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EDITORIAL
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# Survival versus symptom relief: the surgical dilemma in ischemic functional mitral regurgitation

## *Supervivencia frente a alivio de síntomas: el dilema quirúrgico en la insuficiencia mitral funcional isquémica*

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**Keywords:** coronary artery bypass grafting, functional mitral regurgitation, mitral valve, mitral valve repair, transcatheter edge-to-edge repair.

***Palabras clave:*** *injerto de derivación de la arteria coronaria, insuficiencia mitral funcional, válvula mitral, reparación valvular mitral, reparación transcatéter borde-a-borde.*

The management of ischemic functional mitral regurgitation (FMR) continues to represent one of the most debated controversies in contemporary cardiovascular surgery. Few issues highlight so vividly the tension between pathophysiological understanding, surgical practice, and the need for rigorous evidence. In this issue, García-Villarreal presents an incisive analysis of the long-standing question: in patients with ischemic cardiomyopathy, is long-term survival determined primarily by revascularization through coronary artery bypass grafting (CABG), or can it be significantly modified by addressing the secondary lesion-functional mitral regurgitation?

CABG has long been established as a cornerstone of survival in patients with advanced coronary artery disease (CAD) and severe left ventricular dysfunction. The 2021 ACC/AHA/SCAI guidelines clearly confer a Class I recommendation for CABG in patients with multivessel CAD and left ventricular ejection fraction (LVEF) < 35%,[1] a position strongly reinforced by the 10-year outcomes of the STICHES trial, which demonstrated that CABG combined with medical therapy significantly reduced mortality and cardiovascular hospitalizations compared with medical therapy alone.[2] These results leave little doubt that CABG is the fundamental driver of improved long—term outcomes in ischemic cardiomyopathy.

Yet, severe FMR itself carries profound prognostic weight. It is not a primary valvular disease but a marker of advanced ischemic remodeling, with annular dilation and papillary muscle displacement preventing effective leaflet coaptation.[3] Left untreated, severe FMR imposes chronic volume overload on the failing ventricle, accelerating maladaptive remodeling and worsening prognosis. Observational data confirm that increasing FMR severity is directly associated with higher mortality and heart failure admissions, with grade IV patients experiencing less than 45% event-free survival at four years.[4] The natural instinct of the surgeon is to correct what is visibly abnormal-but does this correction alter the trajectory of survival, or simply palliate symptoms?

Guideline recommendations reflect this uncertainty. The 2020 ACC/AHA guidelines on valvular heart disease confer a class IIa indication for mitral surgery in severe FMR during

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CABG,[5] whereas the 2021 ESC/EACTS guidelines offer a stronger class I recommendation.[6] Both acknowledge the prognostic burden of untreated FMR, but both also recognize the absence of consistent evidence for survival benefit.

Indeed, randomized and observational data repeatedly demonstrate that while concomitant mitral surgery reduces postoperative regurgitation and improves early functional class, it does not confer a long-term survival advantage. A large Cleveland Clinic study of nearly 400 patients with severe ischemic FMR found comparable 10-year survival between CABG alone and CABG plus annuloplasty, despite better postoperative valve competence in the latter group.[7] Similarly, randomized trials in moderate FMR have shown durable MR reduction with concomitant repair, but no differences in survival or adverse events at two years.[8] Whether in moderate or severe disease, concomitant mitral surgery improves MR grade and symptoms but does not independently improve long-term mortality.

The conclusion is sobering but clarifying. CABG directly addresses the ischemic substrate and drives survival. Mitral valve intervention addresses the consequence of ischemic remodeling, offering symptomatic relief and quality-of-life benefits, but not proven survival gain. As García-Villarreal has argued elsewhere,[3] isolated mitral surgery in ventricular-type FMR occupies only a limited therapeutic role; its power lies in conjunction with revascularization, and even then, primarily for palliation rather than survival.

The challenge for surgeons and cardiologists is not merely technical—repair or replace—but conceptual: are we treating the cause, or the consequence? Precision requires discernment. In selected patients with severe symptomatic FMR, concomitant valve surgery may be justified; in others, the increased operative risk may outweigh unproven benefit. The emergence of transcatheter edge-to-edge repair[5] may further shift this balance, providing regurgitation relief without the burden of prolonged cardiopulmonary bypass.

This editorial invites us to pause. The instinct to "do more" must yield to the discipline of evidence. CABG remains the anchor of survival in ischemic cardiomyopathy; mitral valve surgery, in this context, is an adjunct—important, but not determinant. The art of cardiovascular surgery may ultimately lie not in correcting every lesion we see, but in discerning which correction truly changes the course of disease.

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ORIGINAL ARTICLE

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# Follow-up of pediatric patients with total correction of tetralogy of Fallot over a 10-year period

## *Seguimiento de pacientes pediátricos con corrección total de tetralogía de Fallot en un periodo de 10 años*

Jaime López-Taylor, David Ramírez-Cedillo, Carlos Jiménez-Fernández, Italo Masini-Aguilera, Miguel Ángel Medina-Andrade, Alondra Contreras-Godínez and Alejandra Peña-Juárez

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### ABSTRACT

**Introduction:** tetralogy of Fallot is a common pathology in infancy. Surgical correction has excellent results although it still presents long term complications. **Material:** this retrospective study examined the outcomes of 70 patients with tetralogy of Fallot who underwent surgical correction. The patients' ages at surgery ranged from 3 to 13 years, with 67% undergoing correction before the age of five. Postoperative follow-up was conducted between 1 and 8 years after surgery. **Results:** the results showed that 25% of patients developed signs of septic shock within the first 36 hours postoperatively, and 22.9% experienced respiratory complications. Conversely, 20% of patients had an uncomplicated postoperative course and were discharged within 10 days. During follow-up, 63% of patients were asymptomatic, while 34% exhibited NYHA functional class II symptoms. Notably, 35.7% of patients had residual ventricular septal defects. Right ventricular dilatation was observed in 50% of cases, and pulmonary insufficiency was classified as severe in 23.3% of cases. **Conclusions:** the study concluded that surgical correction of TF yields satisfactory long-term outcomes, but regular follow-up is crucial to detect complications and facilitate timely interventions. The findings underscore the importance of ongoing monitoring and management to optimize patient outcomes and mitigate potential long-term sequelae.

### *RESUMEN*

***Introducción:*** *la tetralogía de Fallot es una patología común en la infancia. La corrección quirúrgica tiene excelentes resultados aunque todavía presenta complicaciones a largo plazo.* ***Material:*** *este estudio retrospectivo examinó los resultados de 70 pacientes con tetralogía de Fallot que se sometieron a corrección quirúrgica. Las edades de los pacientes en el momento de la cirugía oscilaron entre 3 y 13 años, y el 67% se sometió a corrección antes de los cinco años. El seguimiento postoperatorio se realizó entre 1 y 8 años después de la cirugía.* ***Resultados:*** *los resultados mostraron que el 25% de los pacientes desarrollaron signos de choque séptico dentro de las primeras 36 horas después de la operación y el 22.9% experimentó complicaciones respiratorias. Por el contrario, el 20% de los pacientes tuvo una evolución postoperatoria sin complicaciones y fueron dados de alta dentro de los 10 días. Durante el seguimiento, el 63% de los pacientes estaban asintomáticos, mientras que el 34% presentó síntomas de clase funcional II de la NYHA. Cabe destacar que el 35.7% de los pacientes tenían defectos septales ventriculares residuales. Se observó dilatación del ventrículo derecho en el 50% de los casos, y la insuficiencia pulmonar se clasificó como grave en el 23.3%.* ***Conclusiones:*** *el estudio concluyó que la corrección quirúrgica de la TF produce resultados satisfactorios a largo plazo, pero el seguimiento regular es crucial para detectar complicaciones*

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**Keywords:** cardiac surgery, congenital heart disease, long-term outcomes, pulmonary insufficiency, surgical correction, tetralogy of Fallot.

**Abbreviations:**
CI = confidence intervals
HR = hazard ratios
PI = pulmonary insufficiency
PS = pulmonary stenosis
RV = right ventricular
RVEF = right ventricular ejection fraction
TF = tetralogy of Fallot
VSD = ventricular septal defects

Tetralogy of Fallot (TF) is a prevalent congenital heart defect in infancy. Although the first successful repair was performed in the 1950s, with some authors reporting excellent long-term outcomes,[1,2] the long-term survival rate in patients who underwent repair remains lower than that of the age- and gender-matched general population. Furthermore, late complications such as arrhythmias, sudden death, decreased functional capacity, and re-operations, primarily attributed to the right ventricular (RV) outflow tract reconstruction technique and the approach to addressing the interventricular defect, continue to be a subject of debate. This study investigated the follow-up outcomes after total TF repair, focusing on echocardiographic alterations and demographic and surgical variables in these patients.

## MATERIAL

A retrospective, descriptive study was conducted, reviewing the records of patients diagnosed with TF over a 10-year period. Patients with pulmonary atresia and those referred to the adult cardiology service were excluded. Statistical analysis was performed using SPSS version 15. Quantitative variables were summarized using measures of central tendency (mean or median) and dispersion (standard deviation or interquartile range), depending on normality assumptions assessed via the Shapiro-Wilk test. Categorical variables were summarized as absolute frequencies and percentages. Event-free survival probabilities were estimated using the Kaplan-Meier method and compared using the log-rank test. A bivariate Cox regression model was fitted for all variables, and hazard ratios (HR) with 95% confidence intervals (CI) were reported. Statistical significance was set at $p < 0.05$.

*y facilitar intervenciones oportunas. Los hallazgos subrayan la importancia del seguimiento y el manejo continuos para optimizar los resultados del paciente y mitigar las posibles secuelas a largo plazo.*

***Palabras clave:*** *cirugía cardíaca, cardiopatía congénita, resultados a largo plazo, insuficiencia pulmonar, corrección quirúrgica, tetralogía de Fallot.*

## RESULTS

### Demographic data

The age at surgical correction ranged from 3 to 13 years. Patients were divided into two groups based on age at surgery: group 1 (under five years, 67%, n = 47) and group 2 (over five years, 32.8%, n = 23). Of the 70 patients, 33 (47.1%) were male. Postoperative follow-up time was categorized into three groups: under two years (54.2%), 3-5 years (15.7%), and over five years (30%) *(Table 1)*.

### Surgical treatment

In this section, patients were divided into two groups

1. Palliative treatment

Fourteen patients (20%) underwent palliative surgery (systemic-pulmonary shunt) between 4 and 10 days of life (mean six days). The indications for palliative surgery were: (1) mild to moderate hypoxemia secondary to severe pulmonary branch hypoplasia (Z value < -2.5) in eight cases, and (2) pulmonary annulus hypoplasia (Z value -2) in six cases. Corrective surgery was performed in all patients with a previous systemic-pulmonary shunt, with a mean interval of 18 months (range 12-21 months) after palliative surgery.

**Table 1:** Demographic data of patients with follow-up for tetralogy of Fallot correction (N = 70).

| Variable | n (%) |
|---|---|
| Age at time of correction (mean, six years) | 3-13 |
| Age group at time of correction (years) | |
| < 5 | 47 (67.0) |
| > 5 | 23 (33.0) |
| Gender | |
| Male | 33 (47.0) |
| Female | 37 (53.0) |
| Group based on postoperative time (years) | |
| < 2 | 38 (54.2) |
| 3-5 | 11 (15.7) |
| > 5 | 21 (30.0) |

**Table 2:** Surgical data of patients operated of tetralogy of Fallot (N = 70).

| Variable | n (%) |
|---|---|
| Palliative surgery (PSF) | 14 (20) |
| PSF indication | |
| Hypoplastic branches | 8 |
| Pulmonary annulus hypoplasia | 6 |
| Time from palliative to corrective surgery (mean, 18 months) | 12 to 21 |
| Coronary alterations | 10 (7.0) |
| Patent ductus arteriosus | 6 (8.5) |

2. Total correction

All surgical cases were performed via median sternotomy. Conventional extracorporeal circulation with moderate hypothermia (25-30 °C) and anterograde cardioplegia were used in all cases, with additional myocardial protection measures including saline at 4 °C in the pericardial sac every 15-20 minutes. A longitudinal ventriculotomy was performed, extending towards the annulus, trunk, or branches when hypoplasia was present. The ventricular septal defect was closed with a patch and interrupted sutures on the posterior, inferior, and superior edges, and continuous sutures on the remaining areas. A patch was required in the right ventricular outflow tract in all cases. Coronary circulation abnormalities were found in 10 cases, including anomalous origin of the left anterior descending artery and left main coronary artery from the right coronary artery. Associated patent ductus arteriosus was present in six patients and was ligated prior to cardiopulmonary bypass. Systemic-pulmonary shunts were also addressed prior to bypass *(Table 2)*. Notably, surgical technique details were unavailable for five cases due to the procedure being performed over five years ago.

## Immediate postoperative

Of the 70 patients who underwent surgery, 25% developed signs of septic shock within the first 36 hours postoperatively. Additionally, 16 patients (22.9%) experienced other complications, all of which were respiratory in nature, with pneumonia being the primary diagnosis, requiring mechanical ventilation for a mean duration of six days. In contrast, 20% of patients had an uncomplicated postoperative course and were discharged within 10 days. Five patients (7.1%) developed complete atrioventricular block, with two requiring permanent pacemaker implantation. Chylothorax occurred in three patients (4.3%), two of whom responded to medical treatment, while one required surgical intervention. Re-operation was necessary in two cases (2.8%): one for chylothorax and diaphragmatic paralysis 14 days postoperatively, and another for permanent pacemaker placement 10 days postoperatively. Notably, no patients experienced postoperative hemorrhage or pericardial effusion requiring reintervention or evacuation *(Table 3)*.

## Follow- up

Follow-up was conducted between 1 and 8 years after total correction of TF. Clinically, 63% of patients were asymptomatic, while 34% had NYHA functional class II symptoms, all of whom were in the postoperative group more than five years after surgery. Regarding medical treatment, 66% of patients did not require any medication, while 34% were receiving diuretic therapy. All patients were in sinus rhythm, except for one who had a permanent pacemaker and was being followed up by the electrophysiology department. Two patients presented with postoperative neurodevelopmental changes: one had gait disturbances and was undergoing rehabilitation with partial improvement, while the other had speech disturbances and neurodevelopmental delay *(Table 4)*.

## Residual shunts

The 35.7% had residual ventricular septal defects (VSD); of this group 54% were in the intervention group under five years of age ($p = 0.02$).

## Right ventricular assessment

Right ventricular (RV) dilatation was observed in 50% of cases, with no significant predominance in age at surgery ($p = 0.025$). However, there was a significant association between

**Table 3:** Immediate postoperative data.

| Variable | n (%) |
|---|---|
| Septic shock in the first 36 hours post-surgery | 18 (25) |
| Pneumonia | 16 (23) |
| Days of mechanical ventilation (mean, 6 days) | 4 to 12 |
| Days of stay in the pediatric intensive care unit (mean, 8 days) | 5 to 18 |
| Complications | |
| Complete AV block | 2 (3.0) |
| Chylothorax | 3 (4.2) |
| Re-operations | |
| Pacemaker placement | 1 (1.42) |
| Chylothorax | 1 (1.42) |

AV = atrioventricular

**Table 4:** Clinical data and follow-up patients with correction of tetralogy of Fallot.

| Variable | n (%) |
|---|---|
| Postoperative follow up in years (mean, 4 years) | 1 to 10 |
| Functional class | |
| I | 46 (63) |
| II | 24 (34) |
| Management | |
| No management | 46 (63) |
| Anti-congestive medical therapy | 24 (34) |
| Postoperative neurodevelopmental alteration | |
| Gait and speech | 2 (3) |

postoperative time and RV dilatation, with 53% of patients over five years postoperatively and 26% of patients 3-5 years postoperatively affected. The mean transpulmonary gradient was 24 mmHg (range, 9-51 mmHg). Pulmonary stenosis (PS) was mild in 93.3% and moderate in 6.6% of cases. Pulmonary insufficiency (PI) was classified as mild in 40%, moderate in 36%, and severe in 23.3% of cases. There was no significant association between age at surgery and PI ($p = 0.15$), but a significant association was found between postoperative time and PI, with 66% of patients over five years postoperatively affected, compared to 20% in the 3- to 5-year postoperative group and none in the group under two years postoperatively ($p = 0.000$).

## DISCUSSION

TF is the most prevalent congenital heart defect in infancy, accounting for approximately 5-6% of all congenital heart diseases.[1] Our findings are consistent with the literature, which reports no significant gender predominance, although a slight female preponderance of 53% was observed in our study. The clinical presentation is variable, with symptoms such as progressive cyanosis and decreased physical capacity directly related to right ventricular outflow tract obstruction.[2] TF is characterized by a spectrum of abnormalities, typically classified into two groups based on anatomy: favorable or poor, with a focus on the Z score of the pulmonary branches and annulus. This classification informs management strategies, particularly in the neonatal stage, where poor anatomy may necessitate a staged approach, including initial systemic-pulmonary shunt followed by complete correction. In our study, 20% of cases required systemic-pulmonary shunt, primarily due to pulmonary branch hypoplasia.

The optimal age for total correction of TF remains a topic of debate. Two prevailing schools of thought exist: one advocating for an age-based approach and the other for an anatomy- or physiology-based strategy. While early surgical mortality after TF repair should be rare, no single surgical strategy has proven superior in mitigating the need for late intervention.[3] Since the 1990s, surgical intervention in the first years of life has been preferred, with multiple studies supporting this approach. Barrat-Boyes[4] and Starr et al.[5] demonstrated in 1973 that TF could be corrected with extracorporeal circulation in early life with low morbidity and mortality. More recently, Arsdell, et al.[6] reported that the ideal time for correction is between 3 and 11 months. A systematic review by Martins, et al.[2] concluded that definitive correction in the neonatal stage is a viable option, with an ideal age of 3-6 months for children with mild to moderate symptoms and immediate surgery for those with severe symptoms. However, Castañeda, et al.[7] emphasize the importance of considering preoperative factors, such as branch size and coronary pattern, in determining the optimal surgical approach.

The age range for total repair in our series was 3-13 years, with older age at repair associated with increased risk of postoperative heart failure.[7] Delayed repair can lead to worse long-term prognosis due to prolonged cyanosis, resulting in ventricular fibrosis. Furthermore, delayed repair may necessitate more extensive muscle resection, potentially causing further RV damage. Given the relatively late age of repair in our series, continued follow-up into adulthood is crucial. The number of postoperative patients with TF surviving to adulthood is increasing, with over 90% reaching their third decade.[8] However, life expectancy remains lower compared to the general population.[9]

Surgical repair of TF has a complex history, marked by both successes and limitations. While surgery significantly improves prognosis, it is not curative, leaving residual anatomical and functional abnormalities such as PS, PI, and RV outflow tract obstruction.[1] These lesions require ongoing cardiological follow-up and may necessitate medical or interventional management. In our series, 25 cases had residual VSD, although none required re-operation.

Pulmonary valve competence is a critical factor in long-term outcomes, with PI being a common complication requiring re-operation. In our series, 23% of cases presented with severe PI, with a significant prevalence observed in patients who underwent surgery more than five years ago. Monitoring PI is essential, as it can contribute to RV dysfunction, exercise intolerance, and life-threatening arrhythmias. While magnetic resonance imaging is the gold standard for assessing these complications, transthoracic echocardiography is a more accessible and non-invasive alternative for monitoring patients.

