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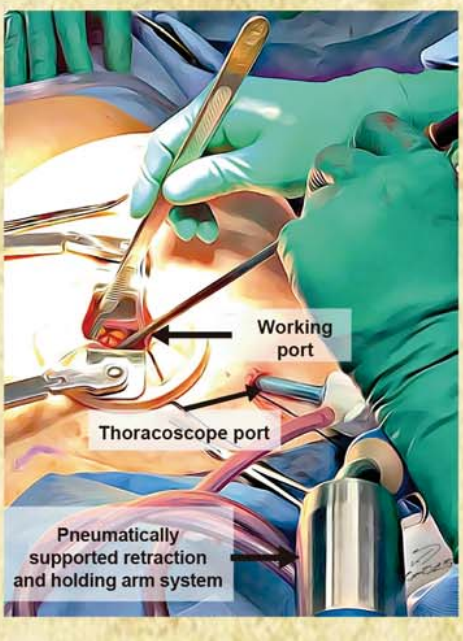

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EDITORIAL
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The NOTION trial: some concerns about structural valve deterioration in surgical bioprosthesis. Fact or fiction?

El ensayo NOTION: algunas preocupaciones sobre el deterioro estructural de la válvula en la bioprótesis quirúrgica. ¿Realidad o ficción?

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Keywords: aortic valve, aortic valve replacement, surgical aortic valve replacement (SAVR), transcatheter aortic valve implantation (TAVI).

Palabras clave: *válvula aórtica, reemplazo valvular aórtico, reemplazo valvular aórtico quirúrgico, implante de prótesis aórtica transcatéter.*

The NOTION 10 years results have been recently presented at the ESC Congress 2023 in Amsterdam. In short, this trial compared TAVI versus SAVR in a large population of patients. The results, by and large, were totally favorable for TAVI in terms of better SVD and PPM.[1] The NOTION trial results at eight years of follow-up showed a significantly higher SVD rate in SAVR than in TAVI (28.3% versus 13.9%, p = 0.0017). In turn, the risk for severe SVD was 6.8% for SAVR versus 2.2% for TAVI (p = 0.068). However, the risk of bioprosthesis valve failure (BVF) did not show any significant difference between them (10.5% versus 8.7%, p = 0.61).[2] Thus, at a glance, SVD seems to be lower after TAVI than SAVR, whilst the two treatments have a very similar risk for BVF.

Nevertheless, there are two crucial points that deserve special scrutiny in this study. First and foremost, let us analyze the endpoints used in the NOTION trial. Bioprosthesis valve dysfunction (BVD) was designed by structural valve deterioration (SVD), defined as moderate SVD (mean gradient ≥ 20 mmHg, increase in mean gradient ≥ 10 mmHg from three months post-procedure, or new or worsening moderate intraprosthetic aortic regurgitation from 3 months post-procedure); and severe SVD (mean gradient ≥ 40 mmHg, increase in mean gradient ≥ 20 mm Hg from 3 months post-procedure, or new or worsening severe intra-prosthetic aortic regurgitation from 3 months post-procedure).

In turn, non-structural valve deterioration (NSVD) was defined as i) moderate to severe patient-prosthesis mismatch (PPM) (indexed effective orifice area ≤ 0.85 cm^2/m^2 for moderate PPM, and ≤ 0.65 cm^2/m^2 for severe PPM) at three months, or ii) more than mild paravalvular leakage (PVL).

From the above, several situations potentially inducing bias in favor of TAVI emerge. A fact that does not represent real life practice is that neither aortic annulus enlargement procedure nor sutureless prostheses were allowed in the NOTION trial. This fact is in line with the result obtained in this trial, up to 28.2% of patients in the surgical arm presented severe PPM.[2]

The definition of SVD using a fixed gradient of ≥ 20 mmHg at any point of cut-off of the study could theoretically affect negatively the SAVR group, if we consider that up to 40% of the patients underwent SAVR had a 19 mm or 21 mm aortic valve bioprosthesis. It has been shown that ≤ 21 mm

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stented bioprosthesis are prone to cause transaortic gradients close than 20 mmHg, without involving SVD.[3]

Regarding the issue related with the use of Trifecta and Mitroflow bioprosthesis up to 40% in the surgical arm of NOTION trial, it is worthy of the following remarks. By means of an issue letter, Abbott announced the decision to withdraw Trifecta and Trifecta GT valves due to the high risk of rapid SVD. "On February 27, 2023, Abbott and the US FDA communicated the potential for early structural valve deterioration (SVD)… for the Trifecta and Trifecta GT valves… Abbott decided to discontinue its Trifecta family of valves".[4] Such information has been also supported by US Food and Drug Administration official website "On July 31, 2023, Abbott announced its decision to stop selling and distributing Trifecta valves, which include the Trifecta Valve and the Trifecta Valve with Glide Technology (Trifecta GT), in the United States".[5]

Several articles have been devoted to the issue of increased rates of early SVD and reoperation for BVD after using Mitroflow aortic valve bioprosthesis.[6-8]

Recently, a report by Mahboubi et al. in which the inherent risk of reoperation for BVF has come to light.[9] This report, the results of 7,037 patients undergoing isolated non-emergent SAVR, between 1980 and 2017 were analyzed. Of the total number of cases, 753 were reoperations and 6,284 were first-time SAVR. Operative mortality was similar in both groups (1.3%). Stroke, sternal infection and renal failure were also similar in both groups. Survival at 1, 5, 10, and 20 years was 94%, 82%, 64%, and 33% for the reoperation group, versus 95%, 86%, 72%, and 46% for primary SAVR.[9] Thus, the risk of mortality and morbidity has decreased considerably in recent years, being similar for SAVR as a primary or reoperation procedure. With this utmost important information, the possibility of reoperation after SAVR should not be taken as a limitation for the selection of the type of prosthesis as well as the type of procedure, whether surgical or percutaneous. This information should be compared in the context of the percutaneous VIV procedure following TAVI or SAVR by BVF.

As a matter of fact, some authors have warned us about the increased number of cardiac operations after TAVI, whilst the interval time between TAVI and operation is decreasing. Main causes for TAVI reoperation were stenosis and/or regurgitation (58%), paravalvular leak (24%) and endocarditis (17%).[10] Operative mortality has been reported as 17.1%.[11] The 8-year cumulative incidence of reoperation was found in 1.9% for TAVI and 14.1% for VIV-TAVI group, respectively.[12] Also, in this report the isolated surgical aortic valve replacement was represented only by 18.2%; all the remainder were related to combined cardiac surgical procedures.[12]

There are still complications after TAVI, which have not been definitively resolved, such as the need for a permanent pacemaker reported as 10.8% at 30-days after procedure.[13]

Thus, the conclusions derived from the NOTION trial must be taken with due caution, and the limitations especially in the surgical arm, must be particularly pointed out. This is of utmost importance when the pursued final objective is the application of TAVI in young and low-risk patients. We need trials being much more representative of reality, both percutaneous and surgical, in order to come to any definite conclusion to be applied in real world practice.

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ORIGINAL ARTICLE

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Comparison between advanced sternal closure and wire in high-risk patients for sternal dehiscence in cardiac surgery

Comparación entre cierre esternal avanzado y alambre en pacientes de alto riesgo de dehiscencia esternal en cirugía cardíaca

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ABSTRACT

Introduction: median sternotomy is currently the standard approach to perform cardiac surgery. One of its complications that significantly increases the patient's morbidity and mortality as well as its cost, is the sternal dehiscence. **Objective:** to identify complications related to sternal closure devices in patients with risk factors for sternal dehiscence such as obesity or overweight. **Material and methods:** ninety-six patients were retrospectively reviewed from 2013 to 2022 with different cardiac procedures that required median sternotomy as well risk factors for sternal dehiscence including obesity or overweight. They were separated into four groups according to the type of external closure and risk factors; clinical and radiological follow-up were performed during the first and third postoperative month. **Results:** in the groups in which titanium plates or cables were placed, there were no failures of the mechanism or complications. However, when compared with the group (group 4) of 58 patients with an average BMI of 29 kg/m^2 in which steel wire number 5 were used, there were a total of 14 patients (24.3%) with at least one broken wire and two (3.5%) of them developed sternal dehiscence. **Conclusions:** patients with obesity or overweight who require median sternotomy and who have risk factors for sternal dehiscence, could benefit from advanced sternal closure.

RESUMEN

Introducción: *actualmente la esternotomía media es el método de abordaje estándar para la realización de la cirugía cardíaca. Una de sus complicaciones que aumenta significativamente la morbilidad y mortalidad del paciente, así como sus costos es la dehiscencia esternal.* ***Objetivo:*** *identificar alguna complicación relacionada con los dispositivos de cierre esternal en pacientes con factores de riesgo para dehiscencia, en el que uno de ellos sea la obesidad o el sobrepeso.* ***Material y métodos:*** *se revisó de manera retrospectiva a un grupo de 96 pacientes desde el año 2013 hasta 2022, en los cuales se realizaron diversos procedimientos cardíacos que ameritaron esternotomía media y que contaban con factores de riesgo para dehiscencia esternal, siendo la obesidad o el sobrepeso uno de ellos. Se les dividió en cuatro grupos de acuerdo con el tipo de cierre esternal y factores de riesgo; se realizó seguimiento clínico y radiológico durante el primer y tercer mes postoperatorio.* ***Resultados:*** *se encontró que en los grupos en los que se colocaron placas o cables de titanio no hubo ruptura de los mecanismos o alguna complicación. No obstante, cuando se compararon con el grupo 4 compuesto por 58 pacientes en el que se utilizó alambre de acero número 5 y que tenían un IMC promedio de 29 kg/m^2, hubo un total de 14 pacientes (24.3%) con ruptura de alambre y dos de ellos (3.5%) desarrollaron dehiscencia esternal.* ***Conclusión:*** *los*

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pacientes que requieren esternotomía media y presentan factores de riesgo para dehiscencia, entre los que destacamos la obesidad o el sobrepeso, se podrían beneficiar de un cierre avanzado de esternotomía.

Keywords: cardiac surgery, complications, sternal closure, sternal dehiscence, sternotomy, titanium plates.

Palabras clave: *cirugía cardíaca, complicaciones, cierre esternal, dehiscencia esternal, esternotomía, placas esternales de titanio.*

INTRODUCTION

Median sternotomy was first described in 1897 by H. Milton and reintroduced in 1956 by Ormand C. Julian.[1] At present, median sternotomy is considered the standard approach in open-heart surgery, with more than one million sternotomies performed annually all over the world.[2]

Since the development of this technique, it was observed that a flawless sternal closure was imperative to avoid dehiscence and deep sternal wound infection, minimizing the morbidity and mortality of the patient and reducing the costs related to these complications.[3] The steel wire has been used in conjunction with different types of techniques and remains the most common device for sternal closure, it offers the correct approximation and bone compression. However, it is not exempt from flaws since it has been shown that sternal stabilization can be suboptimal.[4,5] Has been documented that this type of wire is vulnerable to excessive extension and rupture,[6] which can occur intraoperatively during the twisting of the wires or in the postoperative phase caused by excessive movement of the sternotomy.

Complications of median sternotomy such as sternal dehiscence or deep wound infection are reported between 0.5% and 6.1%, increasing to 12 to 20% in high-risk patients with associated mortality of 14 to 47%.[7,8] Another factor is that the standard closure technique with steel wires limits the early mobilization and rehabilitation, giving priority to bone stabilization at the cost of the patient's mobility and reducing the possibility for early recovery. Those are recommended by the ERAS protocol, widely recognized and accepted throughout the world.[4]

To achieve a successful wound healing, a balance is required between the interaction of biological processes and the biomechanical forces exerted on the bone. The biomechanical principles that promote a proper healing are approximation, alignment, and narrowing of the osteotomy gap.[9] All the above will promote the restoration of blood flow, as well as the stimulation of osteosynthesis. Diverse techniques and mechanisms have considered these principles in order to improve the advanced sternal closure such as wires, clips, bands, plates, and other devices.

Currently the indication for the use of an advanced sternal closure is class IIB of recommendation, with a level of evidence C.[10] The patient needs to have at least two or more risk factors for its use. These factors are divided into preoperative (BMI > 30 kg/m^2, diabetes mellitus, chronic obstructive pulmonary disease, advanced age over 75 years, smoking, NYHA class IV, low left ventricular ejection fraction, osteoporosis, male, peripheral vascular disease, renal failure, and steroid use); and intraoperative (prolonged extracorporeal circulation longer than 300 minutes,[11] use of intra-aortic balloon counter pulsation, bilateral use of the internal mammary artery,[12] asymmetric sternotomy,[13] excessive use of electrocoagulation or bone wax, as well as re-exploration because of bleeding).

Sternal plates and wires in high-risk patients, had managed to reduce the contact tension and improve the stability of sternal closure, reducing the possibility of complications.[14-16]

Our hypothesis is that the use of advanced sternal closure in high-risk patients after cardiac surgery may avoid complications such as sternal dehiscence and will reduce morbidity, mortality, and the expenses derived from complications.

MATERIAL AND METHODS

To demonstrate the efficacy of these sternal closure devices and to identify if a complication occurred, a total of 96 patients operated by the same surgeon and his team were retrospectively identified at our institution, from 2013 to 2022, and received follow up at the first and third month after surgery.

Inclusion criteria for this group of patients were median sternotomy, obesity (BMI > 30 kg/m^2) or overweight (BMI > 25 kg/m^2), T2DM (type 2 diabetes mellitus), smoking, use of the internal mammary artery, advanced sternal closure, or closure of the sternum with the classic technique and steel wires. Exclusion criteria were urgent procedure, asymmetric median sternotomy or fracture of the sternum produced by the retractor, as well as young patients (< 18 years old).

The primary objective of this study was to identify if any kind of complication was observed with the advanced sternal closure devices or the traditional sternal closure technique with steel wires in high-risk patients.

