



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/m² 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/m², 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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Keywords: cardiac surgery, complications, sternal closure, sternal dehiscence, sternotomy, titanium plates.

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

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.

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

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/m², 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/m²) or overweight (BMI > 25 kg/m²), 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

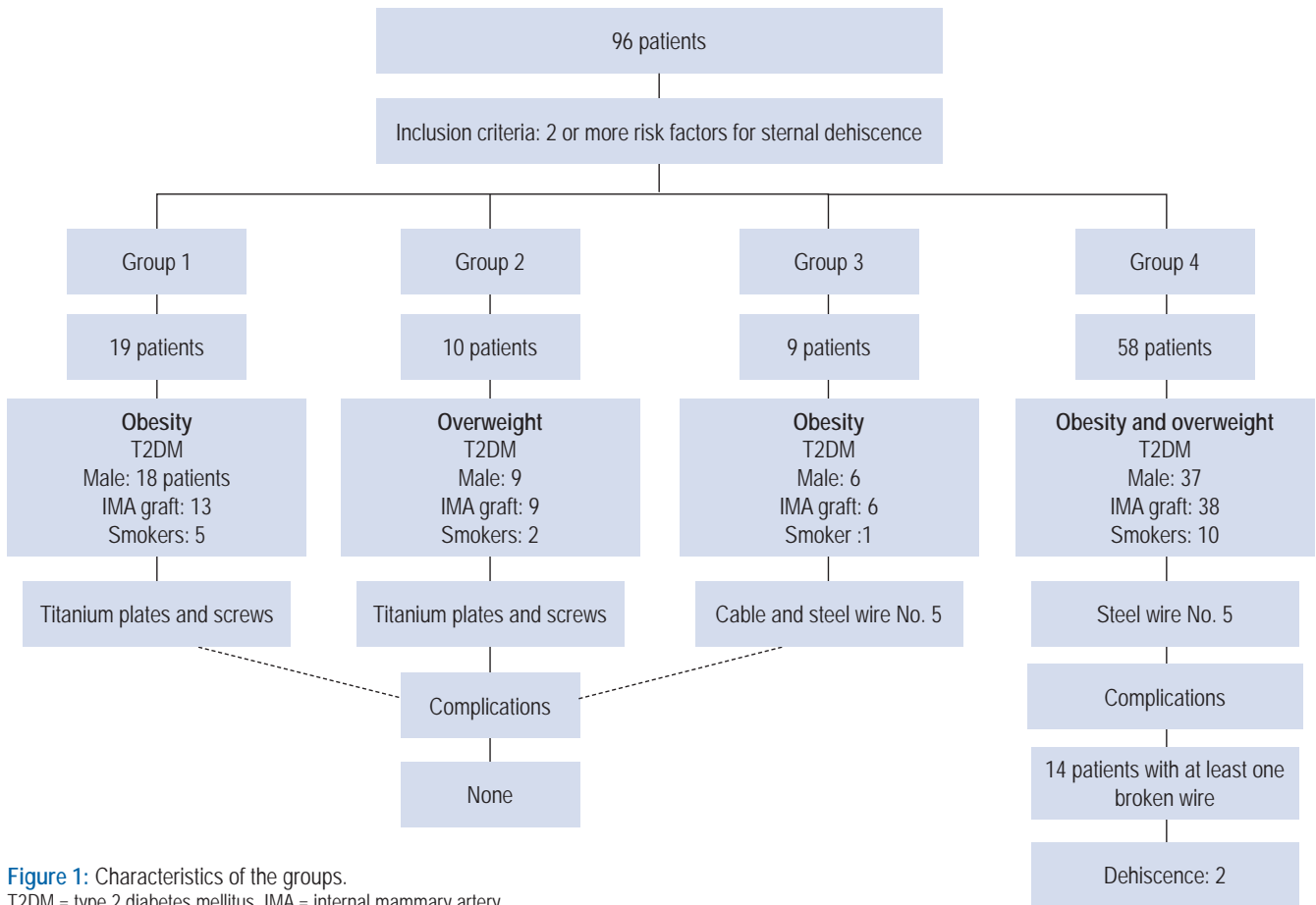


Figure 1: Characteristics of the groups.
T2DM = type 2 diabetes mellitus. IMA = internal mammary artery.

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/m², 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/m², 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/m², 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/m², with similar risk factors for sternal dehiscence, but their sternal closure was done with the traditional technique and steel wires.

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).



Figure 2:
Titanium cable system.

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.

Group	Follow up		
	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.

Type of surgery	Number of patients with complications n (%)				
	1st month		3rd month		Total of patients n (%)
	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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