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Comparative study between aortic valve replacement through full sternotomy versus mini-sternotomy

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Abstract

Background: The superiority of minimally invasive aortic valve replacement (AVR) over the standard approach is the subject of ongoing research. The aim of this study was to compare the outcomes of AVR through full sternotomy versus mini-sternotomy.

Methods: We included 60 patients who had AVR; 30 patients underwent AVR through J- or T-shaped mini-sternotomy, and 30 patients had a full sternotomy. We included patients who had isolated AVR and excluded patients who had a concomitant cardiac procedure, redo surgery, or those who needed annular dilatation. All patients had aortic and right atrial cannulation for cardiopulmonary bypass. Study endpoints were operative times, postoperative complications and duration of ICU and hospital stays.

Results: There were no differences between the two groups preoperatively. Cardiopulmonary bypass time was longer in the mini-sternotomy group (median: 100 (range: 65- 170) vs. 85 (55-160) min, respectively; p= 0.024). Operative time was non-significantly longer in the mini-sternotomy group 5 (4-6) hours vs. 4.5 (4-6) hours in the full sternotomy group (p=0.62). Ventilation time was 10 (4- 50) hours in the mini-sternotomy group vs. 14 (8- 45) hours in the full sternotomy group (p<0.001). ICU stay was shorter in the mini-sternotomy group (2 (1-6.5) vs. 2.5 (1-7) days, respectively, p= 0.014). The total mediastinal drainage was 100 (50 400) ml in the mini-sternotomy group vs. 275 (50- 1000) ml in the full sternotomy group (p= <0.001). There was no difference in wound infection (p= 0.35), tamponade (p>0.99), and hemothorax (p>0.99) between both groups.

Conclusion: Mini-sternotomy AVR had longer cardiopulmonary bypass times; however, there were no differences in the postoperative complications compared to the full sternotomy approach. Mini-sternotomy could be a safe alternative approach to the full median sternotomy for aortic valve replacement.

KEYWORDS
Mini-sternotomy; Aortic valve replacement; Full sternotomy

Introduction

The standard approach of aortic valve replacement (AVR) is through a full median sternotomy. However, its length, possible complications like instability and wound infection, and postoperative pain are the main disadvantages of this approach [1]. Minimally invasive AVR is an alternative approach to the standard sternotomy. There was evolutionary progress in instruments, assisted vision, and

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cardiopulmonary bypass that supported this surgical development [2].

Open heart surgery became more complex and sophisticated due to the intentional trend towards minimally invasive approaches, and this needs more surgical abilities and experiences to be able to have the same quality and results of the traditional techniques [3]. In experienced centers, AVR with minimally invasive techniques became a well-tolerated and efficient technique, allowing better patient satisfaction and fewer complication rates. Advantages of minimally invasive aortic valve surgery technique arise from the concept that patient morbidity and potential mortality could be reduced without affecting the excellent results of the conventional technique. Additionally, the technique has better cosmoses, safer access in the case of redo operations, less postoperative bleeding, and could reduce the intensive care unit and hospital stay [4].

Minimally invasive approaches have a steeper learning curve compared to conventional incisions. However, experienced surgeons consider mini-sternotomy AVR the routine approach for isolated aortic valve surgery to overcome the conceptual "learning curve" [5].

The superiority of minimally invasive aortic valve replacement (AVR) over the standard approach is the subject of ongoing research. The aim of this study was to compare the outcomes of AVR through full sternotomy versus mini-sternotomy.

Patients and Methods:

Our study was carried out on 60 patients who had AVR from June 2017 to January 2020. The Institutional Ethical Committee approved the study, and patients' consent was obtained. All operations were performed by consultant surgeons. Thirty patients underwent AVR through a full sternotomy, and 30 patients had mini-sternotomy. Patient selection was depending on surgeon preference and was not related to patients' specific risk factors, so we have high-risk patients in both groups. All patients who were candidates for isolated AVR were included in the study with the exclusion of patients with combined valve surgery, redo surgery, chest or vertebral wall deformities, small aortic annulus needing annular dilatation.

All patients fulfilling inclusion criteria had preoperative preparation on elective bases. We obtained detailed history, full preoperative laboratory studies, and echocardiographic evaluation.

Surgical technique

The anesthetic techniques were the same for both groups. Monitoring was done using three leads ECG, and after full muscle relaxation, the trachea was intubated orally with an appropriately sized endotracheal tube. After induction, a triple lumen central venous catheter plus a single lumen were inserted into the right internal jugular vein. A urethral catheter was inserted. Transesophageal echocardiography (TEE) was inserted in all patients.

In the mini-sternotomy group, skin incision started at the angle of Luis down to the level of the 4th intercostal space (ICS). The sternal saw was engaged in the upper manubrium, going caudally at the level of right 4th ICS (J Sternotomy) or right and left 4th ICS (inverted T Sternotomy). The pericardium was opened after dissecting the thymus gland and identifying the left innominate vein. The ascending aorta, right atrium were cannulated. An aortic root cannula was inserted for cardioplegia administration and de-airing.
Myocardial protection was achieved with systemic hypothermia (28-32 °C), and antegrade cardioplegia (15-20 ml/Kg as an initial dose followed by 2-10ml/kg every 20-30 minutes).

