatic study allowed diverse MiECC types, reflecting current clinical practice, and permitted various components to optimize CECC. However, biocompatible tubing, retrograde autologous priming, and centrifugal pumps were used in many CECC patients, reflecting a trend towards MiECC that may reduce intergroup differences. Additionally, lower EuroScore II values among participants may partly explain less pronounced findings than prior studies. The main study limitation was a smaller sample size due to early trial termination during the COVID-19 pandemic.

In conclusion, MiECC reduced primary SAEs compared to CECC, was safe for other SAEs, and improved perceived HRQoL. Continuing CECC's convergence with MiECC is likely to further reduce differences between these technologies over time.

COMMENTARY:

MiECC represents a significant advancement in cardiac surgery, anticipated to be widely adopted given its theoretical benefits for patients. However, its widespread use has not been achieved, partly due to the learning curve required for all team members and continuous improvements in CECC techniques.

Perfusionists operate with non-reservoir circuits, reducing risks of air embolism or microbubbles but also limiting the safety margin for handling incidents. Without a venous reservoir, any drainage issue directly impacts pump flow, reducing safety in less experienced hands. Additionally, all blood aspirated from the surgical field and vented through cannulas must go to a cell saver. Using a centrifugal pump introduces nuances, as flow correlates with mean arterial pressure, and excessive VAD pressure can cause insufficient drainage, hemolysis, and microbubble formation.

Surgeons must carefully place venous cannulas to prevent air entry, which can compromise oxygenation and perfusion. These factors may explain MiECC's renal effects (AKIN III stage, requiring renal replacement in CECC 1.9% vs. MiECC 2.5%).

For anesthetists, volume management is more complex, relying on pharmacologically induced vasoconstriction/dilation due to the lack of a venous reservoir. This directly impacts mean perfusion pressure and perfusion quality.

As noted in this article, routine CECC techniques, coupled with smaller circuits and oxygenators, reduce hemodilution and blood contact with air and foreign surfaces, producing results that closely mirror MiECC outcomes. In trained teams, no significant differences emerge, though MiECC shows advantages suggesting CECC's future direction will increasingly resemble MiECC while balancing safety and blood-saving efficacy.

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Monica Requesens Solera

Novoseven® in cardiac surgery hemostasis: the seventh cavalry

A review article on postoperative outcomes of Novoseven® applied for controlling refractory bleeding after aortic surgery.
Recombinant activated factor VII (rFVIIa) was initially developed for treating patients with hemophilia. Its application has since extended "off-label" to achieve hemostasis in patients with uncontrollable bleeding, such as polytrauma cases or postoperative bleeding following certain surgeries.

Two coagulation factors are available: rFVIIa (recombinant activated factor VII, NovoSeven®) and factor 8 inhibitor (FEIBA®). This study focuses on the first, which binds to activated platelets, releases thrombin, and subsequently converts fibrinogen into fibrin to form a stable clot.

Postoperative bleeding is a common complication in surgical treatment of type A aortic dissection and thoracic aortic surgery, often resulting in significant morbidity and mortality. Although there is no consensus definition, refractory bleeding is considered present when bleeding persists despite conventional medical management and after ruling out surgically repairable causes. Coagulopathy in these patients is multifactorial, arising from cardiopulmonary bypass (CPB) usage, hypothermia, acid-base imbalance during circulatory arrest, and preoperative administration of antiplatelet and/or anticoagulant drugs. Moreover, several independent bleeding predictors exist, including advanced age, extreme body mass index, emergency surgery, low hemoglobin levels, and elevated fibrin degradation products.

International guidelines (The European Association for Cardio-Thoracic Surgery and European Association of Cardiothoracic Anaesthesiology) recommend considering rFVIIa for achieving hemostasis in refractory bleeding cases not amenable to surgical intervention, though not as a routine prophylactic measure for bleeding. Potential thromboembolic complications from its use include acute myocardial infarction (AMI), cerebrovascular accidents (CVA), deep venous thrombosis (DVT), and pulmonary embolism (PE).

This article reviews the currently available literature on the use of rFVIIa in treating refractory bleeding after thoracic aortic surgery. A search was conducted in major scientific databases, ultimately selecting 10 publications (n = 649 patients; 319 received rFVIIa, and 330 served as controls). The included patients underwent surgical repair for aneurysms or dissections of the ascending and/or descending thoracic aorta. The selected publications comprised 3 case series, 6 retrospective studies, and 1 non-randomized clinical trial.

The usual rFVIIa doses for hemophilia patients are 90-120 mcg/kg administered intravenously every 2-3 hours until bleeding ceases. However, there are no standardized dosing recommendations for off-label use, with a wide range observed across studies, from 23 to 100 mcg/kg. Additionally, the minimum effective dose to correct coagulopathy without increasing thromboembolic risk has not been defined.

Evaluated outcomes included:

- Changes in International Normalized Ratio (INR): Six studies demonstrated improvement in INR/prothrombin time following rFVIIa administration. Of these, two studies reported significant reductions.

- Postoperative Blood Loss (including drainage output and need for blood product transfusion): Three studies reported a significant reduction in drainage output after rFVIIa administration; one study noted a decreased need for intraoperative blood transfusion, and two studies found this effect in the postoperative period. One study showed no significant differences in postoperative drainage output; two studies reported increased drainage output in the rFVIIa group, though without reaching statistical significance. This latter outcome could be justified, as rFVIIa was administered solely to patients with uncontrollable refractory bleeding.

- Incidence of Thromboembolic Complications (DVT, AMI, PE, CVA, mesenteric ischemia): Seven studies found no significant differences between the two groups.

- Duration of CPB and Aortic Cross-Clamp: One study reported longer aortic cross-clamp time in the rFVIIa group. In studies evaluating CPB duration, no significant differences were found.

- Need for Surgical Reexploration: Five studies found no significant differences; one study noted less need for reoperation in the rFVIIa group, though with limited statistical power due to small sample size; one study reported a higher reoperation rate in the rFVIIa group. The studies did not specify the reason for reexploration (persistent bleeding vs. cardiac tamponade) or intraoperative findings (diffuse coagulopathy vs. bleeding from a specific site related to the initial intervention).

- Postoperative Mortality: Among seven studies including both rFVIIa and control groups, rFVIIa use was not significantly associated with increased mortality.

Due to the heterogeneity of the included studies (in both design and population), not all measured variables could be compared to achieve statistical significance.

rFVIIa was administered both intraoperatively after CPB weaning and postoperatively in the intensive care unit. In one study, it was given prophylactically with platelets immediately after CPB weaning, regardless of postoperative bleeding status.

All studies concluded that there is a potential role for rFVIIa use in this context. However, sufficient evidence to indicate that its use is associated with higher thromboembolic complication rates or mortality was not reached, contrary to findings in previous meta-analyses, likely due to the small sample size. Other limitations of the study include variability in local protocols among different populations and brief and varied follow-up periods, complicating comparisons, and possibly underestimating long-term mortality. Cost-effectiveness of rFVIIa in comparison with other agents was not analyzed, nor were viscoelastic tests such as thromboelastography (TEG) or rotational thromboelastometry (ROTEM) employed.