Complications were defined as acute sternal dehiscence, superficial or deep surgical wound infection, and rupture of the sternal closure device. The patients were classified into four

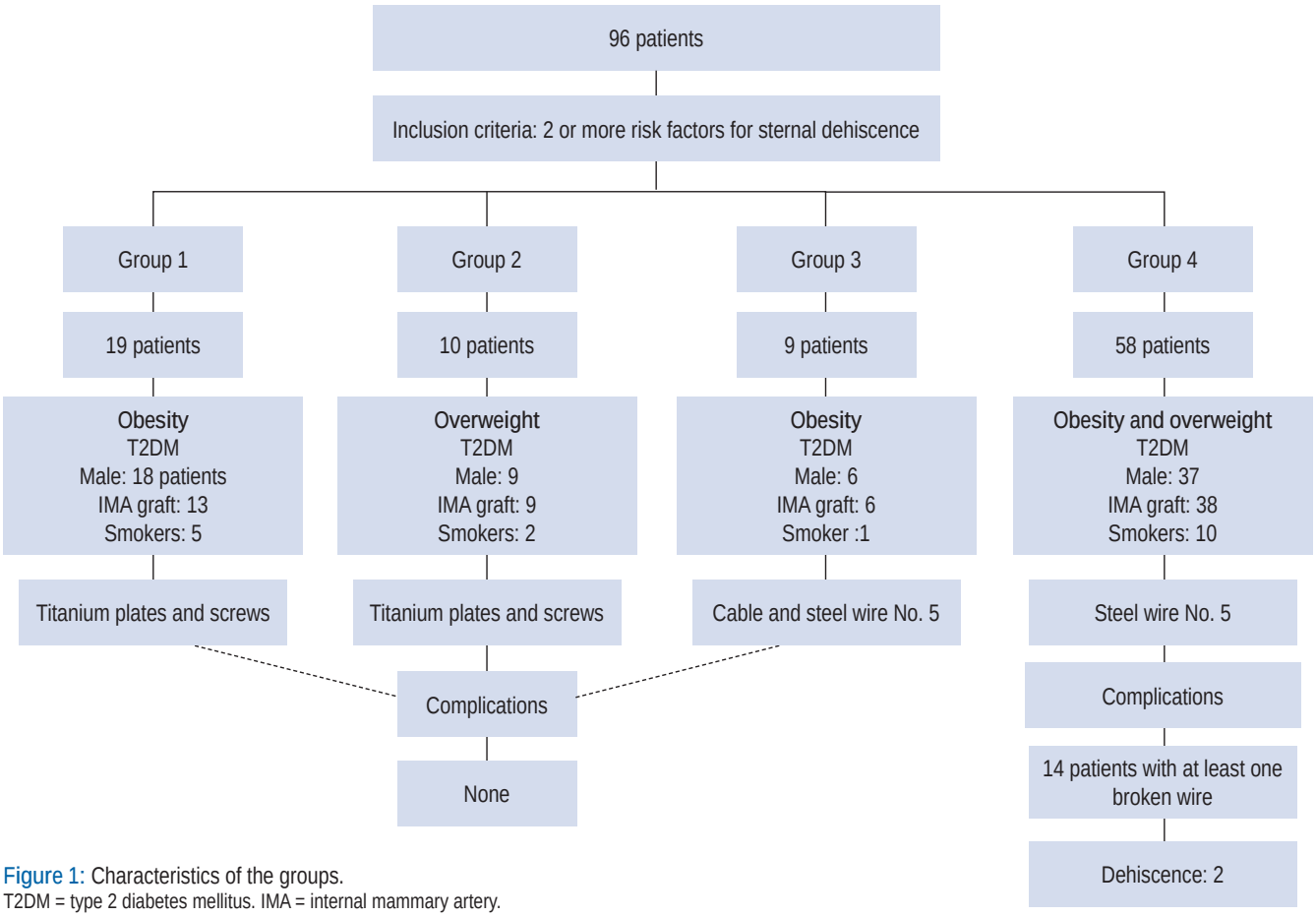

Figure 1: Characteristics of the groups.
T2DM = type 2 diabetes mellitus. IMA = internal mammary artery.

groups depending on the type of sternal closure and risk factors *(Figure 1)*. The average age of each group were 60 years old. Group 1 had a total of 19 obese patients with an average BMI of 32 kg/m^2, T2DM, smoking, male and in 13 of the cases the internal mammary artery was used. Group 2 had a total of 10 overweight patients with an average BMI of 26.25 kg/m^2, T2DM, smoking, male and in seven patients was required the use of internal mammary artery. Group 3 was composed by nine obese patients with an average BMI of 31.56 kg/m^2, T2DM, smoking; in these cases, the titanium cable system was used in conjunction with steel wires *(Figure 2)*. Group 4 had 58 patients with an average BMI of 29 kg/m^2, with similar risk factors for sternal dehiscence, but their sternal closure was done with the traditional technique and steel wires.

Figure 2:

Titanium cable system.

RESULTS

The most common type of surgery performed in all groups was the coronary artery bypass grafting with a total of 54 patients (56.2%), followed by 19 aortic valve replacements (19.2%) *(Table 1)*.

Four groups underwent post-operative follow-ups in the first and third months and were evaluated clinically and radiologically. In groups 1, 2, and 3, there was no evidence of failure in the sternal closure devices or dehiscence,

indicating successful recovery. However, in group 4 *(Table 2)*, during the first month, nine patients (15.5%) were identified with broken wires, and unfortunately, two of them (3.4%) developed sternal dehiscence along with deep wound infections, necessitating prolonged hospitalization. To address these complications, the patients required the use of VAC (vacuum-assisted closure) system and subsequent sternal closure with titanium plates.

Upon reevaluation in the third month, five more patients (8.6%) from the group 4 were found to have broken wires *(Table 3)*. In retrospect, it was discovered that the surgical procedures most commonly associated with complications (broken wires or dehiscence) were coronary artery bypass grafting (50%) and the combination of coronary artery bypass grafting plus mitral valve replacement (35.7%).

Table 1: Type of surgery performed by group of patients.

Type of surgery	Group 1 n (%)	Group 2 n (%)	Group 3 n (%)	Group 4 n (%)	Total n (%)
CABG	12 (63.2)	4 (40.0)	6 (66.7)	32 (55.2)	54 (56.2)
AVR	4 (21.0)	3 (30.0)	1 (11.1)	11 (18.9)	19 (19.9)
CABG + AVR	0	2 (20.0)	1 (11.1)	0	3 (3.1)
CABG + MVR	1 (5.3)	1 (10.0)	1 (11.1)	6 (10.3)	9 (9.4)
MVR	1 (5.3)	0	0	3 (5.3)	4 (4.2)
AVR + MVR	0	0	0	6 (10.3)	6 (6.2)
Surgical resection of atrial mixoma	1 (5.3)	0	0	0	1 (1.0)
Total	19 (100.0)	10 (100.0)	9 (100.0)	58 (100.0)	96 (100.0)

CABG = coronary artery bypass grafting. AVR = aortic valve replacement. MVR = mitral valve replacement.

Table 2: Follow-up and complications.

	Follow up		
Group	1st month	3rd month	Total
1	0	0	0
2	0	0	0
3	0	0	0
4	9 patients with broken wires, 2 of them developed sternal dehiscence and deep wound infection	5 broken wires	14

Table 3: Type of surgery and complication presented in group 4.

	Number of patients with complications n (%)			
	1st month		3rd month	Total of patients n (%)
Type of surgery	Broken wire	Dehiscence	Broken wire	
CABG	4 (57.1)	1 (50.0)	2 (40.0)	7 (50.0)
AVR	0	0	0	0
CABG + AVR	0	0	0	0
CABG + MVR	2 (28.6)	1 (50.0)	2 (40.0)	5 (35.7)
MVR	0	0	0	0
AVR + MVR	1 (14.2)	0	1 (20.0)	2 (14.2)
Total	7 (100.0)	2 (100.0)	5 (100.0)	14 (100.0)

CABG = coronary artery bypass grafting. AVR = aortic valve replacement. MVR = mitral valve replacement.

DISCUSSION

The results obtained from this group of patients are consistent with findings from other studies that evaluated the effectiveness of these advanced sternal closure devices, particularly when compared to traditional steel wires.[17]

We believe that this study can set a precedent for considering the use of these sternal closure devices in patients with high risk factors for sternal dehiscence. By adopting these devices, healthcare providers can offer optimal therapeutic care and subsequently reduce the expenses associated with complications resulting from sternal dehiscence.

According to data collected from 16,256 adults who participated in Ensanut 2018-19, the prevalence of overweight and obesity in adults older than 40 years was 39.1% and 36.1%, respectively.[18] If this trend continues, a significant portion of this population may eventually become candidates for cardiac surgery, meeting the necessary criteria to be considered for an advanced sternal closure. Notably, these advanced closure devices have demonstrated their capability to prevent complications associated with sternal procedures.

Regarding the limitations of our study, these include a relatively small sample size, the retrospective nature of the study, and the absence of a control group. Nevertheless, our findings provide valuable evidence supporting the effectiveness of advanced sternal closure systems, particularly in high-risk patients.

As a conclusion, patients who had risk factors for sternal dehiscence and underwent sternum closure with titanium plates or cable system did not experience any complications during the first or third month of follow-up. However, in the group where steel wires were used, there was evidence of at least one wire rupture, and in two cases, sternal dehiscence developed. Despite the small sample size, it is crucial to note that this study may represent a growing subset of patients across the country who require cardiac surgery and possess concomitant risk factors for sternal dehiscence, potentially leading to increased mortality and morbidity.

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VIEWPOINT

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Could minimally invasive surgical revascularization procedures become the gold standard for ischemic heart disease?

¿Podrían los procedimientos quirúrgicos de revascularización mínimamente invasivos convertirse en el estándar de oro para la cardiopatía isquémica?

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ABSTRACT

Ischemic heart disease is the most common and deadliest heart disease and is a huge health burden costing billions of dollars. The current optimal treatment for this disease is myocardial revascularization and the gold standard method in the medium- and long-term management is coronary bypass surgery. This surgery is a highly invasive operation due to the use of a cardiopulmonary bypass machine and open sternotomy technique; however, at the same time, it has a short-term increase in morbidity and complication rate. Off-pump coronary artery bypass grafting surgery, minimally invasive direct coronary artery bypass surgery, and minimally invasive cardiac surgery-coronary artery bypass grafting were introduced in the past years. However, these treatments have not yet become the widespread gold standard, and discussions on durability and survival are still ongoing. In this review, we will discuss

RESUMEN

La cardiopatía isquémica es la enfermedad cardíaca más común y más mortal, y es una enorme carga para la salud que cuesta miles de millones de dólares. El tratamiento óptimo actual para esta enfermedad es la revascularización miocárdica y el método estándar de oro en el manejo a mediano y largo plazo es la cirugía de bypass coronario. Esta cirugía es una operación altamente invasiva debido al uso de una máquina de derivación cardiopulmonar y técnica de esternotomía abierta; sin embargo, al mismo tiempo, tiene un aumento a corto plazo en la tasa de morbilidad y complicaciones. La cirugía de revascularización coronaria sin circulación extracorpórea y la cirugía mínimamente invasiva con bomba o sin bomba se han introducido en los últimos años. No obstante, estos tratamientos aún no se han convertido en el estándar de oro generalizado y las discusiones sobre la durabilidad y la supervivencia aún están en curso. En esta revisión,

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minimally invasive coronary artery bypass grafting techniques in terms of survival and durability.

Keywords: ischemic heart disease, minimally invasive surgery, myocardial revascularization, off-pump coronary artery bypass.

analizaremos las técnicas de injerto de derivación de arteria coronaria mínimamente invasivas en términos de supervivencia y durabilidad.

Palabras clave: *cardiopatía isquémica, cirugía mínimamente invasiva, revascularización miocárdica, cirugía de revascularización coronaria sin bomba.*

INTRODUCTION

Cardiovascular disease accounts for one-third of all deaths worldwide, with the most common subgroup being ischemic heart disease (IHD), that accounts for more than 9 million deaths annually.[1] According to recent projections, prevalence of IHD is expected to increase gradually in the world due to the rapidly increasing rates of metabolic syndromes such as diabetes and the aging population.[1] Additionally, IHD presents a cumbersome health burden (e.g., the cost of IHD is 1-1.5% of the total gross domestic product in USA), and it is estimated that more than 1 trillion dollars will be spent globally in 2030.[2]

The primary treatment option for ischemic heart disease (IHD) is myocardial revascularization, which can be achieved through either coronary artery bypass surgery (CABG) or percutaneous coronary intervention (PCI).[3] Both CABG and PCI have their own advantages and disadvantages. CABG is associated with better medium- and long-term survival rates, while PCI has a higher likelihood of requiring repeat revascularization procedure.[3] CABG still presents with the same procedural aggressiveness and invasiveness despite its history of more than half a century.[4] Since CABG is traditionally performed with sternotomy, it increases the risk of infection and delays healing. In addition, the cardiopulmonary bypass machine stimulates inflammatory processes, causes hemolysis and poses a significant risk for thromboembolism.[5,6] In an effort to reduce the risks and complications associated with traditional open-heart surgery, such as total sternotomy and the use of cardiopulmonary bypass, many minimally invasive techniques have been developed in recent years.[7] These techniques involve making smaller incisions and using specialized instruments and technology to perform the procedure, which can result in less pain, faster recovery times, and fewer complications. In this review, different minimally invasive CABG techniques are compared in terms of survival, durability, and feasibility.

MINIMALLY INVASIVE APPROACHES

Off-pump coronary artery bypass grafting surgery (OPCAB)

OPCAB, a variation of traditional CABG, involves performing surgery on a beating heart without using a cardiopulmonary bypass machine.[8] This technique is expected to reduce the risk of various complications related to the use of cardiopulmonary bypass, including hemolysis, inflammatory cascades, and thromboembolism, resulting in better outcomes and faster recovery.[8] It is major advantages are shorter in-hospital stays and enhanced recovery.[8]

Controversies surrounding OPCAB mainly relate to the durability and quality of the anastomosis, the learning curve for the procedure, and its effectiveness in reducing major adverse cardiac and cerebrovascular events (MACCE), and in-hospital mortality. Observational studies and single-center studies have reported promising results, showing a reduced length of hospital stay and lower risks of stroke and new-onset atrial fibrillation.[9-11] However, randomized controlled studies have not shown significant benefits in terms of MACCE or in-hospital mortality and have even shown increased rates of repeated revascularization and mortality *(Table 1)*.[12-14]

In the ROOBY trial, although there was no difference between OPCAB and conventional CABG in terms of preoperative complications and recovery, conventional CABG was found to be better in long-term survival.[12] The CORONARY trial found that OPCAB patients had a higher risk of pulmonary complications and higher rates of reoperation without any mortality benefit compared to traditional CABG patients.[13] In addition, the low number of distal anastomoses in the off-pump cohorts in the existing studies in the literature raises concerns about incomplete revascularization of heart teams.[9-14] In contrast, Diegeler et al. showed that patients who underwent OPCAB had lower incidence rates of atrial fibrillation, stroke, and ventilation time, as well as shorter hospital stays, than those who underwent conventional CABG.[14]

Despite concerns about the learning curve for this technique and the potential for fewer anastomoses, OPCAB may offer important advantages over traditional CABG for "subgroups of IHD patients".

