RESEARCH ARTICLE

# Mini-sternotomy versus conventional sternotomy in aortic valve replacement surgery; A comparative study

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## Abstract

**Objectives:** To assess safety; efficacy and efficiency of mini-sternotomy in aortic valve replacement in comparison to conventional sternotomy on short term follow up.

**Methods**: This comparative study between 45 patients having aortic valve replacement via full sternotomy versus 45 others planned for upper j-shaped mini-sternotomy, was conducted from May 2019 to February 2022 in Kafrelsheikh university hospital, Egypt. Data was collected and statistically analysed to assess outcomes.

**Results:** Mini-Sternotomy approach was compared to conventional approach on the aspects of cardio pulmonary by-pass (CPB) ($p$=0.153) and cross clamp (CC) time ($p$=0.673),. There was significantly less postoperative bleeding ($p$<0.001), rate of blood transfusion ($p$<0.001), duration of ICU stay ($p$=0.013) and total hospital stay ($p$=0.022) in mini-sternotomy approach in comparison to conventional sternotomy.

**Conclusion**: For primary isolated AVR, less invasive techniques are a realistic, practical, and good alternative that offers better postoperative results than Full Sternotomy.

**Keywords:** Aortic valve, sternotomy, Blood Transfusion, Pain, Intensive Care Units **DOI: 10.47391/JPMA.EGY-S4-13**

## Introduction

Aortic valve replacement (AVR) is one of the most common cardiac surgical procedures performed worldwide.[1] This is performed when indicated as seen in aortic valve stenosis (AVS) or aortic valve regurgitation (AVR), infective endocarditis or bicuspid aortic valve. Surgical approach used is either by the conventional method or minimally invasive technique.[2]

Conventional approach is through full sternotomy, as the sternum being completely opened from suprasternal notch down to xiphoid, Cardiopulmonary bypass is achieved by inserting cannulas into both the right atrium and the ascending aorta during the surgery. The heart is stopped and a new valve is put in place of the old one.[1]

Minimally invasive aortic valve replacement (MIAVR) was first described by Cosgrove and Sabik in 1996.[3] Since then, minimally invasive techniques for AVR have increasingly gained acceptance in the surgical realm, to achieve equivalent or superior outcomes compared with conventional AVR (CAVR). Encouraging institutional reports of surgical efficacy, reduced trauma, shorter hospitalisation, and improved cosmoses have propelled the expansion of MIAVR in recent years. Manubrium-limited ministernotomy is a novel procedure that allows access to perform the AVR by removing just the top quarter of the sternum, from the sternal notch to 1 cm below the manubrio-sternal junction. The cardiothoracic surgical community prefers this type of surgery, but they suggest that randomized controlled studies should be conducted before acceptance of the approach.[4,5] .Several randomized controlled trials (RCTs) have assessed the efficacy and risks of MIAVR compared with CAVR.[6-8]

However, the small sample sizes and insufficient reporting of postoperative outcomes have left these studies underpowered. Previous studies have demonstrated similar rates of mortality and morbidity for MIAVR and CAVR, but the available evidence for the outcomes was inadequate, thus limiting its applicability to clinical decision making.[8]

This study aimed to assess safety, efficacy and efficiency of mini-sternotomy in aortic valve replacement in comparison to conventional sternotomy on short term follow up.

## Patients and methods

This study was approved by Ethical committee of faculty of medicine Kafrelshikh University, Egypt with code: MKSU 50-6-6. The study was based on the pump times which required 95±20 minutes and 83±19 minutes within mini-sternotomy and conventional sternotomy respectively.[9] The patients were distributed as 1:1 in the two groups. The sample size was calculated using openEpi[10] software with power of study 80% and confidence level 95% in each group which amounted to 42 in each group. Another 20% were added to the calculated sample to cover the potential dropout. Each group thus included 46 patients. One patient

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within each group did not complete the study. The data of 90 (45 in each group) patients of both genders, aged > 18 years presenting to the outpatient clinic of cardiothoracic surgery department at Kafrelsheikh University Hospital, Egypt, having AVR was collected. The two groups had a different surgical approach, either via upper mini-sternotomy (GROUP I) or conventional sternotomy (GROUP II). The study period was from May, 2019 to February, 2022.

Patients were asked for written informed consent to be eligible for the study. The inclusion criteria were all patients diagnosed to have isolated aortic valve cardiac disease either severe regurgitation or stenosis, requiring, non-emergent surgical replacement for the first time.

Exclusion criteria were infective endocarditis, the porcelain aorta, a very short or extremely long ascending aorta, low ejection fraction, or small aortic root for patch augmentation.