The authors of this review conclude that the currently available scientific evidence, although limited, suggests that rFVIIa may be useful in managing refractory bleeding in the postoperative period of thoracic aortic surgery. However, its impact on thromboembolic complication rates and mortality remains unclear.

COMMENTARY:

Cardiac surgery is associated with potential perioperative bleeding and a high likelihood of requiring blood product transfusion (with potential side effects) due to invasive procedures, exposure to CPB, and the need for high doses of anticoagulation. The need for surgical reintervention due to bleeding or cardiac tamponade also increases postoperative morbidity and mortality.

Perioperative management can help maintain adequate hemostasis and minimize bleeding risk, reducing transfusion requirements. Multiple factors increase bleeding risk, such as advanced age, prior dual antiplatelet therapy, preoperative anemia, low body mass index, unscheduled surgery, complex/multiple procedures, non-coronary surgery, or reoperations due to prior cardiac surgery. Identifying patients at higher risk of bleeding is important for pre-, intra-, and postoperative management. Multidisciplinary management among cardiac surgeons, anesthesiologists, perfusionists, and intensivists contributes to minimizing perioperative bleeding, improving outcomes, and reducing costs.

In the postoperative period of cardiac surgery, it is essential to assess the patient's hemostatic status to guide treatment of coagulopathy through blood product transfusion. Current recommendations from international guidelines in this context include:

- Antifibrinolytics like tranexamic acid reduce bleeding, transfusion needs, and reoperation for bleeding.
- Use of fresh frozen plasma (FFP) or prothrombin complex (PCC) to reverse the action of vitamin K antagonists.
- Administration of fibrinogen at low plasma levels (< 1.5 g/L).
- If there is a deficiency in coagulation factors, administer FFP or PCC.
- Consider desmopressin for platelet dysfunction.
- In refractory bleeding not amenable to surgical intervention, consider off-label use of rFVIIa. Prophylactic use is not recommended.

However, adherence to these guidelines remains low, with significant variability in transfusion practices. Beyond re-establishing hemostasis, physiological disturbances that may exacerbate coagulopathy, such as hypothermia and acidosis, should also be corrected.

rFVIIa is considered the final treatment step for refractory bleeding. Although its action is theoretically localized to the vascular injury site, it may induce systemic activation of the coagulation cascade. Its half-life is approximately 2.5 hours.

Off-label use of rFVIIa appears to be associated with an increased risk of thromboembolic complications, although this has not been clearly demonstrated. Additionally, dosage seems to influence complication rates, being more frequent at higher doses. Advanced age and the coagulopathic state/type of bleeding are independent risk factors for thromboembolic events. The bleeding cause also seems relevant, with higher event rates observed in cases of severe traumatic brain injury and cerebral hemorrhage. Notably, in many studies analyzing this issue, patients who developed thromboembolic complications also received other blood products besides

rFVIIa, which may increase thrombotic risk. Current studies suggest that rFVIIa use increases arterial thromboembolic event risk more than venous events.

In recent years, bedside coagulation monitors, such as ROTEM or TEG, have become more widespread, offering qualitative coagulation assessments as an advantage over conventional tests. This is particularly useful in scenarios where patients may have received prior antiplatelet or anticoagulant therapy. Their use has demonstrated reduced transfusion requirements and should be progressively integrated into local perioperative bleeding management protocols.

Large, randomized controlled studies with larger sample sizes are necessary to expand knowledge on the potential benefits and complications associated with rFVIIa use in this context. Furthermore, research should focus on dosing, timing/administration criteria, and cost-effectiveness. Until such studies are conducted, individualization based on patient characteristics and clinical context is essential to assess the risk-benefit in each situation before administration. Currently, “off-label” doses most commonly used to minimize thromboembolic risk are 20-40 mcg/kg.

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Loreto López Vergara

Heparin-Induced Thrombocytopenia Following Cardiac Surgery: What Is the Real Impact?

A retrospective study conducted in the United States analyzed the incidence, outcomes, and costs associated with heparin-induced thrombocytopenia (HIT) in patients undergoing cardiac surgery.

Heparin-induced thrombocytopenia (HIT) is a rare but potentially life-threatening reaction to heparin. It occurs when a patient develops antibodies against a heparin-platelet factor 4 (PF4) complex, leading to platelet activation. This process results in thrombocytopenia and an increased risk of venous and arterial thrombosis, affecting up to 50% of untreated patients.

Diagnosing and treating HIT can be particularly challenging, especially in patients requiring systemic anticoagulation in the perioperative context of cardiac or vascular surgery.

This study aimed to determine the incidence, risk factors, and complications associated with HIT in post-cardiac surgery patients, as well as to analyze the healthcare resource consumption it entails at the hospital level. A retrospective analysis was conducted in the United States (Maryland) from 2012 to 2020. Among 33,583 cardiac surgery patients identified through the Maryland Health Services Cost Review Commission's database, 184 (0.55%) were diagnosed with postoperative HIT. This incidence remained stable throughout the study period. Patients aged 18 years and older with diagnoses identified via ICD-9 and ICD-10 codes were included. Postoperative complications (e.g., hemorrhages, stroke, thromboembolic events), length of hospital stay, mortality, readmission rates, and relevant costs (both for the initial surgery admission and subsequent readmissions) were compared between patients with and without HIT.

Patients with HIT were older (> 80 years; $p < .001$) and presented more severe illness at admission ($p < .001$). Additionally, HIT patients had higher mortality rates (13.6% vs. 2.3%; $p < .001$), longer hospital stays (21 vs. 7 days; $p < .001$), higher hospital costs ($123,160 vs. $45,303; $p < .001$), greater risk of bleeding complications (7.6% vs. 1.1%; $p = .002$), and thromboembolic events (9.8% vs. 1.1%; $p < .001$), even after propensity score analysis. HIT patients exhibited a higher readmission rate than non-HIT patients, bordering statistical significance (63.4% vs. 53.3%; $p = .05$). However, there were no differences in the median number of readmissions or in total costs incurred by both patient groups during readmission periods.

The authors concluded that patients with HIT not only experience worse outcomes and more complications during the postoperative period following cardiac surgery but also generate higher costs during the initial hospital stay. Given these findings, the authors emphasized the need to implement strategies aimed at minimizing the risk of HIT in these patients.

COMMENTARY:

As previously mentioned, HIT is a rare complication; however, considering the risk factors associated with its occurrence—advanced age, surgery, female sex, prior use of unfractionated heparin (particularly at therapeutic doses), renal failure, and ultrafiltration therapies—it has a higher prevalence (1–3%) in patients with cardiovascular conditions, especially those requiring surgical intervention.