Minimally invasive direct coronary artery bypass surgery (MIDCAB)

The survival of patients with IHD depends, at a large extent, on the treatment and patency of the left anterior descending (LAD) and left main coronary arteries (LMCA). One of the oldest techniques for restoring arterial flow to the heart is bypass surgery, which involves anastomosis of the left intrathoracic artery (LITA) to the LAD.[15] Stenting is useful in single-vessel coronary artery disease, and has been

shown to fail in the long term while surgery is successful in the long term. However, it might have severe complications due to invasiveness. To overcome these problems, a minimally invasive direct CABG (MIDCAB) technique was developed in US, as an alternative to conventional heart surgery or stent placement.[16]

MIDCAB is an off-pump technique that has been discussed in terms of anastomosis quality, graft patency, and success rate compared to elective PCI in single-vessel disease.[16] The patency of the LITA after MIDCAB is reportedly 100% in the first six months, with a 10-year patency rate above 90%.[17] In terms of long-term survival, Mastroiacovo et al. found a 15-year and 20-year survival of 83% and 70%, respectively. It is considered as a high rate for patients with IHD. Thence, MIDCAB is considered a powerful option for the treatment of single-vessel coronary disease.[18]

Recently published American guideline on ischemic heart disease recommended 2a PCI for the treatment of LAD or left main (LM) coronary artery disease, at which point MIDCAB may be beneficial for long-term survival and repeated revascularization.[19] The meta-analysis from Gianoli et al. comparing MIDCAB and PCI revealed that PCI had a lower in-hospital mortality rate, whereas MIDCAB demonstrated superiority in terms of long-term survival and repeated revascularization.[20] In another meta-analysis, MIDCAB was found to be superior in major cardiac events from 6-months to 1-year, and repeated revascularization.[21] Additionally, MIDCAB was found to be superior in the relief of angina symptoms compared to PCI.[22] Piperata et al. showed the less invasive version of MIDCAB, they safely performed robotic-assisted MIDCAB for 17 patients without postoperatively 30-day mortality.[23]

In the management of single vessel coronary artery disease, MIDCAB should be given serious consideration as a strong option for coronary surgery. To better understand its effectiveness, further subgroup studies are needed. Additionally, it is important to invest more in the development of surgical instruments and techniques in this direction.

Minimally invasive cardiac surgery-coronary artery bypass grafting (MICS-CABG)

In an effort to minimize the invasiveness of treating IHD via open median sternotomy, several off-pump techniques were developed such as off-pump median sternotomy (OPCAB) and off-pump thoracotomy (MIDCAB) for single vessel disease.[24] However, recent advances in cannulation techniques, endoscopic surgical instruments, and surgical experience have led to the introduction of Minimally Invasive Cardiac Surgery-Coronary Artery Bypass Grafting (MICS-CABG) as a viable alternative for multi-arterial coronary disease.[24]

In a study with 450 patients who underwent MICS-CABG conducted by McGinn et al., MICS-CABG using an average of 3 grafts was found to have no major cardiac adverse events (MACCE) in the first six months, with 100% LITA patency and an overall graft patency of 92%.[25] Rajput et al. reported positive results with MICS-CABG for multivessel IHD, performing the procedure on 100 patients with an average of 2.33 grafts.[26] One of the benefits of minimally invasive heart surgery is the potential to reduce the risk of intraoperative and in-hospital mortality, thus allowing for surgery in patients with surgical gray zone. In a study by Barsoum et al., MICS-CABG was found to be associated with better recovery and overall survival rate than conventional CABG in upper 75 years old multivessel IHD patients.[27] Despite these favorable studies, Teman et al. found no significant difference in mortality and MACCE between 139 MICS-CABG and 278 ON CABG patients.[28]

Based on the available evidence, it appears that MICS-CABG is a feasible surgical option for patients with IHD who fall into the “gray zones”. However, further research is needed to fully understand its efficacy and identify which patient groups may benefit most from this procedure.

MINIMALLY INVASIVE CORONARY ARTERY BYPASS GRAFTING POTENTIAL

Off-pump financial benefits and no inferiority to on-pump CABG

Studies comparing the financial costs of OPCABG and ONCABG have shown that OPCABG has either significantly lower initial hospitalization costs or no significant difference compared to ONCABG. The total length of postoperative stay, total blood products used, and type of surgical device used is identified as the main causes of the financial gap between the two procedures. However, this financial gap is closing as follow-up is longer, possibly because hospital readmissions are more frequent in OPCAB.[29-31] The overall cost of the procedures evaluated with their outcomes by the means of cost per quality-adjusted life-year (QALY) gained showed a higher cost-effectivity for the OPCAB. QALY for both of the procedures was found similar.[32,33] Patients who underwent OPCAB have a more rapid recovery and fewer postoperative complications (postoperative stroke, new-onset renal insufficiency, respiratory failure) with lower in-hospital mortality rates.[34,35] For the first month after the surgery, OPCAB’s resolutions are more favorable than ONCAB’s. However, long-term outcomes are not accordant with short-term outcomes. OPCAB over the time of one year lost its superiority over ONCAB. The long-term outcomes of OPCAB are still controversial, debating whether OPCAB has worse long-term survival and a higher rate of incomplete

myocardial revascularization after one year.[29-36] However, it is worth mentioning the results of some previous studies could be influenced by the lack of modern equipment and inadequate experience.[36] Lamy et al. demonstrated no significant difference in the first 30-days, 1-year, and 5-year composite outcomes with a similar rate of repeat revascularization.[13] Additionally, OPCAB was found to be beneficial for high-risk patients, without any specified reasons.[37] As mentioned earlier, it can be due to reduced risk of massive hemolysis, over-induced inflammatory cascades, and thromboembolisms. Overall OPCAB showed similar outcomes with similar or less resource utilization compared to ONCAB with minor superior outcomes in the first month after the procedure. OPCAB is financially beneficial with no inferiorities in the short term. Still, more studies must be done on long-term outcomes.

PCI-stent versus MIDCAB-CABG for single-vessel disease

MIDCAB and PCI are both revascularization techniques used for patients with single-vessel disease, especially left anterior descending artery revascularization or left main stem revascularization, however, their clinical outcomes and superiority have been subject to debate. The comparison between the two procedures has been evaluated in the literature in terms of several outcomes, including MACCE, target vessel revascularization (TVR), QALY, and length of stay (LOS). Deppe et al. conducted a meta-analysis with 2,885 single-vessel disease patients; they found that PCI had an increased incidence of MACCE after six months of follow-up. Additionally, PCI was associated with an increased rate of repeat TVR.[38] TVR rate might be from 3.8 to 5 times higher for PCI compared to MIDCAB shown meta-analysis.[38,39] PCI has higher recurring angina rates in six months of follow-up but it loses its significance over 1-year of follow-up and has similar rates of angina recurrence as MIDCAB.[21] Rao et al. have demonstrated that even with higher costs compared to PCI, the QALY gained over the long term favors MIDCAB. Therefore, MIDCAB is considered more cost-effective with favorable outcomes in the long-term.[40] In a meta-analysis by Gianoli et al. MIDCAB has a higher mortality rate, which is associated with cardiac mortality in short-term follow-up; however, MIDCAB showed better survival rates in the long-term.[20] Further studies are required for comparison of PCI with second-gen DES and MIDCAB. Overall, when considering MACCE, TVR, and cost-effectiveness, MIDCAB is considered superior to PCI in the long-term.

MICS-CAB versus conventional CABG for multivessel disease

The benefits of minimal invasiveness over various forms of sternotomy have been theorized and demonstrated in numerous studies, i.e., Lapierre et al.[41] state a shorter hospital stay, significantly fewer wound infections, and a faster return to physical activity in the MICS-CABG group compared to the OPCAB group, although with a larger proportion of MICS-CABG group receiving single-vessel vascularization. Ziankou et al. compared conventional CABG, OPCAB, and no-touch aorta MICS-CABG (MVST-CABG). They demonstrated less intraoperative blood loss and fewer blood transfusions in the MVST-CABG group. Being predominantly an off-pump procedure, MICS-CABG offers the advantage of avoiding or minimizing aortic clamping and manipulation, which are known to correlate with peri-operative neurological complications.[42] Nevertheless, Liang et al.[43] showed no significant differences in rates of stroke between conventional and MICS-CABG; therefore, further investigation might be needed.

Possible reservations regarding a more widespread implementation of MICS-CABG include the risk of incomplete vascularization and problems with patency in the long run. However, McGinn et al.[25] demonstrated complete revascularization in 95% of patients that received MICS-CABG. Lapierre et al.[41] achieved complete revascularization in all patients regardless of MICS-CABG or OPCAB, and Liang et al.[43] demonstrates no significant differences in repeat revascularization in conventional CABG vs MICS-CABG. Despite the excellent short-term results, data regarding long-term follow-up is relatively scarce.

The steep learning curve remains an issue but can possibly be overcome by prepping for cannulation for CPB, and it is advisable to acquire a large experience in performing conventional off-pump CABGs through a sternotomy approach and MIDCAB procedures before beginning with MICS-CABG surgery.[5] As a result, MICS-CABG is

Table 1: Randomized controlled trials about On pump versus Off pump.

Endpoints	GOPCABE[14]	CORONARY[13]	ROOBY[12]
Short term mortality	No significant difference	No significant difference	No significant difference
MACCE (major cardiac adverse events)	No significant difference	No significant difference	No significant difference
Long term outcome	No significant difference	No significant difference	Favors on on-pump CABG

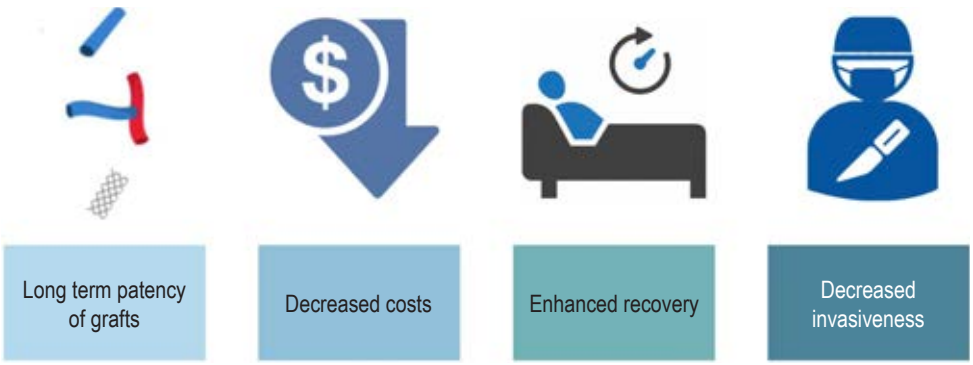

Figure 1:

Potential of minimally invasive surgical revascularization.

demonstrated to be comparably excellent to conventional CABG in terms of short and mid-term outcomes. Nevertheless, most studies point to the possibility of selection bias and the highly limiting inclusion criteria for MICS-CABG procedures. Longer follow-up durations and the results of the ongoing MIST trial (The Minimally Invasive Coronary Surgery Compared to Sternotomy Coronary Artery Bypass Grafting Trial, NCT03447938) might encourage more widespread implementation of MICS-CABG programs.[44]

CONCLUSIONS

IHD is the leading cause of cardiovascular mortality worldwide. Current interventions such as CABG and PCI are curative, yet they present nontrivial complications such as an increased risk for mortality (e.g. CABG) or increased need for revascularization (e.g. PCI). Recent guidelines have shifted to favor PCI due to its lack of invasiveness and risk for mortality. However, novel surgical interventions such as OPCAB, MIDCAB and MICS-CABG may allow for a less invasive procedure with a decreased risk of mortality and need for revascularization. Advantages of MIDCAB and MICS-CABG allow for a minimally invasive approach, while OPCAB allows for a more visible surgical area. However, disadvantages include the need for a quality anastomosis and the lack of evidence surrounding the procedures. More studies should be done on the mid- to long-term effectiveness of OPCAB, MIDCAB and MICS-CABG. Additionally, further comparison should be done between the three compared to the standard of care, either CABG or PCI.

In conclusion, novel minimally invasive CABG techniques may provide patients and surgeons with a more optimal way to reduce cost, mortality, and the need for revascularization regarding IHD *(Figure 1)*.

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Aortic coarctation versus aortic arch interruption: not all is what it seems

Coartación aórtica versus interrupción del arco aórtico: no todo es lo que parece

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ABSTRACT

Interruption of the aortic arch is a rare congenital heart disease, representing 1% of the series. We present here the case of a young male patient with hypertension refractory to treatment, precordial pain, headache, decreased pulses in lower extremities. Initially diagnosed with aortic coarctation, surgical resolution was made. Aortic coarctectomy was planned. However, after surgical examination in the operating room, an interrupted aortic arch was found, and Dacron graft interposition was performed.

Keywords: aortic coarctation, congenital heart disease, interrupted aortic arch.

RESUMEN

La interrupción del arco aórtico es una cardiopatía congénita poco frecuente, representa el 1% de éstas. Se presenta el caso de un paciente masculino joven con hipertensión refractaria a tratamiento, dolor precordial, cefalea, disminución de los pulsos a nivel de extremidades inferiores. Inicialmente se diagnosticó como coartación aórtica, y se realizó cirugía. En un principio estaba planeada una coartectomía aórtica, sin embargo, tras la exploración quirúrgica, se evidenció un arco aórtico interrumpido, realizando una interposición de injerto de Dacrón.

Palabras clave: *coartación aórtica, cardiopatía congénita, interrupción del arco aórtico.*

INTRODUCTION

Interrupted aortic arch (IAA) is a rare heart disease, occurring approximately three times per million births.[1] Other sources suggest that it is found in 1% of congenital heart disease. We can define it as the lack of continuity between the ascending and descending aorta.

Its presentation is very common during the first weeks of life. Early intervention in the first weeks is mainly required to improve patient mortality.[2] It is rarely a condition that manifests in isolation. Most commonly, IAA is found in association with other cardiac defects such as patent ductus arteriosus, ventricular septal defect mainly ventricular septal defect, left ventricular outflow tract obstruction, aorto-pulmonary window, aberrant innominate arteries.[3] The main differential diagnosis in these patients is aortic coarctation, which is defined as an eccentric narrowing of an aortic focal segment.[4]

Anatomically, IAA can be classified into three types; type A refers to a discontinuity of the arch distal to the left subclavian artery at the level of the aortic isthmus, type B is a discontinuity between the left common carotid and the left subclavian artery, and type C refers to a discontinuity that occurs between the innominate artery and the common carotid

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artery.[5] In adulthood, type B is more common in 53% of cases, followed by type A in 43%, and type C in 4%.[6]

CLINICAL CASE

A 17-year-old male during childhood she presented with atypical precordial pain recurrent to physical activity, with subsequent cessation of symptoms at six years of age. At 17 years of age, began again with precordial symptomatology, with exacerbation and progression of precordial pain on two occasions, with intensity 10/10, lasting 15 minutes. In the last episode, a holocranial pulsatile headache with intensity 8/10 was present.