The optimal surgical technique for TF repair remains a topic of debate, with various approaches aimed at preserving pulmonary valve function. In our series, mild PS was observed in 93% of patients, which may be protective and delay the

need for pulmonary valve replacement.[10] Further research is needed to determine the most effective surgical strategies and to improve long-term outcomes for patients with TF.

### Pulmonary insufficiency

Severe PI is a common cause of progressive RV dilatation and dysfunction in patients with TF repair, and is associated with decreased functional class, arrhythmias, and sudden death. Progressive RV dilatation may be a primary sign of RV dysfunction and an indication for pulmonary valve replacement.[11] PI is a frequent complication after TF surgery, and its negative consequences on RV function have been well-established. The use of transannular patch techniques, as seen in our series, may contribute to the development of PI.

In our study, the frequency of severe PI was 23.3%, primarily affecting patients who underwent surgical correction more than five years ago. Notably, the degree of PI was not directly associated with RV function as assessed by echocardiogram. Only two patients had decreased RV ejection fraction (RVEF), which is consistent with some reports in the literature, such as the study by Frigiola et al.,[12] where the severity of PI was independent of RVEF. However, this finding contradicts other studies, like the one by Kjaergaard et al.,[13] which reported lower RVEF in patients with severe PI compared to those with moderate PI. Further research is needed to clarify the relationship between PI and RV function in patients with TF repair.

## CONCLUSIONS

Surgical treatment of TF is a medical success story, yet it remains a topic of debate. Various management strategies have been proposed, including age-based and anatomy-based approaches. Over the years, surgical management of TF has evolved significantly, resulting in excellent early outcomes with near 100% survival for patients without genetic syndromes. The primary goal of current surgical therapy is to minimize late RV dysfunction by reducing the extent of surgical injury during initial repair. As surgical techniques continue to advance, outcomes are expected to improve.

Although long-term outcomes after TF repair are generally good, postoperative sequelae are common and can persist over time. Regular follow-up with adequate monitoring is crucial to avoid missing the optimal time for reintervention. MRI is the gold standard for assessing RV function, but echocardiography remains an essential tool for evaluation. A multidisciplinary approach is necessary to ensure optimal care and management of patients with TF, both in the short- and long-term.

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ORIGINAL ARTICLE

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# Ten-year experience in cardiac surgery for congenital heart disease at a high specialty hospital

## *Experiencia de 10 años en cirugía cardíaca para cardiopatías congénitas en un hospital de alta especialidad*

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### ABSTRACT

**Objective:** to describe the initial historical experience of a third-level hospital in surgery for congenital cardiovascular malformations performed by a single surgeon, to present the postoperative results based on their morbidity and mortality, and to compare the preoperative surgical risk with internationally accepted quality standards. **Material:** a retrospective, analytical, cross-sectional clinical study was carried out, which included pediatric patients diagnosed with congenital heart disease who underwent surgery over a 10-year period. Sociodemographic, diagnostic, therapeutic, morbidity and mortality variables were considered. **Results:** a total of 112 patients with congenital heart disease were studied. A predominance of females and schoolchildren was observed in this series. The main malformations operated on were patent ductus arteriosus and atrial septal defects. A morbidity of 22% and an overall mortality of 8% were observed. **Conclusions:** the creation of regional third-level hospitals has promoted the development of pioneering programs in cardiovascular surgery such as the one described in this article, obtaining favorable results comparable with international mortality standards. However, the care of increasingly complex heart diseases remains a challenge to face in the future.

**Keywords:** cardiac surgical procedures, congenital heart disease, health services.

### *RESUMEN*

***Objetivo:*** *describir la experiencia histórica inicial de un hospital de tercer nivel en cirugía de malformaciones congénitas cardiovasculares por un único cirujano, exponer los resultados postoperatorios en función de su morbimortalidad, y comparar el riesgo quirúrgico preoperatorio con los estándares internacionalmente aceptados de calidad.* ***Material:*** *se realizó un estudio clínico retrospectivo, analítico y de corte transversal donde se incluyeron pacientes pediátricos con diagnóstico de cardiopatía congénita operados en un periodo de 10 años. Se consideraron variables sociodemográficas, diagnósticas, terapéuticas, morbilidad y mortalidad.* ***Resultados:*** *se incluyeron 112 pacientes con cardiopatías congénitas. Se observó una predominancia del género femenino y los escolares en la serie. Las principales malformaciones operadas fueron la persistencia del conducto arterioso y la comunicación interauricular. Se observó una morbilidad del 22% y una mortalidad global del 8%.* ***Conclusiones:*** *la creación de hospitales regionales de tercer nivel ha impulsado el desarrollo de programas pioneros en cirugía cardiovascular como el expuesto en este artículo, obteniendo resultados favorablemente comparables con los estándares internacionales de mortalidad. Sin embargo, la atención de cardiopatías cada vez más complejas sigue siendo un reto a vencer en el futuro.*

***Palabras clave:*** *procedimientos quirúrgicos cardíacos, cardiopatías congénitas, servicios de salud.*

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**Abbreviations:**
ASD = atrial septal defect
CPB = cardiopulmonary bypass
PDA = patent ductus arteriosus
RACHS-1 = Risk Adjustment in Congenital Heart Surgery -1 Scale
VSD = ventricular septal defect

Heart defects are the most frequent congenital malformations[1] and are the result of an alteration in the heart morphology during intrauterine development[2] that lead to a functional impact at birth. The worldwide incidence is 8 to 12 per 1,000 newborns, and they are associated with an increased perinatal and long-term morbidity and mortality.[3] Clinical presentation has a wide spectrum that ranges from the absence of symptoms to cyanosis, shock and heart failure. During the first month of life, at least one third of congenital heart defects will require some type of intervention with a high risk of death. They can also be detected in the pediatric stage due to a delay in timely diagnosis.[4]

Surgery is one of the therapeutic alternatives for congenital heart disease. Although there are several perioperative risk scales, the most widely used due to its practicality is the Risk Adjustment in Congenital Heart Surgery -1 Scale (RACHS-1) developed by Boston Children's Hospital, which classifies 207 surgical procedures into six groups with increasing mortality risk. The procedures with the lowest surgical risk are placed in the first group, while the sixth group contains those with the greatest surgical complexity and highest risk of perioperative mortality.[5]

Regionalization aims to rationalize medical care based on the population and existing resources, in order to increase the number of treated cases, improve the quality of care and reduce mortality. Based on international recommendations, Mexico requires 21 to 25 specialized medical-surgical centers, of which there are 10, eight of them located in Mexico City, one in Monterrey and one in Guadalajara. The high frequency of congenital heart disease implies the need for more prepared cardiovascular surgical centers.[1] Our Institution (Ixtapaluca Regional High Specialty Hospital) is one of the hospitals that was created in the country to meet these decentralization needs, formally beginning its healthcare activities in 2012.[6] The objective of this article is to describe the initial historical experience at our Institution in the surgical therapeutic approach to cardiac malformations in pediatric patients, to present the postoperative results based on their morbidity and mortality, and to compare the preoperative surgical risk with internationally accepted quality standards.

## MATERIAL

A retrospective, analytical, cross-sectional clinical study was designed including all pediatric patients operated on for congenital heart disease at our Institution from the beginning of its cardiac surgical care activities (2013) until completing the first 10 years of institutional experience by a single surgeon. All pediatric patients with congenital heart disease were included, without distinction of gender or surgical opportunity (elective or emergency surgery). Those patients that were not operated on at our institution in the indicated period were excluded.

**Table 1:** Sociodemographic variables.

| Variable | n (%) |
|---|---|
| Gender | |
| Male | 43 (38) |
| Female | 69 (62) |
| Age | |
| Neonates (< 1 month) | 9 (8) |
| Young infants (1 month to one year) | 12 (11) |
| Older infants (> 1 year to two years) | 17 (15) |
| Preschoolers (Three to five years) | 31 (28) |
| Schoolchildren (Six to 12 years) | 35 (31) |
| Adolescents (13 to 17 years) | 8 (7) |
| Diagnosis according to sequential classification | |
| Malformations of venous return | 2 (2) |
| Atrial malformations | 25 (22) |
| Malformations of the AV connection | 0 (0) |
| Ventricular malformations | 14 (12) |
| Malformations of the VA connection | 0 (0) |
| Malformations of the great arteries | 68 (61) |
| Other congenital and/or pediatric heart diseases | 4 (3) |
| Operative risk (RACHS-1 scale) | |
| RACHS-1 of 1 | 83 (74) |
| RACHS-1 of 2 | 9 (8) |
| RACHS-1 of 3 | 4 (4) |
| RACHS-1 of 4 | 5 (4) |
| RACHS-1 of 5 | 2 (2) |
| RACHS-1 of 6 | 0 (0) |
| RACHS-1 Non-classifiable | 10 (9) |
| Type of procedure | |
| Primary surgery | 112 (99) |
| Re-operation | 1 (1) |
| Opportunity of surgery | |
| Elective | 89 (78) |
| Urgent | 24 (22) |
| Need for CPB | |
| Without CPB | 74 (65) |
| With CPB | 39 (35) |
| Cardiothoracic surgical procedure performed | |
| Cardiovascular procedure | 111 (98) |
| Thoraco-pulmonary procedure | 2 (2) |
| Total number of surgical procedures performed | 113 (100) |
| Total number of patients operated | 112 (100) |

AV = atrioventricular. CPB = cardiopulmonary bypass. RACHS-1 = Risk Adjustment in Congenital Heart Surgery -1. VA = ventriculoarterial.

**Table 2:** Diagnostic variables.

| Sequential classification | n (%) |
|---|---|
| Level 1 - Venous return | 2 (2) |
| Obstructive supracardiac TAPVC | 1 (1) |
| Non-obstructive supracardiac TAPVC | 1 (1) |
| Level 2 - Atrial | 25 (22) |
| Ostium secundum type ASD | 23 (20) |
| ASD + Amplatzer failure | 1 (1) |
| Common atrium + left superior vena cava | 1 (1) |
| Level 3 - AV connection | 0 (0) |
| Level 4 - Ventricular | 14 (12) |
| Perimembranous VSD | 12 (10) |
| Infundibular VSD | 2 (2) |
| Level 5 - VA Connection | 0 (0) |
| Level 6 - Great arteries | 68 (61) |
| Aortic coarctation | 2 (2) |
| Aortic coarctation + aortic arch hypoplasia | 3 (3) |
| Type A aortic arch interruption | 3 (3) |
| PDA | 58 (51) |
| PDA + major aortopulmonary collateral arteries | 1 (1) |
| AoPu window + anomalous origin of PA from Ao + AoCo + aortic arch hypoplasia | 1 (1) |
| Level *- Other congenital and/or pediatric heart diseases | 4 (3) |
| Complete congenital AV block | 2 (1) |
| Mediastinal hemorrhage + stroke post VSD closure | 1 (1) |
| Bilateral hemopneumothorax | 1 (1) |

* Unclassifiable level. Ao = aorta. AoCo = aortic coarctation. ASD = atrial septal defect. AV = atrioventricular. PDA = patent ductus arteriosus. Pu = pulmonary. TAPVC = total anomalous pulmonary vein connection. VA = ventriculoarterial. VSD = ventricular septal defect.

Sociodemographic variables, weight, height, diagnosis, need for cardiopulmonary bypass (CPB), postoperative morbidity and mortality, and the preoperative RACHS-1 scale were taken into account. Data were obtained from the institutional electronic medical record and compiled in an Excel spreadsheet in order to subsequently be analyzed with SPSS v.21 statistical software. Numerical variables are presented as mean ± standard deviation, with minimum and maximum variability ranges. Categorical variables are presented as frequency (n) and percentage in relation to the population at risk. Institutional operative mortality was compared with that predicted by the RACHS-1 risk scale using the $\chi^2$ test, calculating the Odds Ratio with a 95% confidence interval. A $p < 0.05$ was considered statistically significant. The study was registered and approved by the institutional research and research ethics committees. Confidential handling measures for the data obtained were followed.

## RESULTS

This study presents 112 pediatric patients diagnosed with congenital heart disease operated on at a third-level hospital as an initial experience, exposing the results in the three stages of the surgical procedure: preoperative, intraoperative and postoperative.

### Preoperative results

*Table 1* shows the sociodemographic characteristics, diagnosis according to the type of malformation, preoperative history, and immediate postoperative results. Regarding gender, it can be observed that more than half of the patients were women (female:male ratio of 1.6:1). Almost a third of the patients were schoolchildren, followed by preschoolers and older infants. According to the sequential classification of congenital heart defects, more than half of the pediatric patients were operated on for level 6 malformations (of the large vessels), followed by atrial (level 2) and ventricular (level 4) malformations. All patients were given the RACHS-1 surgical risk scale, classifying them into 6 main risk categories and a complementary category of non-classifiable ones. It can be observed that more than half of the cases were classified in category 1 (73%), and almost a tenth of them were unclassifiable (9%). All patients underwent primary surgery, except for one case that needed re-operation (1%). According to the clinical condition of the heart disease at the time of hospitalization, most of the surgeries performed were scheduled, with less than a quarter of the surgical procedures being urgent. Almost two thirds of the surgeries were performed without CPB and the rest required CPB. It can also be observed that almost all of the surgeries performed were cardiovascular procedures, with those of a thoracopulmonary nature being practically negligible.

### Intraoperative results

*Table 2* shows the cardiovascular diagnoses of the patients on admission to the operating room. More than

**Table 3:** Postoperative morbidity variables.

| Overall operative morbidity (23 of 112 patients) | n (%) |
|---|---|
| Right pneumothorax | 2 (2) |
| Respiratory infection | 5 (4) |
| Anaphylactic shock and surgical wound infection | 3 (3) |
| Re-coarctation | 1 (1) |
| Hemopneumothorax | 3 (3) |
| Mediastinal hemorrhage and stroke | 1 (1) |
| Intraoperative hemorrhagic shock | 2 (2) |
| Post-surgical AV block | 3 (3) |
| Residual VSD with hemodynamic repercussions | 3 (3) |
| Total | 23 (22) |

AV = atrioventricular. VSD = ventricular septal defect.

**Table 4:** Postoperative mortality variables.

| Diagnosis of the deceased patients | Overall operative mortality n (%) | Cause | Age |
|---|---|---|---|
| VSD | 2 (1.79) | Septic shock<br>Cardiogenic shock | Three months<br>Four years |
| VSD + ASD + PDA | 1 (0.89) | Severe PAH | Two years |
| PDA + endocarditis | 1 (0.89) | Massive pulmonary hemorrhage | Eight years |
| Coarctation of aorta + hypoplasia of the aorta | 1 (0.89) | Cardiogenic shock | One month |
| Supracardiac obstructive TAPVC | 1 (0.89) | Biventricular failure | Two months |
| Mediastinal hemorrhage and stroke after VSD closure | 1 (0.89) | Cerebral edema due to intraoperative hypoxia due to CPB | Nine years |
| AoPu window + AoCo + LSCV anomalous origin of RPA from Ao + PDA | 1 (0.89) | Severe PAH | 14 days |

Ao = aorta. AoCo = aortic coarctation. ASD = atrial septal defect. CPB = cardiopulmonary bypass. LSCV = left superior vena cava. PAH = pulmonary arterial hypertension. PDA = patent ductus arteriosus. Pu = pulmonary. RPA = right pulmonary artery. TAPVC = total anomalous pulmonary vein connection. VSD = ventricular septal defect.

**Table 5:** Observed mortality compared with predicted values of the RACHS-1 scale.

| Risk | Patients, n | Deaths, n | Expected mortality, % | Obtained mortality, % | p |
|---|---|---|---|---|---|
| 1 | 83 | 1 | 0.4-2.5 | 1.2 | NS |
| 2 | 16 | 1 | 3.8-8.6 | 6.3 | NS |
| 3 | 6 | 0 | 18.4-22.4 | 0 | NS |
| 4 | 4 | 3 | 29.4-34.2 | 75 | 0.005 |
| 5 | 0 | 0 | 36.4-42.4 | SD | – |
| 6 | 0 | 0 | 48.2-54.0 | SD | – |
| NC | 5 | 4 | ? | 80 | ? |

108 classifiable and 5 not classifiable.
NC = not classifiable. NS = not significant. SD = standard deviation. RACHS-1 = Risk Adjustment in Congenital Heart Surgery -1.

half of the patients operated on in our center presented malformations at the level of the large vessels, with the most frequent diagnosis being a patent ductus arteriosus (PDA) in its different varieties, followed by aortic arch defects, among which the interruption of the aortic arch and aortic coarctation stand out. In this last pathology, it is important to mention the concomitant presence of aortic arch hypoplasia. Atrial malformations were the second cause of surgical intervention, with ostium secundum type atrial septal defect (ASD) being the most frequent. All of them corresponded to those without margins for intervention, except for one case of failure due to this therapeutic modality. It is worth mentioning that there was another case of common atrium ASD with concomitant persistent left superior vena cava. Ventricular defects occurred in less than a quarter of the patients, with a perimembranous ventricular septal defect (VSD) predominance, except for two infundibular VSD cases. Although RACHS-1 level 1 predominates in this series, it should be noted that a significant percentage of the operated patients had a greater complexity, such as an unclassifiable level.

## Postoperative results

*Table 3* shows the operative morbidity, which occurred in less than a quarter of the patients in our series. Complications include respiratory infections, cardiac arrhythmias, surgical wound dehiscence, and hemopneumothorax. *Table 4* details the cause of mortality according to age group, underlying cardiovascular diagnosis for each deceased patient. It can be observed that more than half of the patients who died were neonates and infants (56%), most of whom had critical congenital heart disease. The most frequent causes of death were cardiogenic shock, septic shock, and pulmonary arterial hypertension. *Table 5* shows the mortality rates of our study series compared to the RACHS-1 scale, where we can observe

a statistically significant difference in those patients with category 4 only, who had higher mortality than predicted.

## DISCUSSION

Congenital heart defects are the most common malformations at birth and include a wide range of pathologies and surgical techniques that are applied to a no less wide spectrum of patients. Currently, mortality from these diseases are considered as an indicator of progress. This was established at a global level in the sustainable development as a goal in order to reduce deaths in children under five years of age with these malformations. In Mexico, the health system was traditionally centralized in large cities, which promoted that patients with congenital heart defects received late and fragmented care, leading mortality from these diseases to be 1.3 times higher compared to international statistics.[7] In the last two decades, the Ministry of Health implemented a regionalization care project for patients with congenital heart defects with the objective of diminishing mortality. The Cardiovascular Diseases Committee of the European Association of Cardiothoracic Surgery recommends that one hospital with cardiovascular surgery service must be established for every 4 million inhabitants.[8] Taking into account these recommendations, and knowing the population of our country in 2010, at least 25 hospitals with these characteristics were required. Despite this fact, in that year there were only 11 hospitals in the country, of which 8 of them were in Mexico City. In order to improve the coverage of specialized care at a national level, High Specialty Regional Hospitals were built, among which our hospital center was created. Our work team was a pioneer in the 10-year cardiac surgical experience that is presented in this study starting in 2013. Therefore, the initial percentage of pediatric patients operated on was low.