It is essential to understand that there is no dose of heparin low enough to completely prevent the development of HIT. Even heparin flushes or heparin-coated catheters may

be sufficient to trigger it. Additionally, HIT can occur with exposure to any form of heparin, regardless of the administration route or exposure duration. However, diagnosis requires a marked thrombocytopenia (a sudden or ≥ 50% decrease from baseline counts) and a positive test for PF4-heparin antibodies, without other apparent causes for thrombocytopenia. This point is critical given the broad differential diagnosis of thrombocytopenia in these patients (e.g., hemorrhage, sepsis, DIC, extracorporeal circulation-related consumption). The isolated presence of these antibodies does not increase thromboembolic risk, and current guidelines do not recommend routine antibody screening. This represents one of the study's main limitations, as the method used for HIT diagnosis and heparin exposure route is unclear. Additionally, both HIT and other diagnoses relied on whether they were coded using the ICD. Furthermore, the ICD code for thrombotic events does not specify when these events occurred. These factors may have introduced unmeasured variables that could confound the identified associations.

HIT typically occurs 5–10 days after heparin exposure, which explains the prolonged hospital stays and delayed discharges observed in this study, even in the absence of other surgical complications. On the other hand, the lack of statistically significant differences in the average number of readmissions and associated hospital costs between the two patient groups suggests that the major implications of this condition concerning morbidity and mortality occur during the acute phase. Therefore, it is during this period that attention should be focused.

The first thing to recognize is that the evidence available to guide management in this context is limited. This is due not only to the low incidence of HIT but also to the diagnostic challenges it presents, especially when urgent surgery is required, leaving insufficient time for a comprehensive preoperative evaluation. Moreover, avoiding intraoperative heparin exposure entirely may not always be feasible.

According to current guidelines, the cornerstone of treatment is to avoid unnecessary heparin exposure and ensure close monitoring for bleeding and thromboembolic complications, along with appropriate clinical and platelet count surveillance. Many hospital laboratories do not perform functional PF4-heparin antibody tests, and sending these tests to external facilities can take several days. This underscores how therapeutic decisions can vary significantly depending on the urgency of the surgery.

In urgent cases, a presumptive diagnosis is necessary. This can be established using a validated scoring system, known as the 4Ts, which evaluates the degree of thrombocytopenia, timing of onset in relation to heparin administration, presence of thrombosis, and other potential causes of thrombocytopenia. If a high probability of HIT is determined in a patient requiring urgent surgery, they should be managed as if HIT were present until definitive test results are available. The therapeutic options in such scenarios include:

1. Performing plasmapheresis or administering intravenous immunoglobulin before surgery if heparinization cannot be avoided.

2. Using alternative anticoagulants, such as bivalirudin, argatroban, or fondaparinux, depending on the clinical context and anticoagulation requirements.

3. Co-administering an antiplatelet agent with heparin, such as a glycoprotein IIb/IIIa receptor antagonist (e.g., tirofiban).

4. Administering epoprostenol alongside heparin.

All of these approaches are reasonable for managing HIT, although the level of supporting evidence is low, and no clear preference for one over another has been established. Generally, the choice depends on the clinician's expertise, institutional experience, and resource availability.

In cases of elective surgery, the management algorithm is more defined, as it is often possible to refine the diagnosis and, as recommended, delay surgery whenever feasible. Ideally, surgery should be postponed until PF4-heparin antibodies are no longer detectable, which typically takes approximately three months (up to 100 days).

In both surgical scenarios, and regardless of the chosen preoperative or intraoperative management strategy, postoperative anticoagulation—whether therapeutic or prophylactic—in a patient diagnosed with HIT must be performed using a heparin-free agent. However, restarting anticoagulation specifically for HIT in patients re-exposed to heparin is not indicated unless recurrent thrombocytopenia due to HIT reoccurs.

Gathering evidence on this topic confirms that HIT has a significant negative impact on patient prognosis. Nonetheless, the uncertainty surrounding the understanding and management of this condition remains a challenge, underscoring the need for vigilance in monitoring all patients with significant thrombocytopenia following cardiovascular surgery.

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Irene Cid Tovar

Acute Kidney Failure in Cardiac Surgery: Are Amino Acids Part of the Solution?

A randomized, multicenter clinical trial to assess whether perioperative amino acid administration reduces the incidence of postoperative acute kidney failure.

Acute kidney injury (AKI) is one of the most frequent complications occurring in the immediate postoperative period of cardiac surgery. Even mild AKI is associated with increased morbidity and mortality. Severe cases often require renal replacement therapy, leading to higher costs, reduced quality of life, and increased long-term mortality.

Animal studies have shown that protein loading may enhance glomerular filtration, introducing the concept of renal functional reserve, which represents the kidneys' ability to compensate or increase functionality in states of high metabolic demand or intrinsic kidney disease. It has been suggested that this renal functional reserve can be enhanced by protein loading, potentially providing a nephroprotective effect.

The PROTECTION study aimed to confirm or refute the hypothesis that intravenous amino acid therapy decreases the incidence of postoperative AKI compared to a placebo. This international, double-blind, randomized clinical trial included adult patients undergoing elective cardiac surgery with cardiopulmonary bypass (CPB). The amino acid infusion began at the time of surgery and continued for up to 72 hours or until ICU discharge, initiation of renal replacement therapy, or death (whichever occurred first). The patient's attending physician managed all other aspects of perioperative care. AKI was evaluated based on serum creatinine levels during the first 7 days post-surgery.

The primary outcome was the incidence of AKI within the first postoperative week, defined by KDIGO criteria based on serum creatinine levels. Secondary outcomes included AKI severity per KDIGO criteria, use and duration of renal replacement therapy during hospital stay, ICU and hospital length of stay, mechanical ventilation duration, and all-cause mortality from ICU discharge, hospital discharge, and at 30, 90, and 180 days post-randomization.

A total of 3,511 patients were analyzed. Regarding the primary outcome, a higher incidence of AKI was observed in the placebo group (555 vs. 474 patients; RR = 0.85; 95% CI = 0.77-0.94; p = .002) at hospital discharge. Most patients experienced mild AKI (KDIGO grade I), but significant differences were also observed in severe AKI cases (grade III) between the two groups (29 in the intervention group vs. 52 in the placebo group; RR = 0.56; 95% CI = 0.35-0.87). No statistically significant differences were found for the secondary outcomes, adverse events, or drug reactions.

The authors conclude that amino acid infusion appears to be safe and effective in preventing AKI in cardiac surgery patients. The low incidence of severe AKI (KDIGO grade III) in the amino acid group suggests not only a reduction in AKI incidence but also its severity.

COMMENTARY:

As previously mentioned, AKI is a common complication during the postoperative period of cardiac surgery, associated with high morbidity and mortality, increased costs, prolonged hospital stays, and reduced quality of life.

Regarding the clinical management of postoperative AKI, as explored in this article, I would like to briefly comment on the key aspects of diagnosis and treatment of postoperative AKI.

The KDIGO classification based on diuresis and serum creatinine levels (a substance directly linked to glomerular filtration without tubular secretion or reabsorption) was used for diagnostic purposes. This classification divides AKI into:

KDIGO Classification of Acute Kidney Injury

Stage	Serum Creatinine (mg/dL)	Urine Output (mL/kg/h)
0	Increase < 0.3 mg/dL from baseline	≥ 0.5 mL/kg/h
I	Increase > 0.3 mg/dL within 48 hours or 2-2.9 times baseline over 7 days	< 0.5 mL/kg/h for 6-12 hours
II	Increase ≥ 2-2.9 times baseline	< 0.5 mL/kg/h for >12 hours
III	Increase ≥ 3 times baseline; creatinine ≥ 2.5 mg/dL; renal replacement therapy required	< 0.3 mL/kg/h for 24 hours or anuria > 24 hours

The main limitation of this scale is that serum creatinine reflects renal function rather than injury. In cases where a drop in glomerular filtration rate is due to hemodynamic disturbances without significant tubular cell damage, the risk of poor outcomes is lower.