The patient was evaluated by Cardiology. A grade I/II systolic murmur was identified, with irradiation to the scapular region. On palpation of the extremities, absence of pelvic limb pulses was found. Computed tomography (CT) angiography with reconstruction was performed, showing para-intervertebral, internal mammary and bilateral axillary circulation, with intraluminal reinforcement upon administration of iodinated radiopaque, and evidence of coarctation of the proximal descending aorta *(Figure 1)*.

A transthoracic echocardiogram reported critical post-ductal aortic coarctation, bicuspid aortic valve with mild regurgitation, mild dilatation of the aortic root, left ventricular ejection fraction 60%, pulmonary arterial systolic pressure 17 mmHg, without data of pulmonary hypertension nor associated shunt. There was evidence of a left aortic arch with presence of coarctation at 39 mm from the emergence of the left subclavian artery, with narrowing up to 6 mm, with maximum gradient of 11 mmHg. A second control transthoracic echocardiogram was performed demonstrating situs solitus, levocardia, no atrial septal defects, no ventricular septal defects, left ventricular ejection fraction 83%, bicuspid aortic valve with mild dysplasia, left aortic arch with moderate hypoplasia and juxta-ductal aortic coarctation.

The patient was evaluated by cardiothoracic surgery and scheduled for surgical resolution of aortic coarctation by means of aortic coarctectomy.

Surgical resolution was approached by left posterolateral thoracotomy through the 3rd left intercostal space, without extracorporeal circulation. Dissection of the thoracic aorta and the isthmus up to the emergence of the brachiocephalic trunk was performed, as well as control of intercostal arteries in the thoracic aorta. Adequate control of the intercostal arteries was key to avoid bleeding due to the large number of collateral vessels developed. Apparent coarctation of the aortic arch distal to the left subclavian artery was observed.

Aortic arch and thoracic aorta clamping were performed. Before resolution of the aortic interruption, the ductus arteriosus was sectioned and sutured with 5-0 polypropylene. Subsequently, the hypoplastic segment was sectioned. An anastomosis is performed with a 16 mm Dacron graft with 4-0 polypropylene and a polytetrafluoroethylene (PTFE) felt patch is placed at the end of the aortic arch. The PTFE patch was placed at the junction between the end of the aortic arch and one end of the Dacron graft. This PTFE felt patch dressing or also called "Bigotera" will function as a reinforcement at the suture line of the anastomosis. The same technique was used to perform the anastomosis in the distal segment of the thoracic aorta *(Figure 2)*. Once both anastomoses were performed, hemostasis was verified. Surgical sealant (CoSeal) was placed in both graft anastomoses, pleural drains were inserted and surgical closure was carried out.

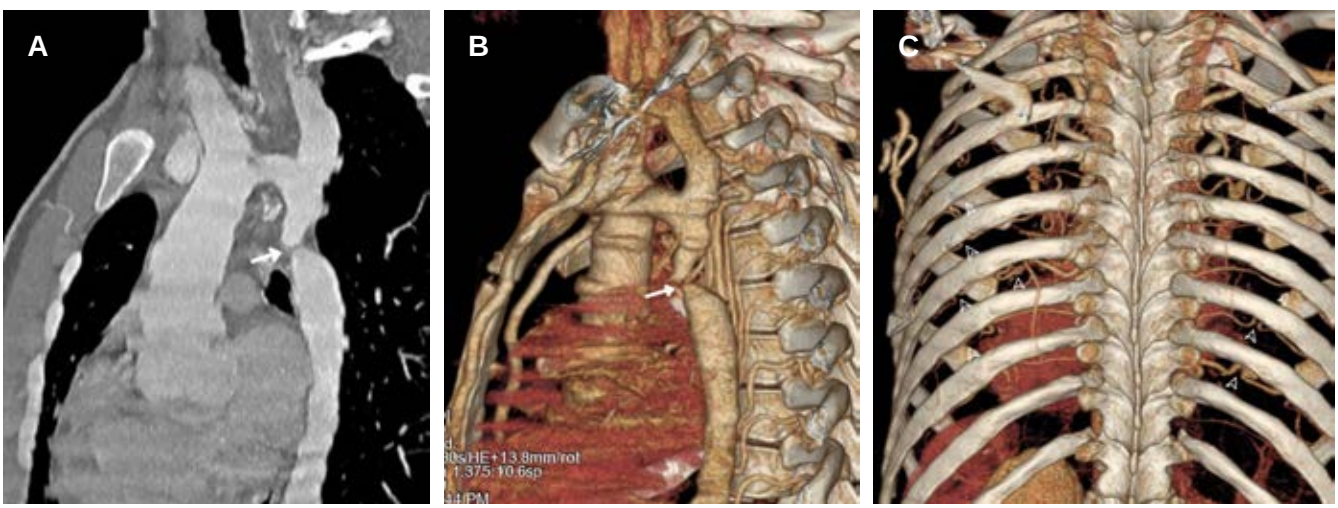

Figure 1: Preoperative angiotomography demonstrating defect distal to the left subclavian artery. A and B) White arrows indicating the defect. C) Arrow-heads on the costal ridge indicating increased flow in the posterior intercostal arteries, which generates erosion of the inferior costal border.

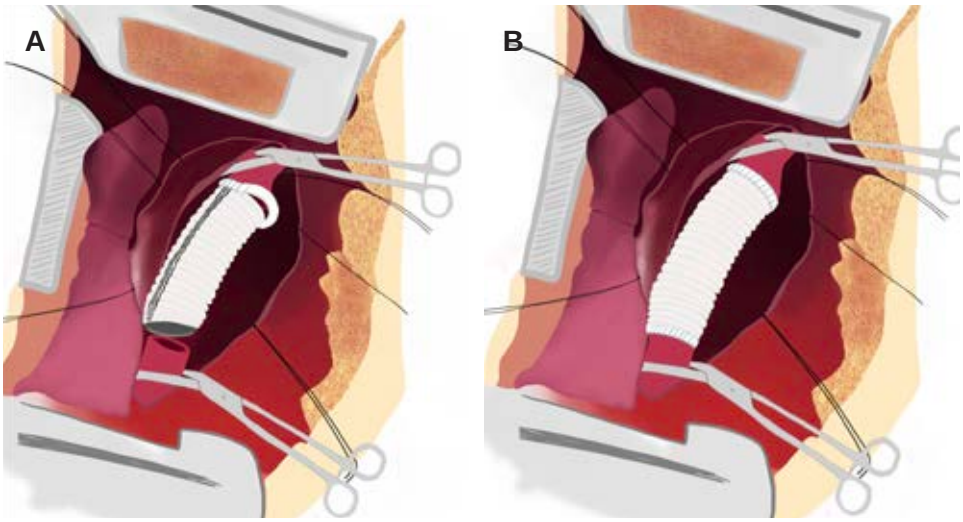

Figure 2:

Animated representation of Dacron graft interposition. A) Depicts proximal anastomosis of the graft to the aortic arch and placement of the polytetrafluoroethylene (PTFE) patch by continuous suture. B) Representation of the result of the interposition of the Dacron graft with the placement of PTFE patches for the reinforcement of both ends of the anastomosis.

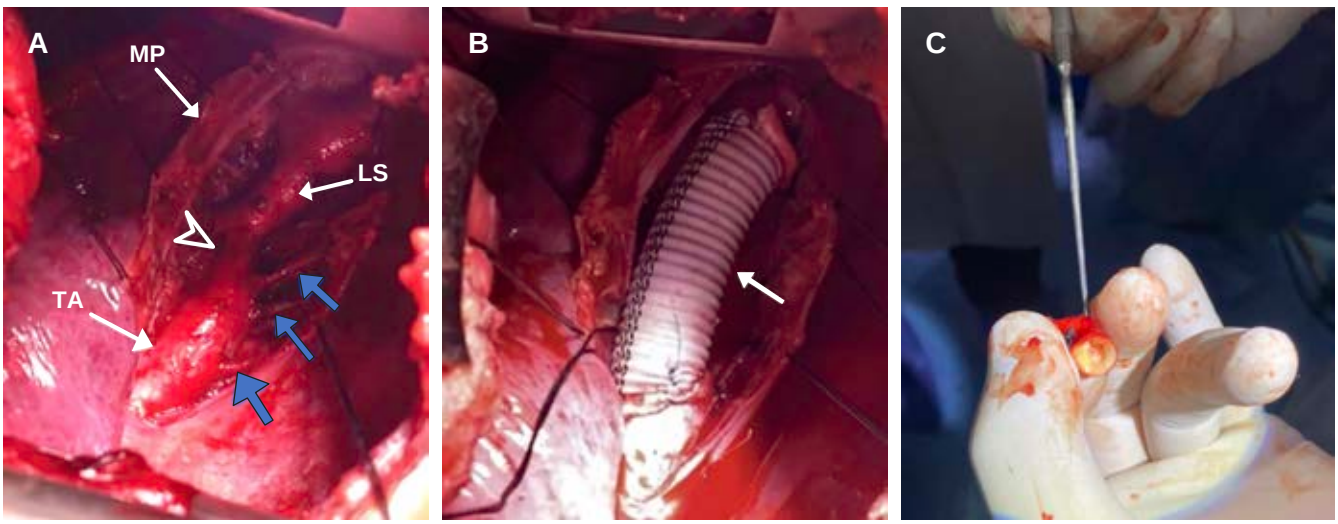

Figure 3: A) Image showing the defect (arrow head) prior to defect repair showing left subclavian artery (LS), vertebral arteries (blue arrows). B) Image showing defect repair with 16 mm Dacron graft (white arrow). C) Exploration of the hypoplastic segment with the nerve hook. The lumen of the defect segment was not perforated.
MP = mediastinal pleura. LS = left subclavian artery. TA = thoracic aorta.

The aortic cross-clamp time was 54 minutes. The patient was evaluated in the operating room by anesthesiology with transesophageal echocardiography and a residual gradient of 5 mmHg was identified.

Once the procedure was completed, the hypoplastic segment was explored. When attempting to explore the segment with the nerve hook, the segment did not pass through the section of what was believed to be the coarctation. At that point, an aortic arch interruption was diagnosed in the operating room, as opposed to an aortic coarctation as preoperatively diagnosed *(Figure 3)*.

A transthoracic echocardiogram during the first day in the intensive care unit reported no data of pulmonary hypertension, no shunts observed, preserved systolic function with ejection fraction of 56%. At the level of the thoracic aorta, a prosthetic tube with laminar flow, without gradient and without leakage was observed. Postoperative CT angiography was made reporting vascular structures at the thoracic level and its collaterals within the normal range, prosthetic tube at the level of the origin of the descending aorta intact and without contrast leakage *(Figure 4)*.

Postoperative course was uneventful. Length of stay in the intensive care unit was three days. In-hospital stay was seven days. Follow-up was performed two weeks after hospital discharge at the outpatient clinic. Patient evolution has been favorable without requiring subsequent rehospitalization.

COMMENT

Interrupted aortic arch is a rare congenital heart disease in which there is an interruption of the lumen and anatomical continuity between the ascending and descending arteries of the aorta.[3] The most common type found in adulthood is type A, in 79%. Such as the one found in the case presented here, type A, distal to the left subclavian artery. Due to this disposition of the defect, there is a difference in oxygen saturation where the upper extremities have greater oxygenation than the lower extremities.[5] IAA is considered incompatible with life when the ductus arteriosus closes and the defect is not corrected. Most cases of IAA are associated with patent ductus arteriosus in 98% of cases.[4] The survival of cases where the interruption persists into adulthood is due to the development of an extensive collateral network, which is vital for maintaining distal flow. Patency of the ductus arteriosus is another key point that allows survival in adult patients.[7]

The presence of IAA, patent ductus arteriosus and ventricular septal defect has been termed the triad of interrupted aortic arch.[3] In the case we presented herein, the ductus arteriosus was present, but with absence of ventricular septal defect.

According to the cases reported in a review by Gordon et al.[1] where IAA persisted into adulthood, the age range for surgical correction was 18 to 72 years. Of 38 cases, only five were in the age range of 18 to 21 years, such as our case. Predominant sex in the revision was male. Our case presented here was a male.

The diagnosis is mainly suspected on clinical presentation of symptoms. The most common finding is hypertension refractory to treatment. Another finding on physical examination is the discrepancy in blood pressure in the extremities. On measurement, the pressure in the lower extremities is usually more diminished. Other symptoms include claudication, evidence of aortic insufficiency and congestive heart failure.

The studies of cabinet that support the diagnosis are the radiography of thorax of first instance. This study usually demonstrates notches at the level of the inferior border of the costal arches. This is known as Roesler's sign, due to tortuosity in the intercostal arteries, due to increased flow. A transthoracic echocardiogram with Doppler is performed to identify the discontinuity in the flow. Magnetic resonance angiography helps to demonstrate heart malformations.[3] Especially in our case presented here, a diagnostic echocardiogram was performed without the presence of an interruption. Coarctation is evidenced presenting a gradient, so initially the diagnosis of aortic coarctation is given by cardiology.

Although the initial proposal was to treat the patient by interventionist methods, after diagnostic doubt, surgical approach was considered. In a series of cases analyzed by Gordon et al.,[3] 54% of the adult patients with IAA underwent surgical treatment by lateral thoracotomy sternotomy for its correction. Eight percent received interventional management by stents and 10% refused surgical management and received only medical treatment. Pharmacological therapy was applied to reduce pulmonary hypertension.