This study presents the results of our surgical procedures performed by a single surgeon on patients under 18 years of age with congenital heart disease at a third level regional hospital. This historical experience in cardiovascular surgery at our site began with a 12-year-old boy with patent ductus arteriosus, which was closed without complications and was chosen particularly for the high success rate of the surgical procedure.

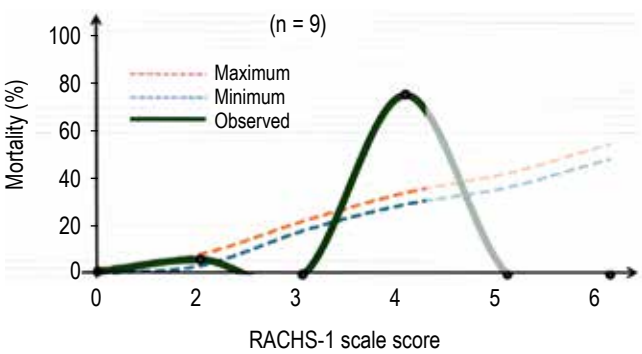


**Figure 1:** Observed mortality compared with predicted values of the RACHS-1 scale.
RACHS-1 = Risk Adjustment in Congenital Heart Surgery -1.

According to the literature, congenital heart defects mainly affect males. The data analysis of this study disagrees with this statement because a predominance of the female gender was observed in our series. However, it was also documented that atrial septal defect and patent ductus arteriosus were more frequent in women as observed in this study. In contrast, aortic stenosis, coarctation of the aorta and transposition of the great arteries were more frequent in males and were more serious heart diseases as well.[9] The procedures in these series were performed in schoolchildren and preschoolers. This is observed since, at the beginning of the congenital heart disease surgery program in our institution, we chose patients of these ages because they had lower surgical risk.

In the last 10 years of our experience, the most frequent heart disease was patent ductus arteriosus, probably due to hypobaric hypoxia associated with the altitude of the State of Mexico, where most of our patients came from.[10] The most frequently occurring heart diseases worldwide are ventricular septal defect, atrial septal defect, patent ductus arteriosus, pulmonary stenosis, tetralogy of Fallot, aortic stenosis, aortic coarctation, and transposition of the great arteries.[11,12] The initial experience that we present in this article included a minority of complex heart diseases, due to the rigorous selection that we made in our patients. This strategy allowed us to obtain a favorable historical experience in a newly created hospital, with recent personnel, processes, and machinery. Additionally, the beginning of a surgical program with this type of cases also offered the advantages of a low failure rate, low probability of needing postoperative therapy, and decreased costs and complications.

When analyzing our results applying the mortality predicted by the RACHS-1 scale, we observed that in categories 1, 2 and 3 we had a mortality rate that was favorably compared with internationally accepted standards, despite being a newly created center *(Fig. 1)*. For this reason, we also observed a statistically significant increase in operative mortality with increasing complexity of the cardiovascular surgery performed. Although 90% of the surgical procedures presented were concentrated in the lowest risk groups (categories 1, 2 and 3), our surgical series was not exempt from higher risk procedures, as corroborated by the 9% of patients operated on with unclassifiable risk. It is important to highlight that this scoring system does not allow determining the operative mortality of individual patients since it does not incorporate other variables recognized as determinants of mortality, such as pathological background and the opportunity of surgery,

among others.[13,14] Although there is a direct correlation between surgical risk and RACHS-1 category, in our experience, patients with higher complexity were mainly associated with an incomplete or nonspecific diagnosis. It is also important to mention that the historical experience created was not only based on elective patients, because there were 22% of patients who required urgent intervention, which increased the complexity.

## CONCLUSIONS

Developing a surgical program for congenital heart disease represents a great challenge for the health personnel involved, since a series of administrative, technical, economic and, mainly, human resources problems must be considered. Many of the patients who underwent surgery were candidates for therapeutic intervention. However, the appropriate specialists in this area were not available at the beginning of our center experience. Although this is a clear example that shows the need for strengthening of the cardiovascular team, it must also be recognized that its absence allowed the consolidation of our surgical service, since this therapeutic alternative is useful in these circumstances. Finally, this set the precedent for continuing to progress in the future for establishing our center as a regional reference in increasingly complex pathology in the area of congenital heart disease.

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# Incidence of cardiac tumors in a high-specialty hospital

## *Incidencia de tumores cardíacos en un hospital de alta especialidad*

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### ABSTRACT

**Introduction:** primary cardiac tumors are rare entities with an incidence that varies significantly between hospitals. Advances in diagnostic techniques such as echocardiography and surgery with cardiopulmonary bypass have notably improved their management. This study aimed to determine the incidence and clinical characteristics of cardiac tumors at the General Hospital of Mexico "Dr. Eduardo Liceaga" during the 2024-2025 period. **Material:** a prospective, descriptive, and cross-sectional cohort study was conducted between March 2024 and March 2025. Eleven patients over 18 years old with a confirmed diagnosis of cardiac tumor were included. **Results:** an incidence of 4.21% was documented in relation to the total number of surgeries performed (261). The majority of patients were female (63.64%) with an average age of 56 years. All tumors were primary, with 90.9% being benign (myxomas) and 9.09% malignant (sarcoma). The most common location was the left atrium (72.72%). All patients underwent surgery via median sternotomy, with an average surgical time of 195 minutes. Two patients (18.18%) required reoperation due to bleeding. No mortality was recorded within the first 30 days postoperatively. The average hospital stay was 9.27 days. **Conclusion:** atrial myxoma is the most common primary cardiac tumor, particularly in middle-aged women, with a predominance in the left atrium. Surgery remains the treatment of choice, showing a low rate of complications and favorable short-term outcomes. Continued multicenter studies are essential to strengthen the epidemiological understanding of these neoplasms.

**Keywords:** cardiac tumor, atrial myxoma, cardiac surgery, benign tumors.

### *RESUMEN*

***Introducción:*** *los tumores cardíacos primarios son entidades raras cuya incidencia varía significativamente entre centros hospitalarios. Con el avance de técnicas diagnósticas, como la ecocardiografía y la cirugía con circulación extracorpórea, su manejo ha mejorado notablemente. Este estudio tuvo como objetivo determinar la incidencia y características clínicas de los tumores cardíacos en el Hospital General de México "Dr. Eduardo Liceaga" durante el período 2024–2025.* ***Material:*** *se realizó un estudio de cohorte prospectivo, descriptivo y transversal entre marzo de 2024 y marzo de 2025. Se incluyeron 11 pacientes mayores de 18 años con diagnóstico confirmado de tumor cardíaco.* ***Resultados:*** *se documentó una incidencia del 4.21% en relación con el total de cirugías realizadas (261). La mayoría de los pacientes fueron mujeres (63.64%) con una edad promedio de 56 años. Todos los tumores fueron primarios, siendo el 90.9% benignos (mixomas) y 9.09% malignos (sarcoma). La aurícula izquierda fue la localización más común (72.72%). Todos los pacientes fueron operados mediante esternotomía media, con un promedio de tiempo quirúrgico de 195 minutos. Dos pacientes (18.18%) requirieron reintervención por sangrado. No se registró mortalidad a los 30 días postoperatorios. La estancia hospitalaria promedio fue de 9.27 días.* ***Conclusión:*** *el mixoma auricular es el tumor cardíaco más frecuente, especialmente en mujeres de edad media, con predominancia en la aurícula izquierda. La cirugía continúa siendo el tratamiento de elección con baja tasa de complicaciones y buenos resultados a corto plazo. Es fundamental continuar con estudios multicéntricos para fortalecer el conocimiento epidemiológico de estas neoplasias.*

***Palabras clave:*** *tumor cardiaco, mixoma atrial, cirugía cardíaca, tumor benigno.*

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The first description of cardiac tumors was made by Realdo Colombo in 1559. The advent of cardiopulmonary bypass in 1953, pioneered by John Gibbon, and the development of echocardiography, enabling non-invasive diagnosis of intracardiac masses, significantly influenced their management. Today, surgical techniques have been standardized, yielding minimal mortality rates.[1] Cardiac tumors can be divided into primary cardiac tumors, which originate in the heart, and secondary tumors, which have metastasized to the heart. Primary cardiac tumors can be further subdivided into benign tumors representing 75% and malignant tumors accounting for 25%.[2] Primary cardiac tumors are rare, with an incidence of 1.38 to 30 per 100,000 people per year. The most common tumors in patients over the age of 16 are myxomas (50%), lipomatous tumors (21%), and papillary fibroelastomas (16%).[3] Secondary involvement of the heart is relatively uncommon. It has been found that 10-20% of patients who die from metastatic cancer have involvement of the heart or pericardium. Surgical resection is rarely possible or advisable for these tumors, and treatment is usually limited to the drainage of malignant pericardial effusions and/or diagnostic biopsies.[1-4] The clinical presentation of cardiac tumors varies according to tissue origin and may manifest as valvular lesions, infarction or myocardial dysfunction, atrial fibrillation, hypercoagulable syndromes, or antiphospholipid syndrome.[1-5]

## MATERIAL

We conducted a prospective, descriptive cohort study with a non-experimental, cross-sectional design, collecting primary data from March 2024 to March 2025, at our institution. The study focused on patients diagnosed with cardiac tumors in the Department of Cardiology, aiming to determine the incidence of these tumors. Our sample consisted of 11 patients aged 18 and above.

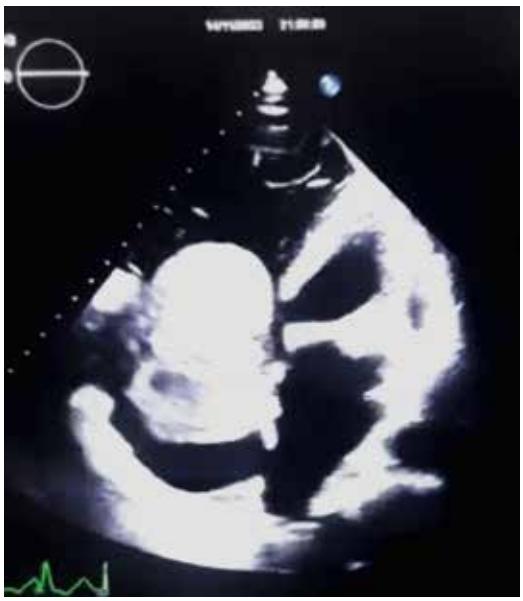

**Figure 1:** Transthoracic echocardiogram showing an intracavitary mass in the right atrium compatible with a cardiac tumor.

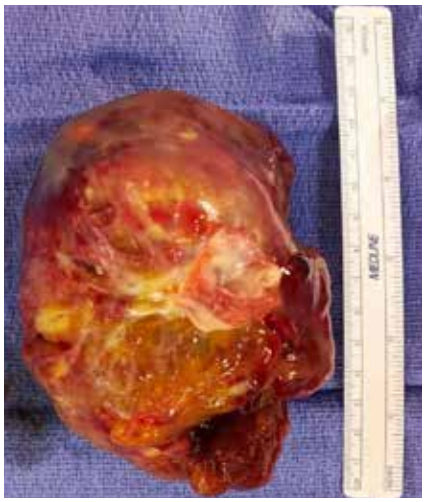

**Figure 2:**

Large right atrial myxoma with estimated dimensions of 12.5 × 9 cm, observed during surgical resection.

## RESULTS

Eleven cases of cardiac tumors were documented between March 2024 and March 2025, accounting for 4.21% of 261 surgeries performed. A female predominance was observed, with 63.64% (n = 7) of cases, while males represented 36.36% (n = 4). The mean age at presentation was 56 years (± 14), with a range of 42 to 71 years. All tumors were primary, with 90.9% (n = 10) being benign and 9.09% (n = 1) malignant, corresponding to myxomas *(Fig. 1)* and a sarcoma *(Fig. 2)*, respectively. The left atrium was the most common location, accounting for 72.72% (n = 8) of cases, followed by the right atrium with 27.27% (n = 3); all tumors were attached to the atrial septal wall.

Surgical management via median sternotomy was performed in all patients. Cardiopulmonary bypass averaged 71 minutes (range: 34-180 min), with aortic cross-clamp time averaging 51 minutes (range: 32-75 min) for left atrial tumors. The mean operative time was 195 minutes (range: 102-300 min), and intraoperative blood loss averaged 727.27 mL (range: 50-3,000 ml). Tumor resections were associated with valve replacement in 18.18% of cases (n = 2), due to damage to the valvular annulus anatomy causing severe insufficiency. Reoperation was required in 18.18% (n = 2) of patients due to postoperative bleeding within the first 24 hours. No mortality was recorded within the first 30 days after the operation.

Histopathological examination revealed atrial myxoma as the predominant benign tumor type, while the malignant

tumor was diagnosed as a high-grade spindle cell sarcoma. Tumor dimensions ranged from 4.3 × 3.8 cm to 12.5 × 9 cm *(Fig. 3)*. The average length of hospital stay was 9.27 days (range: 6-15 days). All relevant information for this case series is summarized in *Table 1*.

## DISCUSSION

Over the years, the incidence of cardiac tumors has been studied in an effort to identify epidemiological patterns and characterize the affected patient population. Therefore, it is appropriate to compare the results found in different healthcare centers to identify each of these determining elements.

In terms of incidence, the study conducted by Alfaro et al. at the Centro Médico Nacional Siglo XXI reported a rate of 0.16%, similar to that found by Naranjo at the Instituto Nacional de Cardiología Ignacio Chávez, with an incidence of 0.12%. These results contrast significantly with the findings of this study conducted at the General Hospital of Mexico "Dr. Eduardo Liceaga", which reported a 4.21% incidence among all cardiac surgeries performed during the study period. A common finding across all comparative studies is the predominance of the female gender, with a significantly higher frequency than males, most often presenting in the sixth decade of life, exceeding 60% in all cases.[6,7]

Atrial myxoma was the most frequently observed primary cardiac tumor, found in 84% of cases in the study by Alfaro et al., at Centro Médico Nacional Siglo XXI, 75% in the study by Jiménez et al., at Centro Médico ABC, and 70% in the study by Naranjo (2016) at the Instituto Nacional de Cardiología Ignacio Chávez. Our findings reflect a similar trend, with atrial myxomas accounting for 90% of the cases[7,8]

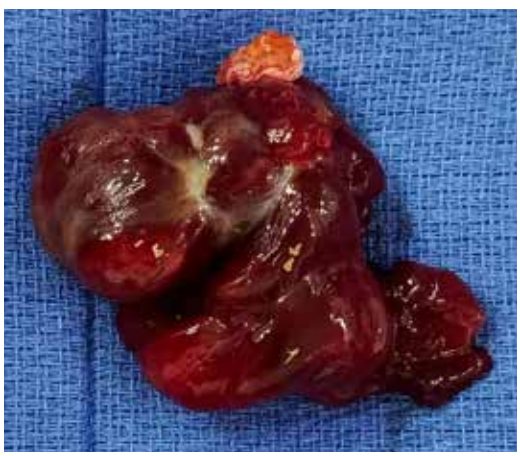

**Figure 3:** Cardiac spindle cell sarcoma: macroscopic image of the tumor after excision.

**Table 1:** Cardiac tumor cases series.

| Variable | Value |
|---|---|
| Number of cases (N) | 11 |
| Percentage of cardiac surgeries, n (%) | 11/261 (4.2) |
| Age (years), mean ± standard deviation | 56 ± 14 |
| Age (years), range | 42-71 |
| Gender, n (%) | |
| Male | 4 (36.7) |
| Female | 7 (63.3) |
| Tumor type, n (%) | |
| Benign | 10 (90.9) |
| Malignant | 1 (9.09) |
| Tumor location, n (%) | |
| Left atrium | 8 (72.8) |
| Right atrium | 3 (27.2) |
| Cardiopulmonary bypass time (min), median [range] | 71 [34-180] |
| Aortic cross-clamp time (min), median [range] | 51 [32-75] |
| Operative time (min), median [range] | 195 [102-300] |
| Intraoperative bleeding (ml), median [range] | 727.3 [50-3,000] |
| Valve replacement, n (%) | 2 (18.2) |
| Reoperation for chest bleeding, n (%) | 2 (18.2) |
| 30-day mortality, n (%) | 0 (0.0) |
| Tumor size (cm) | From 4.3 × 3.8 to 12.5 × 9 |
| Mean hospital stay (days), median [range] | 9.27 [6-15] |

The left atrium was confirmed as the most common anatomical location for cardiac tumors, found in 72.72% of cases in our study. This aligns with the results reported by Naranjo, who found left atrial involvement in 80% of cases, and Poterucha et al., who reported 75% involvement in the left atrium and 10-15% in the right atrium.[3,7]

The presentation of symptoms is generally nonspecific and variable. However, once an intracardiac mass is detected, it does not contraindicate surgical intervention. Echocardiography was the main diagnostic method used in all reported cases.

When an intracardiac mass is suspected, echocardiography is the initial diagnostic tool of choice, as it provides essential information about the size, anatomical location, and extent of the mass, as well as its functional implications, such as flow obstruction, valvular involvement, cardiac contractility, presence or absence of pericardial metastasis, and pericardial effusion.[3,7,8]

The most common postoperative complication reported in the literature, postoperative bleeding, was observed in 18.18% of patients in this study, necessitating surgical reintervention. No mortality was recorded within the 30-day postoperative period, consistent with the absence of perioperative deaths in the reviewed studies.

Regarding hospital length of stay, the study by Jiménez et al., reported an average stay of 9.5 days. Similarly, our study

found an average stay of 9.27 days, indicating significant concordance between both findings.[8]

## CONCLUSIONS

Primary cardiac tumors are rare entities, with a higher incidence of benign tumors, confirming the predominance of atrial myxoma as the most common primary tumor, most frequently located in the left atrium and more commonly affecting women. The incidence of these neoplasms was found to vary significantly among different hospital centers, highlighting the importance of conducting multicenter studies to enable a more precise characterization of their epidemiology and management.

Surgery remains the treatment of choice, with favorable outcomes in most cases, a low rate of postoperative complications, and the absence of 30-day mortality, which reinforces the safety of the surgical approach in this patient group. Finally, the comparison with previous studies reaffirms the relevance of continued analysis and documentation of the clinical course of patients with cardiac tumors to optimize therapeutic strategies and improve clinical outcomes.

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EXPERT OPINION

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# Limitations and concerns of the MATTERHORN: implications for clinical practice

## *Limitaciones y cuestionamientos del estudio MATTERHORN: implicaciones para la práctica clínica*

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### ABSTRACT

The MATTERHORN trial, named after the iconic Alpine peak, aimed to establish a new therapeutic standard in functional mitral regurgitation (FMR) by comparing surgical mitral valve (MV) intervention with transcatheter edge-to-edge repair (TEER). However, its design introduced key limitations that challenge the real-world relevance of its findings. Sponsored by the MitraClip manufacturer, the trial excluded coronary artery bypass grafting (CABG) from the surgical arm-despite CABG being a guideline-supported therapy in ischemic FMR-thus comparing TEER against a non-standard surgical strategy. A limited 12-month follow-up, reliance on a non-inferiority design with unclear margins, and an endpoint heavily influenced by non-cardiac rehospitalizations further weakened its statistical robustness. Patient selection skewed toward low-risk profiles with mild or atrial-type FMR, suboptimal guideline-directed medical therapy, and significant echocardiographic data gaps. Crucial hemodynamic markers and structural durability outcomes were also omitted. These combined flaws render the trial's claims of therapeutic equipoise questionable. Rather than establishing a new benchmark, MATTERHORN underscores the urgent need for rigorously designed studies capable of providing definitive, guideline-relevant evidence for managing FMR.