In the full sternotomy group, the sternal notch and the tip of the xiphoid process were identified by palpation. The incision was begun approximately 2 cm below the sternal notch and extended approximately 2 cm beyond the distal tip of the xiphoid process and extended with electrocautery down to the sternal periosteum. The linea Alba was divided at the xiphoid, and a plane was created behind the sternum using blunt finger dissection above the suprasternal ligament. Other operative steps were similar in both groups.

Outcomes

The following data were recorded; total operative time, aortic cross-clamp, cardiopulmonary bypass time, type and size of the implanted aortic valve, need for DC shock. Postoperative data included hours of mechanical ventilation, postoperative blood loss, and need for re-exploration, and length of ICU stay. Length of hospital stay, sternal wound infection, and pleural collection were compared between both groups. Postoperative pain was evaluated using a 10-point numeric rating scale [6].

Statistical analysis:

Data were collected and analyzed using the statistical package of social science (SPSS) v21 (IBM Corp, Armonk, NY, USA). Student's "t" test was used for quantitative data analysis, while qualitative data (ordinal, categorical) were analyzed using the chi-square test (x2) or Fisher's Exact Test. Continuous data were presented as median and range and categorical variables as number and percentages. For all statistical comparisons, a P-value of <0.05 was considered significant.

Results

Preoperative data

No statistical differences were found between the two groups as regards demographic and preoperative data. In the mini-sternotomy group, there were 15 males (50%) vs. 22 males (73.7%) in the sternotomy group (p= 0.11). As regards NYHA classification, in the mini-sternotomy group, 16 (53.3 %) patients were in class II, 14 (46.7%) were in class III. While in the sternotomy group, 15 patients (50%) were in class II, 15 patients (50%) were in class III.

No significant differences were found between the studied groups regarding preoperative echocardiography findings. Meanwhile, the percentage of heavy aortic calcification in the mini-sternotomy group was 46.7% and 50% in the sternotomy group. The number of patients with severe aortic regurgitation in the mini-sternotomy group was 15 (50%) and 14 in the sternotomy group (46.67%). (Table 1).

Operative data

The length of the incision in the mini-sternotomy group was 7.96 ± 1.45 cm, while in the full sternotomy group was 22.46 ± 1.6 cm (P-value < 0.01).

In our study, we had seven patients with an inverted T incision and 23 patients with J incision in the mini-sternotomy group. There were no statistically significant differences between the two groups regarding the cross-clamp time. Meanwhile, there was a significant difference regarding the total cardiopulmonary bypass (CPB) time, which was shorter in the full sternotomy group. (Table 2).

The number of patients who received DC shock was 17 in the mini-sternotomy group vs. 20 in the full sternotomy group (p-value 0.43).

Table 1: Demographic and preoperative clinical classification and preoperative echocardiography findings. (Continuous data were presented as median and range and categorical data as number and percentage)

	Mini-sternotomy (n= 30)	Sternotomy (n= 30)	p-value
Age (years)	45 (18 - 83)	46.5 (21 - 69)	0.900
BSA (m2)	1.9 (1.3 - 2.3)	1.9 (1.5 - 2.4)	0.912
Euro Score	2.08 (1.5 - 17.98)	2.02 (1.5 - 4.4)	0.445
Ejection fraction (%)	60 (45 - 75)	62 (31 - 74)	0.553
Left ventricle end-systolic diameter (cm)	3.7 (2.6 - 5.3)	4.1 (2.3 - 6.1)	0.524
Left ventricle end-diastolic diameter (cm)	5.5 (3.4 - 6.9)	5.9 (2.8 - 4.5)	0.475
Aortic root diameter (cm)	3.1 (2.5 - 3.8)	3.3 (2.5 - 3.9)	0.167
Annular diameter (cm)	2.3 (2.1 - 3)	2.5 (1.9 - 3.2)	0.103
Mean aortic valve gradient (mmHg)	32 (12 - 60)	23 (5 - 66)	0.135
Peak aortic valve gradient (mmHg)	51.5 (12 - 62)	40.5 (13 - 97)	0.351

Table 2: Intra-operative and postoperative data. (Continuous data were presented as median and range and categorical data as number and percentage)

