COMPARISON OF EARLY OUTCOME OF AORTIC VALVE REPLACEMENT BETWEEN MINIMALLY INVASIVE CARDIAC SURGERY AND STANDARD MEDIAN STERNOTOMY

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KEYWORDS

Minimally invasive cardiac surgery, aortic valve replacement, sternotomy, postoperative outcomes

ABSTRACT:

Background: Minimally invasive cardiac surgery (MICS) for aortic valve replacement (AVR) has gained attention due to its potential advantages over conventional sternotomy, including reduced surgical trauma, faster recovery, and lower complication rates. This study aimed to compare early postoperative outcomes between MICS and sternotomy in a Bangladeshi population. Methods: This comparative prospective cohort study included 30 patients who underwent AVR, with 15 undergoing MICS and 15 undergoing sternotomy at BSMMU, Dhaka, Bangladesh. Baseline characteristics, operative parameters, and early postoperative outcomes were analyzed. Statistical comparisons were performed using appropriate tests, with $p < 0.05$ considered significant. Results: Baseline characteristics were comparable between groups. MICS had longer operative (180.5 ± 25.3 vs. 160.2 ± 20.1 min, $p = 0.04$) and cardiopulmonary bypass times (95.1 ± 14.6 vs. 85.7 ± 12.8 min, $p = 0.05$). However, MICS was associated with shorter ventilation time (6.2 ± 2.4 vs. 10.5 ± 3.1 hours, $p = 0.02$), ICU stay (48.3 ± 10.7 vs. 72.1 ± 15.2 hours, $p = 0.01$), and hospital stay (6.4 ± 1.2 vs. 10.2 ± 1.5 days, $p < 0.001$). MICS patients had lower chest tube drainage (300 ± 85 vs. 450 ± 120 ml, $p = 0.003$), transfusion rates (20% vs. 53.3%, $p = 0.04$), and postoperative pain scores (3.1 ± 1.0 vs. 5.2 ± 1.3, $p < 0.001$). Complication rates, including mortality, bleeding, atrial fibrillation, and acute kidney injury, were similar. Conclusion: MICS for AVR demonstrated superior early recovery outcomes compared to sternotomy, with shorter hospital stays, reduced pain, and lower blood loss, without increasing major complications. These findings support the broader adoption of MICS in appropriate patients.

INTRODUCTION

Aortic valve replacement (AVR) is the common treatment in those with severe aortic valve disease, both aortic stenosis and regurgitation [1]. The operation has traditionally been performed through a full median sternotomy, which is extremely good for the exposure of the surgical field. The technique, however, does involve significant operative trauma, protracted recovery, and potential complications like infection of the wound, excessive bleeding, and sternal instability [2]. In the past few years, minimally invasive cardiac surgery (MICS) techniques have evolved as acceptable alternatives, with an aim towards minimizing surgical trauma without compromising on the safety and efficacy of conventional methods [3].

Minimally invasive aortic valve replacement (MIAVR) can be achieved by several techniques, including right anterior thoracotomy, partial sternotomy, and other limited access [4]. Of these, right anterolateral mini-thoracotomy has become more popular because of its perceived advantages, such as less blood loss, shorter in-hospital stay, quicker recovery, and better cosmetic results [5]. These advantages notwithstanding, there are still issues about longer operating time, greater technical difficulty, and the possibility of longer cardiopulmonary bypass and cross-clamp times [6]. Therefore, comparative research is in order to determine whether MIAVR has superior early postoperative outcomes compared with the conventional sternotomy approach, particularly among Bangladeshi patients, wherein exposure to novel surgical techniques may be limited [7].

Few worldwide studies have proved benefits of MIAVR, including reduced time on mechanical ventilation, reduced length of intensive care unit (ICU) stay, reduced need for blood transfusions, and reduced wound infection rate [8, 9]. However, most of these studies have been conducted in high-resource settings, and limited data are available on its use and effectiveness in developing countries like Bangladesh [10]. With the increasing burden of cardiovascular disease in Bangladesh and the growing need for novel cardiac surgical treatments, determining the safety and effectiveness of MIAVR is crucial to optimizing patient outcome and guiding surgical decision-making [11].