### *RESUMEN*

*El ensayo MATTERHORN, llamado así por el icónico pico alpino, tuvo como objetivo establecer un nuevo estándar terapéutico en la insuficiencia mitral funcional (FMR, por sus siglas en inglés) comparando la intervención quirúrgica de la válvula mitral (VM) con la reparación transcatéter de borde a borde (TEER, por sus siglas en inglés). Sin embargo, su diseño introdujo limitaciones clave que cuestionan la relevancia de sus hallazgos en la práctica clínica. Patrocinado por el fabricante de MitraClip, el ensayo excluyó la cirugía de revascularización coronaria (CABG, por sus siglas en inglés) del brazo quirúrgico, a pesar de ser una terapia respaldada por las guías para la FMR isquémica, comparando así la TEER con una estrategia quirúrgica no estándar. Un seguimiento limitado de 12 meses, la dependencia de un diseño de no inferioridad con márgenes poco claros y un criterio de valoración muy influenciado por las rehospitalizaciones no cardiacas debilitaron aún más su robustez estadística. La selección de pacientes se inclinó hacia perfiles de bajo riesgo con FMR leve o de tipo auricular, terapia médica subóptima basada en las guías y una importante falta de datos ecocardiográficos. También se omitieron marcadores hemodinámicos cruciales y resultados de durabilidad estructural. Estas deficiencias combinadas cuestionan las afirmaciones del ensayo sobre el equilibrio terapéutico. En lugar de establecer un nuevo punto de referencia, MATTERHORN subraya la urgente necesidad de estudios rigurosamente diseñados capaces de proporcionar evidencia definitiva y relevante para las directrices sobre el manejo de la FMR.*

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**Keywords:** functional mitral regurgitation, guideline-directed medical therapy, mitral valve surgery, mitral valve repair, non-inferiority trial design, transcatheter edge-to-edge repair.

***Palabras clave:*** *insuficiencia mitral funcional, tratamiento médico basado en guías clínicas, cirugía valvular mitral, reparación valvular mitral, estudios de no inferioridad, reparación transcatéter borde-a-borde.*

**Abbreviations:**
ACC/AHA = American College of Cardiology/American Heart Association
ARNi = angiotensin receptor neprilysin inhibitors
CABG = coronary artery bypass grafting
EROA = effective regurgitant orifice area
ESC/EACTS = European Society of Cardiology/European Association for Cardio-Thoracic Surgery
FMR = functional mitral regurgitation
GDMT = guideline-directed medical therapy
HF = heart failure
HFrEF = heart failure with reduced ejection fraction
ITT = intention-to-treat
LV = left ventricular
LVAD = left ventricular assist device
MV = mitral valve
SGLT2i = sodium-glucose co-transporter 2 inhibitors
STS-PROM = Society of Thoracic Surgeons Predicted Risk of Mortality
TEER = transcatheter edge-to-edge repair

Named after one of the most emblematic peaks in the Alps, the MATTERHORN trial sought to attain similar symbolic prominence in the therapeutic landscape of functional mitral regurgitation (FMR). By comparing surgical mitral valve (MV) intervention with transcatheter edge-to-edge repair (TEER), the study attempted to provide clarity on a domain long mired in clinical equipoise. However, rather than offering solid ground, the trial's design and execution introduce critical uncertainties that dilute the applicability of its findings to real-world decision-making.

The trial –formally registered as *A Multicenter, Randomized, Controlled Study to Assess Mitral Valve Reconstruction for Advanced Insufficiency of Functional or Ischemic Origin* (NCT02371512)– was industry-sponsored by Abbott Vascular, the manufacturer of the MitraClip system. A total of 210 patients with symptomatic FMR despite guideline-directed medical therapy (GDMT), and explicitly without indication for coronary artery bypass grafting (CABG), were randomized to either surgical MV intervention or TEER. The primary efficacy outcome was defined as a composite of death, hospitalization for heart failure (HF), MV reintervention, left ventricular assist device (LVAD) implantation, or stroke at 12 months. The primary safety endpoint comprised major adverse events within 30 days of the procedure.[1]

Yet, the comparative framework raises substantial methodological and conceptual red flags. First, the decision to exclude CABG –a class I indication in patients with ischemic FMR and multivessel disease– renders the surgical arm artificially limited, diminishing the generalizability of the results.[2,3] Moreover, comparing TEER (a therapy granted class IIa status) with standalone MV surgery (typically class IIb in the absence of CABG) does not reflect a comparison between two equally endorsed strategies, but rather places a procedure with limited support under unfair scrutiny.[4] This inherent imbalance in therapeutic class recommendations undermines the study's clinical relevance, especially when one considers that CABG remains the only intervention in this setting with robust evidence for improved survival.[5,6]

Additionally, concerns arise from the trial's sponsorship and design, both of which introduce the potential for bias in endpoint selection, interpretation, and dissemination. Industry funding in cardiovascular trials has historically been associated with more favorable outcomes for the sponsor's product.[7] Given the commercial interest in expanding the indications for MitraClip, scrutiny of both trial conduct and conclusions is essential.

Also, the brevity of the follow-up period in the MATTERHORN (12 months) further limits the scope of interpretation. Indeed, the inherent chronicity of HF renders the MATTERHORN trial's 1-year follow-up data demonstrably insufficient for a definitive assessment of TEER efficacy. This limitation is starkly demonstrated by the COAPT trial, where the cumulative incidence of the composite endpoint of all-cause death or HF hospitalization in the TEER-treated cohort rose from 33.9% at 1 year to a striking 73.6% at five years,[8] unequivocally underscoring the critical necessity of extended observation periods for accurate evaluation of long-term therapeutic impact.

## METHODOLOGICAL AND STATISTICAL ISSUES

A fundamental limitation of the MATTERHORN trial lies in its exclusive reliance on an intention-to-treat (ITT) analysis. While ITT is the gold standard in superiority trials to preserve randomization and avoid attrition bias, its utility in non-inferiority designs is more contentious. In such settings, ITT can obscure meaningful differences between interventions, particularly when crossovers, withdrawals, or protocol deviations occur—factors that are common in interventional cardiology trials.[9] A per-protocol or as-treated analysis, ideally presented alongside ITT, would have provided complementary insight and may have altered the interpretation of efficacy.

The reported composite event rates –18.2% in the TEER group and 25% in the surgical group– yielded a non-significant

p-value of 0.234. While statistically neutral, this result is prone to misinterpretation in the context of non-inferiority trials, where absence of difference is not synonymous with equivalence.[10] Furthermore, the trial should have adopted a one-sided alpha level of 0.025, corresponding to a two-tailed trial, such as the MATTERHORN (but not the 0.05 cited by the authors), consistent with regulatory standards. In turn, this turns out to be highly problematic, given the small sample size and modest event frequency. Low statistical power under such conditions heightens the risk of type II error, potentially overlooking clinically meaningful differences.[11]

Perhaps the most contentious aspect is the pre-specified assumption of a 35% event rate in the control (surgical) group, used to calculate the non-inferiority margin. This figure appears inflated when contrasted with real-world data. For instance, contemporary analyses of patients with STS-PROM scores exceeding 2% report composite adverse event rates closer to 19.2%, especially in experienced surgical centers.[12] Overestimating the control event rate artificially widens the margin for declaring non-inferiority, thereby making it easier for the experimental arm to appear comparable–even when a clinically relevant difference may exist.[13] This design flaw is not unique to MATTERHORN; similar criticisms have emerged regarding other device trials seeking regulatory approval based on lenient non-inferiority frameworks.[14]

Moreover, the use of a composite endpoint –while increasing event counts– risks diluting the relevance of hard outcomes such as mortality or stroke, especially when driven by softer events like rehospitalization. This statistical strategy, though efficient, may not align with clinical priorities and complicates interpretation when the components vary substantially in clinical weight.[15]

## ENDPOINTS AND EVENT INTERPRETATION

The MATTERHORN trial employed a composite primary endpoint for primary efficacy outcome, a composite of death, hospitalization for HF, MV reintervention, LVAD implantation, or stroke at 12 months. While composite endpoints can enhance statistical efficiency by increasing event rates, they often conflate outcomes of disparate clinical relevance, potentially skewing interpretation.[16] In MATTERHORN, the most statistically significant component was rehospitalization –specifically, all– cause hospital readmission–rather than cardiovascular-specific events, which dilutes the primary endpoint's capacity to reflect true therapeutic benefit.

This is particularly problematic when the significance of the composite is driven by non-cardiac hospitalizations. In the trial, all-cause rehospitalization favored TEER (24.7%) over surgery (39.0%), yet the observed difference lost statistical significance when stratified into cardiac versus non-cardiac causes. Only the non-cardiac rehospitalizations demonstrated statistical separation between groups, suggesting that this result was incidental rather than causally linked to the MV intervention.[17] Including such variables in the composite endpoint undermines its specificity and inflates perceived benefit.[18]

Further inconsistencies emerged regarding MV reinterventions. At the 30-day follow-up, surgical patients had more reinterventions reported. However, at 1 year, the trend reversed: five TEER patients versus two surgical patients required MV reintervention. This shift not only contradicts earlier data but also raises concerns about the adjudication of such events. The lack of clarity around what constituted a "reintervention" compromises transparency.

Lastly, the trial did not perform a hierarchical testing procedure to control for multiplicity. As such, the isolated significance of a single component (rehospitalization) cannot be interpreted independently without adjustment for multiple comparisons. This is a major shortcoming in trial methodology, as it inflates the chance of type I error and presents a misleading narrative of clinical benefit.[19]

## CLINICAL RELEVANCE OF THE SURGICAL COMPARATOR

A critical flaw in the MATTERHORN trial lies in the choice of surgical comparator. All patients randomized to surgery underwent isolated MV intervention, explicitly excluding CABG, even when coronary disease was present in 43.7% of the series. This is a striking deviation from established guidelines. Both the American College of Cardiology/American Heart Association (ACC/AHA) and the European Society of Cardiology/European Association for Cardio-Thoracic Surgery (ESC/EACTS) confer a class I recommendation for MV surgery *only when performed concomitantly with CABG* in patients with FMR and suitable coronary anatomy.[2,3] When surgery is done in isolation, as in MATTERHORN, the recommendation is downgraded to class IIb, reflecting a weaker evidence base and uncertain clinical benefit.

This context renders the trial's comparison asymmetrical: TEER, a guideline-supported intervention with a class IIa recommendation, was pitted against an off-guideline surgical approach. Consequently, any equivalence or non-inferiority observed is of limited relevance, as it does not reflect standard-of-care surgical management in this population. The trial therefore risks generating conclusions that are misaligned with clinical practice and unsuitable for guideline formulation.

Further compromising the comparator is the unexpected distribution of surgical techniques. Of the surgical group, 28% underwent MV replacement, rather than repair. The

trial offers no prespecified criteria to justify this decision. MV repair and replacement are not equivalent procedures–repair is associated with lower thromboembolic risk. Conversely, MV replacement is typically associated to lower reoperation rates for recurrent mitral regurgitation, while survival rate remains without statistical significance at 1-year [hazard ratio: 0.79, 95% CI: 0.42-1.47; p = 0.45) and two-years of follow-up [hazard ratio: 0.79, 95% CI: 0.46-1.35; p = 0.39), respectively.[20,21]

Standardization of surgical technique is crucial in comparative trials. Yet in MATTERHORN, no centralized surgical protocol, intraoperative echocardiographic standards, or independent surgical adjudication were described. Without these controls, inter-operator variability can significantly influence outcomes, introducing noise and confounding the treatment effect.[22,23] For instance, leaflet tethering, annular size, or papillary muscle displacement may have influenced the decision to replace rather than repair, but these anatomical factors were neither quantified nor reported. Therefore, by including a mixed cohort with both procedures –and without stratifying outcomes accordingly– the trial fails to account for this fundamental heterogeneity in surgical risk and prognosis.

## PATIENT SELECTION AND POPULATION RISK PROFILE

The MATTERHORN trial sought to investigate whether TEER is non-inferior to MV surgery in patients with FMR who are ostensibly at high surgical risk, according to the authors. However, this premise appears to be fundamentally flawed, as the enrolled population's average Society of Thoracic Surgeons Predicted Risk of Mortality (STS-PROM) score was a mere 2.2%, categorizing most patients as low surgical risk. This is particularly problematic given that current clinical guidelines for FMR do not consider surgical risk as a determining factor in the decision-making paradigm.[2,3] Consequently, the trial's design and findings may be rendered incongruous with real-world clinical practice, where treatment decisions are guided by established guidelines criteria rather than surgical risk profiles. This incongruity calls into question the external validity of the trial's findings and undermines their generalizability to real-world FMR populations.

Moreover, over half the patients enrolled were presumed to have atrial-type FMR (Carpentier type I), a variant characterized by mitral annular dilatation in the setting of preserved left ventricular (LV) function and atrial enlargement, often seen in long-standing atrial fibrillation. Atrial-type FMR has a more favorable natural history and better surgical outcomes than ventricular-type (Carpentier type IIIb), which is driven by LV remodeling, leaflet tethering, and poor systolic function.[24-27] This distinction is crucial because the latter represents the canonical FMR phenotype for which both surgical and transcatheter interventions are intended. Yet, MATTERHORN fails to stratify outcomes based on FMR subtype, thereby introducing a substantial source of biological heterogeneity into the results. Even within ventricular-type FMR, the study does not report the morphology of leaflet tethering-specifically, whether it was symmetric or asymmetric. This is a critical omission, as symmetric tethering is typically associated with global LV remodeling, whereas asymmetric tethering reflects localized remodeling, often in the posterobasal or inferior wall of the LV. These distinct patterns not only signal different pathophysiological processes but also imply divergent surgical strategies and prognostic expectations.[4,28] The lack of such granularity in MATTERHORN reflects an oversimplified echocardiographic assessment of mitral regurgitation mechanism and undermines both the internal and external validity of the trial.

Another critical point is the echocardiographic definition of FMR severity. According to both American and European guidelines, an EROA $\geq$ 40 mm$^2$ is required to define severe FMR in most cases.[29,30] The median effective regurgitant orifice area (EROA) in MATTERHORN was only 20 mm$^2$ ($\pm$ 10 mm$^2$), with only one third of patients falling below the conventional threshold for severe FMR. Indeed, Wang et al. have emphasized the fact that approximately 60% of the patients in the MATTERHORN had non-severe FMR.[31] The inclusion of patients with non-severe FMR, such as moderate (grade 2+) or moderate-to-severe (grade 3+) MR weakens the validity of the intervention and blunts any treatment effect, particularly when analyzing hard outcomes such as survival or rehospitalization.

Taken together, the selection of low-risk patients, inclusion of predominantly atrial-type FMR, inadequate characterization of tethering morphology, and questionable severity thresholds suggest a trial population in whom the potential benefit of any intervention –surgical or transcatheter– would be inherently limited. These design choices bias the study toward a neutral outcome and favor non-inferiority conclusions, which may not hold in patients with truly severe, symptomatic, ventricular-type FMR–the population most in need of guideline-informed therapy.[2,3]

## INCOMPLETE DATA AND INADEQUATE MEDICAL THERAPY

A notable limitation of the MATTERHORN trial is the substantial amount of missing echocardiographic data during follow-up, with over 60% of patients lacking complete MV parameters at one year.[32] This high attrition rate in imaging undermines the reliability of longitudinal valve assessment and hampers robust evaluation of procedural durability

and functional outcomes. Echocardiographic follow-up is essential to quantify residual mitral regurgitation, ventricular remodeling, and leaflet motion post-intervention, factors directly impacting clinical prognosis.

Moreover, the trial reveals a concerning underutilization of GDMT, a cornerstone in managing patients with FMR and HF with reduced ejection fraction (HFrEF). Only 10.5% of surgical patients were discharged on triple therapy (beta-blocker, renin-angiotensin system inhibitor, and mineralocorticoid receptor antagonist), and there was negligible use of contemporary agents such as sodium-glucose co-transporter 2 inhibitors (SGLT2i), and angiotensin receptor neprilysin inhibitors (ARNi).[33] Given the demonstrated survival and morbidity benefits of comprehensive GDMT in HFrEF,[34] failure to optimize medical treatment confounds interpretation of procedural efficacy and blunts the generalizability of outcomes. Besides that, Adamo et al.[35] demonstrated a direct correlation between GDMT uptitration post-TEER and a composite endpoint of mortality and HF hospitalization at three-year follow-up, with a hazard ratio of 0.54 (95% CI: 0.38-0.76), thereby conferring a significant survival benefit in favor of GDMT uptitration. That means that inadequate medical optimization may have artificially elevated event rates and masked the potential incremental benefit of either surgical or transcatheter intervention. The absence of standardized GDMT protocols and inconsistent implementation between study arms further complicates direct comparison. These deficiencies highlight the imperative for future trials to rigorously enforce GDMT adherence to isolate the true impact of device-based therapies in FMR.

## UNREPORTED HEMODYNAMIC OUTCOMES AND STRUCTURAL DURABILITY

A critical shortcoming of the MATTERHORN trial is the omission of key hemodynamic parameters following TEER, specifically residual trans-mitral gradient and MV area measurements. These markers are fundamental to evaluating procedural success, as elevated post-procedural gradients may predispose patients to mitral stenosis and adverse clinical outcomes. It has been demonstrated that up to 26.4% of cases post-TEER exhibits a mean trans-mitral gradient > 5 mmHg. In turn, a significant independent association has been observed between elevated mean trans-mitral gradient ≥ 5 mmHg and increased risk of all-cause mortality, with a hazard ratio of 1.38 (95% CI: 1.08-1.76, p = 0.009). The absence of these data limits the ability to discern the functional quality of the valve repair, a vital consideration given the known trade-off between mitral regurgitation reduction and iatrogenic mitral stenosis inherent to the TEER technique.[36]

In addition, the trial did not systematically assess or report structural MV repair failure rates, an endpoint increasingly recognized as more objective and clinically meaningful than reoperation rates alone. Structural durability reflects the intrinsic longevity and performance of the repair device or surgical intervention and has significant implications for patient prognosis and subsequent management. Reoperation rate after MV procedures is potentially confounded by numerous factors, including medical indications, patient choices, and clinician decisions. Therefore, quantifying failure rate based on the presence of 3+ or 4+ mitral regurgitation may offer a more robust and reliable measure of procedural efficacy.[37] Without such data, the long-term efficacy and safety profile of TEER versus surgical MV repair remain inadequately characterized.