To identify patients with renal injury, biomarkers like cystatin C (a sensitive renal function marker) and lipocalin 2 (a marker of injury and a predictor of renal damage in patients without chronic kidney disease) are proposed.

In this study, AKI was diagnosed by serum creatinine levels per KDIGO classification. Therefore, we cannot ascertain whether the amino acid infusion provides functional benefits or actual renal tubular protection. The reduction in grade III AKI suggests a genuine therapeutic effect, although there were no significant secondary outcome differences in functional status, quality of life, or survival.

Currently, effective therapeutic strategies for AKI treatment are lacking, so management focuses on preventive measures.

Intraoperative measures to prevent AKI include avoiding hypotension, maintaining a mean arterial pressure above 65 mmHg, and using propofol, which may have protective effects. Surgical aspects, such as minimizing CPB time, are also considered to reduce AKI risk.

Perioperative preventive strategies include:

- Volume resuscitation: Ensure adequate volume replacement with crystalloids, avoiding colloids like gelatin or albumin due to their association with increased AKI incidence.
- Blood pressure maintenance: Noradrenaline is the vasopressor of choice, with vasopressin or methylene blue as alternatives if hypotension persists.
- Avoidance of nephrotoxins: Discontinue nephrotoxic drugs such as ACE inhibitors, ARBs, or diuretics before surgery.
- Hyperglycemia avoidance: Strict glucose control is recommended.
- Diuretics: No role in AKI prevention or treatment.

These measures are recommended to reduce postoperative AKI incidence in surgical patients. However, in this study, perioperative management was left to the discretion of

the attending physician and was not protocolized. Differences in management across multiple centers could have influenced results.

In conclusion, the findings of this study are promising, suggesting that amino acid infusion may serve as a preventive strategy against postoperative AKI with a low risk of complications. Further studies are needed to precisely evaluate renal injury and ensure protocolized perioperative management per current recommendations.

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José Manuel Martínez Comendador

Review of the Most Relevant Cardiac Surgery Articles of 2022: Overview Following the Conclusion of 2023

Review article from Thoracic and Cardiovascular Surgeon that revisits the most relevant articles published in 2022 in the field of cardiac surgery.

As is customary in the *Thoracic and Cardiovascular Surgeon*, and consistent with its tradition over the past decade, once again they provide a summary of the most interesting and significant articles in cardiac surgery for the year 2022. In this blog entry, our objective is to provide a coherent and structured account of these highlighted studies from 2022 and to attempt to emphasize in the commentary the most relevant conclusions of these studies, while also outlining some of the new trends in cardiac surgery that emerged throughout 2023. Given the abundance of evidence and the complexity of synthesizing it without losing essential information, this article will exceptionally have a longer length than usual. The innovations and trends in 2023 are based on selected articles and were exhaustively analyzed week by week in our blog "Cirugía Cardíaca Hoy," allowing us to offer a contextualized analysis of the research from the previous year.

– Ischemic Heart Disease:

In 2022, two prominent clinical trials raised concerns regarding the impact of invasive treatments on chronic coronary syndrome. One of these was the ISCHEMIA trial, which showed no improvement in survival with invasive diagnosis and treatment in symptomatic patients with inducible ischemia under medical management. The other was the REVIVED study, which demonstrated that percutaneous coronary intervention (PCI) had no significant impact on survival compared to medical treatment in patients with ischemic heart failure (ejection fraction equal to or less than 35%) and inducible ischemia. It is important to note that the invasive arm of the ISCHEMIA study included a minimal percentage of patients undergoing coronary artery bypass grafting (CABG). Grouping CABG and PCI under the generic term “revascularization” is unhelpful in this context, as both methods use completely different revascularization mechanisms, and their outcomes vary considerably depending on the context, as demonstrated repeatedly in the literature.

Interestingly, during 2022, cardiology literature tended to downplay the proven efficacy of CABG (compared to PCI) in improving survival for most patients with left main coronary artery disease (LMCA) and triple-vessel disease, particularly those with complex coronary anatomy, or in other words, with an intermediate or high Syntax SCORE.

In this regard, a meta-analysis conducted by Gaudino et al. in the same year, based on contemporary clinical trials and encompassing a total of 2,523 patients (all receiving at least aspirin, statins, and beta-blockers), reaffirmed findings established over 30 years ago (when optimal medical treatment was not yet available): improved survival with CABG compared to PCI.

Furthermore, in 2022, evidence continued to accumulate regarding the benefits of medical treatment in the context of CABG. For instance, a sub-analysis of the ticagrelor clinical trial in CABG, published by Heer et al., revealed that optimal medical therapy reduces morbidity and mortality. Another meta-analysis, which included four clinical trials, demonstrated that the use of ticagrelor in the postoperative period after CABG improves graft patency, though with the drawback of an increased bleeding risk.

Senior et al., after analyzing the ISCHEMIA trial population, concluded that stress testing alone is insufficient to detect LMCA disease, highlighting the necessity of anatomical imaging tests. Meanwhile, Ono et al. suggested that the presence of proximal lesions in the left anterior descending artery in SYNTAXES trial patients should not influence the selection between PCI or CABG. However, Ninomiyha et al. demonstrated that CABG is superior to PCI for bifurcation lesions. In a sense, the advantage of CABG over PCI does not stem from addressing an isolated lesion but from mitigating the overall risk of coronary events, as Gaudino et al. demonstrated in another meta-analysis. In other words, if the risk of coronary events is high, CABG is superior to PCI, whereas if the risk is low, PCI is not inferior. This hypothesis has been tested repeatedly in the evidence and cannot be ignored.

Caldonazo et al. demonstrated a significant advantage in mortality and long-term major events with CABG compared to PCI by analyzing the most relevant registries from 18 different countries, without finding significant differences in periprocedural mortality. These results are, moreover, consistent with previously published clinical trials. Additionally, very similar outcomes were replicated in the study by Derrick et al., who compared CABG with PCI in left main coronary artery disease among Canadian patients with chronic coronary disease through propensity score analysis.

In specific cases of acute coronary syndromes, CABG has also recently shown benefits over PCI, as observed in diabetic patients in the study by Ram et al. A similar survival benefit was found in the study by Rocha et al. in patients with multivessel disease treated with CABG. Additionally, the meta-analysis by Tasoudis et al. corroborated this benefit, this time in patients on dialysis.

Although CABG's reiterated superiority over PCI is mostly observed in clinical registries, with the inherent biases these entail, the overwhelming amount of studies supporting CABG and the scarcity of studies in favor of PCI underscore the importance of making decisions in consensus with the Heart Team. This consensus approach is essential to counteract the documented tendency to favor PCI in centers lacking a systematically implemented Heart Team with cardiac surgery representation, as demonstrated by El-Andari et al. in an interesting Canadian study that same year.