This study aimed to compare the early results of AVR done by minimally invasive right anterolateral mini-thoracotomy with the conventional median sternotomy method. The primary objective was to compare operative time differences, postoperative recovery duration, postoperative pain, complication rates, and short-term patient outcomes. Comparing evidence-based early results, this study aimed to make significant contributions to determining the feasibility and benefits of MIAVR in Bangladesh. These findings may help to create guidelines for patient selection, surgeon preference for technique, and perioperative management strategies to enhance the quality of care in cardiac surgery.

METHODOLOGY & MATERIALS

This comparative prospective cohort study was conducted in the Department of Cardiac Surgery at Bangabandhu Sheikh Mujib Medical University, Dhaka, from January 15, 2024, to January 15, 2025. The study population included patients undergoing aortic valve replacement (AVR) using either minimally invasive cardiac surgery (MICS) or standard median sternotomy. A total of 30 patients were enrolled and divided into two equal groups: Group A (n=15) underwent AVR via a right anterolateral mini-thoracotomy, while Group B (n=15) underwent AVR via standard median sternotomy. Patients were considered eligible for the study if they had severe aortic valve disease requiring surgical replacement and were determined to be a candidate for either minimally invasive or traditional sternotomy techniques based on preoperative assessment. Excluded were also patients with history of cardiac surgery, severe left ventricular impairment (ejection fraction <30%), extensive coronary artery disease that required concomitant revascularization, or severe comorbidities such as advanced renal failure or untreated infections to preserve a homogenous study population and minimize confounding variables.

Preoperative assessment included clinical history, echocardiogram, routine blood tests, and risk stratification. All procedures were performed on cardiopulmonary bypass with general anesthesia. Group A underwent a right anterolateral mini-thoracotomy approach with femoral arterial and venous cannulation. In Group B, a full median sternotomy was performed with routine aortic and right atrial cannulation. The same operator team performed all the procedures to limit heterogeneity. Operative variables like cross-clamp time, cardiopulmonary bypass time, and total operating time were noted.

Postoperative results were measured within a 10-day follow-up, including ventilation duration, ICU stay, hospital stay, blood loss, transfusion needs, pain scores, and early complications like wound infections, atrial fibrillation, and acute kidney injury. Pain was assessed via the Visual Analog Scale (VAS) on day three postoperative. Data were analyzed using SPSS version 25 (IBM Corp., Armonk, NY, USA). Descriptive statistics were used to summarize baseline characteristics and postoperative outcomes, while comparisons between the two groups were

performed using independent t-tests for continuous variables and chi-square tests for categorical variables. A p-value of <0.05 was considered statistically significant.

Results

Table 1: Baseline Characteristics of Patients (n = 30)

Characteristics	Group A (MICS, n=15)	Group B (Sternotomy, n=15)	p-value
Age (years, mean ± SD)	55.3 ± 9.4	56.1 ± 8.7	0.78
Male (%)	10 (66.7%)	11 (73.3%)	0.68
Hypertension (%)	9 (60%)	10 (66.7%)	0.71
Diabetes (%)	5 (33.3%)	6 (40%)	0.71
Ejection Fraction (%)	52.1 ± 5.8	51.8 ± 6.1	0.87

Table 1 shows the baseline characteristics of the study population. The mean age was 55.3 ± 9.4 years in the MICS group and 56.1 ± 8.7 years in the sternotomy group (p = 0.78). Males comprised 66.7% (n=10) in Group A and 73.3% (n=11) in Group B (p = 0.68). Hypertension was present in 60% (n=9) of MICS patients and 66.7% (n=10) of sternotomy patients (p = 0.71), while diabetes was noted in 33.3% (n=5) and 40% (n=6), respectively (p = 0.71). The mean ejection fraction was 52.1 ± 5.8% in Group A and 51.8 ± 6.1% in Group B (p = 0.87). No significant differences were observed between the groups, confirming comparability.