Finally, a striking disparity exists between the MATTERHORN trial's officially registry data (NCT02371512) and published results.[1] Despite initiation in 2015 with an anticipated completion by 2019, the registry has remained dormant since 2017, contravening established protocols. The assertion of patient enrollment until 2022[1] starkly contrasts with the registry's inactivity in the official website (NCT02371512), casting doubt on the trial's conduct. Moreover, the brevity of the follow-up period, limited to only one-year, appears anomalous given the nine-year interval between enrollment commencement and publication date in 2024, underscoring the need for more protracted follow-up, at least five years or even longer, to yield meaningful conclusions.

## CONCLUSION

The MATTERHORN trial's lofty ambitions to redefine the treatment paradigm for FMR are starkly at odds with its findings, which are irreparably compromised by egregious methodological flaws. Despite its namesake's majestic peak, the trial's results are decidedly underwhelming, offering little more than a faint glimpse of potential equipoise between TEER and MV surgery in a narrowly defined, low-risk cohort. The study's glaring shortcomings, including a woefully inadequate comparator arm and haphazard endpoint reporting, render its conclusions tenuous at best. In light of these profound limitations, the trial's findings must be viewed with extreme skepticism. To truly illuminate the optimal treatment strategies for FMR, future studies must prioritize rigorous methodological design, standardized surgical techniques, and comprehensive endpoint definitions that capture the full spectrum of clinical, hemodynamic, and structural outcomes. Only then can the field move beyond the MATTERHORN trial's meager contributions and toward a more nuanced understanding of TEER and surgery in managing FMR.

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# Deconstructing the interplay: CABG and concomitant mitral valve surgery in ischemic functional mitral regurgitation. Which one drives long-term survival?

## *Descifrando la interacción: revascularización coronaria y cirugía valvular mitral concomitante en la insuficiencia mitral funcional isquémica. ¿Cuál de ellos determina la sobrevida a largo plazo?*

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### ABSTRACT

The intricate management of ischemic functional mitral regurgitation (FMR) in patients undergoing coronary artery bypass grafting (CABG) remains a formidable challenge and a subject of continuous scientific discourse. While the profound impact of CABG on survival in patients with significant coronary artery disease (CAD) and left ventricular (LV) dysfunction is well-established, the precise, independent benefit derived from adding concomitant mitral valve (MV) surgery for FMR warrants a comprehensive and nuanced discussion, especially given the inherent increase in surgical complexity. It is crucial to note that in FMR, the valvular incompetence is a consequence, rather than the cause, of an underlying pathology that distinctly differs from primary mitral regurgitation. Specifically, FMR in these patients predominantly stems from ischemic LV dysfunction, which precipitates MV annular deformation and papillary muscle displacement, thereby hindering effective MV leaflet coaptation.

**Keywords:** coronary artery bypass grafting, functional mitral regurgitation, mitral regurgitation, mitral valve, mitral valve repair, mitral valve replacement.

### *RESUMEN*

*El complejo manejo de la insuficiencia mitral funcional (FMR, por sus siglas en inglés) isquémica en pacientes sometidos a cirugía de revascularización coronaria (CABG, por sus siglas en inglés) sigue siendo un desafío formidable y un tema de continuo debate científico. Si bien, el profundo impacto de la CABG en la supervivencia de pacientes con enfermedad arterial coronaria significativa y disfunción del ventrículo izquierdo está bien establecido, el beneficio preciso e independiente derivado de agregar cirugía valvular mitral concomitante para la FMR justifica un análisis exhaustivo y matizado, especialmente dado el aumento inherente en la complejidad quirúrgica. Es crucial señalar que, en la FMR, la incompetencia valvular es una consecuencia, más que la causa, de una patología subyacente que difiere claramente de la insuficiencia mitral primaria. Específicamente, la FMR en estos pacientes se deriva predominantemente de la disfunción isquémica del ventrículo izquierdo, que precipita la deformación anular mitral y el desplazamiento de los músculos papilares, dificultando así la coaptación efectiva de las valvas de la mitral.*

***Palabras clave:*** *revascularización coronaria, insuficiencia mitral funcional, insuficiencia mitral, válvula mitral, reparación valvular mitral, reemplazo valvular mitral.*

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**Abbreviations:**
CABG = coronary artery bypass grafting
CAD = coronary artery disease
FMR = functional mitral regurgitation
LV = left ventricular
LVEF = left ventricular ejection fraction

According to the 2021 American College of Cardiology, American Heart Association and Society for Cardiovascular Angiography and Interventions (ACC/AHA/SCAI) Guideline for Coronary Artery Revascularization,[1] coronary artery bypass grafting (CABG) is recommended to improve survival rates for certain patients with stable ischemic heart disease. CABG is notably indicated as a class I recommendation for patients with multivessel coronary artery disease (CAD) and severe left ventricular systolic dysfunction (left ventricular ejection fraction [LVEF] < 35%) or significant left main stenosis. For patients with a LVEF between 35-50%, the recommendation shifts to class IIa. For patients with normal LVEF and significant stenosis in three major coronary arteries, CABG may be considered reasonable to improve survival, albeit with a weaker class IIb recommendation.

The present analysis focuses specifically on cases where CAD is the primary pathological disease. In contrast, scenarios where valvular disease (aortic, mitral, or tricuspid) is the primary indication for surgery, and there is concomitant CAD with significant (> 70%) proximal stenosis, concomitant CABG may be warranted in such cases.[2] However, since the underlying pathophysiology differs from that of functional causes, these cases are beyond the scope of this analysis. Similarly, patients with atrial-type functional mitral regurgitation (FMR) were excluded because their pathophysiology and clinical implications are fundamentally different.

## CABG as a paramount driver of survival

It is unequivocally evident that CABG stands as a paramount driver of survival in patients with multivessel CAD and severely compromised left ventricular ejection fraction (LVEF ≤ 35%). Based on the groundbreaking findings of the STICH trial (NCT00023595), a landmark randomized controlled study with a 10-year follow-up period, Velazquez et al.[3] compellingly demonstrated that the combined approach of CABG and optimal medical therapy significantly reduces long-term mortality and hospitalization rates for cardiovascular issues compared to medical therapy alone. Specifically, the hazard ratios of 0.84 (p = 0.02) for primary events, 0.79 (p = 0.006) for cardiovascular mortality, and 0.72 (p < 0.001) for death or cardiovascular hospitalization underscore the unequivocal benefits of CABG in this high-risk population. These findings furnish robust evidence that revascularization confers a dramatic improvement in long-term survival by mitigating underlying myocardial ischemia and facilitating crucial LV reverse remodeling, thereby defining the therapeutic paradigm for patients with ischemic cardiomyopathy.

## The prognostic burden of FMR in heart failure: a critical determinant of mortality and morbidity

However, the presence of severe FMR itself introduces a significant independent prognostic burden, correlating directly with increased morbidity and mortality in patients with ischemic cardiomyopathy. Uncorrected severe FMR imposes chronic volume overload on an already compromised left ventricular (LV), accelerating ventricular dilatation, perpetuating dysfunction, and exacerbating symptoms of heart failure (HF). Therefore, can we affirm that FMR serves as a marker of poor prognosis and mortality in patients with HF? The study by Nasser et al. provides compelling evidence that FMR serves as a robust marker of poor prognosis and mortality in patients with HF. A strong graded association was observed between the severity of FMR and the risk of mortality or hospitalization, with progressively higher grades of FMR corresponding to a significantly increased risk. Specifically, compared to grade I FMR, patients with grade II FMR had a 47% increased risk (Hazard Ratio [HR]: 1.47, p = 0.107). Those with grade III FMR demonstrated a nearly three-fold increased risk (HR: 2.72, p < 0.001), and those with grade IV FMR exhibited a more than three-fold increased risk (HR: 3.48, p < 0.0001). The 4-year death or admission-free survival rates demonstrated a discernible inverse correlation with FMR severity, ranging from 83.5% in grade I to 44.7% in grade IV (p < 0.0001).[4] These findings unequivocally support the notion that FMR is a potent predictor of adverse outcomes in HF patients. Then, the critical question then arises: does addressing this severe valvular pathology with concomitant mitral valve (MV) surgery, beyond the benefits of revascularization alone, further enhance survival?

## Guideline recommendations for concomitant mitral valve surgery in patients with severe functional mitral regurgitation undergoing CABG

Current guidelines, including the 2020 American College of Cardiology/American Heart Association (ACC/AHA) Guidelines for Valvular Heart Disease[5] confer a class IIa recommendation for concomitant MV surgery in patients with severe FMR undergoing CABG, while the 2021 European Society of Cardiology (ESC)/European Association for Cardio-Thoracic Surgery (EACTS) guidelines for Valvular Heart Disease[6] provide a class I recommendation for MV repair or replacement in similar scenarios. This strong

endorsement reflects the clinical consensus about the detrimental impact of untreated severe FMR on prognosis, underscoring the necessity for intervention in cases where CABG is being considered. MV surgery in severe FMR does not translate into improved long-term survival.

While CABG definitively tackles the etiological ischemic substrate, the concomitant MV surgery serves to manage the profound pathological consequence of severe regurgitation. The primary aims of MV surgery in this setting are to achieve a durable reduction in MR, facilitate favorable LV reverse remodeling by alleviating chronic volume overload. This translates as better quality of life and symptoms improvement, but not better survival. Although establishing an independent, additional survival benefit over and above the CABG for severe FMR remains challenging through randomized trials –given the ethical implications of withholding MV surgery for severe cases during a planned cardiac surgery– the aggregate body of evidence, including observational studies and expert consensus, supports the belief that optimal management of severe FMR is integral to maximizing overall long-term outcomes. By eliminating a major source of myocardial inefficiency and progressive ventricular dysfunction, MV surgery contributes synergistically with revascularization (but not alone per se) to enhance the cardiac overall performance. Nevertheless, it is imperative to emphasize that, hitherto, *no impact on survival* has been observed after adding MV surgery to CABG in FMR.

A seminal study conducted by Mihaljevic et al.[7] provides compelling evidence that the addition of MV surgery to CABG does not confer a long-term survival benefit in patients with moderate-to-severe FMR. In a retrospective analysis of 390 patients with severe ischemic mitral regurgitation (3+/4+) who underwent CABG with (n = 290) or without (n = 100) MV annuloplasty, the investigators observed comparable survival rates at 1, 5, and 10 years postoperatively, with actuarial survival rates of 88%, 75%, and 47% in the CABG-alone group, and 92%, 74%, and 39% in the CABG plus MV annuloplasty group (p = 0.6). Notably, while the combined procedure resulted in a significant reduction in postoperative mitral regurgitation (48% vs 12% at 1 year, p < 0.0001) and provided early symptomatic relief, it did not translate into improved long-term functional status or survival, with 23% and 25% of patients in NYHA functional class III/IV at 5-year follow-up, respectively.

## No evidence for MV surgery benefit in non-severe FMR

Yet, this recommendation is viewed through the lens of a crucial trade-off. Adding MV surgery to CABG invariably prolongs cardiopulmonary bypass and aortic cross-clamp times, thereby increasing the immediate perioperative risks, including higher rates of mortality and morbidity. This increased risk profile must be carefully taken into account, particularly when considering patients with less than severe FMR.

In this regard, a meta-analysis of patients with ischemic *moderate FMR* undergoing CABG with or without MV repair or replacement was performed. It was composed by 13 articles, out of them, 4 were randomized control trials and nine were retrospective cohort studies, and revealed that, although long-term mortality was lower in the CABG-only group compared to the CABG plus MV surgery group, the difference was statistically insignificant (RR: 0.88, 95% confidence interval [CI]: 0.77, 1.02); conversely, NYHA scores were significantly lower in the CABG plus MV repair group compared to the CABG-alone group (mean difference: 0.39, 95% CI: 0.06, 0.72), ultimately suggesting that concomitant MV surgery during CABG may *not yield significant benefits in terms of clinical outcomes or survival*.[8]

A comprehensive meta-analysis of 1038 patients with *less than severe FMR* yielded intriguing insights into the comparative efficacy of CABG alone (n = 423) versus combined CABG and MV repair/replacement (n = 615). Although the combined CABG plus MV surgery approach demonstrated a notable reduction in postoperative mitral regurgitation grade (weighted mean difference [WMD]: 1.34, 95% CI: 0.47 to 2.21, p = 0.003), this improvement did not translate into significant differences in in-hospital mortality (odds ratio [OR]: 0.84, 95% CI: 0.44 to 1.61, p = 0.60), NYHA functional class (WMD: 0.33, 95% CI: -0.29 to 0.94, p = 0.30), or long-term survival (OR: 0.77, 95% CI: 0.34 to 1.73, p = 0.53), thereby raising questions about the incremental benefits of adding MV surgery to CABG in patients with non-severe FMR. While MV surgery with concomitant CABG improves postoperative MR grade, *there is no evidence for superiority in mortality, functional class, and long-term survival*.[9]

Another meta-analysis of 14 studies (n = 2,836) found that adding MV surgery to CABG did not significantly impact in-hospital mortality or 1-, 3-, or 5-year survival compared to CABG alone [in-hospital mortality (OR = 1.45, 95% CI: 0.93-2.28, p = 0.10) and one- (OR = 0.89, 95% CI: 0.68-1.15, p = 0.37), three- (OR = 1.10, 95% CI: 0.79-1.55, p = 0.56) and five- (OR = 0.93, 95% CI: 0.73-1.18, p = 0.55)], respectively. Therefore, while concomitant MV surgery during CABG yields superior postoperative mitral regurgitation outcomes, *the current evidence fails to demonstrate significant benefits* of combined surgery over CABG alone *in terms of in-hospital mortality and long-term survival*.[10]

A comprehensive meta-analysis of nine observational studies encompassing 2,479 patients with *ischemic moderate or severe FMR* revealed that concomitant MV surgery during CABG yielded *no discernible benefits in terms of late mortality* compared to CABG alone (relative risk [RR]: 1.02, 95% CI: 0.90-1.14, p = 0.73).[11]

Similarly, in patients with moderate ischemic FMR undergoing CABG, the addition of MV repair provided more durable correction of mitral regurgitation (32.3% vs 11.2% moderate or severe residual mitral regurgitation at two years, $p < 0.001$), *but did not significantly improve survival* (mortality rate: 10.6% vs 10.0%; hazard ratio, 0.90; $p = 0.78$) or reduce overall adverse events or readmissions.[12]

## CONCLUSIONS

In conclusion, while MV surgery alone effectively reduces postoperative mitral regurgitation and alleviates symptoms –thereby enhancing short-term quality of life– it is CABG that remains the cornerstone of long-term survival, as it directly targets the underlying ischemic substrate in patients with severe LV dysfunction and FMR. Accordingly, given that CABG serves as the principal determinant of survival in the surgical management of ventricular-type FMR, isolated MV surgery –performed in the absence of concomitant CABG– has been downgraded to a class IIb recommendation. In contrast, transcatheter edge-to-edge repair, which likewise excludes surgical revascularization, retains a class IIa indication due to its less invasive nature and procedural advantages. The overarching conclusion supported by current evidence is thus unequivocal: isolated MV surgery without CABG occupies a markedly limited therapeutic role in ventricular-type FMR, a perspective previously articulated by García-Villarreal.[13] Therefore, a balanced strategy that simultaneously prioritizes improved survival and quality of life enhancement is justified, to the extent possible–and such an approach warrants careful reconsideration before being pursued in clinical practice.

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# Left atrial appendage aneurysm as a cause of ischemic vascular event: case report and review of the literature

## *Aneurisma de la orejuela izquierda como causa de evento vascular isquémico: reporte de caso y revisión de la literatura*

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### ABSTRACT

Left atrial appendage aneurysm is a rare entity, with only a few cases reported in the literature, but with significant potential clinical implications. We present the case of a patient who experienced an ischemic vascular event. Imaging studies revealed a left atrial appendage aneurysm. Due to the high embolic risk, surgical management was performed by means of surgical exclusion of the left atrial appendage. The postoperative course was favorable.

**Keywords:** cerebrovascular accident, emblolism, left atrial appendage, left atrial appendage aneurysm, left atrial appendage exclusion.

### *RESUMEN*

*El aneurisma de la orejuela izquierda es una entidad rara, con pocos casos reportados en la literatura, pero con potenciales implicaciones clínicas significativas. Presentamos el caso de una paciente que debutó con evento vascular isquémico. La evaluación con estudios de imagen evidenció un aneurisma de la orejuela izquierda. Dado el alto riesgo embólico, se decidió el manejo quirúrgico mediante exclusión de la orejuela izquierda. La evolución postoperatoria fue favorable.*

***Palabras clave:*** *accidente vascular cerebral, embolismo, orejuela izquierda, aneurisma de orejuela izquierda, exclusión de orejuela izquierda.*

Left atrial appendage aneurysm (LAAA) is an extremely rare cardiac anomaly, with its exact prevalence remaining uncertain and poorly documented in the current literature.[1,2] The most common symptoms include palpitations, dyspnea, and thromboembolic events.[1-3] These manifestations often result from the aneurysm's predisposition to atrial arrhythmias and systemic embolism.[2,3] In some cases, LAAA is incidentally diagnosed during imaging studies performed for other reasons.[2,4] The diagnosis is typically confirmed using echocardiography, the most widely used imaging modality for this condition.[1-4] Transthoracic and transesophageal echocardiography are commonly employed to assess the size and morphology of the aneurysm.[1,2] Additionally, cardiac computed tomography (CT) and magnetic resonance imaging (MRI) are useful for confirmation.[4] The primary treatment for LAAA is surgical resection, which has shown favorable outcomes and symptomatic improvement.[1,2,4-7] Surgery is recommended to prevent severe complications, even in asymptomatic patients.[6]

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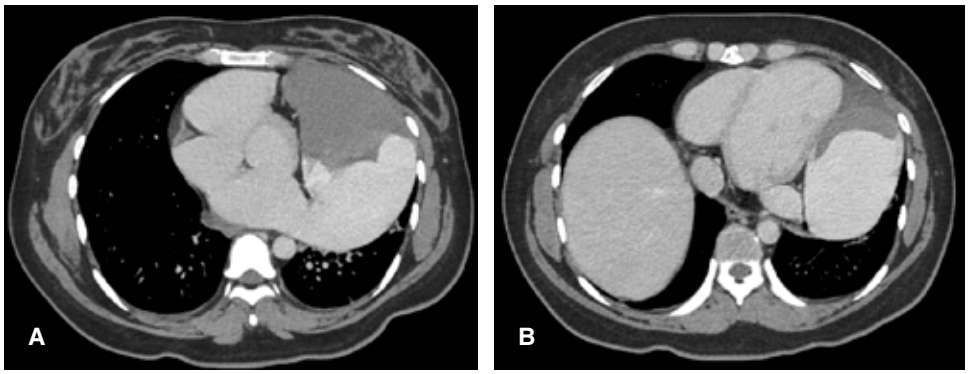


**Figure 1:**

Contrast-enhanced cardiac computed tomography (CT) demonstrating a giant left atrial appendage aneurysm (LAAA). The aneurysmal sac is clearly opacified with contrast, confirming communication with the left atrium. The image illustrates the large size of the aneurysm and its anatomic relationships with adjacent cardiac structures, including the left ventricle, pulmonary veins, and mitral valve.

## CASE REPORT

A 36-year-old female patient with a history of atrial flutter presented with sudden-onset headache, left-sided hemiplegia, and transient monocular vision loss, which spontaneously resolved. She also reported dyspnea and pleuritic chest pain lasting 48 hours.