	Mini-sternotomy (n= 30)	Sternotomy (n= 30)	P-value
Operative time (hour)	5 (4- 6)	4.5 (4- 6)	0.615
Cross-clamp time (min)	70 (40- 107)	60 (33- 110)	0.208
Cardiopulmonary bypass time (min)	100 (65- 170)	85 (55- 160)	0.024
Ventilation (hour)	10 (4- 50)	14 (8- 45)	<0.001
ICU (day)	2 (1-6.5)	2.5 (1- 7)	0.014
Pain score	3.5 (1- 6)	4 (1- 8)	0.023
Length of hospital stay (days)	7 (5- 12)	9 (6- 24)	<0.001
Postoperative ejection fraction (%)	55.5 (35- 78)	62 (37- 74)	0.186
Aortic valve gradient (mmHg)	16.5 (10- 32)	15 (7- 28)	0.065
Total Mediastinal blood drain (ml)	100 (50 400)	275 (50- 1000)	<0.001
Operative blood transfusion (units)	0 (0- 2)	1 (0- 3)	0.005
Postoperative blood transfusion (units)	0 (0- 3)	1 (0- 4)	0.012
Wound infection	1 (33.3%)	4 (13.8%)	0.35
Tamponade	2 (6.7%)	2 (6.7%)	>0.99
Liver and kidney dysfunction	0	1 (3.3%)	>0.99
Hemothorax	0	1 (3.3%)	>0.99

Aortic valve prosthesis size ranged from 19-25 mm. In the mini-sternotomy group, 36.7% of the patients had a valve size of 21 and 43.3% of the sternotomy group, and 36.7% of the mini-sternotomy group had valve size 23 and 53.3% in the sternotomy group (P-value= 0.07).

Postoperative data

None of the patients extubated intra-operatively. The median ventilatory time for the mini-sternotomy group was 10 hours, and 14 hours in the full sternotomy group. In the mini-sternotomy group, the pain score in the first postoperative day was 4± 0.62, while in the full sternotomy group was 5.1 ± 0.8 (P-value= 0.023).

The echocardiographic assessment showed that the EF in the mini-sternotomy group was 55%, while it was 62% in the sternotomy group. There was no paravalvular leak in all patients. In the mini-sternotomy group, total blood drainage ranged from 50-400 ml, with a median of 100 ml. In the sternotomy group, the blood loss ranged from 50-1000ml, with a median of 275 ml. (Table 2)

Two patients (6.67 %) in the mini-sternotomy group had exploration for bleeding, and one patient (3.3%) had superficial wound infection and treated with antibiotics and frequent dressing. In the full sternotomy group, two patients (6.9%) had exploration for bleeding, and four patients (13.8 %) had superficial wound infection and treated with antibiotics and frequent dressing. One patient (3.4%) developed left pleural effusion treated with left intercostal tube drainage. One patient had elevated liver and kidney enzymes and resolved with medical treatment. (Table 2).

Discussion

The advantages of mini-sternotomy include lower surgical trauma, less postoperative bleeding, less wound infection, and less pain with better patients' recovery and long-term outcomes, especially in elderly and redo patients [7]. Mikus and colleagues [8] reported that mini-sternotomy was as safe as the full sternotomy technique as regard mortality and morbidity rates. It was proved that less length of incision, less tissue dissection, and no interference with the diaphragm would improve the outcomes, especially respiratory function [9].

In our study, our patients were younger than the other studies. Neely and coworkers [10] had a mean age of 65.9 ± 14.9 years, and Lehmann and associates [11] reported a mean age of 50 years. The younger age in our series was attributed to the rheumatic fever, which is endemic in Egypt as most developing countries.

The mini-sternotomy group had longer bypass time than the full sternotomy group secondary to time-consumed in de-airing and for insertion of the mediastinal drain and pacemaker wire. However, the total operative time was not different between the two groups. This can be explained by the less time required for hemostasis in the mini-sternotomy group. Additionally, this less invasive technique requires experience to operate in the small operative field.

Other studies [12] showed that the CPB time in the mini-sternotomy group was 106.2 ± 27 minutes and 75.5±19.8 minutes in full sternotomy group. Neely and colleagues [10] found that CPB time in the mini-sternotomy group was 120 ± 30 minutes and 79 ± 12 minutes, in the sternotomy group.

Patients undergoing AVR through mini-sternotomy have better postoperative course as they had significantly less amount of total mediastinal drainage, blood transfusion, and less time of mechanical ventilation and ICU stay and less postoperative pain score and less length of hospital stay, and better cosmetic and wound satisfaction. [4,8,10,12-16]

Neely and colleagues [10], Gilmanov and coworkers [4] reported that during entry, it is accessible to stop bleeding from the minimally invasive incision. Still, sternal bleeding from a full sternotomy continues all through the operation even continues to bleed after reapproximating the sternum. The percentage of re-exploration for bleeding was the same in both groups (6.67%). Merwe and coworkers [12] reported that the percentage of re-exploration after mini-sternotomy was 6.8 %, which is close to our results.

Regarding the pleural collection, two months postoperatively, two patients (6.6%) developed this complication in both groups, which respond to diuretics. Other studies [12] showed that 10% of their patients developed postoperative pleural effusion that required drainage.

Limitations:

The main limitations of the study were the small number of patients and the short-term follow-up period. Additionally, this was a single-center experience, and generalization of the results may not be feasible.

Conclusion

Mini-sternotomy AVR had longer cardiopulmonary bypass times; however, there were no differences in the postoperative complications compared to the full sternotomy approach. Mini-sternotomy could be a safe alternative approach to the full median sternotomy for aortic valve replacement.

Conflict of interest: Authors declare no conflict of interest.

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