Table 2: Operative and Postoperative Outcomes

Variables	Group A (MICS, n=15)	Group B (Sternotomy, n=15)	p-value
Total Operative Time (min)	180.5 ± 25.3	160.2 ± 20.1	0.04*
Cross-Clamp Time (min)	75.6 ± 12.2	68.4 ± 10.5	0.07
Cardiopulmonary Bypass Time (min)	95.1 ± 14.6	85.7 ± 12.8	0.05*
Ventilation Time (hours)	6.2 ± 2.4	10.5 ± 3.1	0.02*
ICU Stay (hours)	48.3 ± 10.7	72.1 ± 15.2	0.01*
Hospital Stay (days)	6.4 ± 1.2	10.2 ± 1.5	<0.001*
Chest Tube Drainage (ml)	300 ± 85	450 ± 120	0.003*
Blood Transfusion (%)	3 (20%)	8 (53.3%)	0.04*
Pain Score (VAS, Day 3)	3.1 ± 1.0	5.2 ± 1.3	<0.001*

Table 2 compares operative and early postoperative outcomes between the two groups. The total operative time was significantly longer in the MICS group (180.5 ± 25.3 min) compared to the sternotomy group (160.2 ± 20.1 min, p = 0.04). Cross-clamp and cardiopulmonary bypass times were slightly higher in MICS, with CPB time showing statistical significance (p = 0.05). Postoperatively, MICS patients had significantly shorter ventilation time (6.2 ± 2.4 vs. 10.5 ± 3.1 hours, p = 0.02), ICU stay (48.3 ± 10.7 vs. 72.1 ± 15.2 hours, p = 0.01), and hospital stay (6.4 ± 1.2 vs. 10.2 ± 1.5 days, p < 0.001). MICS was also associated with lower chest tube drainage (300 ± 85 vs. 450 ± 120 ml, p = 0.003) and reduced blood transfusion requirements (20% vs. 53.3%, p = 0.04). Pain scores on postoperative day 3 were significantly lower in the MICS group (3.1 ± 1.0 vs. 5.2 ± 1.3, p < 0.001), indicating better early recovery.

Table 3: Early Postoperative Complications (Within 10 Days)

Complications	Group A (MICS, n=15)	Group B (Sternotomy, n=15)	p-value
Mortality (%)	0 (0%)	1 (6.7%)	0.31
Reoperation for Bleeding (%)	1 (6.7%)	2 (13.3%)	0.54
Wound Infection (%)	0 (0%)	3 (20%)	0.07
New-Onset Atrial Fibrillation (%)	2 (13.3%)	4 (26.7%)	0.39
Acute Kidney Injury (%)	1 (6.7%)	3 (20%)	0.29

Table 3 presents the early postoperative complications within 10 days after surgery. Mortality was observed in 1 patient (6.7%) in the sternotomy group, while no deaths occurred in the MICS group (p = 0.31). Reoperation for bleeding was required in 6.7% (n=1) of MICS patients and 13.3% (n=2) of sternotomy patients (p = 0.54). Wound infections were more frequent in the sternotomy group (20% vs. 0%, p = 0.07), though not statistically significant. New-onset atrial fibrillation occurred in 13.3% (n=2) of MICS patients and 26.7% (n=4) of sternotomy patients

(p = 0.39). Acute kidney injury was observed in 6.7% (n=1) of MICS patients compared to 20% (n=3) in the sternotomy group (p = 0.29). Although none of the complications reached statistical significance, trends suggest a lower incidence of major complications in the MICS group.

DISCUSSION

Minimally invasive cardiac surgery (MICS) for aortic valve replacement (AVR) has gained popularity due to its potential benefits in reducing surgical trauma and enhancing recovery. Our study compared early postoperative outcomes between MICS and sternotomy in a Bangladeshi population, and our findings align with previous research, reinforcing the advantages of MICS.

Both groups in our study had identical baseline features, including age, gender, diabetes, hypertension, and ejection fraction. This homogeneity ensures that observed variations in postoperative results are likely to be caused by the operative technique rather than patient characteristics. Ghanta *et al*. and Hancock *et al*., emphasized that a similarity of baseline features is key to fair comparison in studies involving MICS vs. sternotomy [12, 13].

One of the major findings was higher operative and CPB times for the MICS group compared with sternotomy (180.5 ± 25.3 vs. 160.2 ± 20.1 min, p = 0.04; 95.1 ± 14.6 vs. 85.7 ± 12.8 min, p = 0.05). The same trend has been noted by Russo *et al*. and Khalid *et al*., who demonstrated that MICS is more technically demanding and takes more time on exposure and cannulation [14, 15]. The research conducted by Olsthoorn *et al*. and Mubarak, however, reports that with increasing surgical experience, operating times with MICS approach those done with sternotomy [16, 17].