There is no doubt that optimizing CABG outcomes requires maintaining graft patency. In a post hoc analysis of the COMPASS study, Alboom et al. reported a higher-than-expected graft failure rate of the right internal thoracic artery (27% within a year of surgery), detected by computed tomography. Conversely, a retrospective study reaffirmed the excellent results of the radial artery as a second graft option. Gaudino et al., analyzing data from the four largest clinical trials, concluded that the radial artery as a second graft is superior to the saphenous vein or the right internal thoracic artery. To clarify this topic, Urso et al., in a dual meta-analysis, demonstrated that using a bilateral internal thoracic artery is superior to a combination of internal thoracic and radial arteries, although significant differences only emerge after more than 10 years of follow-up. Other authors, like Doenst et al., also emphasized that surgical precision and experience in performing anastomoses may play a role as crucial as graft type selection.

– Aortic Valve Disease:

Following the publication of the new valve disease guidelines in 2021, the advancement of transcatheter aortic valve implantation (TAVI) over surgical aortic valve replacement (SAVR) for severe aortic stenosis (AS) gained momentum. In 2022, Myer et al. published a position statement from surgical societies highlighting the strengths and limitations of the VARC 3 definitions.

The only randomized study that compared TAVI with SAVR was the UK TAVI trial, which found no significant differences in 1-year mortality between the groups when analyzing patients over 70 years with moderate risk, reinforcing the evidence for equally favorable or slightly better short-term outcomes with TAVI. In another original study, Chung et al. showed that high-risk patients with CoreValve spent more time at home (an additional 4 weeks in the first year) compared to those who underwent surgery, with no other significant differences after 4 years of follow-up.

In summary, it appears well established that SAVR results in slightly higher transvalvular gradients and an increased incidence of atrial fibrillation, while TAVI procedures are associated with a greater need for pacemaker implantation, a higher tendency for thrombosis (with clinically uncertain implications in many cases), more paravalvular leakage, and possibly slightly lower long-term survival. In this regard, in 2022, a Polish registry showed better 5-year survival with SAVR but equally favorable or slightly better short-term results with TAVI. These findings confirm results previously observed in German, Italian, and French registries. However, a post hoc analysis by O'Hair et al. of patients from three intermediate- to high-risk trials (U.S. CoreValve High Risk Pivotal, SURTAVI, and CoreValve Extreme Risk Pivotal) revealed that structural valve degeneration (SVD) at 5 years was lower with TAVI than with surgical bioprostheses. Therefore, the potential survival difference favoring SAVR likely results from a combination of factors rather than a single one. Given these results, along with the guidelines that set an arbitrary age threshold of over 75 years for TAVI and under 75 years for SAVR in low-risk patients, it is crucial to adopt a flexible approach, considering individual patient characteristics within the context of the local Heart Team.

In patients with mild to moderate renal insufficiency, studies such as the GARY registry found no differences between TAVI and SAVR after five years. Other studies, such as the PROTECTED TAVR trial, showed no reduction in stroke incidence with TAVI when using embolic protection devices.

The AVATAR clinical trial demonstrated improved morbidity and mortality outcomes in asymptomatic patients with severe aortic stenosis who underwent surgical treatment compared to conservative management.

Other authors have focused on specific complications. Fukui et al. demonstrated that TAVI bioprostheses undergoing deformation during implantation represent a risk factor for prosthetic thrombosis, also referred to as hypoattenuated leaflet thickening (HALT).

On the other hand, Squiers et al., through a meta-analysis, demonstrated that the Carpentier Edwards® Magna Ease® surgical bioprosthesis has greater durability than the Mitroflow®/Crown® or St. Jude Trifecta® bioprostheses. The St. Jude Trifecta® valve, specifically, was withdrawn from the market the following year due to its high risk of SVD after 5 years. In any case, the study suggests that it is not simply whether the prosthesis is porcine or bovine pericardial but rather the specific design characteristics of each prosthesis that determine the long-term performance of a bioprosthesis. These positive results for the Carpentier Edwards® Perimount® bioprosthesis (predecessor of the Carpentier Edwards® Magna Ease®) were confirmed in the Swedish SWEDEHEART registry, which analyzed nearly 17,000 patients with surgical bioprostheses. Lastly, Sotade et al. demonstrated similar outcomes when comparing biological and mechanical valves in patients aged 55 to 64 years over a 10-year follow-up; however, with longer follow-up, mechanical valves showed a mortality advantage, likely due to a reduced incidence of reoperations.

The Ross procedure was evaluated in two studies in 2022, with an average patient age of 40 years. In the study by El-Hamansy et al., superior survival and lower incidence of

valve-related complications at 15 years were observed in patients undergoing the Ross procedure, after matching this group with those receiving mechanical and biological prosthetic aortic valve replacements. In another study by Mazine et al., these same differences were found when comparing the Ross procedure with bioprostheses. Therefore, these two publications reaffirm that the Ross, once considered a high-risk option, is now a feasible and real alternative.

A similar shift has occurred in aortic valve replacement reoperations, which carried nearly a 4% risk in the 1980s. Studies like the one by Mahboubi et al. currently place this risk at 1.3%, a level comparable to primary intervention for a native aortic valve. This is an important consideration for Heart Teams in decision-making for these patients.

– Mitral Valve Disease:

As with the aortic valve, direct comparisons between interventional and surgical treatments for the mitral valve have become increasingly rare over the past two years, aligning with established clinical guidelines and the drastic reduction in surgical indications. In a meta-analysis by Nappi et al., which evaluated the impact of 12 clinical trials on the invasive treatment of functional mitral regurgitation (MR), it was concluded that functional MR is a complex entity in which MitraClip® only reduces hospital readmissions compared to medical treatment. However, in a retrospective study, Sannino et al. found no significant improvement in MR when comparing MitraClip® with conservative treatment, but they did observe better survival in patients who no longer had severe MR, regardless of the treatment type. Similar results were obtained a year earlier in a two-year analysis of the COAPT study. Both studies suggest that durable elimination of MR, irrespective of the mechanism or treatment modality, appears to offer the greatest potential to increase survival.

Conversely, surgical mitral repair continues to show superior outcomes in terms of survival compared to mitral valve replacement, as reflected in two publications from 2022. Other studies also showcase the relentless progress in the surgical field of the mitral valve. Sabatino et al. demonstrated that it is possible to safely discharge selected patients three days postoperatively. Additionally, other studies reinforce the excellent long-term results of surgical mitral repair for structural MR. Increasingly, research confirms the trend toward non-sternotomy approaches with favorable results, though robotic surgery does not demonstrate a significant improvement in pain management.

– Tricuspid Valve Disease:

Undoubtedly, the most relevant publication in 2022 was the CTSN Tricuspid trial, in which 401 patients were randomized to concomitant tricuspid annuloplasty versus isolated mitral valve surgery in patients with mild to moderate tricuspid regurgitation (TR). The study demonstrated greater freedom from TR progression in the tricuspid annuloplasty group, though at the cost of a higher incidence of pacemaker implantation (2.5% vs. 14.1%). Other publications also emphasized isolated TR, increasingly recognized as a more harmful condition than previously thought.