A review by Krishna et al.[8] analyzed the experience in one center with a population of 12 patients. Ten extra-anatomic bypasses were performed in a single stage. Of this group, five patients underwent ventral aortic repair via midline sternotomy. This approach was preferred due to excessive bleeding with the left posterolateral thoracotomy approach. This technique avoids the extensive net of collateral vessels in the chest wall. In two patients, a descending thoracic to subclavian aortic bypass graft was performed. These patients were boarded

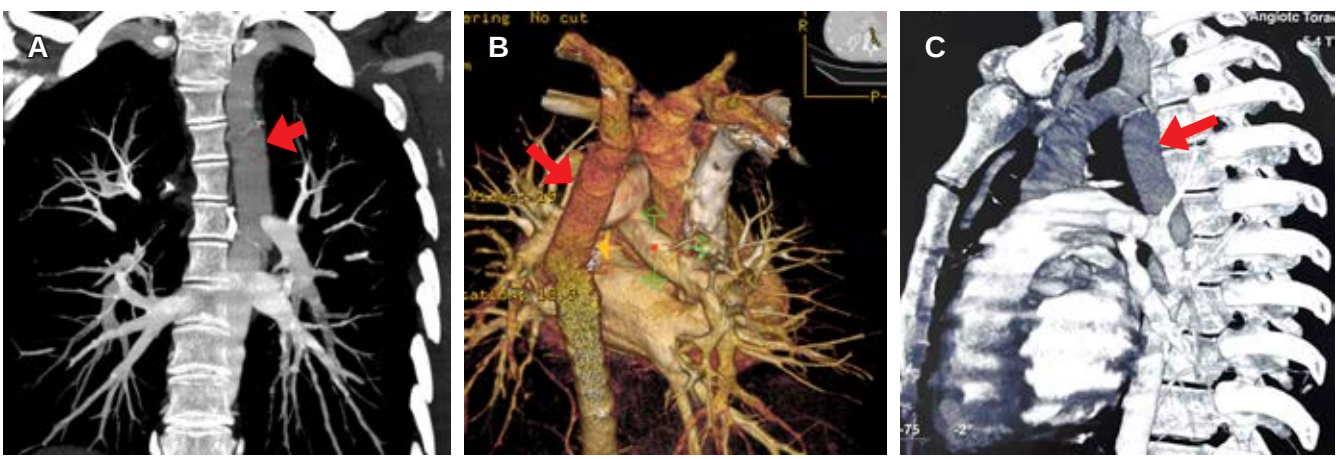

Figure 4: Angiotomography images with reconstruction of great vessels showing a graft at the level of the descending aorta. A) coronal plane. B) Reconstruction of great vessels posterior view. C) Sagittal plane. Red arrows indicate graft location.

previously approached by posterolateral thoracotomy. All repairs were performed without extracorporeal circulation.

Undoubtedly, advances in surgical techniques have allowed lower risk of morbidity and mortality, with favorable results. For this reason, surgical repair is the treatment of choice in adults with IAA.[9] The aim of surgical treatment in IAA is to repair the defect and repair some other lesion in a single stage. Extra-anatomic bypass, end-to-end anastomosis, graft interposition or percutaneous stent placement have been proposed as surgical resolutions.[10] End-terminal anastomosis is suggested in newborns, infants, older children and adults, while graft interposition is an excellent option in adult populations.[3]

In the case presented here, we decided to perform a section of the portion where the defect was located and subsequently a Dacron graft interposition was performed. The patient had no bleeding during the postoperative period. No additional interventions were required. At two months of follow-up the patient is stable. Systemic arterial hypertension has subsided. No additional hospitalization was required.

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Avoiding lethal mediastinal injuries, Steinmann nail migration

Evadiendo lesiones letales de mediastino, migración de clavo de Steinmann

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ABSTRACT

We present the case of a 29-year-old male, who was admitted with respiratory distress with unsatisfactory evolution. With the history and complementary studies, an intrapulmonary foreign body was diagnosed with involvement of the main bronchi. He underwent surgery, extracting a foreign body (Steinmann nail) in the upper lobe of the right lung. Because of its presentation, location and challenging treatment, the case is presented to show the most relevant clinic-surgical and pathological aspects.

Keywords: foreign body, lung, bronchus, bronchoscopy, Steinmann nail.

RESUMEN

Se presenta el caso de paciente masculino de 29 años, el cual ingresó por cuadro de dificultad respiratoria con evolución no satisfactoria. Con los antecedentes y estudios complementarios, se diagnosticó un cuerpo extraño intrapulmonar con afectación de bronquios principales. Fue intervenido quirúrgicamente, extrayendo cuerpo extraño (clavo de Steinmann) en lóbulo superior del pulmón derecho. Por su presentación, localización y dificultad para su tratamiento, se expone este caso para mostrar los aspectos clínico-quirúrgicos y patológicos más relevantes.

Palabras clave: *cuerpo extraño, pulmón, bronquio, broncoscopia, clavo de Steinmann.*

INTRODUCTION

Bronchial foreign bodies in adult patients are a rare clinical entity in contrast to pediatric age.[1] The initial aspiration is usually manifested by cough, dyspnea, asphyxia and/or cyanosis, although sometimes the clinical manifestations are not so striking and can go unnoticed or be confused with other pathologies such as bronchitis, bronchiectasis and pneumonia.[2] In patients with a history of osteosynthesis, the risk of migration of the material exists and multiple cases have been described since 1943, some involving mediastinal structures with fatal outcomes.[3] Our work aims to reflect the challenge involved in the diagnosis and treatment of an atypical cause of foreign body in the tracheobronchial area, with a clinical picture of cough and dyspnea in an adult patient, associated with a previous surgical intervention.

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CLINICAL CASE

We present here the case of a 29-year-old male patient, who denies chronic degenerative diseases of importance, important surgical history about trochiter fracture and right shoulder dislocation in September 2022, managed conservatively; later with fracture displacement, being operated in March 2023. He was taken to his local General Hospital where closed reduction and immobilization were performed, with a review appointment at two months, where surgical management was decided, and he underwent surgery in March 2023, performing arthrodesis with placement of Steinmann nail. One month after surgery, he began with episodes of isolated chest pain, as well as non-productive cough and dyspnea of medium efforts, as well as gradual migration of the Steinmann nail. He went for follow-up evaluation and a control X-ray was performed, showing migration of the nail to the thorax, for which reason he was referred to our institution for evaluation by thoracic surgery.

Initial chest X-ray showed a metallic object in the thorax involving right and left hemithorax and mediastinum. There was no evidence of pleuropulmonary syndromes. Chest tomography demonstrated a metallic object in the thorax with involvement of the right lung which passes through the right main bronchus, carina, lodging in the left main bronchus *(Figure 1)*.

The patient was admitted to the emergency room without dyspnea at rest or desaturation, hemodynamically stable. In the operating room, a bronchoscopy was performed in which a foreign body was observed in the right main bronchus passing through the carina and left main bronchus, without other apparent lesions *(Figure 2)*. It was decided to perform a median sternotomy approach. Dissection of the superior cava, aorta and right pulmonary artery was performed to expose the trachea, site of perforation. Tracheal perforation closure is repaired with prolene. Right pleura was opened to remove the nail under direct vision by

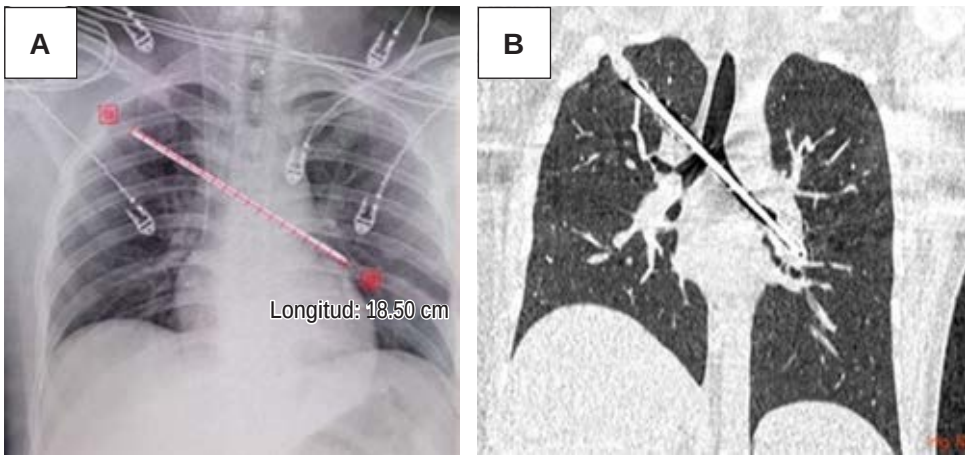

Figure 1:

A) Anteroposterior thoracic radiograph showing a foreign body (Steinmann nail) at mediastinal level. B) Coronal section of tomography showing a foreign body (Steinmann nail) which is introduced at the level of the carina towards the left pulmonary bronchus.

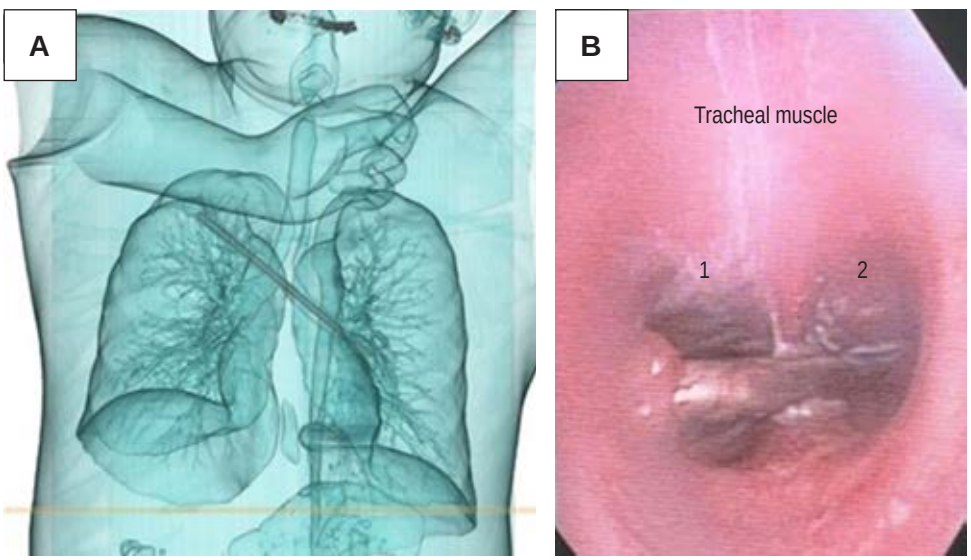

Figure 2:

A) 3D reconstruction of the tracheobronchial tree in which a nail is observed at the level of the carina, heading to the left bronchus. B) Bronchoscopy where a nail is observed at carina level. 1) Right main bronchus. 2) Left main bronchus.

a counter opening in the right hemithorax. Right upper lobe exit orifice was repaired with absorbable suture. Adequate closure of the trachea was verified with a new perioperative bronchoscopy and two mediastinal tubes were placed. Conventional sternotomy closure was performed *(Figure 3)*.

Patient with adequate postoperative evolution. Mediastinal tubes were removed on the fourth postoperative day and the patient was discharged from our institution *(Figure 4)*.

COMMENT

Bronchial foreign bodies are an infrequent and occasional pathology in the adult population, as opposed to children. In Hollinger's classic 1978 study, only 6% of all airway foreign bodies occur in patients older than 14 years of age.[4]

If the foreign body is small and non-irritating, symptoms may be minimal, with an asymptomatic interval of hours, days or months, followed by chronic cough and increased secretions. Then, with local inflammatory reaction, erosion, perforation and infection, purulent or hemoptotic sputum, fever and prolonged or recurrent bronchopneumonia may occur.[5]

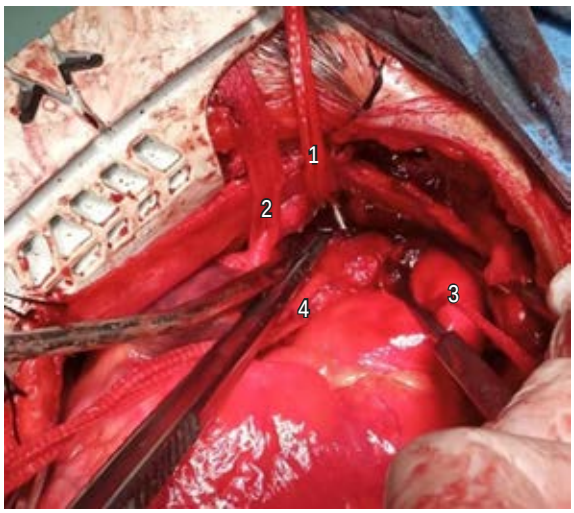

Figure 3: 1) Referred Steinmann nail. 2) Superior vena cava. 3) Ascending aorta. 4) Pulmonary artery.

Regarding the location in the airway, most published series report the following locations according to frequency: right main bronchus (60-65%), left main bronchus (25-30%) and subglottic-trachea (9-12%). Distribution is similar to that found in pediatric age.[6]

Any undiagnosed bronchial foreign body will inexorably go through this period, which in turn goes through several states: a) the foreign body behaves as a bypass or free passage valve (bronchial pseudo asthma); b) as a one-way valve (air admission); c) as a total closure valve or airflow strangulation.[7]

This case described is an unusual bronchial foreign body presentation, which was secondary to migration of osteosynthesis material. Migration of nails and fixation wires is most likely to occur in the joints and bones of the rib cage, such as the clavicle, humerus, sternoclavicular joint, and acromioclavicular joint.[8] Migration sites include the spinal canal, trachea, spleen, pulmonary artery, heart, mediastinum, lung, subclavian artery, and ascending and abdominal aorta.[9]

Several theories have been proposed to explain the migration of nails and fixation wires, including muscle activity, regional bone resorption, and the great freedom of motion of the shoulder. Muscle activity and regional bone resorption may cause nails and wires to break, which may facilitate their migration. The great freedom of motion of the shoulder may contribute to migration by allowing the nails and wires to move.[9]

Although bending the free end of the nails may help prevent migration, it is not always effective. The duration of device implantation is also a risk factor.[9] It has been reported that nails and fixation wires can migrate from the site where they were placed, even up to six years later.[10] Internal fixation devices should be removed at the appropriate time to avoid loosening, infection, or migration. The appropriate time to remove nails is when the fracture has healed, usually four to six weeks after

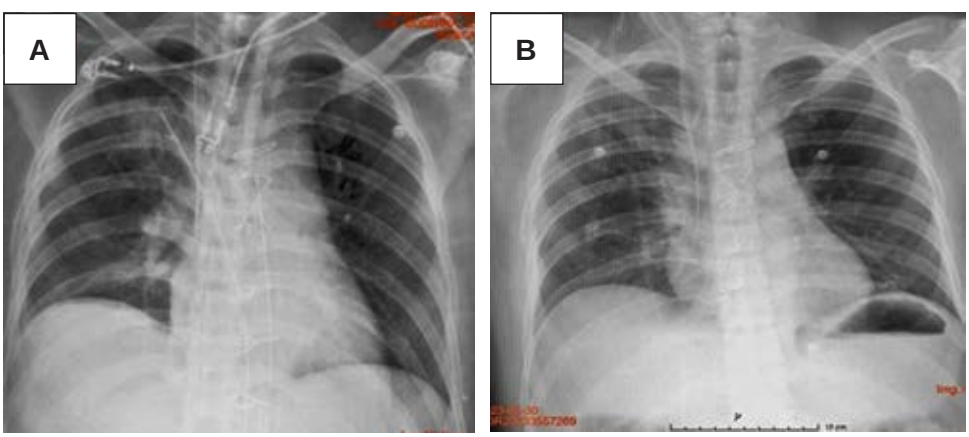

Figure 4:

A) Postoperative radiography after removal of Steinmann nail, showing drainage tube at mediastinum level without presence of emphysema and pneumomediastinum. B) Control X-ray prior to discharge of the patient.

placement. If a device breaks or changes position, it should be removed immediately.[8]

Symptoms may include chest pain, back pain and hemoptysis. Serious complications include perforation of major blood vessels, such as the innominate vein, ascending aorta, and superior vena cava, as well as pneumothorax.[10]

In 2015, 102 cases of fixation nails that moved to different parts of the mediastinum had been reported. Most of these cases occurred after fixation of trauma to the shoulder girdle. Eleven patients died due to severe cardiovascular complications, and 15 patients had aortic perforation, some of whom had cardiac tamponade resulting in the death of four patients.[3]

Treatment of choice, after a high clinical and radiological suspicion, consists of performing laryngoscopy or bronchoscopy, under maximum safety conditions and with minimal trauma. It is important to initially revise the upper esophagus and always be prepared for an emergency tracheotomy or cricothyrotomy, due to the possibility of the foreign body moving during the surgical procedure and producing a complete and fatal obstruction. When all these procedures are unsuccessful, the surgical approach should be resorted to either by thoracotomy or video-assisted thoracic surgery.[11]

Thoracoscopic removal of intrathoracic foreign bodies can be performed safely if it does not cross the mediastinum and if the patient can tolerate single-lung ventilation. Otherwise, thoracotomy and sternotomy (as in this case described) are safe and could be used to remove migrated nails. Sternotomy may be considered more appropriate in the presence of injury to the heart or great vessels.[9]

CONCLUSIONS

As a conclusion, migration of osteosynthesis material is a rare problem. Even so, several cases of migration to the thorax and mediastinum have been described in patients with joint fixation in the thoracic cage. Some of these cases have had fatal consequences. In our case, the factors contributing to the development of this complication were the prolonged time since fixation and the fact that the free end of the Steinmann nail had not been bent. This highlights the importance of close follow-up and fixation of the osteosynthesis material to avoid this type of complication. Fortunately, the patient presented image on radiography that allowed an integral approach, from the bronchoscopy to the surgical procedure, with adequate post-surgical evolution, achieving the extraction of the foreign object (Steinmann nail), without presenting lesions in adjacent structures, allowing a quick recovery and discharge.

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CASE REPORT
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Frozen elephant trunk. First case in a Mexican single center. Technical overview and experience

Trompa de elefante congelada. Primer caso en un solo centro mexicano. Revisión técnica y experiencia

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ABSTRACT

This article presents the clinical applications of the frozen elephant trunk, discusses the historical aspects, the report of the first clinical case in our hospital and the evolution of the surgical technique for the treatment of Stanford A aortic dissections in our department. The objective is to report the first case of frozen elephant trunk technique in our institution.

Keywords: acute aortic dissection Stanford A, frozen elephant trunk (FET), selective antegrade cerebral perfusion, thoracic endovascular aortic repair (TEVAR), total arch replacement.

RESUMEN

Este artículo presenta las aplicaciones clínicas de la trompa de elefante congelada, discute los aspectos históricos, el reporte del primer caso clínico en nuestro hospital y la evolución de la técnica quirúrgica para el tratamiento de las disecciones aórticas Stanford A en nuestro servicio. El objetivo es reportar el primer caso de técnica de trompa de elefante congelada en el Instituto Nacional de Cardiología "Ignacio Chávez" en la Ciudad de México.

Palabras clave: *disección aórtica aguda Stanford A, trompa de elefante congelada, perfusión cerebral anterógrada selectiva, reparación endovascular torácica aórtica, reemplazo total del arco.*

INTRODUCTION

In 1983 Borst et al. introduced the two-stage elephant trunk principle as a surgical treatment strategy for extensive thoracic aortic disease.[1] This approach is based on the prosthetic replacement of the entire arch with an elephant trunk extension of the arch graft. In 2003, Karck et al. reported four patients with descending aortic aneurysms or chronic aortic dissection, who had open aortic arch replacement with stent-graft insertion in the descending aorta. They used a custom-made stent-graft (Chavan-Haverich, Curative Medical Devices Gmbh, Dresden). They found complete thrombosis in the descending aorta or false lumen around the stent-graft. This was the first report in which this method was called "frozen elephant trunk (FET)".[2]

FET is indicated for distal aortic arch aneurysms, proximal and descending thoracic aortic aneurysms, type B chronic aortic dissection, residual dissection after proximal aortic repair, and type I acute aortic dissection. In addition, the FET can be used in patients with complicated type III aortic

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dissection, including retrograde dissection in zone 2, short landing zone (< 2 cm) for thoracic endovascular aortic repair (TEVAR) in zone 2, or aortic arch diameter > 40 mm. FET is also indicated in type IA endoleak after TEVAR or in patients with stent-induced reentry. In a study from Essen, an angioscope was used in 124 patients to identify the position and morphology of distal reentry sites in patients with AD type I/III. This showed that there was reentry in 73% of the patients 5 cm distally to the origin of the left subclavian artery and 31% in the range of 6-10 cm.[3]

The two commercially available FET prostheses in Europe are E-vita Open Plus™ (Jotec, Hechingen, Alemania) and Thoraflex Hybrid™ (Vascutek Terumo, Renfrewshire, Scotland, Reino Unido). Both devices are available in different sizes and with different delivery systems.

Compared to the E-vita Open Plus device, the Thoraflex Hybrid system has a simpler deployment system, has a gelatin-sealed vascular prosthesis, and its nitinol ring arrangement exerts less radial force compared to the z-stent design of the E-vita Open Plus device. Both FET devices have radiopaque markers for identification in subsequent imaging studies.[4] Other commercially available prostheses are the Cronus (MicroPort, Shanghai, China) and the Frozenix (Japan Lifeline, Tokyo, Japan).[5]

Neurological complications such as permanent stroke and spinal cord ischemia are the most devastating complications of aortic surgery.

In a meta-analysis by Preventza et al. it was found that in cases of acute type A aortic dissection that landing zone at T8 or beyond or a stent graft length of 15 cm or more was a significant predictor of spinal cord injury. This is extremely important, as the industry is developing single-graft stents to treat extensive aortic pathology.[6]

Circulatory arrest in moderate hypothermia is associated with equivalent operative mortality and morbidity and visceral organ functions compared with deep hypothermia in patients with acute type A aortic dissection undergoing total arch replacement under unilateral selective antegrade cerebral perfusion.[7]

Despite increasing experience in specialized centers with broader practice in aortic arch surgery, in-hospital mortality after FET remains not insignificant (up to 17%) and the postoperative course is often complicated by the occurrence of stroke (2.5 to 20%), spinal cord injury (2 to 21%), and renal dysfunction (up to 35%).[8]

CLINICAL CASE

We present the case of a 52-year-old male patient. Prior to his admission, he reported the presence of oppressive, sudden, tearing pain, intensity 10/10, accompanied by dyspnea and weakness of the lower limbs, diaphoresis, with suspicion of acute coronary syndrome. CT angiography was performed and it was classified as Stanford B DeBakey III aortic dissection, referred to our institute for surgical treatment.

Upon admission, conscious, oriented, Glasgow 15 points, presented elevated blood pressure (163/88 mmHg), nitroprusside 0.5 µg/kg/min was started. The electrocardiogram showed sinus rhythm, 85 bpm, PR 0.16, QRS 0.12, QT 0.40, normal axis, in the paraclinical examinations a hemoglobin of 10.3, hematocrit of 31.1, and creatinine of 1.48 stand out.

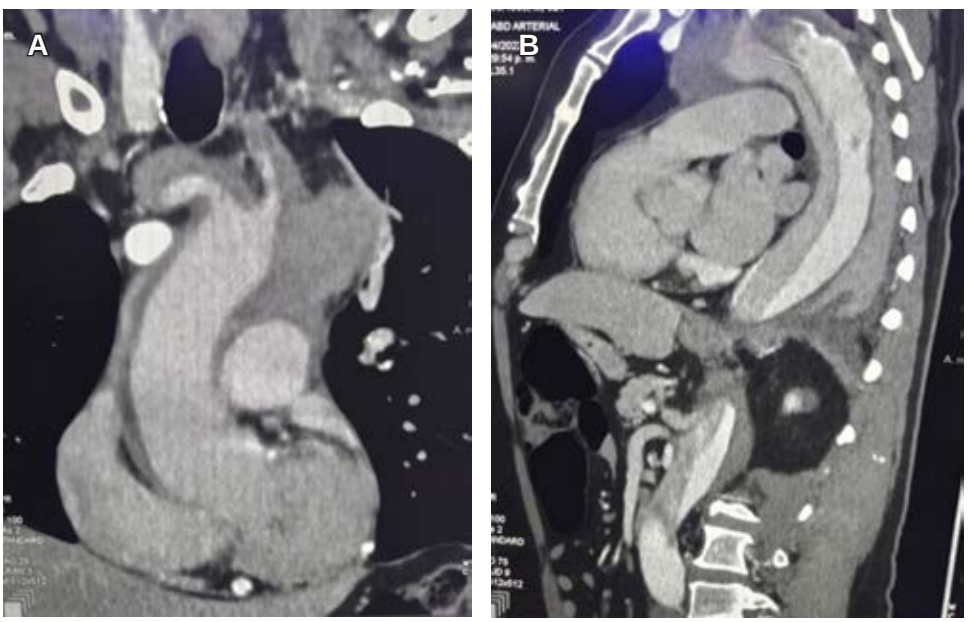

Figure 1:

A) CT angiography showing intramural hematoma extending to the proximal arch; B) dissection flap from the brachiocephalic trunk extending to the left internal iliac artery.

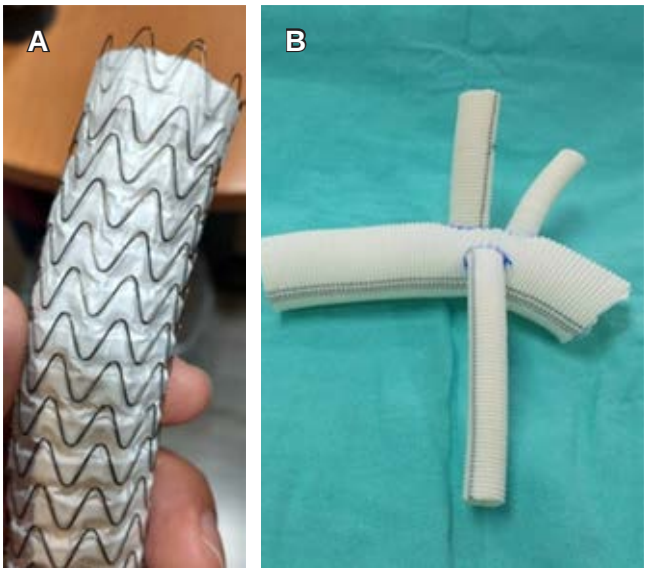

Figure 2: A) GORE® Stent Graft 31 mm × 15 cm; B) woven Dacron graft for aortic arch.

The echocardiogram reported a Stanford A dissection, flap dissection at the level of the brachiocephalic trunk, left atrial dilation, left ventricular concentric remodeling, left ventricular systolic function 60%, normal right ventricular systolic function, mild aortic regurgitation, mild mitral regurgitation, without evidence of pericardial effusion or intracavitary thrombus.

CT Angiography showed intramural hematoma that begins in the sinus of Valsalva and extends to the proximal arch, dissection flap that begins in the brachiocephalic trunk and extends to the right common carotid, proximal third of the left common carotid, and the subclavian artery and continues to the distal third of the left internal iliac artery, the right renal artery arises from the false lumen, the rest of the visceral branches emerge from the true lumen *(Figure 1)*.

With the previous studies it was decided to undergo surgical treatment. We were provided with a 31 mm × 15 cm GORE® endoprosthesis *(Figure 2A)*, we manually made a 32 mm woven Dacron tube with a 10 mm chimney and another tube of 10 mm for the left carotid and one of 12 mm that will serve for the brachycephalic trunk *(Figure 2B)*. An ultrasound-guided right common femoral puncture was performed and a 6 Fr introducer was placed; a right infraclavicular incision was made, the right subclavian artery was located and vascular control performed and 5/0 purse-string tourniquet, left infraclavicular incision was made and end-to-side anastomosis is performed with a 10 mm woven Dacron tube, median sternotomy was performed and extended with left cervicotomy. Mediastinal structures were dissected, carotid sheath was also dissected, with vascular control of the carotid artery. One vascular shunt was placed, an end-to-side anastomosis performed with a 10 mm woven Dacron. Then, pericardium was incised, the edges marsupialized, a simple purse-string was placed in the right atrium and in the right upper pulmonary vein, and heparin administered, with optimal activated coagulation time, the right subclavian artery was cannulated with a 17 Fr cannula, a trilumen catheter is placed for distal perfusion in the right subclavian artery, the right atrium and right upper pulmonary vein were also cannulated. The body temperature was lowered to reach 18 ºC. Then, aortic cross-clamping was performed, aortotomy and direct Custodiol as cardioplegia administered into coronary ostia. Proximal aorta was reinforced with Teflon bands and aortic valve resuspension and anastomosis of a 32 mm woven Dacron tube were performed in ascending aorta. In deep hypothermia, the centrifugal pump was stopped and selective cerebral perfusion was started with a roller pump at 800 ml per minute. Aorta was unclamped and aortic arch resection performed, a hydrophilic guidewire passed through a femoral introducer under vision with true light echocardiography, a GORE-type thoracic endoprosthesis releaser ® was directed 31 mm × 15 cm in the descending aorta, stent was released without complications *(Figure 3A)*. Anastomosis of the endoprosthesis to a 32 mm woven Dacron tube and later to a woven tube of the proximal aorta (supracoronarian) was performed *(Figure 3B)*. The cannula was connected to the arch chimney and the flow is restarted with a centrifugal pump, an end-to-end anastomosis performed from a 10-mm woven tube of the left common carotid to a 10-mm aortic tube. Anastomosis was subsequently performed from the brachycephalic trunk to a woven Dacron tube of 12 mm supra-aortic. Temperature rise began, at optimal temperature extracorporeal circulation is weaned, achieving it on the first

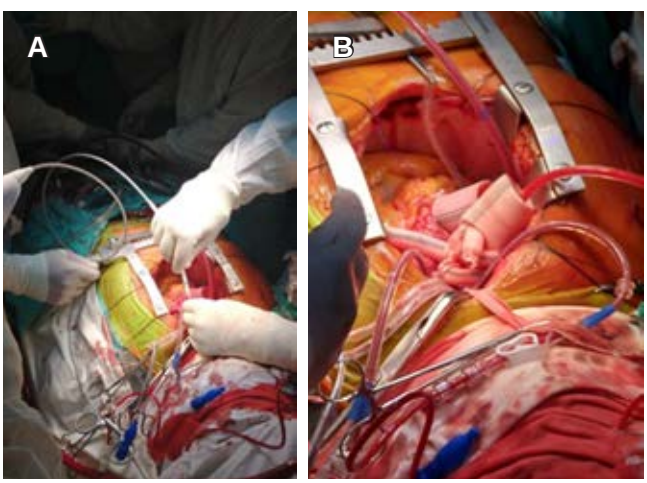

Figure 3: A) Trans-operative release of a stent into the descending aorta; B) distal to proximal woven Dacron tube anastomosis.