Routine preoperative assessment and preparation either laboratory or radiological was done. Coronary angiography was performed in patients with history of chest pain especially those with aortic valve stenosis or age more than 40 years.

All patients were operated under General anaesthesia with invasive blood pressure monitoring using arterial cannula mainly in radial artery, central venous catheter insertion, positioned in flat supine position and properly covered with sterile sheets only exposing clean, disinfected anterior chest wall down to level below xiphoid.

J-shaped mini-sternotomy technique was used for Group I: Skin incision was made two-finger breadth below the Jugulum till 3$^{rd}$ costal cartilage at mid-line. Using sternal saw, sternotomy was performed from midline starting at suprasternal notch down through the manubrium and the body till 2$^{nd}$ intercostal space then curving the line of cleavage towards right 3$^{rd}$ costal cartilage. This made the J-shaped sternal cleavage line.

Aortic cannulation was done through the ascending aorta whereas venous cannulation was through the right atrium. Ante-grade cardioplegia was used for myocardial protection by ready-made cardioplegia with 20 ml/kg and venting it via pulmonary artery.

Using interrupted pledged braided sutures and a transverse aortotomy, the aortic valve was inserted as per usual procedure. Depending on the technique, the aortotomy was closed with either single- or double-layered sutures.

With the minimally invasive approach, conventional mobilisation of the heart was not feasible, thus paediatric paddles were administered to the epicardium if necessary.

To overcome the difficulty of retrosternal tube insertion through a narrow field, tube insertion was done during reperfusion time as the heart was still empty. Chest wall opening for the tube could be used also for administration of pacemaker wires when needed.

The sternum was closed with two wires in the manubrium and two wires from the body of the sternum up to the manubrium.

Full-sternotomy technique for Group II: standard median cleavage of sternum was performed. Cannulation was done via the ascending aorta with two-stage right atrial cannulation for venous drainage. Same venting and cardioplegia was used in group I. All valves were inserted using interrupted sutures.

All patients were assessed intra-operatively for time of the entire surgery, total bypass time, cross clamp time, need for blood transfusion and if conversion of mini-sternotomy to full sternotomy was needed.

Patients of the two groups were compared postoperatively for amount of bleeding and need for reopening, time of mechanical ventilation, duration of ICU stay, postoperative mortality, superficial and deep wound infection and frequency of sternal dehiscence.

**Statistical analysis:** A report form was filled to capture the clinical data. SPSS version 20 was used to compile and analyze the data in order to acquire the results:

The following descriptive statistics were computed for the provided data: For quantitative data, the mean and standard deviation, qualitative data frequency and distribution were used. To determine a statistically significant difference across the several groups, Students-T test was applied. The mean of two sets of quantitative data was compared using this formula. The chi square test (X2-value) and the Fishers Exact test were used to compare categorical data across groups (FET).Correlation coefficient was applied: to find the relationship between variables. A $p$ value <0.05 was considered statistically significant (*).

## Results

A total of 45 patients in each group of mini-sternotomy and conventional sternotomy approaches were included. The males were 35 (77.8%) and 34 (75.6%) in the two groups respectively. Females were 10 (22.2%) and 11 (24.4%) in the two groups respectively (p=0.803). The mean age was not significantly higher among those within conventional sternotomy approach 42.53 ± 11.82 years compared to mini-sternotomy 41.4 ± 12.83 years (p= 0.666) Prosthetic size was comparable in both groups (21.6 ± 1.8mm vs 21.5 ± 1.5mm, p=0.881) Table (1).

Cross-clamping time was 76.24 ± 8.65 min, 75.38 ± 10.63 min and CPB 100.51 ± 12.33 min, 96.64 ± 13.12min in mini-sternotomy group and conventional group, respectivel. There was no significant different *p*<0.673, *p*< 0.153 respectively, Operative time was comparable between mini-sternotomy and conventional group 203.16±25.62 min vs 196.33 ± 27.86 min. respectively (*p* = 0.115) Table-1.

Two of 45 (4.4%) patients planned for mini-sternotomy, were converted to conventional approach due to lack of vision in one patient, and bleeding in the other.

There was a statistically significant difference between mini-sternotomy and conventional groups regarding post-operative bleeding, 349.31±74.83ml, 481.76±120.04 ml (*p*<0.001) Table (1), and amount of blood transfusion as two units of packed RBCs were used in 1(2.2%), 7(15.6%), and one unit in 11(24.4%), and 21(46.7%) in mini-sternotomy and conventional groups respectively. (*p*<0.001) (Figure 1).