Transthoracic echocardiography revealed an aneurysmal dilation of the left atrial appendage, confirmed by cardiac CT and MRI *(Fig. 1) (Fig. 2)*. Due to the high embolic risk, urgent surgical management was indicated. Under cardiopulmonary bypass with femoral cannulation and median sternotomy, the left atrial appendage was accessed through the posterior interatrial groove. Surgical exclusion was performed using double-layer continuous polypropylene sutures reinforced with teflon patches to ensure a watertight closure and prevent dehiscence *(Fig. 3)*.

The postoperative course was uneventful, with chest drains removed on the third day and no embolic recurrence. The patient was discharged on anticoagulation therapy and scheduled for clinical follow-up.

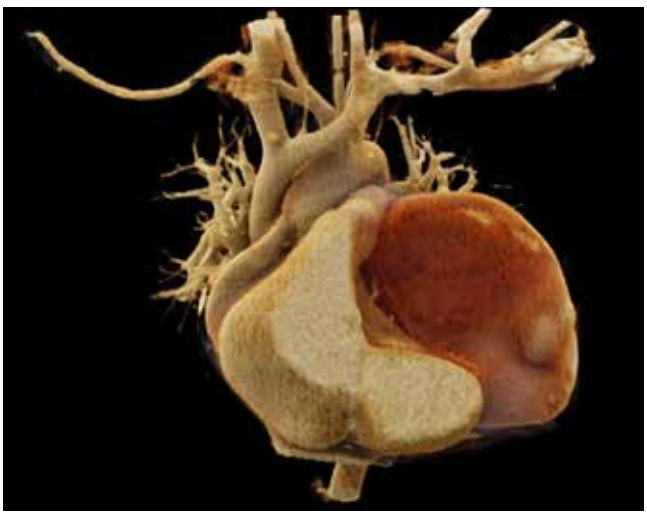

**Figure 2:** Three-dimensional volume-rendered reconstruction of the cardiac CT scan, highlighting the morphology and extent of the LAAA. The reconstruction provides a clear spatial understanding of the aneurysm's origin and helps differentiate it from other cardiac or extracardiac masses. This 3D visualization was instrumental in establishing the diagnosis and in surgical strategy planning.

## DISCUSSION

LAAA is a rare cardiac anomaly, with less than 150 cases reported,[1,2] since its initial description by Dimond et al. in 1960.[8] It can be either congenital –associated with dysplasia of the pectinate muscles and atrial wall weakness– or acquired, often secondary to elevated left atrial pressure due to mitral valve disease or atrial arrhythmias such as atrial fibrillation or flutter.[2,4] The clinical presentation is variable, ranging from asymptomatic to life-threatening thromboembolic events.[2] Symptoms may include palpitations, dyspnea, chest discomfort, or neurological deficits. Atrial arrhythmias are frequently reported and are believed to increase the risk of systemic embolism.[4] Transthoracic and transesophageal echocardiography are commonly used for initial diagnosis, while cardiac CT and MRI provide detailed anatomical information critical for surgical planning.[4-6] In our case, CT angiography and 3D reconstruction were fundamental in defining the size of the aneurysm and relationship to adjacent structures, thus guiding the surgical strategy. Although there are no formal guidelines due to the rarity of the condition, most authors agree that surgical treatment should be considered in the presence of symptoms, thrombus, progressive enlargement, or high embolic risk—even in asymptomatic patients.[1,2,4,6,7] Surgical approaches include resection or exclusion of the aneurysm under cardiopulmonary bypass, with favorable outcomes reported in most cases.[1,2,4,7] Our patient underwent successful surgical exclusion with an uneventful recovery. Histopathological examination of the resected specimen revealed organized thrombi and fibrosis,

consistent with chronicity and high embolic potential—supporting the surgical indication. Alternative treatments such as transcatheter closure or anticoagulation have been reported but are generally reserved for high-risk surgical candidates or small, stable aneurysms without thrombus.[1,2] This case highlights the importance of considering LAAA as a potential source of embolism, particularly in young patients without other evident cardiovascular risk factors and emphasizes the value of early surgical intervention to prevent serious complications.

## CONCLUSIONS

Although LAAA is a rare condition, its recognition is crucial due to its association with significant cardiovascular morbidity and mortality. Surgical resection remains the gold standard of treatment, while medical management focuses on addressing thromboembolic complications and atrial arrhythmias. Its association with atrial fibrillation and cerebrovascular events underscores the importance of early diagnosis and appropriate therapeutic strategies.

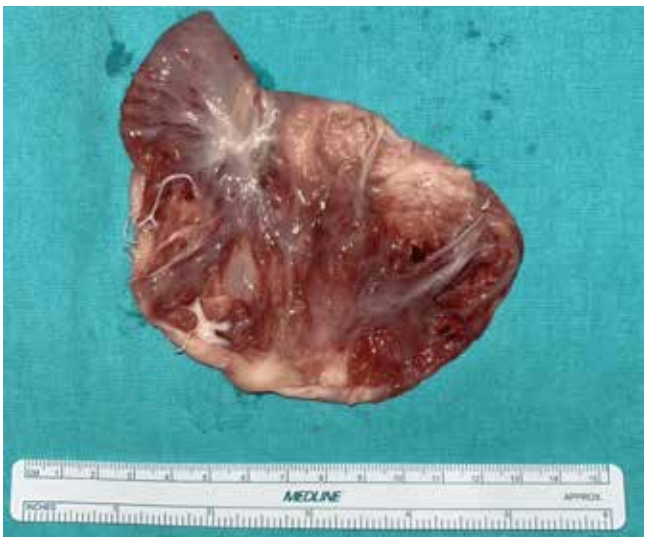


**Figure 3:** Gross pathological specimen of the resected left atrial appendage aneurysm. The specimen measures approximately 10 cm in its largest dimension. The internal surface reveals multiple laminated thrombi and fibrotic changes of the aneurysmal wall, consistent with chronic remodeling and stasis. These findings support the high embolic potential and the indication for surgical exclusion.

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# Coronary aneurysm: incidental finding

## *Aneurisma coronario: hallazgo incidental*

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### ABSTRACT

Coronary artery aneurysm is a rare entity in the general population. We present the case of a 51-year-old male patient with unstable angina, in whom an aneurysm of the anterior descending coronary artery was identified during percutaneous coronary intervention. The surgical treatment consisted of ligation, resection, and coronary revascularization, achieving a satisfactory recovery. The patient was discharged on the 5th postoperative day. Aneurysmal surgery is crucial in the management of true aneurysms, particularly in symptomatic patients, as a preventive and optimal measure.

**Keywords:** aneurysmal surgery, coronary artery aneurysm, coronary artery ectasia, coronary revascularization, percutaneous coronary intervention, unstable angina.

### *RESUMEN*

*El aneurisma de la arteria coronaria es una entidad rara en la población general. Presentamos el caso de un paciente masculino de 51 años con angina inestable, en quien se identificó un aneurisma de la arteria coronaria descendente anterior durante la intervención coronaria percutánea. El tratamiento quirúrgico consistió en ligadura, resección y revascularización coronaria, logrando una recuperación satisfactoria y siendo dado de alta cinco días después. La cirugía aneurismática es fundamental en el tratamiento de aneurismas verdaderos, especialmente en pacientes sintomáticos, como medida preventiva y óptima.*

***Palabras clave:*** *cirugía de aneurisma, aneurisma de las arterias coronarias, ectasia de las arterias coronarias, revascularización coronaria, intervención percutánea coronaria, angina inestable.*

**Abbreviations:**
AF = atrial fibrillation
AV = atrioventricular
CT = computed tomography
ECG = electrocardiogram
ICU = Intensive Care Unit
LVEF = left ventricular ejection fraction
PCI = percutaneous coronary intervention
TEE = transesophageal echocardiogram

Coronary aneurysms are characterized by focal arterial dilatations that preserve the integrity of the vessel wall, comprising its three distinct layers (intima, media, and adventitia), within a specific arterial segment.[1] The reported incidence of coronary aneurysms varies considerably, with studies citing a prevalence of up to 5%, and a notable predilection for male patients.[1] A widely accepted criterion for defining an aneurysm is a diameter exceeding 1.5 times the normal size of the adjacent segment of the same coronary artery.[2] Various risk factors have been identified, including advanced age, atherosclerosis, vasculitis, autoimmune disease, Kawasaki disease, Takayasu arteritis, and a history of cardiac catheterization with stent placement.[2,3]

Coronary aneurysms can occur at various locations, but they are particularly prevalent in the left anterior

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descending coronary artery, especially in proximal segments. This predilection is attributed to increased stress during systole and a higher density of arterial branches in these regions.[3] Aneurysms can be further classified based on their morphology, specifically the largest diameter of the aneurysmal sac. Saccular aneurysms are characterized by a transverse diameter exceeding the longitudinal diameter, whereas fusiform aneurysms exhibit a longitudinal diameter that surpasses the transverse diameter.[1]

Establishing a diagnosis poses a significant challenge, as most patients are asymptomatic and coronary aneurysms are often discovered incidentally. Diagnostic modalities such as coronary angiography and coronary computed tomography (CT) are available, typically detecting these lesions incidentally. CT scans offer the added advantage of assessing aneurysm size, thrombosis, and arterial calcification, providing valuable insights for clinical management.[2]

Clinically, patients with coronary aneurysms may present with acute coronary syndrome, the severity of which depends on the size and location of the affected coronary segment. Reported symptoms include dyspnea, angina, vertigo, and in severe cases, cardiac tamponade secondary to rupture or arterial embolization, which can lead to cerebral infarction.[1,2]

Managing asymptomatic patients poses a considerable challenge. According to some authors, surgical intervention is warranted in patients with severe coronary artery stenosis, fistulas, cardiac tamponade or compression, high risk of rupture, or aneurysms that develop after cardiac catheterization.[3]

Currently, there are no well-established or substantiated criteria for determining the optimal treatment approach, either medical or surgical, for asymptomatic patients.[3]

Surgical treatment is the cornerstone for patients presenting with clinical signs or complications. However, for asymptomatic patients, consideration should be given to established indications for surgical intervention, including aneurysm size (> 20 mm or > 4 times the diameter), concomitant valvular disease, aneurysms located near major branch bifurcations (e.g., left main trunk), and compression of adjacent vascular or cardiac structures. These criteria can help guide more objective surgical decision-making in asymptomatic patients. Conversely, some authors advocate for percutaneous coronary intervention (PCI) in patients with smaller aneurysms (< 10 mm) without involvement of the left coronary bifurcation. Additional treatment options include antiplatelet therapy, such as aspirin or clopidogrel, and statins to mitigate potential complications. Nevertheless, despite ongoing efforts, the optimal treatment strategy for patients with coronary aneurysms remains to be fully elucidated.[4,5] Treatment modalities for coronary artery aneurysms encompass ligation, resection, and revascularization. Nevertheless, further research is warranted to develop more tailored medical-surgical approaches for individual patients, highlighting the need for continued investigation in this area.[3-6]

## CLINICAL CASE

A 51-year-old male patient with a 21-year history of systemic arterial hypertension, currently under treatment, and a history of smoking, presented with progressive dyspnea with moderate to severe exertion, paroxysmal nocturnal dyspnea, and symptoms of heart failure, including dry cough and lower extremity edema. Six months later, physical examination revealed a grade IV holosystolic murmur in the mitral valve region. Diagnostic testing included an electrocardiogram (ECG) showing mitral valve prolapse, left ventricular hypertrophy, and a chest X-ray indicating grade two cardiomegaly. A subsequent echocardiogram performed one month later showed a left ventricular ejection fraction (LVEF) of 48%, severe mitral regurgitation, eccentric left ventricular dilatation and hypertrophy, extensive akinesia of the inferolateral and basal inferior segments, and posterior mitral valve prolapse. In May 2024, the patient presented to the emergency department with symptoms of decompensated heart failure. An ECG revealed atrial fibrillation (AF) with a QRS complex duration of 100 ms, a QRS axis of 0º, and various voltage criteria for left ventricular hypertrophy, as well as a prolonged QTc interval of 508 ms. The AF was successfully converted to sinus rhythm using the antiarrhythmic drug amiodarone. A transesophageal echocardiogram (TEE) was subsequently performed, which diagnosed severe Carpentier IIIA mitral regurgitation, LVEF of 45%, generalized hypokinesia, and moderate tricuspid regurgitation. Selective coronary angiography was then performed, which revealed a focal type 3 aneurysm in the mid-segment of the left anterior descending coronary artery, measuring 20 × 9 mm *(Fig. 1) (Fig. 2)*. The angiographic diagnosis was a focal aneurysm in the left anterior descending artery, dilated cardiomyopathy with mildly reduced LVEF, and moderate to severe mitral regurgitation. Based on these findings, it was decided to proceed with cardiac surgery, including mitral valve replacement with a 33-mm mechanical prosthesis and, concomitantly, coronary artery bypass grafting or left anterior descending artery plasty.

Cardiac surgery was performed. A standard sternotomy and conventional cardiopulmonary bypass were performed through the ascending aorta and bicaval cannulation. Surgical inspection revealed a focal aneurysm of the left anterior descending coronary artery in the middle third of segment 6, measuring 3 cm in length and 1 cm in diameter *(Fig. 3)*. Furthermore, the mitral valve was retracted in the P3 segment and prolapsed in the A1-A2 segments. A 300-ml pericardial effusion was observed. The aneurysm was dissected and a 3-cm arteriotomy was performed, followed by resection and

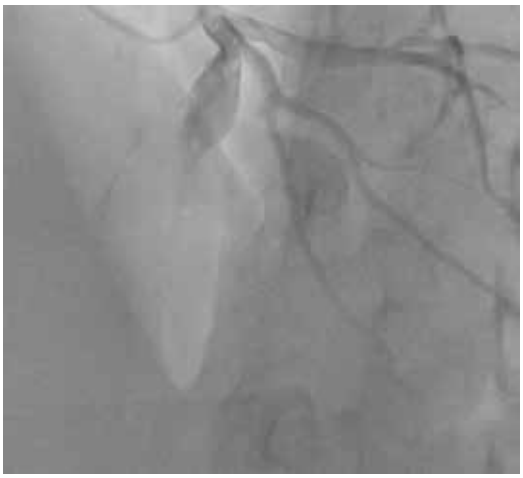

**Figure 1:** Left anterior descending coronary artery in the middle segment with focal aneurysm.

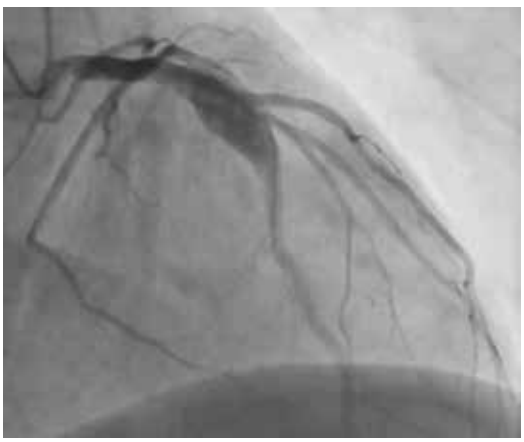

**Figure 2:** Catheterization of left anterior descending artery with giant aneurysm.

plication *(Fig. 4)*. The anterior leaflet of the mitral valve was resected, and a 33-mm mechanical mitral valve was implanted using the conventional technique, verifying its correct opening and closing. After aortic unclamping, atrioventricular (AV) block was observed, prompting the insertion of an epicardial pacing lead. Two chest tubes were also placed. Finally, sternal closure was performed with multiple guidewires.

The patient was admitted to the Intensive Care Unit (ICU) with invasive mechanical ventilation, receiving dual vasopressor and inotropic agents, with an epicardial sentinel pacemaker, and an ECG in sinus rhythm, complete left bundle branch block, and bilateral mediastinal tubes. During his ICU course, he presented hemodynamic instability and a paroxysm of atrial fibrillation, so he was started on antiarrhythmic therapy with amiodarone, lidocaine, and magnesium sulfate, with an adequate response. He subsequently remained hemodynamically stable without the use of vasopressors or inotropes, and extubation was successful. Elective left anterior descending coronary angiography revealed a type 3 irregular tubular and concentric mid-segment lesion, with a maximum residual stenosis of 50% at the bifurcation of the first diagonal branch and TIMI 3 distal flow. The decision was made to discharge him from the ICU. The following day, the patient presented with oppressive chest pain at rest lasting 40 minutes with ST-segment depression in V2-V4. A cardiac biomarker waveform was performed, resulting in a troponin I level of 2.13 ng/ml. He did not show any characteristic signs of myocardial injury, although he did present alternating AF with a heart rate of 35-37 bpm. A 24-hour Holter monitor was performed, which did not show any AF paroxysms. The patient was ultimately discharged and received cardiac rehabilitation follow-up.

## COMMENT

Optimal treatment for patients with coronary artery aneurysms undoubtedly poses a significant challenge. In symptomatic patients, ligation, resection, and revascularization are generally preferred to prevent complications and mortality.[1,2] However, asymptomatic patients with coronary aneurysms present a dilemma regarding the best treatment approach and timing of surgical intervention. According to some authors, surgical treatment is preferred to avoid medium-

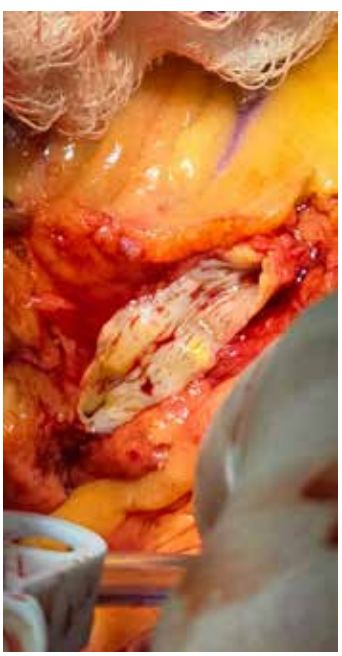

**Figure 3:**

Focal aneurysm of the left anterior descending coronary artery, 3 cm in length, in the middle third.

**Figure 4:**

Arteriotomy and plasty.

or long-term complications.[3,6] As previously mentioned, there is a lack of concrete data to guide surgical intervention in asymptomatic patients with coronary aneurysms. Nevertheless, the American College of Cardiology recommends considering aneurysm size, location, and individual risk factors when determining the optimal treatment strategy, advocating surgical resection in patients with giant aneurysms (> 20 mm or > 4 times the vessel diameter) or aneurysms located in the left main coronary artery.[4] Other authors propose similar criteria for asymptomatic patients with incidental aneurysms, recommending surgical treatment in cases of concomitant valvular disease, aneurysms near bifurcations of major branches, multiple or giant aneurysms, or rapid aneurysm growth.[5] When considering medical treatment and follow-up for asymptomatic patients, it is still unclear which patients would benefit most from this approach; however, individual risk factors should be carefully assessed to prevent fatal complications. In this case, resection, arteriotomy, and plication were performed without revascularization. The reasoning for not performing revascularization was that the patient was not present with coronary artery stenosis at the time of surgery. Ultimately, a satisfactory outcome was obtained despite the lack of a literature describing a gold standard procedure or technique.