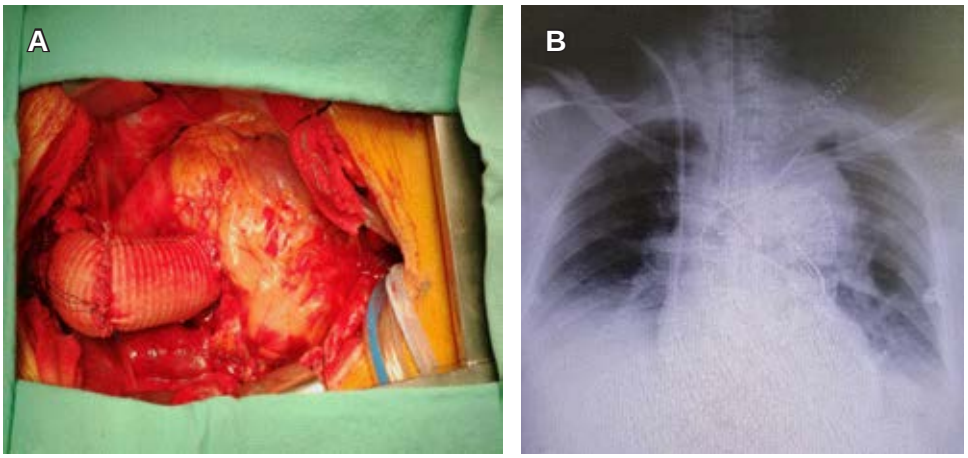

Figure 4:

A) Final result of the replacement of arch and ascending aorta; B) chest X-ray showing the endoprosthesis.

attempt, in hemodynamic stability structures are decannulated and anastomosis is performed from 10 mm woven Dacron used as chimney to 10 mm woven Dacron extraanatomical that passes through the left pleura to the left subclavian artery *(Figure 4A)*. Protamine was administered, hemostasis performed and chest draining tubes placed. Chest closure was performed as usual. Surgical procedure concluded without complications. In ICU, a chest X-ray was requested, without observing changes *(Figure 4B)*.

COMMENT

Acute type A aortic dissection is one of the most complicated and life-threatening conditions of the cardiovascular system. Over the past two decades, the frozen elephant trunk technique has emerged as a valid and attractive option for treating aortic disease when the thoracic arch and aorta are involved, in both elective and emergency settings. The technique converts the conventional elephant trunk procedure, which is inherently a two-stage operation, into a one-stage repair by completely replacing the aortic arch with a surgical prosthesis comprising a stented distal portion deployed in the distal tract of the arch. aortic and proximal descending thoracic aorta.[9]

In a meta-analysis by Lin et al.,[10] in-hospital mortality rate of 8% was reported, and the rate of stroke, spinal cord injury, renal failure, and frequency of reoperations resulting from bleeding was ≤ 5%, which indicates that the technique apart from being reproducible is safe and provides excellent surgical results.

The improvement of our technique makes us think that we can achieve even better results with the joint work of a specialized aortic group that includes perfusion, anesthesiology, and intensive care, among others, who have extensive training in aortic pathology.

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CASE REPORT

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The potential for MINIAVR: an innovative approach in patients with complex conditions

El potencial de MINIAVR: un enfoque innovador en pacientes con afecciones complejas

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ABSTRACT

Ankylosing spondylitis is a chronic, inflammatory disease that rarely involves the heart, often causing aortic valve regurgitation with aortitis. Transcatheter aortic valve implantation has been explored as a treatment option, but it may not be suitable for all cases. Minimal invasive cardiac surgery highlights its potential benefits for patients with limited respiratory and renal function and chest wall deformities, emphasizing the importance of individualized assessment for innovative approaches in complex conditions.

Keywords: ankylosing spondylitis, aortic valve regurgitation, aortic valve replacement, minimally invasive cardiac surgery.

RESUMEN

La espondilitis anquilosante es una patología crónica e inflamatoria que en pocas ocasiones afecta al corazón, ocasionando insuficiencia aórtica con aortitis. Se ha explorado la opción de colocación de válvula aórtica percutánea, sin embargo, no es factible en todos los casos. La cirugía cardíaca mínimamente invasiva puede beneficiar a pacientes con función renal y respiratoria alterada, así como con deformidad torácica, se realiza énfasis en la valoración individualizada de cada paciente con características complejas.

Palabras clave: *espondilitis anquilosante, regurgitación de la válvula aórtica, sustitución de la válvula aórtica, cirugía cardíaca mínimamente invasiva.*

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INTRODUCTION

Ankylosing spondylitis (AnSp) is a chronic, inflammatory, and rheumatic disease categorized under the group of spondyloarthropathies (SPAs). It is a complex and debilitating disease with a worldwide prevalence ranging from 0.9 to 1.9%.[1,2] It predominantly affects the sacroiliac joint and spine, with less frequent involvement of peripheral joints and the possibility of non-joint manifestations.[3] Sacroiliitis represents the earliest recognized manifestation of AnSp, but it can also extend to peripheral joints and extra-articular structures. Inflammatory changes involving enthesis, the insertion point of tendons, ligaments, capsules, or fascia into bone, are considered characteristic findings in AnSp and other SPAs.[1]

Within AnSp, cardiac involvement is a relatively uncommon condition, affecting 2 to 10% of patients, and is often characterized by aortic insufficiency, aortitis, or disturbances in heart conduction.[2-4] Valvular heart disease and conduction blocks in AnSp are closely associated with aortitis and HLA-B27. Inflammation and fibrosis in the aortic root, cardiac valves, and the subaortic and interventricular septum can lead to dilation of the aortic outflow tract, valve thickening, regurgitation, and occasionally high-degree heart block.[3,5-7] It is suggested that heart rhythm disturbances are due to inflammation-induced damage to the interventricular septum wall and atrioventricular (AV) node dysfunction result from impaired arterial supply to the AV node.[3]

Aortic valve disease in AnSp often arises due to the expansion of the aortic root caused by the development of fibrous tissue along the intima. Research has shown that this inflammatory process, accompanied by platelet aggregation and excessive fibroblast activity causes proliferative endarteritis which results in fibrotic tissue thickening and aortic root dilation. Then, the process reaches the aortic annulus, and it causes the basal thickening of the cusps which finally leads to aortic regurgitation (AR).[4]

It has been proposed that transcatheter aortic valve implantation (TAVI) could be a reasonable option of treatment,[4,8] especially in patients with ankylosed cervical spine, restricted neck motion and difficult airway management;[9] it is worth noting that TAVI for isolated chronic AR poses challenges due to aortic annulus and root dilation and lack of sufficient leaflet calcification in many patients. Risks associated with TAVI for AR treatment include a high incidence of the need for a second valve,[10] transcatheter valve migration and significant paravalvular leak. TAVI is rarely considered feasible, and only in carefully selected patients with severe AR and high surgical risk, provided that valvular calcification and annular size are suitable for the transcatheter approach. However, in patients with isolated severe AR who require surgical aortic valve replacement (AVR) being candidates for surgery, TAVI should not be performed (class of recommendation III).[11] In addition, data on TAVI in patients younger than 75 years are still limited.[12]

Understanding the complexities of AnSp and its potential impact on various systems, including the cardiovascular system, is critical for effective management and patient care. This case report aims to summarize and highlight our strategy for current surgical practice in these high-risk patients.

CASE REPORT

We present a case study of a 51-year-old male with a medical history of psoriatic AnSp who experienced symptoms of spinal stiffness, pain, and bilateral knee arthritis. Despite prolonged use of nonsteroidal and steroidal anti-inflammatory drugs, he continued to suffer from multiple relapses of psoriatic lesions, leading to the initiation of monthly monoclonal antibody treatment.

In December 2020, the patient had been hospitalized and diagnosed with heart failure (HF), ischemic heart disease, and severe AR. As part of his treatment, he underwent cardiac catheterization and percutaneous transluminal coronary angioplasty of obtuse marginal coronary artery. In addition, the patient was prescribed guideline-directed medical therapy for HF, with included a neprilysin inhibitor, angiotensin receptor blocker, beta-blocker, sodium-glucose co-transporter 2 inhibitor, diuretic, and aldosterone antagonist. Considering his complex medical history, the patient was evaluated for a TAVI procedure. However, he declined this option due to personal reasons. Consequently, he was discharged with appropriate medical management and care to be provided at home. Three months later, the patient's dyspnea progressively worsened. He also developed orthopnea, paroxysmal nocturnal dyspnea, and occasional effort-related chest pain. These symptoms prompted him to seek medical attention at our facility.

Upon arrival, the patient presented with spinal stiffness and pain, as well as bilateral knee and hip arthritis. Upon cardiac auscultation, a diastolic murmur was detected, primarily localized in the aortic region; spinal mobility was severely restricted, likely stemming from the complete stiffness affecting the entire vertebral column, particularly evident in the rectification of the cervical column, and a prominent lordosis in the thoracic column; additionally, his knee joints exhibited noticeable swelling.

The echocardiograms demonstrated an enlarged left ventricle with an end-diastolic diameter of 60 mm and an ejection fraction of 49%. Additionally, severe AR was evident, with aortic jet quantified at 100% of the left ventricular outflow tract, vena contracta of 6 mm, and an aortic valve area of 2.1 cm^2 with an aortic valve characterized by fibrotic margins and thickening of the cusps. Laboratory results

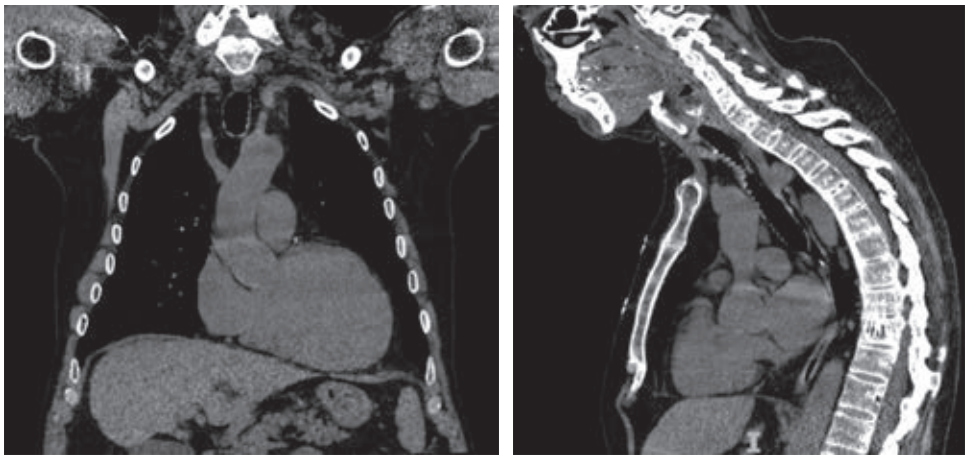

Figure 1:

CT-scan revealing vertebral body fusion of posterior processes of cervical and thoracic column, resulting in complete cervical rectification, severe thoracic lordosis and deformation of the thoracic region.

indicated potential kidney impairment with a creatinine clearance of 39.2 ml/min, and elevated inflammation markers with globular sedimentation rate of 26 mm/h, and C-reactive protein levels at 50 mg/l. Moreover, respiratory function testing exhibited a mild restrictive process, and cervical X-ray showed vertebral body fusion, producing total spine rectification in "bamboo spine". Notably, a CT scan revealed a 17 mm-long atheromatous plaque occupying 40% of the right external iliac artery; vertebral body fusion of posterior processes of cervical and thoracic column, producing total cervical rectification, extreme thoracic lordosis and thoracic deformation *(Figure 1)*.

These comprehensive findings not only offered essential insights into the patient condition, but also enable a tailored management and treatment approach. Patient medical condition, characterized by severe spinal and inflammatory compromise, restricted chest mobility, and impaired renal function, deemed conventional heart surgery a potentially dangerous option. However, considering the isolated AR without valvular calcification, the Heart-Team found TAVI unsuitable and instead opted for minimal aortic valve replacement (MINIAVR). This decision was based on the recognition that conventional heart surgery carried significant risks for the patient, while TAVI was not the appropriate course of action, given the specific aortic pathology.

In April 2021, MINIAVR was performed via a right mini thoracotomy, involving a 5 cm skin incision placed on the second intercostal space, without the need for rib resection and preserving the right internal thoracic artery *(Figure 2)*. Owing to the patient's cervical stiffness resulting in total spine rectification referred to as "bamboo spine", alongside the inherent inability to extend the cervical region, an awake intubation procedure was performed. Using flexible fiberoptic guidance with aScope 4 Broncho (Ambu Corp, Ballerup, Denmark), a 37 Fr double-lumen tube was advanced into the left bronchus. Once the correct placement

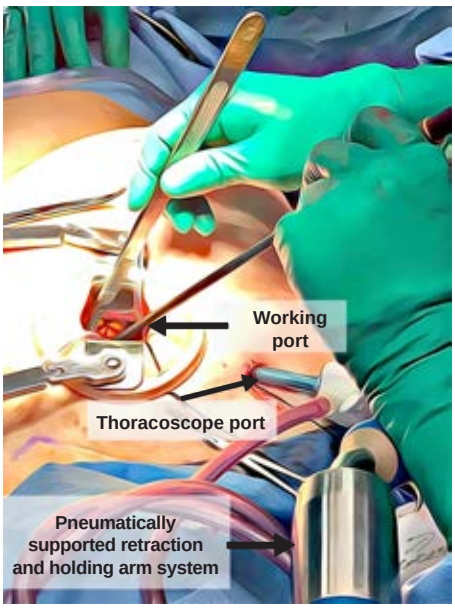

Figure 2: Surgical field perspective during minimally invasive aortic valve replacement through a right anterior thoracotomy approach. The surgeon establishes a working port via a 5 cm incision, through which the entire surgical procedure is conducted. Note the thoracoscope inserted through the second intercostal space along the midclavicular line.

of the orotracheal tube was confirmed, the anesthetic protocol was maintained.