Russo et al. suggested that isolated tricuspid surgery, performed on a beating heart, is associated with improved survival. Additionally, new predictive scales for prognosis in tricuspid surgery have begun to emerge. Färber et al. demonstrated that the MELD score (Model for End-Stage Liver Disease) with a score above 20 points is a much better predictor of mortality than traditional cardiac surgery scores. Meanwhile, Dreyfus et al. proposed the TRI-SCORE with exactly the same objective.

– Aortic Diseases:

In 2022, multiple publications pointed to the positive outcomes associated with frozen elephant trunk techniques in aortic dissection surgery, especially in specialized centers and in younger patients with specific anatomical criteria.

In terms of alternative treatments, a retrospective series from Italy reported on high-risk type A aortic dissection patients treated using aortic wrapping with Teflon sheets, without the use of extracorporeal circulation. This study demonstrated an acceptable short-term mortality rate (9%) and very favorable three-year outcomes (83% survival), suggesting this less invasive approach could be viable for borderline patients, particularly those with limited life expectancy.

In the context of malperfusion syndrome, a meta-analysis revealed improved outcomes when revascularization was performed prior to aortic repair surgery, compared to an approach prioritizing aortic repair first. This may signal a paradigm shift from current practices.

– Advanced Heart Failure (AHF):

In the field of advanced heart failure, 2022's highlight was undoubtedly the first xenotransplant performed on a 57-year-old patient using a genetically modified pig heart. However, after the initial days, the patient required mechanical circulatory support and ultimately passed away 60 days later, with cytomegalovirus infection suggested as the primary cause. This milestone opens the door to an unexplored path.

Regarding long-term left ventricular assist devices (LVADs), the MOMENTUM3 trial provided a new tool, the HM3 score, which appears to accurately predict outcomes for these patients, facilitating future decision-making.

COMMENTARY:

– Ischemic Heart Disease:

Summarizing the 2022 publications in this field, we can conclude that:

– Evidence supporting coronary surgery as the gold standard for treating coronary artery disease, especially in cases of multivessel and/or high anatomical complexity, continues to grow.

– Among patients selected for CABG worldwide, long-term survival appears superior to those treated with PCI, regardless of geographic location. Importantly, there seems to be no difference in 30-day mortality between CABG and PCI in risk-adjusted patients.

– Graft patency is essential for achieving the benefits of CABG treatment. In 2022, evidence favoring the radial artery as the best second graft continued to accumulate, and long-term patency of the right internal thoracic artery was called into question.

Furthermore, the accumulated evidence in 2023 does not contradict the previous year's findings and offers new insights:

– Following the controversial REVIVED study in 2023, new reviews evaluated revascularization in ischemic dilated cardiomyopathy. Although the role of viability studies remains unclear, complete revascularization and next-generation optimal medical therapy (OMT) are essential for improving prognosis in these patients.

– In 2023, a substantial amount of information regarding coronary grafts was again accumulated, reaffirming the preference for arterial grafts and an individualized revascularization strategy, as reflected in the consensus document published by EACTS

and STS on the indications and surgical management of various graft types in coronary artery bypass surgery.

– Additionally, numerous articles confirm the ongoing advancement of coronary surgery as a primary option for LMCA disease, with PCI downgraded to a class IIa recommendation for SYNTAX scores below 22.

– In 2023, further significant publications recommended surgical revascularization for coronary arteries with patent stents, particularly if the stents are non-drug-eluting, showing that graft patency is unaffected when revascularizing an occluded right coronary artery. The trend toward hybrid revascularization was addressed last year, highlighting favorable outcomes. Consensus documents on revascularization in stable coronary artery disease proved highly practical and useful. Furthermore, evidence continued to accumulate in the field of mechanical complications; for instance, the importance of ECMO in the management algorithm for ventricular septal defects was confirmed in most European hospitals with cardiac surgery units.

– Aortic Valve Disease:

Perhaps the most relevant takeaway from 2022 is that in the treatment of severe aortic stenosis, TAVI yields similar or slightly better short-term results compared to SAVR, while the latter has fewer long-term complications and possibly better five-year survival. In younger patients, the Ross operation may offer superior long-term outcomes compared to SAVR, primarily due to a lower incidence of valve-related complications.

With the 2023 publications in mind, we could add that the expansion of sutureless surgical prostheses continued to show favorable results, with lower pacemaker implantation rates and excellent overall performance, and their use in combined surgeries now seems well-established. The elevated risk associated with surgical intervention in patients with a prior TAVI (with mortality above 10%) has also been increasingly recognized, an adjustment we will inevitably need to make.

Regarding TAVI, there has been an extensive volume of publications. Some continue to emphasize the poor prognosis associated with paravalvular leaks (even minor ones) and the need for pacemaker implantation post-implant. Other authors describe acceptable results with TAVI in bicuspid valves and even in cases of aortic insufficiency. There is also growing evidence on the good results of non-transfemoral TAVI (an area in which surgeons have a significant role to play), especially the transcarotid approach.

In low-risk patients, the three-year favorable outcomes of the Evolut Low-Risk trial for TAVI and the five-year favorable outcomes of the PARTNER 3 trial for surgery will undoubtedly shape future meta-evidence and clinical guideline recommendations. Additionally, studies with positive outcomes for redo-TAVI (valve-in-valve) have begun to emerge, establishing it as a real option that expands the decision-making spectrum for patients with dysfunctional percutaneous prostheses.

– Mitral Valve Disease:

In summary, in the field of mitral surgery during 2022, the evidence supported the concept that the most significant long-term benefits, including survival, are associated with the degree of MR reduction and the durability of the repair, regardless of treatment type.

In 2023, the five-year outcomes of the COAPT study confirmed the trend toward clinical improvement and reduced mortality that had already been observed in the initial 48-month study on MitraClip® compared to OMT in patients with moderate-to-severe

secondary MR. Other publications delved into a better understanding and classification of primary MR, clearly differentiating five phenotypes.

In strictly surgical terms, additional evidence accumulated in 2023 supporting left ventricular reverse remodeling with any type of mitral repair. Large case series with the Commando operation position this technique as a feasible and definitive solution for surgically addressing complex diseases of the fibrous skeleton of the heart. Moreover, the mitral valve-in-valve option was established as a viable alternative in cases of degenerated bioprostheses, and the open surgical implantation of balloon-expandable valvular prostheses for severe mitral annular calcification may now provide a solution for previously inoperable cases.

– Tricuspid Valve Disease:

Summarizing 2022 in this field, growing evidence supports concomitant treatment of TR during cardiac surgery, as this seems to prevent its progression, although at the cost of a higher incidence of pacemaker implantation. Additionally, isolated TR surgery shows that perioperative risk is influenced by the degree of systemic congestion, where liver function plays a significant role. Surgery performed on a beating heart could offer benefits and mitigate risks concerning early postoperative right ventricular function.