Mini-sternotomy patients had significantly shorter ICU stay 3.07 ±0.45 days and total hospital stay 7.09 ± 0.4 days when compared to conventional group that were 3.49 ± 1.01 days and 7.53 ±1.2 days, (*p*=0.013) & (*p*=0.022) respectively.

Intubation time was two hours in 3(6.7%) and 2(4.4%),

**Table-1:** Comparision between the studied groups regarding demographic data and operative data:

| Parameter | Groups Mini-Sternotomy approach N=45 (%) | Conventional approach Sternotomy N=45 (%) | Test χ2/t | *p-value* |
|---|---|---|---|---|
| **Gender:** | | | | |
| **Male** | 35/45 (77.8%) | 34/45 (75.6%) | 0.062 | 0.803 |
| **Female** | 10/45 (22.2%) | 11/45 (24.4%) | | |
| **Mean Age (year)** | 41.4 ± 12.83 | 42.53 ± 11.82 | -0.436 | 0.666 |
| **Valve ring size (mm):** | 21.53 ± 1.570 | 21.60 ± 1.850 | 0.151 | 0.881 |
| **Mean Operative time (min.)** | 203.16 ± 25.62 | 196.33 ± 27.86 | 1.209 | 0.115 |
| Range | 160 – 240 | 160 – 240 | | |
| **Mean CPB time (min.)** | 100.51 ± 12.33 | 96.64 ± 13.12 | 1.441 | 0.153 |
| Range | 79 – 123 | 75 – 115 | | |
| **Mean Cross clamp time (min.)** | 76.24 ± 8.65 | 75.38 ± 10.63 | 0.424 | 0.673 |
| Range | 60 – 92 | 60 – 91 | | |
| **Mean Blood loss (ml)** | 349.31 ± 74.83 | 481.76 ± 120.04 | -6.281 | <0.001** |
| Range | 170 – 550 | 280 – 800 | | |

**$\chi^2$ Chi square test t independent sample t test**

**Table-2:** Comparison between the studied groups regarding hospital stay and complications

| Parameter | Groups Mini-Sternotomy approach N=45 (%) | Conventional approach Sternotomy N=45 (%) | Test χ2/t | *p-value* |
|---|---|---|---|---|
| Mean ICU stay (day) | 3.07 ± 0.45 | 3.49 ± 1.01 | -2.556 | 0.013* |
| **Range** | **2 - 4** | **2 - 6** | | |
| Mean LOS (day) | 7.09 ± 0.4 | 7.53 ± 1.2 | -2.35 | 0.022* |
| **Range** | **6 - 8** | **6 - 9** | | |
| Duration of MV: | | | | |
| 2 hours | 3/45 (6.7%) | 2/45 (4.4%) | 1,198 | 0.274 |
| 3 hours | 1/45 (2.2%) | 7/45 (15.6%) | | |
| 3 – 4 hours | 41/45 (91.1%) | 26/45 (57.8%) | | |
| 4 hours | 0/45 (0%) | 9/45 (20%) | | |
| 5 hours | 0/45 (0%) | 1/45 (2.2%) | | |
| Wound infection | | | | |
| No | 44/45 (97.8%) | 43/45 (95.6%) | Fisher | >0.999 |
| Yes | 1/45 (2.2%) | 2/45 (4.4%) | | |
| Sternal dehiscence: | | | | |
| No | 45/45 (100%) | 44/45 (97.8%) | Fisher | >0.999 |
| Yes | 0/45 (0%) | 1/45 (2.2%) | | |
| Reopening (bleeding) | | | | |
| No | 43/45 (95.6%) | 42/45 (93.3%) | Fisher | >0.999 |
| Yes | 2/45 (4.4%) | 3/45 (6.7%) | | |
| Mortality: | | | | |
| No | 45/45 (100%) | 45/45 (100%) | Fisher | >0.999 |

**t independent sample t test χ2Chi square for trend test **p≤0.001 is statistically highly significant**

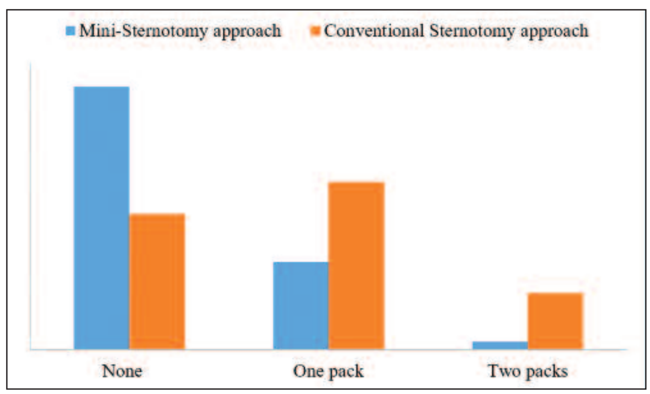


**Figure 1:** Simple bar chart showing comparison between the studied groups regarding amount of blood transfusion needed (p<0.001)

three hours in 1(2.2%), and 7(15.6), three to four hours in 41 (91.1%) and 26 (57.8%), four hours in 0(0%) and 9(20%) and five hours in 05(0%) and 1(2.2%) in mini-sternotomy and conventional groups respectively. (*p*=0.274) Table-2.