Due to the presence of atheromatous plaque in the right external iliac artery, access to the left femoral vessels was achieved through a 1 cm inguinal incision. For femoral venous cannulation, the BioMedicus multistage cannula was used, while femoral arterial cannulation was achieved with the BioMedicus Nextgen arterial cannula (Medtronic Inc, Minneapolis, Minn). The placement of the cannula was guided by transesophageal echocardiography and fluoroscopy.

Once cardiopulmonary bypass was established using vacuum-assisted drainage (40 to 60 mmHg), a vent cannula was inserted through the right superior pulmonary vein. Throughout the entire procedure, the Aesculap EinsteinVision 3D thoracoscope was utilized (B. Braun, Melsungen, DE-HE), inserted cephalad to the working port, but through the working port itself. The patient was cooled to 36 ºC, the aorta was cross-clamped with a Chitwood aortic cross-clamp inserted through an incision in the second intercostal space, right anterior axillary line. Antegrade cardioplegic solution was administered into the aortic root, and the aortic leaflets were removed *(Figure 3)*. Subsequently, a mechanical Open Pivot aortic valve (Medtronic Inc, Minneapolis, Minn) was implanted using 2-0 polyester sutures. To secure the valve in place, an automatic knot-tying device, Cor-Knot Mini (LSI Solutions, Victor, NY), was employed *(Figure 4)*. The aortic cross clamp time was 57 minutes accompanied by 90 minutes of cardiopulmonary bypass. Due to his hemodynamic conditions and uneventful surgery, we performed ultrafast-track protocol and continue patient care process in the Intensive Care Unit (ICU). Pathology examination revealed a focal decrease in elastic fibers, fibrosis, and an increase in stromal collagen fibers. Additionally, there was a focal lymphocytic inflammatory infiltrate, primarily observed

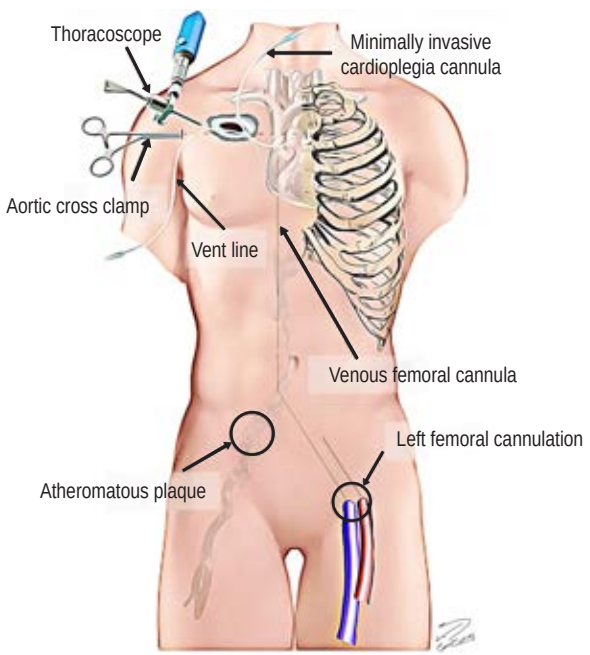

Figure 3: Operative setup for minimally invasive aortic valve replacement via right anterior thoracotomy. Thoracoscope inserted through a designated port. Aortic cross-clamp positioned through the second intercostal space along the right anterior axillary line. It is important to note left femoral cannulation employed due to the presence of iliac atheromatous disease.

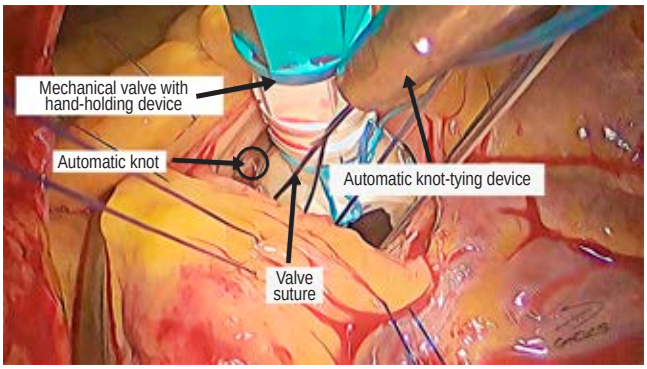

Figure 4: Thoracoscope image of intraoperative field. Mechanical aortic valve secured in place using an automatic knot-tying device.

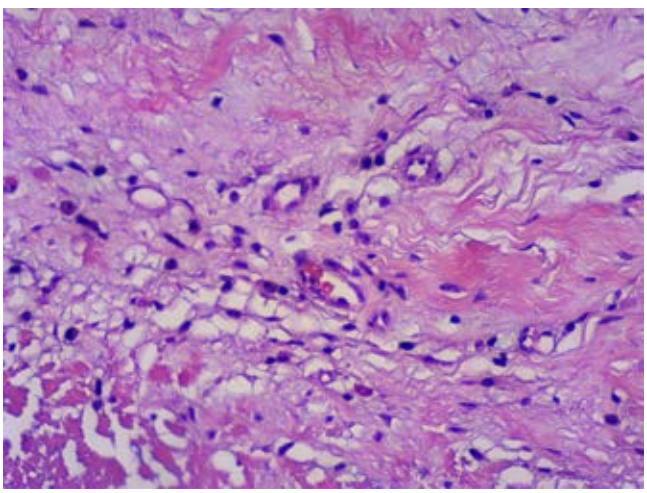

Figure 5: Aortic leaflet. Focal lymphocytic inflammatory infiltrate, primarily observed in the perivascular region.

in the peri-vascular region of the aortic leaflets *(Figure 5)*. The patient remained in the ICU for an uneventful 72-hour period; symptoms improved significantly, and he was able to be discharged home in stable condition on the sixth day following the surgery. Notably, this accomplishment marks the first instance of a minimally invasive cardiac surgery with this technique, particularly in a patient with extreme thoracic and neck deformities, reported in the state of Nuevo León up until April 2021.

COMMENT

The significance of a multidisciplinary approach, specifically the Heart-Team approach, is paramount in our medical center. We place great emphasis on conducting comprehensive reviews, thorough assessments, and providing continuous management for patients throughout the entire

diagnostic and treatment process. Integrating multiple disciplines in the pre, trans and postoperative phases is a key factor contributing to improved patient outcomes.[12]

Preoperative evaluation

Effective and consistent preoperative planning holds utmost importance as it lays the foundation for an efficient minimally invasive cardiac surgery. By proactively identifying potential complications before surgery, we can address them, promptly minimizing any hindrances to the patient's recovery. Among the specific preoperative conditions that require special attention in minimally invasive approaches are chronic lung diseases, cerebrovascular diseases, peripheral artery disease, chest wall abnormalities, lung irradiation, and previous cardiac and/or lung surgeries. Standard preoperative evaluation procedures for these cases encompass electrocardiogram, chest X-ray, complete blood laboratory tests, echocardiogram, and cardiac catheterization, resembling those conducted in full sternotomy cases. However, it is crucial to acknowledge that certain variations may exist in the preoperative investigations for standard AVR.

The role of computed tomography (CT) in the preoperative assessment of minimally invasive procedures cannot be overstated. CT scan offers valuable insights into the patient's anatomy, facilitating safer execution of the procedures.[9,11-14] Detailed information about the lungs, airway, chest wall, mediastinum, heart, major blood vessels, and peripheral vascular anatomy is made available through CT scans. Notably, CT findings related to peripheral artery disease hold particular significance. The presence of peripheral artery disease can influence the surgical approach and requires careful consideration during the planning phase.

Surgical technique

MINIAVR is performed through a right mini thoracotomy, involving a 5 cm skin incision placed on the second intercostal space, without the need of rib resection. During the procedure, utmost care is taken to preserve the right internal thoracic artery. To gain access to the femoral vessels, a 1 cm inguinal incision is made. Femoral venous and arterial cannulation is accomplished using dedicated cannula. The placement of the cannula is always guided by transesophageal echocardiography and fluoroscopy. Once cardiopulmonary bypass is established using vacuum-assisted drainage, a vent is inserted through the right superior pulmonary vein.[13-15] Throughout the entire procedure, a 3D thoracoscope is utilized, inserted cranial to the working port, but through the working port itself. The thoracoscope, also known as a thoracoscopic camera or *video*-assisted thoracoscopic surgery system, plays a crucial role in the minimal invasive aortic valve replacement technique we employ *(Figure 3)*. The role of the thoracoscope is to provide a clear and magnified view of the surgical field without the need for a large chest incision. It can be inserted through a small incision in the chest wall, between the ribs or throughout a dedicated working port, and connected to a high-definition camera or a 3D camera.[15,16] This camera displays real-time images of the surgical area on a monitor, allowing the surgeon to visualize and navigate inside the chest during the procedure. With the assistance of the thoracoscope, the surgeon can precisely access and manipulate the aortic valve and surrounding structures *(Figure 6)*. This visualization aids in accurately placing and suturing the prosthetic valve in position, ensuring proper alignment and functioning. It also helps the surgeon to identify and address any complications or challenges that may arise during the surgery. The patients are cooled to 36 ºC; subsequently, the aorta is cross-clamped with an aortic cross-clamp inserted through an incision in the second intercostal space, right anterior axillary line or through the working port with a flexible aortic clamp. Antegrade cardioplegic solution is administered into the aortic root or directly to coronary ostia *(Figure 3)*. Careful consideration is given during the aortic incision in the anterior ascending aorta to prevent extension towards the pulmonary artery. An automatic knot-tying device is always used to secure the prosthetic valve in place.

Rationale for MINIAVR

MINIAVR presents potential advantages in pulmonary function, particularly in patients with reduced respiratory reserve or poor lung function. The maintenance of sternal integrity, achieved by avoiding a full sternotomy, could prove beneficial in reducing complications associated with traditional AVR, such as prolonged recovery time and increased pain.[17]

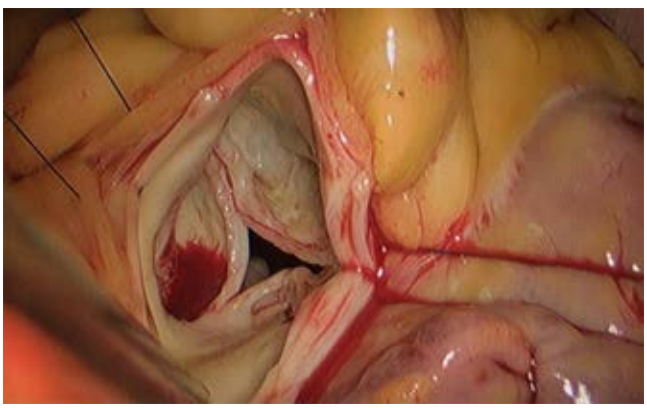

Figure 6: Thoracoscopic view of the aortic valve revealing fibrotic leaflets thickening.

Limited studies on MINIAVR in patients with poor lung function exist, but the available evidence suggests positive outcomes, demonstrating shorter ICU and hospital stays with a trend towards higher survival rates, reduced post-operative complications, implying potential benefits for lung function in this patient population. These findings highlight the potential of a minimally invasive approach in improving pulmonary outcomes for patients undergoing AVR.[17-19]

Moreover, MINIAVR has demonstrated significant benefits for patients with pre-existing renal dysfunction, a condition known to increase operative mortality and impact long-term survival in heart surgery patients. The renoprotective effect of minimally invasive surgery has been supported by evidence in mitral valve surgery.[20] Studies have reported a lower incidence of worsening on chronic kidney injury, despite longer cardiopulmonary and aortic cross clamping times, along with fewer composite complications, shorter ICU and hospital stays. Notably, minimally invasive cardiac surgery has been associated with a remarkable 60% risk reduction in the development of acute kidney injury.[21] Additionally, MINIAVR has been found to carry a lower risk of acute kidney injury compared to TAVI, further highlighting its potential to provide better outcomes and safeguard renal function in patients with renal dysfunction undergoing aortic valve procedures.[22]

While TAVI is an effective and minimally invasive procedure for treating aortic stenosis in selected patients, it should be approached with caution when considering severe pure AR due to certain concerns. In a particular study involving 43 patients with severe AR where TAVI was attempted, the overall success rate was 74.4%; of note, 18% of cases required a second valve during the index procedure.[10] Furthermore, subsequent studies were reviewed in a meta-analysis of 237 patients with severe pure AR who underwent TAVI. The results showed that the procedure success ranged from 77 to 100%. However, there was a notable 7% risk of needing to implant a second device due to prosthesis migration or severe procedural AR.[23] Considering these findings, it becomes evident that TAVI in severe pure AR presents challenges and carries a risk of requiring a second valve due to various factors, including prosthesis displacement and procedural complications. As a result, careful evaluation and consideration of alternative treatment options may be necessary for patients with this specific condition.

Despite the absence of existing publications on the advantages of MINIAVR in patients with chest wall deformities, our technique has allowed us to demonstrate its feasibility, safety, and positive outcomes. Notably, we successfully applied this approach to a patient with AnSp, a condition associated with challenging chest wall anatomy. The favorable results in this patient highlight the potential benefits of MINIAVR for individuals with chest wall deformities, shedding light on a novel and effective option in cardiac surgery for this specific patient population. It is essential to recognize that chest wall deformity is often considered a relative contraindication for MINIAVR due to potential technical challenges and increased risks associated with altered chest anatomy.[14,15,24] However, our experience with this particular patient emphasizes the importance of individualized assessment and surgical expertise in determining the suitability of MINIAVR in such cases. With careful patient selection and meticulous surgical planning, our report underscores the potential of MINIAVR as an innovative and effective approach in addressing complex patient conditions, contributing valuable insights that warrant further exploration and advancement in the field of cardiac surgery.

As a conclusion, while MINIAVR merges as a decisive and innovative approach for patients with severe isolated AR and complex conditions, this report emphasizes the importance of a multidisciplinary approach (heart team), comprehensive preoperative planning, and the use of advanced imaging techniques to ensure successful outcomes in high-risk patients. It also offers potential benefits in patients with pulmonary and renal impairment. Individualized patient assessment and surgical expertise are crucial in successful MINIAVR procedures. This case report sheds light on its feasibility and warrants further exploration to advance cardiac surgery practices.

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