## CONCLUSIONS

In this patient, a surgical approach involving ligation, dissection, and arteriotomy was employed due to the symptomatic presentation and large size of the aneurysm, which was complicated by valvular involvement, thereby increasing the risk of complications. A multidisciplinary approach is essential in managing this type of pathology, ensuring timely and optimal treatment to achieve the best possible outcome. Further research and development of standardized algorithms are necessary to inform evidence-based treatment planning and guide clinical decision-making.

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# Type A thymoma surgically resected by minimally invasive thymectomy

## *Timoma tipo A resecado quirúrgicamente mediante timectomía de mínima invasión*

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### ABSTRACT

Thymoma is the most common mediastinal tumor and consists of a neoplasm of thymus epithelial cells. The presence of neck masses can cause local compressive symptoms. Surgery is the primary treatment. Recently, minimally invasive approaches assisted by thoracoscopy have been proposed. These approaches are characterized by shorter hospital stays, low morbidity rates, and good cosmetic results. However, it is important to individualize the best type of approach for each patient, highlighting the importance of complete surgical resection in the management of these tumors.

**Keywords:** mediastinum, minimally invasive surgical procedures, thoracic neoplasms, thoracic surgical procedures, thoracoscopy, thymoma.

### *RESUMEN*

*El timoma es el tumor mediastínico más común y consiste en una neoplasia de las células epiteliales del timo. Provoca síntomas compresivos locales como efecto de una masa en el cuello. La cirugía es el tratamiento principal. Recientemente, se han propuesto abordajes mínimamente invasivos asistidos por toracoscopia. Estos abordajes se caracterizan por estancias hospitalarias más cortas, bajas tasas de morbilidad y buenos resultados estéticos. Sin embargo, es importante individualizar el mejor tipo de abordaje para cada paciente, destacando la importancia de la resección quirúrgica completa en el manejo de estos tumores.*

***Palabras clave:*** *mediastino, procedimientos quirúrgicos mínimamente invasivos, neoplasias torácicas, procedimientos quirúrgicos torácicos, toracoscopia, timoma.*

**Abbreviations:**
CT = computerized tomography
LVSF = left ventricular systolic function
RCBPM = Registry of Population-Based Cancer in Mexico
WHO = World Health Organization

Mediastinal masses situated in the anterior compartment are the most prevalent.[1] According to the literature, approximately 54% of mediastinal tumors in adults arise in the anterior mediastinum, whereas 20% occur in the middle mediastinum and 26% in the posterior mediastinum.[2] These masses originate from either mediastinal structures or structures that traverse the mediastinum during embryological development, as well as from metastatic deposits of primary neoplasms located elsewhere. Thymoma is the most prevalent mediastinal tumor, representing a neoplasm that originates from the

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epithelial cells of the thymus.[3] This condition predominantly affects adults, with a peak incidence occurring between the ages of 55 and 65.[4]

In our country, according to historical data from the Registry of Population-Based Cancer in Mexico (RCBPM), between 2010 and 2016, 757 cases of thymus neoplasms were reported; of these, 63.5% corresponded to thymomas and 36.5% to thymic carcinomas. Furthermore, it is observed that thymoma is more frequent in women, with a ratio of 1.6 women for every affected man.[5]

The clinical manifestations of thymoma include cough, dyspnea, and chest pain, often accompanied by local compressive symptoms such as a neck mass or superior vena cava syndrome. Notably, over 40% of patients with thymoma develop paraneoplastic syndromes, with myasthenia gravis being a prominent example.[6]

The association between thymomas and autoimmune disorders is well established. The underlying mechanism for thymoma-related autoimmunity is thought to involve tumor-induced damage that compromises the thymus's ability to maintain self-tolerance, thereby increasing the likelihood of autoimmune disease development.[7]

According to the 2021 World Health Organization (WHO) classification of thymus and mediastinum tumors,[8] thymomas are classified into:

1. Type A and AB. Considered neoplasms with low malignant potential and low probability of recurrence.
2. Type B1 and B2. Considered to have moderate malignant potential and moderate probability of recurrence.
3. Type B3. Considered of high malignant potential and high probability of recurrence.
4. Type C. These correspond to thymic carcinomas and are neoplasms with a high probability of metastatic dissemination.

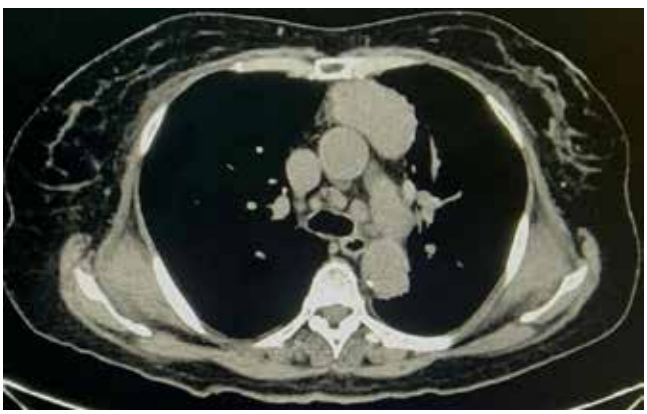

**Figure 1:** Axial computed tomography scan showing a mediastinal mass above the pulmonary artery.

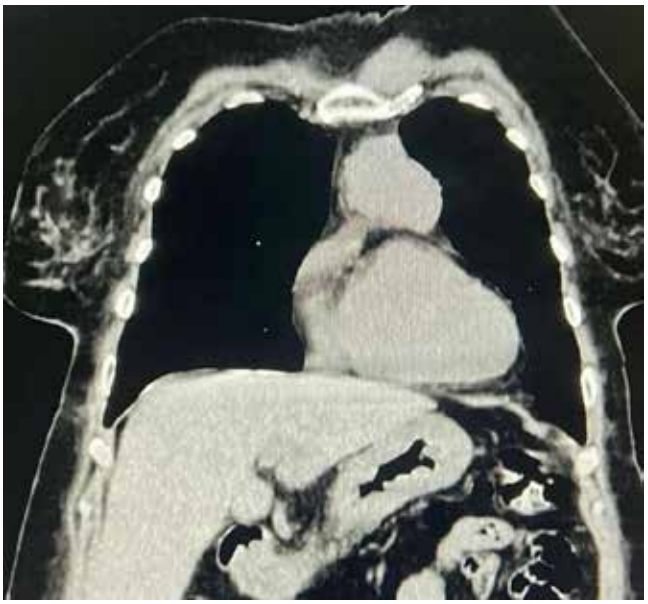

**Figure 2:** Coronal computed tomography scan showing a mediastinal mass above the heart.

## CASE DESCRIPTION

This is a 75-year-old female patient who was admitted at our institution on January 10th, 2025. Her current condition began a week before her admission with dysphagia, moderate dyspnea, dry cough that rapidly progressed to productive, fever and malaise. A computerized tomography (CT) scan showed a mass with well-defined borders in the anterior mediastinum measuring approximately 54 × 59 × 34 mm *(Fig. 1) (Fig. 2)*.

Furthermore, the lung fields exhibited multiple *ground glass* lesions, prompting admission with a diagnosis of mediastinal mass under investigation and pneumonia. A pneumonia panel was conducted, which yielded positive results for *Mycoplasma pneumoniae*. An echocardiogram, comprising M-mode, two-dimensional, and pulsed wave Doppler imaging, revealed concentric left ventricular hypertrophy with preserved left ventricular systolic function (LVSF). Subsequently, a CT-guided biopsy of the mediastinal mass was performed, which confirmed a type A thymoma. An anti-acetylcholine receptor antibody study was also conducted, with negative results, effectively ruling out myasthenia gravis. Finally, on January 20th 2025 the patient was scheduled for a minimally invasive thymectomy procedure.

The surgical procedure was initiated with a video-assisted approach, utilizing three trocars placed in a diamond configuration along the anterior and mid-axillary line. The camera was inserted through the medial port, and dissection of the mediastinum was initiated, revealing a post-biopsy

puncture hematoma. Upon opening the mediastinum, a highly vascularized and firm mediastinal mass was encountered, which proved challenging to mobilize. Distal dissection was performed, and a bilobed tumor was identified, extending to the contralateral hemithorax with multiple feeding vessels. Given the complexity of the tumor's anatomy, direct assistance via mini-sternotomy was undertaken to facilitate visualization and mobilization of the mass. Subsequently, the surgical specimen, measuring approximately 10 × 7 cm and characterized by a bilobed, heart-shaped configuration, was mobilized and extracted along with perilesional lymph nodes *(Fig. 3)*.

## COMMENT

Surgical resection is widely regarded as the most effective treatment modality for thymomas, irrespective of their histological classification.[6] Nevertheless, the optimal approach to thymectomy remains a topic of debate. A surgical technique is deemed effective if it can achieve complete resection of the thymus, thereby ensuring thorough removal of the gland.

Recently, minimally invasive approaches, including thoracoscopic and robotic-assisted techniques, have been proposed as viable alternatives. These approaches are distinguished by shorter hospital stays, low morbidity rates, favorable cosmetic outcomes, and remission rates comparable to those achieved with traditional open approaches.[9] However, transcervical-transsternal thymectomy, which involves an invasive approach via median sternotomy, enables the resection of a larger amount of ectopic thymic tissue, including perithymic, mediastinal, and cervical fat.[10]

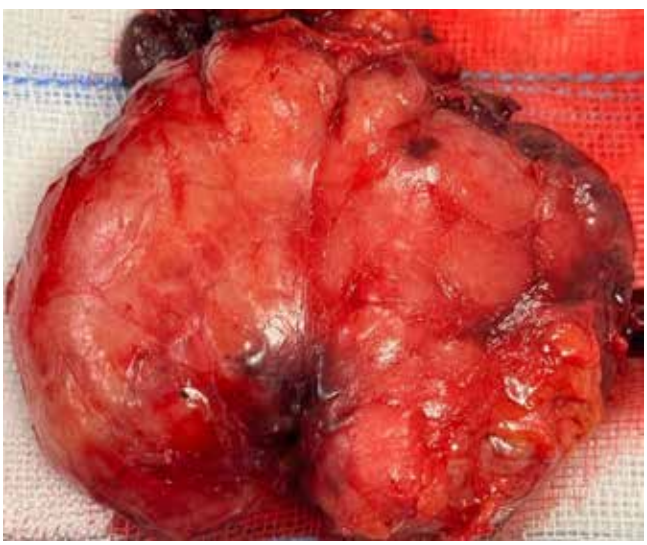

**Figure 3:** Surgical specimen measuring approximately 10 × 7 cm in length, bilobed.

However, it is important to note that several factors that influence the clinical outcome post-thymectomy, in addition to the presence of ectopic thymic tissue, must be considered. These factors include the histopathological characteristics of the thymoma, as well as its aggressiveness and whether it is found with infiltration into other adjacent tissues or if there are complications such as the development of myasthenia gravis[11] or compression of mediastinal structures due to mass effect such as pulmonary stenosis[12] or cardiac tamponade.[13] However, it is important to note that the complications do not usually occur in patients with type A thymomas since these are usually well-defined tumors with a histological architecture composed of well-organized oval or spindle-shaped epithelial cells with a better prognosis. In contrast, type B or AB thymomas present a mixed cellular pattern with abundant presence of lymphocytes, which results in a moderate to high malignant potential as well as a high recurrence rate.[14]

## CONCLUSIONS

Minimally invasive thymectomy is a cutting-edge technique that offers a valuable alternative to traditional thymectomy via median sternotomy. However, it is crucial to emphasize the importance of radical thymectomy, which enables the removal of not only the thymus but also the surrounding adipose and ectopic tissue that may contribute to the recurrence of symptoms. Furthermore, when selecting an appropriate surgical approach, it is essential to consider specific tumor characteristics, such as size. A thymoma larger than 5 cm that infiltrates the capsule or surrounding structures is a key exclusion criterion for a minimally invasive approach.[15,16]

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# David procedure: surgical technique step-by-step

## *David procedure: técnica quirúrgica paso a paso*

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### ABSTRACT

The David procedure, also known as aortic root reimplantation, is a surgical technique used to treat aortic root aneurysms, with or without aortic valve insufficiency. This article presents a step-by-step guide to the surgical technique of the David procedure, supplemented by personal insights and oral contributions from Dr. Tirone David, the creator of the reimplantation technique.

**Keywords:** aortic aneurysm, aortic root, aortic valve, aortic valve sparing, aortic valve regurgitation, David procedure.

### *RESUMEN*

*El procedimiento de David, también llamado aortic root reimplantation, se utiliza para tratar quirúrgicamente los aneurismas de raíz aórtica, con o sin insuficiencia valvular aórtica. En este artículo se presenta paso a paso la técnica quirúrgica del procedimiento de David, incluyendo aportaciones personales del autor, así como comunicaciones personales del Dr. Tirone David, creador de la técnica de reimplantación.*

***Palabras clave:*** *aneurisma aórtico, raíz aórtica, válvula aórtica, preservación de la válvula aórtica, insuficiencia aórtica, procedimiento de David.*

The aortic valve-sparing operations (AVS) have represented a paradigm shift in the surgical management of aortic aneurysms, aiming to preserve the native aortic valve in patients with aortic aneurysm, with or without aortic insufficiency. To optimize the outcomes of these procedures, it is essential to elucidate the underlying pathophysiological mechanisms driving aneurysm formation.

Furthermore, understanding the impact of aneurysm formation on the three-dimensional dynamics of the aortic root and ascending aorta is crucial for the successful implementation of aortic valve-sparing operations. This requires a comprehensive analysis of the spatial and temporal relationships between the aortic valve, aortic root, and ascending aorta, as well as the biomechanical properties of these structures. Indeed, a major obstacle hindering progress in AVS operations, aside from the complexity of the surgical technique itself, lies in the fact that many professionals involved fail to accurately differentiate between aortic root aneurysms and ascending aortic aneurysms. This is critically important for selecting the right surgical technique. A comprehensive comparison of the distinguishing characteristics between aortic root aneurysms and ascending aortic aneurysms is provided in *Table 1*.[1]

In order to facilitate a full understanding of this subject, it is imperative to begin by exploring the fundamental concepts, including the anatomy and morphology of the aortic root and ascending aorta.

## ANATOMY OF THE AORTIC ROOT

The aortic root is a complex anatomical entity composed of five primary elements; namely, the aortic annulus, aortic

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leaflets (also known as aortic cusps), sinuses of Valsalva, interleaflet triangles, and the sinotubular junction. The ascending aorta originates just above the sinotubular junction. By definition, the aortic root encompasses the region between the sinotubular junction and the basal ring aortic or aortoventricular junction, including both structures. The total height of the aortic root is no more than 2-3 cm *(Fig. 1)*.[2]

## Aortic annulus and aortoventricular junction

A supplementary component that can be incorporated into the aortic root complex is the aortoventricular junction, which represents the interface between the left ventricular outflow tract and the aortic root itself. This junction is situated below the level of the true aortic annulus, where the aortic leaflets are anchored to the aortic root. The collagenous tissue at the attachment point of each leaflet is referred to as the annulus. Notably, the aortoventricular junction is predominantly muscular, whereas the aortic annulus is essentially fibrous. Moreover, the aortoventricular junction exhibits a circular configuration, situated immediately below the "surgical" aortic annulus, which exhibits a crown-like shape, situated just superior to the aortoventricular junction. The interleaflet triangles deserve special consideration into the pathogenesis of aortic insufficiency.[3,4] The dilation of the aortic root results in a geometric alteration of the subcommissural triangles, characterized by a widening of their bases and a reduction in commissural heights, ultimately affecting the coaptation area.[1]

As depicted in *Fig. 2*, the distinct morphological characteristics of both the true and "surgical" annuli are clearly discernible.[2]

## Aortic leaflets (aortic cusps)

A pivotal consideration in the decision-making process for AVS surgery is the evaluation of the aortic leaflets. The morphology and, more importantly, the extent of the leaflets are critical determinants. As a general rule, a leaflet length < 13 mm (measured from the aortic annulus to the nodule of Arantious) contraindicates AVS. Additionally, an aneurysmal diameter exceeding 60 mm at the level of the Valsalva sinuses often results in compromised aortic cusps (fenestrated, detached, or shortened). The best way to assess the aortic cusps is by transesophageal echocardiography.[1]

To ensure durable repair, sufficient leaflet tissue must be preserved to facilitate optimal coaptation. A coaptation height of ≥ 8 mm is generally considered necessary to achieve a satisfactory coaptation surface.[5] Inadequate coaptation may lead to early onset of aortic valve regurgitation following repair.

## Sinuses of Valsalva (aortic sinuses)

The aortic sinuses of Valsalva and the sinotubular junction are characterized by a predominance of elastic tissue in their walls, which are generally thinner than those of the ascending aorta. Indeed, the sinuses of Valsalva are the most vulnerable structures, where the aortic root aneurysm typically begins to dilate.[6] From this point, the aneurysmal dilation extends both upward, frequently reaching or surpassing the sinotubular junction, and downward, resulting in dilation of the aortic annulus. These three structures are comprised between the basal ring and the sinotubular junction.

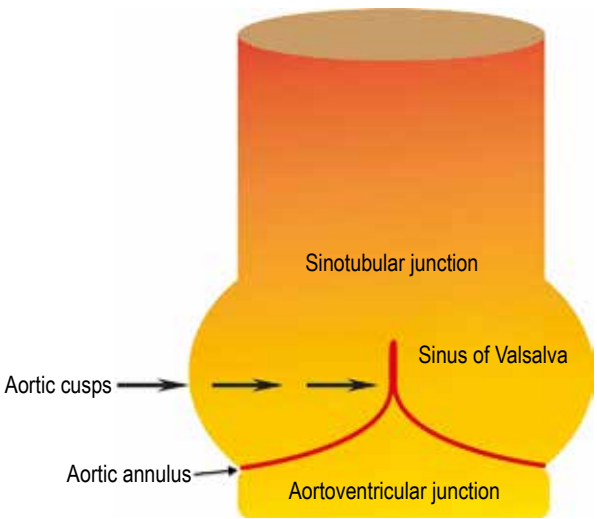


**Figure 1:** Aortic root.
With permission of: García-Villarreal OA.[2]

**Table 1:** Main differences between aortic root aneurysm and ascending aorta aneurysm.

| Aortic root | Ascending aorta |
|---|---|
| Starting on the sinuses of Valsalva | Starting on the medial portion of the ascending aorta |
| Expanding towards sinotubular junction and ascending aorta | Expanding towards up and down the ascending aorta |
| Annulus dilation almost always | Annulus remains unaffected |
| Associated to genetic diseases | Associated to degenerative diseases |
| Between 2nd and 4th decade of life | Between 5th and 7th decade of life |

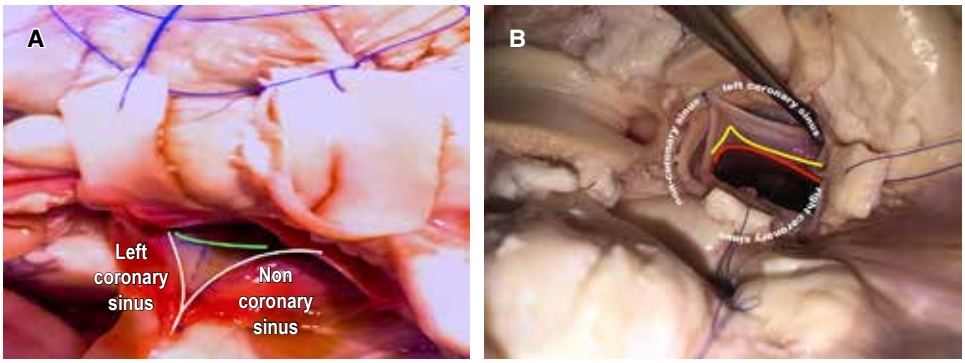


**Figure 2:**

True (aortoventricular junction) and surgical aortic annuli. Dissection on a pig heart. **A)** Green line= aorto-ventricular junction, white line = aortic annulus. **B)** Red line= aorto-ventricular junction, yellow line= aortic annulus. With permission of: García-Villarreal OA.[2]

### Sinotubular junction

The sinotubular junction exhibits a direct relationship with the extent of aortic valve cusps coaptation. Research conducted by Maselli et al., has shown that the diameter of the sinotubular junction exerts a significant influence on the degree of aortic cusp coaptation.[7] Indeed, the dilation of the sinotubular junction can cause aortic insufficiency due to outward deviation of the commissures.[8]

## DAVID PROCEDURE STEP-BY-STEP

There are two surgical techniques to solve the problem of aortic root aneurysm; namely, David procedure (also known as aortic root reimplantation), and the Yacoub procedure (aortic root remodeling). Despite being distinct procedures, they share a common objective. The David procedure is particularly suited for cases with aortic annular dilation, commonly seen in aortic root aneurysms. In contrast, the Yacoub procedure may be preferred (due to its technical simplicity) in cases without aortic annular dilation, such as ascending aortic aneurysms involving the sinotubular junction and the sinuses of Valsalva.