There was statistically no-significant difference between mini-sternotomy and conventional groups regarding occurrence of wound infection in 1(2.2%), 2(4.4%)

($p>0.999$) respectively, sternal dehiscence 0(0%), 1(2.2%) ($p>0.999$) respectively, reopening due to bleeding was encountered in 2(4.4%) and 3(6.7%) ($p>0.999$) respectively. There was no mortality in either group. Table 2.

## Discussion

According to our findings, the CPB and CC times were not statistically different between groups I and II ($p=0.153$ and 0.673, respectively) in our research. These results are in accordance with Kirmani et al.[11] The CPB and CC times of the two groups varied significantly in studies by Dogan et al.[6] and Semsroth et al.[12] Other studies, on the other hand, report that patients who had mini-sternotomy had lower CPB and CC times.[13]

There were two of 45 (4.4%) cases in which the procedure had to be changed to a complete sternotomy, one of them was due to bleeding from an unknown source. The second patient had to be converted because the aortic root and right atrial appendage were difficult to approach. Compared to previous research (ranging from 0% to 4%), this conversion rate from mini to full sternotomy was rather high (e.g. 0.3%).in Lehmann et al.[14] and 2.5% in Neely et al.[13]

Due to the steep learning curve and technical demands, this approach requires a longer period of time and more experience to reach perfection.

Implant size did not change significantly between the two groups, however Mazine et al. suggest that it might influence the duration of the CPB and CC.[15]

From the time of admission in the ICU until the time of extubation, the duration of mechanical ventilation was calculated. This research found that postoperative mechanical breathing in (group I) patients was not statistically shorter than in the traditional group. This compares with the findings of other researchers, such as Kirmani et al.[11] Those who believe that a smaller incision contributes to better respiratory movement by retaining the integrity of the thoracic cage believe that the MV time after mini-sternotomy is much shorter than after a large sternotomy.[13, 14, 16]

In this study, Mini-sternotomy patients stayed in the ICU for a shorter period of time. ICU stays were found to be longer than previously thought, according to a number of published research papers.[13, 17] According to our findings, this might be related to reduced ventilation time and early ambulation and release from the ICU to the ward. When compared to a previous research, there were no significant differences in ICU length of stay in either group.[16]

Group I was found to have a significantly reduced length of stay in the hospital. As more research shows similar results, this becomes relevant.[17] In Mini-sternotomy patients' the postoperative hospital stays were somewhat shorter, but the difference was not statistically significant.[11, 16]

In group I, two patients (4.4 percent) encountered bleeding, whereas in group II, 3(6.7%) patients experienced postoperative haemorrhage, which lead to the conclusion that there was no significant difference between the two groups. Re-operation for bleeding has been studied by almost all researchers.[13, 13, 17, 18]

Careful haemostasis and correct placement of the drain in both procedures contribute to less reoperation for bleeding. The heart is still on bypass, allowing the surgeons to properly position the drain in mini-sternotomy group and ensure appropriate drainage.

Patients with mini-sternotomy were found to have no need for sternal re-suturing compared to the conventionsl group, which had one patient (2.2 percent). Harky et al. could improve on this study's non-significant findings.[17] This is attributed to the surgeons ability and experience for closing the patients in both groups.

In both groups, no deaths were reported. Other studies have reported similar results[10, 12, 13] which reported no change in postoperative mortality, which could be most likely due to the study's small sample size.

According to another research, mini-sternotomy method considerably reduces postoperative mortality (0% mortality in mini-sternotomy group and 4.8 % mortality in full sternotomy group) ($p<0.001$) in a greater number of patients.[19]

## Conclusion

For primary isolated AVR, less invasive techniques are a viable, practical, and repeatable alternative that give better postoperative results than full sternotomy, even if artistic considerations are not taken into account.

**Disclaimer:** The abstract has not been previously presented or published in a conference, also the manuscript was not part of a research, PhD or thesis project.

**Conflict of interest:** No conflicts of interest

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