In 2023, the most relevant publications continued along the same lines, with increasing attention given to isolated TR, an aspect previously less emphasized. The importance of early surgery for severe isolated TR has been highlighted more and more, along with new and more comprehensive classifications of TR and the application of VARC criteria to standardize the results of invasive treatments. Additionally, the increasingly utilized TRI-SCORE appears to accurately assess the risk-benefit balance of invasive treatment options versus conservative management. Meanwhile, the MELD score has proven useful in risk assessment, as traditional risk stratification systems have limited predictive capacity, particularly in cases of secondary hepatic dysfunction.

Finally, in 2023, new insights emerged regarding percutaneous procedures. The TRILUMINATE study concluded that edge-to-edge transcatheter tricuspid valve repair (TTVR) in severe TR reduces TR grade and is associated with improved quality of life, suggesting a growing role for interventional treatment in this field.

– Aortic Disease:

During 2023, evidence continued to accumulate, reinforcing findings from the previous year and further supporting the suitability of frozen elephant trunk techniques for specific patients. However, an even greater emphasis has been placed on the importance of a personalized strategy for managing type A aortic dissections. Additionally, significant publications continued to support the growing trend toward using TEVAR for non-complicated type B aortic dissections. The importance of the TEM classification in decision-making for these patients has been underscored, reflecting the complexity of acute aortic pathology as a whole.

Other studies provided new insights into various surgical strategies and neuroprotection techniques in aortic arch surgery, among many other innovations.

– Advanced Heart Failure:

In addition to the xenotransplant performed in 2022, the year 2023 marked a significant exploration of innovative and impactful topics in the field of transplantation, highlighting the excellent outcomes achieved in both national and international transplants from controlled donation after circulatory death (DCD) donors. Moreover, the implementation of new prioritization criteria on the waiting list in Spain has reshaped the landscape of

transplants, as previously discussed. Evidence continues to support expanding the donor pool, including donors with a history of hepatitis C (HCV) positivity.

In 2023, research continued to expand the bibliography supporting both the short- and long-term benefits of durable assist devices, reaffirming their status as indispensable devices. Additionally, numerous publications have reinforced the utility, appropriate use, and excellent outcomes of veno-arterial ECMO, particularly in cases of cardiogenic shock or secondary to myocardial infarction. These devices, increasingly common in our practice, have become integral to our clinical approach.

As we can see, cardiac surgery, much like other specialties, is closely linked to technological and scientific developments. Mahatma Gandhi once said that “technology becomes a tool when it reaches the hands of people capable of doing extraordinary things.” In our clinical practice, these devices serve as the fundamental instruments enabling us to perform extraordinary acts directly benefiting our patients.

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Juan Esteban De Villarreal Soto

New procedures for a minimally invasive era: transapical beating-heart septal myectomy for hypertrophic obstructive cardiomyopathy.

This study, conducted as a prospective, single-center (Tongji Hospital in Wuhan, China), single-arm trial by a single surgeon, is the first in humans to assess the transapical beating-heart septal myectomy (TA-BSM) procedure.

Hypertrophic obstructive cardiomyopathy (HCM) is a genetic and familial condition with variable clinical evolution. It is characterized by left ventricular hypertrophy (LVH) in the absence of other etiologies, such as aortic stenosis or sustained arterial hypertension. HCM can vary morphologically, with common forms being basal, midventricular, apical, and diffuse. The basal septal hypertrophy phenotype is the most common, while the midventricular variant accounts for up to 9.4% in Japanese series. Less commonly, the apical form predominates, with hypertrophy concentrated in the apex, causing diastolic dysfunction without obstructive gradients.

This variability results in a range of clinical presentations, from asymptomatic patients to cases of sudden death. The primary prognostic factor in HCM is obstruction of the left ventricular outflow tract (LVOT), making most medical and surgical treatments focus on reducing this obstruction. Extended septal myectomy (ESM) is the treatment of choice for patients with HCM and an LVOT gradient >50 mmHg (at rest or with stress) who remain symptomatic despite optimal medical management. New therapies/procedures for HCM have been developed, reducing the incidence of HCM advancing to the “burn out” phase, where cardiac transplantation becomes necessary.

Li et al. developed a device using negative pressure and aspiration, comprising a bullet-headed resection tube, a multifunctional handle, and a catheter connecting the device chambers. The resection tube itself includes an outer layer, a tubular blade, a piercing needle, and a multi-porous tunnel. Using this device, they completed and published their initial cases of transapical beating-heart septal myectomy (TA-BSM) in patients with resting HCM and obstruction, avoiding median sternotomy and cardiopulmonary bypass (CPB).

This study aims to evaluate TA-BSM outcomes in patients with resting or provoked LVOT gradients >50 mmHg and a maximum septal thickness >15 mm, with symptoms refractory to medical treatment. Patients were divided into two groups: the latent obstruction group (patients with provoked obstruction despite low resting gradient <30 mmHg) and the resting obstruction group (patients with resting LVOT obstruction with a gradient >30 mmHg). A total of 120 patients participated in the study, with 33 in the latent obstruction group and 87 in the resting obstruction group.

The primary objective was procedural success, defined as a maximum LVOT gradient (after provocation) of less than 30 mmHg, residual mitral regurgitation grade ≤1+, and absence of mortality at six months post-procedure. Secondary objectives included a composite of adverse events: 30-day mortality, iatrogenic ventricular septal defect, left ventricular apical tear, conversion to median sternotomy, iatrogenic valvular injury, device-related embolization, or stroke.

The procedure is performed under general anesthesia, using a left mini-thoracotomy to access the left ventricular apex. A standard transapical approach is employed, with tobacco-pouch sutures reinforced with Teflon patches for the apical puncture and subsequent dilation of the incision. Guided by intraoperative 3D transesophageal echocardiography (TEE), the device location is determined in both depth (mid-esophageal long-axis view) and resection window orientation (transgastric short-axis

view). The initial resection is performed on the basal anterior septum, 5–10 mm below the right coronary sinus (mid-esophageal long-axis view) and extending to the septum midpoint (transgastric short-axis view). Morphological and hemodynamic characteristics, including septal thickness, LVOT gradient, and residual mitral regurgitation, are assessed after each resection. On average, 3-6 resections are necessary to achieve technical success. After completing the resections, an isoproterenol challenge is performed; if the provoked gradient exceeds 30 mmHg, additional resection is required.

A propensity score-matched analysis revealed significant differences in pre-procedure characteristics. Patients with resting obstruction had a greater septal thickness (22 mm vs 20 mm; $p = .029$), larger left atrial size ($p = .027$), and a higher rate of mitral regurgitation >2+ (90.8% vs 63.6%; $p < .001$). Patients with latent obstruction showed more mitral subvalvular anomalies (30.3% vs 6.9%; $p = .003$). No significant differences were found in other clinical characteristics, including age, symptoms, comorbidities, and medical history. The primary goal was achieved in 31/33 (93.9%) latent obstruction patients and 80/87 (92%) resting obstruction patients. Secondary outcomes included one case of 30-day mortality, one iatrogenic ventricular septal defect, one left ventricular apical tear, two median sternotomy conversions, one iatrogenic valvular injury, and five device-related embolizations, although not all were associated with stroke. No differences were observed between groups in myocardial weight resected, ICU stay, or rates of left bundle branch block. The duration of mechanical ventilation was significantly shorter in patients with latent obstruction (2.9 h vs 4.3 h; $p < .010$).