This manuscript is exclusively devoted to David procedure.

### Aortic root surgical dissection

After aortic cross-clamping, surgical dissection of the aortic root begins by transecting the aorta transversely, 1 cm above the sinotubular junction. The level of dissection is not the same for all the entire aortic root.[9] Typically, the dissection of the aortic root begins after having completely transected the aorta at the height corresponding to the sinotubular junction. The dissection starts at the level of the non-coronary sinus, which is resected leaving a 5 mm free margin from the aortic annulus *(Fig. 3)*. Subsequently, the left coronary ostium is resected from the inside of the sinus of Valsalva, and finally, the right coronary ostium is resected in a similar manner, also from the inside. Minimal dissection around the coronary ostia is recommended, ideally not exceeding 3 mm. This cautious

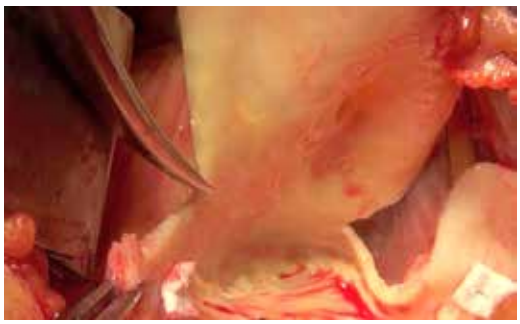

**Figure 3:** Sectioning of the non-coronary sinus of Valsalva, maintaining a 3-5 mm tissue margin.
With permission of: García-Villarreal OA.[2]

approach reduces the risk of injury to the coronary ostia. Now, the aortic root is dissected from the atrial plane using blunt dissection with scissors, commencing from the midpoint of the nadir of the non-coronary sinus and advancing towards the non-coronary/left coronary commissure. This dissection separates the aortic root from the roof of the left atrium *(Fig. 4)*. At this point, the plane of dissection external to the root corresponds to a level approximately 3 mm below the line of insertion of the aortic annulus internally. The dissection of the anatomical plane continues until the nadir of the left coronary sinus is reached. As a reference point, the plane of dissection external to the root is equivalent to a horizontal line extending from the nadir of the non-coronary sinus to the nadir of the left coronary sinus. In this region, the aortoventricular junction is fibrous, allowing for a more extensive dissection than in the surrounding areas of the aortic root, where the internal aortic annulus and the external plane of dissection converge at a similar level. Afterwards, the dissection then proceeds from the nadir of the non-coronary sinus towards the commissure between the left coronary sinus and the right coronary sinus, using scissors. As the dissection advances, it is crucial to maintain a precise awareness of the anatomical landmarks, including the membranous and muscular interventricular septum, to prevent unintended perforation. A

limited dissection area may be necessary to ensure a secure anastomosis between the aortic root and the graft. This necessitates a careful balancing act, as excessive dissection can compromise the integrity of the surrounding tissues. Then, the plane between the aorta and pulmonary artery is dissected by using electrocautery. At this point the dissection is very limited in order to avoid any damage on the pulmonary artery trunk. Finally, as the dissection advances towards the nadir of the left coronary sinus, only a limited dissection is performed to reach the roof of the left atrium.

An entire view of the dissected aortic root can be appreciated in *Fig. 5*.

## Graft selection

There are several methods for selecting the diameter of the Dacron graft. Some are highly sophisticated, while others are relatively simple. As a general rule, the average length of the aortic leaflets (from the annulus to the nodule of Arantius) can be used as a reference point and multiplied by two.[10] For example, if one cusp measures 13 mm, another 15 mm, and another 16 mm, the average would be 14.6 mm, and multiplied by two would be 29.3 mm (if the result is not a whole number, the next highest size is chosen, i.e., 30 mm). As a general rule, a range of graft tube sizes between 28 mm

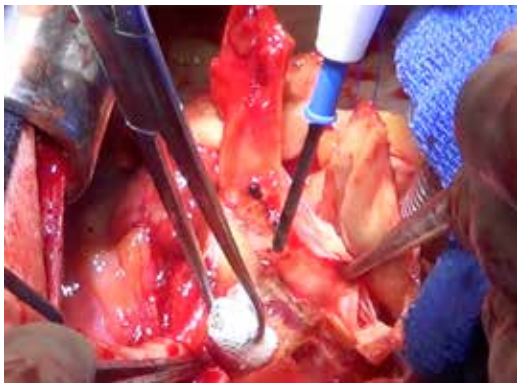

**Figure 4:** Surgical dissection of the aortic root. The roof of the left atrium is dissected from the aortic root.
With permission of: García-Villarreal OA, et al.[14]

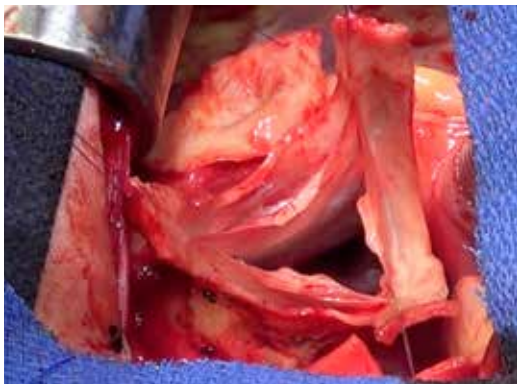

**Figure 5:** The entire dissection of the aortic root is shown in this intraoperative photography.
With permission of: García-Villarreal OA, et al.[14]

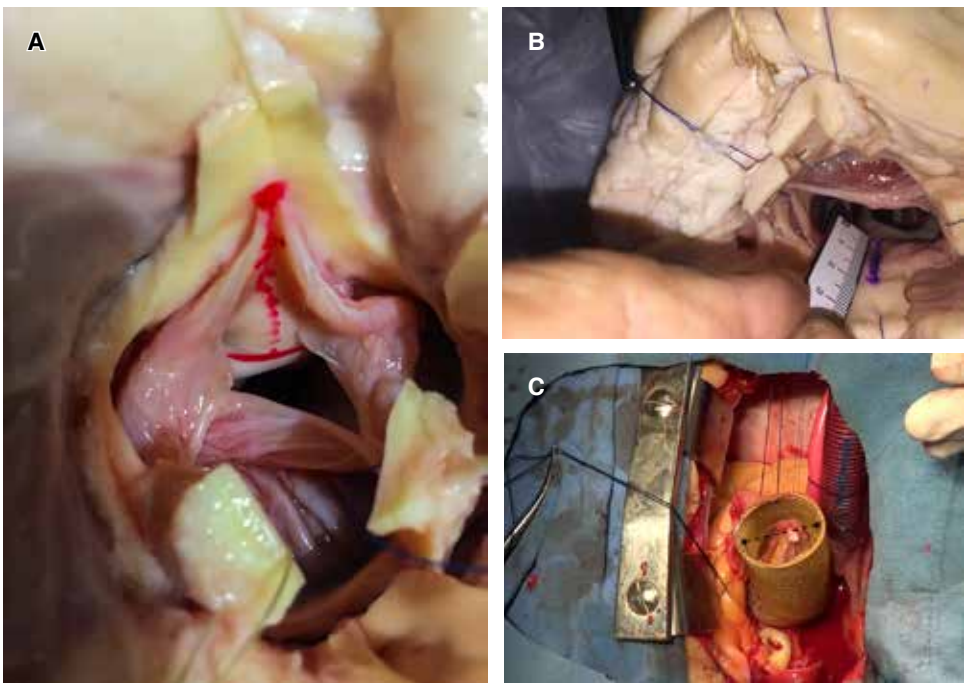


**Figure 6:**

Sizing the graft. **A)** Distance between internadir line (NC/LC sinuses) and the NC/LC commissure. **B)** Measuring the distance. **C)** Dotted line represents the same distance obtained from the measurement described in B; this is the size of the graft. Pictures A and B are working on a pig heart dissection. Picture C is taken from a surgical procedure.
LC = left coronary. NC = non-coronary.
With permission of: García-Villarreal OA.[2] García-Villarreal OA.[12]

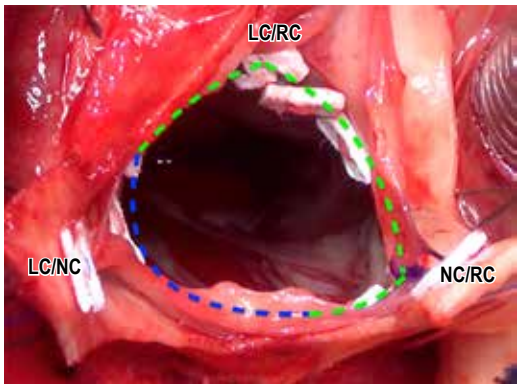


**Figure 7:** Intraoperative view of the placement of "U" fashioned sutures using teflon felt pledgets at the aortoventricular junction. Note that the plane of the sutures is not uniform around the aorta. The plane is entirely horizontal from the nadir of the non-coronary sinus to the nadir of the left coronary sinus (dotted line in color blue). The remainder is placed immediately below the fibrous aortic annulus in a crown-shape fashion (dotted line in green color).
LC/NC = left coronary/non-coronary commissure. LC/RC = left coronary/right coronary commissure. NC/RC = non-coronary/right coronary commissure.
With permission of: García-Villarreal OA, et al.[14]

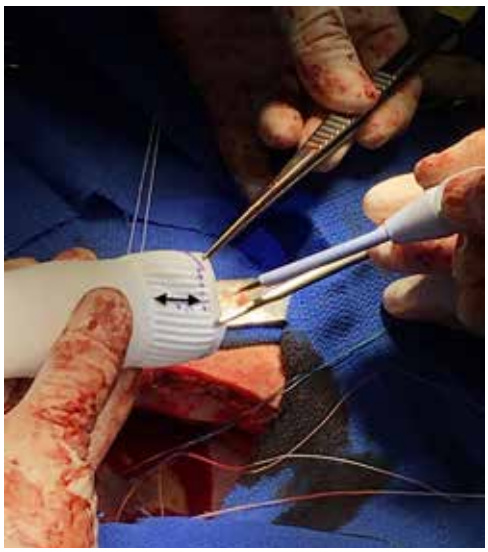

**Figure 8:** A line is drawn in the inferior aspect of the Valsalva graft, according to the height corresponding to each commissure in the aortic root. The black arrow indicates the same distance as obtained measuring the height of the commissure in the aortic root.
With permission of: García-Villarreal OA, et al.[14]

and 34 mm is usually employed. Alternatively, another method of measurement involves obtaining the distance between the midpoint of the basal line of the interleaflet triangle and the highest point of the corresponding commissure. The most accessible commissure is the left coronary/non-coronary commissure. The obtained length corresponds to the size of the tube to be used[11,12] *(Fig. 6)*.

## Graft placement including the coronary button anastomoses

Classically, sutures are placed using 3/0 polyester material reinforced with Teflon felt pledgets. The sutures are placed in a U-stitch fashion, from the interior to the exterior, with a total of 12 sutures: one suture below each commissure and two additional sutures between each commissural pair. The precise

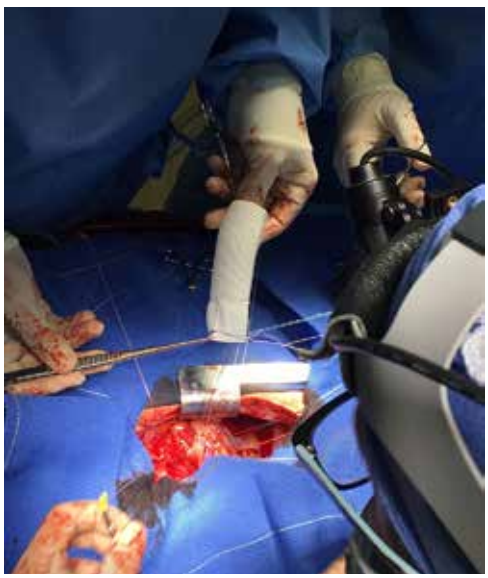

**Figure 9:** Attachment of the aortoventricular junction sutures to the Valsalva graft, facilitating secure fixation and optimal positioning.
With permission of: García-Villarreal OA, et al.[14]

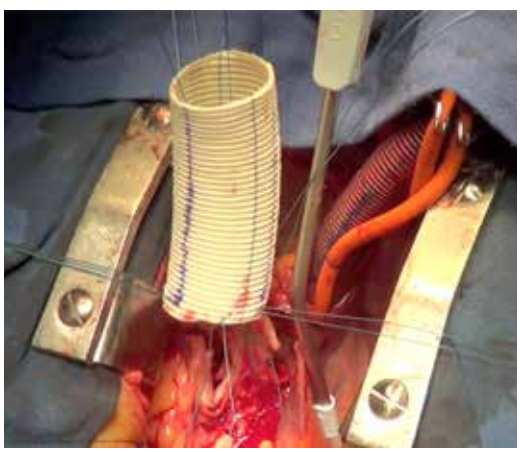

**Figure 10:** Placement of the basal sutures in a straight graft.
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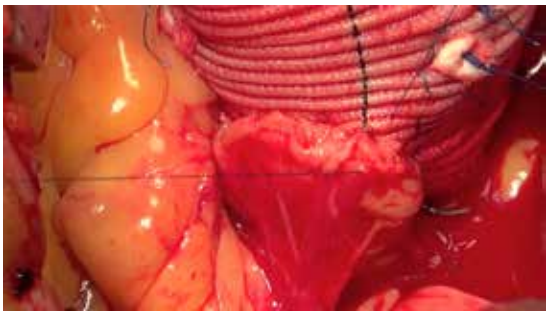

**Figure 11:** Anastomosis of the coronary artery button to the prosthetic Dacron graft.
With permission of: García-Villarreal OA.[12]

placement of sutures and the careful management of tissue planes are critical in order to prevent inadvertent damage to the aortic cusps.[2] The final arrangement of the sutures inside the aortic root is illustrated in *Fig. 7*.[11,13]

Similarly, the sutures are placed on the inferior aspect of the Dacron graft, from the inside to outside, following a more or less equidistant pattern with respect to the aortic root. The portion of the tube corresponding to the commissure of the left and right coronary sinuses typically receives a small notch, corresponding to a horizontal plane slightly higher than the rest. Once the tube is positioned, encompassing the three commissures with their corresponding leaflets, each suture is gently tied, bearing in mind that these sutures are not hemostatic, but rather serve to secure the tube in position. The graft is gently pulled upwards. and the commissures are fixed into the graft by 4/0 polypropylene pledgeted suture, in "U" fashion.

Alternatively, when using a Valsalva graft (David V), the method for placing sutures in the tube is substantially different. Since the tube is divided into thirds, as well as the height in the horizontal plane that marks the height of the commissures, the way to place the basal sutures is marked at the bottom of the tube, according to the measured distances between a commissure and the midpoint of the corresponding internadir line. This is done for each commissure. Usually, there is a smaller commissural distance than the others, which almost always corresponds to the commissure between the left and right coronary sinuses. Taking as a reference the highest horizontal line in the transverse plane of the tube, the distance is measured and marked at the bottom of the graft. Next, a continuous line is drawn to discreetly connect each of the points circumferentially *(Fig. 8)*. This line will serve as the reference point for passing each of the sutures from the aortoventricular junction *(Fig. 9)*. Of note, with this variation, every commissural suture corresponds exactly to the horizontal margin in the graft.

The idea is to include the entire aortoventricular junction, including the interleaflet triangles, within the Dacron tube, since these triangles represent an extension of the muscular aortoventricular junction and are prone to future dilation.[14]

On the other hand, when a simple and straight graft is utilized (David I), all sutures are placed at the same horizontal level *(Fig. 10)*. Consequently, the level at which each commissure is anchored is slightly different from one another.

Next, to facilitate the procedure, the graft is transected above the level of the commissures, as the subsequent step involves performing the true hemostatic anastomosis of the free edge of the aortic root with the Dacron graft, using a 4/0 polypropylene running suture entering and exiting the tube. The procedure begins at the right coronary sinus, from the non-coronary/coronary right commissure to the coronary right/left commissure. Subsequently, the same procedure is performed from the coronary left/right commissure to the coronary left/non-coronary commissure. Throughout this process, it is crucial to constantly verify that the leaflets are not incorporated into the suture line, which exclusively includes the free edge of the aortic root.

By clamping the upper end of the tube, a hydrostatic test is now performed to assess the degree of competence of the aortic valve. Subsequently, the left coronary button is anastomosed to the Dacron graft. The location of the orifice in the tube is slightly above the hemostatic suture line. Next, the right coronary button is anastomosed in a horizontal plane between the superior level of both commissures. Consequently, the right button ends up being positioned in a more superior plane than the left one. This approach avoids any potential kinking of the right coronary artery. Both anastomoses are performed with polypropylene 5/0 running suture *(Fig. 11)*.

Finally, the anastomosis of the Dacron graft to the normal aortic wall tissue is performed, preferably using a telescoping technique with a 4/0 polypropylene running suture.

## ACKNOWLEDGMENTS

I would like to extend my gratitude to Dr. Tirone David for his invaluable contributions and personal communications, including his teachings in the operating room at Toronto General Hospital.

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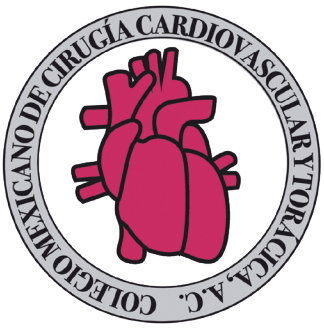


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