The authors conclude that TA-BSM yields favorable results according to reference standards. The findings support using this device in symptomatic patients with latent obstruction regardless of resting LVOT gradients. However, larger series with long-term follow-up are necessary.

COMMENTARY:

This study presents disruptive findings for the future of invasive HCM management. Other approaches/modalities emerging for HCM treatment include transaortic myectomy via right anterior mini-thoracotomy and transmitral myectomy. Unfortunately, the outcomes of these approaches have not yet been rigorously studied. Transmitral myectomy, while advantageous in cases requiring mitral valve replacement, requires detachment and reattachment of the anterior mitral leaflet in patients with a normal valve, which may distort the valve leaflets, leading to higher rates of residual mitral regurgitation.

This study offers a promising minimally invasive solution. Li et al.'s team from Wuhan, China, recently described a novel transapical beating-heart septal myectomy technique. This procedure is made possible by an innovative instrument with a bullet-headed resection tube. Close communication with the echocardiographer is necessary to guide septal resection, avoiding injury to other intracardiac structures. Similar to thoracoscopic and anterior mini-thoracotomy approaches, this minimally invasive beating-heart access allows for faster postoperative recovery with less pain. Additionally, avoiding CPB can reduce risks of bleeding, AF, stroke, and other complications associated with cannulation and CPB itself.

Surgical treatment of HCM remains the choice for patients who are symptomatic despite optimal medical management. This study shows that TA-BSM yields favorable results according to reference standards and allows real-time visualization of gradient resolution.

However, this study has limitations: it is a single-center study with all procedures performed by a single surgeon, a relatively small sample size favoring selection bias,

and this procedure is not feasible for patients requiring other types of concomitant cardiac surgery. Additionally, high-quality TEE imaging is required for precise localization and resection of hypertrophied myocardium, necessitating close cooperation with the echocardiographer.

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Bunty Ramchandani

Time to take care of the cardiac surgeon, ergonomics in the operating room

National survey on musculoskeletal injuries among cardiothoracic surgeons in the United States.

The term ergonomics is far from unfamiliar; it has become a fundamental feature in new products we integrate into our daily lives. Ergonomics applies scientific methods to design objects, systems, or environments for human use, with primary goals of ensuring safety, comfort, usability, performance, and productivity. A wealth of literature documents that prolonged surgical shifts in ergonomically poor postures lead to an increase in technical errors, sick leave, and discomfort among surgeons.

Today's study reflects the cardiothoracic community's concern over musculoskeletal injuries resulting from suboptimal ergonomics and extended hours in the operating room. It is an anonymous survey of 33 questions designed to assess the musculoskeletal health, ergonomic perceptions, and habits of American cardiac surgeons.

Among 600 surveyed surgeons, the prevalence of musculoskeletal injuries attributed to long hours in the OR was 64%; a third of the surgeons had to take medical leave to recover, and 20% required chronic pain management. Cervical spine injuries were the most common, affecting 35% of participants, followed by lumbar pain in 30%. Multivariable analysis identified cardiac surgery as a risk factor for these occupational injuries (OR = 1.8). Notably, 90% of surgeons believed their institutions failed to provide ergonomic education or materials for performing their duties.

The study concludes that the incidence of occupational injuries in the cardiothoracic community is alarmingly high, leading to substantial sick leave and even early retirements. This survey underscores the need to improve postural education and adopt techniques that enhance ergonomic habits in the OR.

COMMENTARY:

As a congenital cardiac surgeon, I was unaware of the concept of OR ergonomics until I read this article. A subsequent Pubmed® search yielded hundreds of articles on the topic. However, it is surprising that this is the first study addressing ergonomics in the cardiothoracic community. The lack of awareness is evident in the 20% response rate from the 2,800 surveyed surgeons. The majority of respondents were male (92%), over 55 years old, with more than 20 years of experience. Female representation was low, with only 48 participants. However, they are particularly vulnerable to poor ergonomic habits as the entire OR environment is built around a typically taller male phenotype with larger hands. Alarmingly, 97% (n = 371) of surgeons with musculoskeletal injuries did not seek treatment, simply ignoring the issue.

The article briefly mentions various strategies employed by respondents to combat these injuries. Some performed short stretching sessions during surgery, others used anti-fatigue mats. Emphasis was placed on OR table height and elbow flexion angles based on the procedure. Thoracic surgeons showed greater awareness of adopting ergonomic postures during procedures.

Each surgical specialty has its own working style. In cardiac surgery, when a patient is connected to a cardiopulmonary bypass machine, every minute counts, and the goal is to complete the procedure as swiftly as possible. There is no time to step back and stretch your back or neck. Preparing for the toll of a typical four-hour or longer surgery begins before and continues after the OR. Like athletes, cardiac surgeons must prepare

their bodies for long hours in the OR. Some colleagues engage in weightlifting, others run or swim, and some practice high-intensity interval training (Tabata) to precondition themselves and prevent injuries from our surgical practice. Our surgeries involve diverse body postures; sometimes, one can be seated, as when harvesting an internal mammary artery or performing video-assisted thoracoscopic surgery. In other cases, neck strain is necessary, as when initiating the repair of a right partial anomalous pulmonary venous drainage and placing the first intracaval shunts. Unlike thoracoscopic or robotic surgeries, our procedures rarely involve a static neck position. Constant movement is required to check hemodynamic status on the monitor, communicate with the anesthesiologist or perfusionist, or adjust focus when sutures get entangled outside the field of vision. The weight of the loupes and headlights, which have fortunately modernized with lighter materials, adds to this strain.

Regarding loupes, there is much debate about the level of magnification. Personally, I use 2.5x magnification, which, with my focal length, allows me to operate comfortably with my elbows flexed at 90 degrees. Some surgeons prefer to have their hands closer to their faces, requiring a greater elbow flexion angle, leading each to choose a different focal length. I use this magnification for both adult congenital and neonatal surgeries. In my case, higher magnification only adds extra weight to the nose, becoming burdensome after several hours of surgery. For this reason, I prefer the headlamp on my head rather than on the loupes. Some colleagues use 3.5x magnification for neonatal surgery, while others use 4x for coronary surgery, ending up with more cervical discomfort by the end of the day due to the added weight. The magnification level is a critical ergonomic consideration based on case specifics. The situation changes when assisting instead of operating; peripheral vision is more useful than the loupe view in this role. In these cases, loupes should not obstruct the view of the surgical field.

In conclusion, the cardiothoracic community must become more aware of OR ergonomics, adopt proper postural habits, and take appropriate measures to prevent injuries. Our bodies, like cars in a 24-hour Le Mans race, require pit stops to maintain peak performance. Ignoring this will soon condemn us to careers marred by injuries and personal lives plagued by pain.

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