Even in spite of longer operating times, MICS had improved postoperative recovery. Ventilation time was significantly less (6.2 ± 2.4 vs. 10.5 ± 3.1 hours, p = 0.02), and ICU stay was also less (48.3 ± 10.7 vs. 72.1 ± 15.2 hours, p = 0.01) that are determinants to minimize respiratory complications and maximize hospital resource utilization. This agrees with the report from Eqbal *et al*., that MICS is associated with significant reduction in ICU and hospital stay [18]. Duration of total hospital stay was also shorter in the MICS group (6.4 ± 1.2 vs. 10.2 ± 1.5 days, p < 0.001), in agreement with Pojar *et al* [19].

One of the significant advantages observed was smaller chest tube drainage (300 ± 85 vs. 450 ± 120 ml, p = 0.003) and fewer transfusions (20% vs. 53.3%, p = 0.04) in the MICS group. These findings are consistent with the findings of Hlavicka *et al*., who established that MICS is associated with reduced blood loss and lower transfusion requirements [20]. Transfusion of blood has also been linked with increased morbidity in cardiac surgery patients, which renders this an important advantage of MICS [21].

Another significant observation was the significantly lower postoperative pain in the MICS group (VAS 3.1 ± 1.0 vs. 5.2 ± 1.3, p < 0.001). This concurs with studies by Whiteley *et al*., which demonstrated that smaller incisions and lesser tissue disruption in MICS yield lower pain scores and improved early mobilization [22].

There was minimal mortality in the two groups, with one patient (6.7%) in the sternotomy group having passed away within 10 days (p = 0.31). Although not statistically significant, Mahmud *et al*., and Ryaan *et al*., also found that MICS is not linked to a rise in early mortality [23, 24].

Reoperation for bleeding was slightly higher among the sternotomy group (13.3% vs. 6.7%, p = 0.54) and not significant statistically. From a study conducted by Olsthoorn *et al*., and Synthee *et al*., evidence proves that MICS, with a reduction of surgical trauma, may reduce reoperation risk [16, 25].

Wound infections were also more common in the sternotomy group (20% vs. 0%, p = 0.07), consistent with Wadud *et al*., and Russo *et al*., who reported significantly lower infections in MICS as a result of smaller incisions and less exposure to environmental contaminants [14, 26]. Sternal wound infections in sternotomy patients can lead to severe complications, increased length of stay, and higher healthcare costs [18].

New-onset atrial fibrillation (AF) was lower in the MICS group (13.3% vs. 26.7%, p = 0.39), in line with findings by Kofler *et al*., and Kirmani *et al* [27, 28]. This decreased inflammatory reaction with MICS may be a contributory factor. Acute kidney injury (AKI) was reduced in the MICS group (6.7% versus 20%, p = 0.29), consistent with results from Hlavicka *et al*., which determined that while the duration of CPB is longer with MICS, the decreased systemic inflammatory response acts to mitigate renal dysfunction [20].

Our findings validate the benefits of MICS for AVR, particularly improved recovery, less pain, reduced blood loss, and shorter hospitalization. These are critical advantages in resource-limited settings like Bangladesh, where

optimal use of hospital resources is needed [23]. Additionally, studies by Ghanta *et al*., and Russo *et al*., explain the economic benefits of MICS in terms of reduced ICU and hospital stay [12, 14].

However, MICS is a procedure that requires special experience and training. The longer operative and CPB times in our study indicate the technical complexity of the procedure. With increasing experience on the surgeon's part, the times can be reduced, further establishing MICS as a viable option [17, 24]. Patient selection is also important, as patients with severe valve disease, history of prior cardiac operations, or major comorbidities can be poor candidates [15, 29].

Limitations of the study

The main limitations of this study include the small sample size (n = 30), which limits the generalizability of the findings. Additionally, the short follow-up period of 10 days does not allow for the assessment of long-term outcomes. Furthermore, as a single-center study, there is a potential for selection bias, which may affect the overall applicability of the results.

CONCLUSION

Our study demonstrates that MICS for AVR offers several advantages over sternotomy, including faster recovery, lower pain, reduced blood loss, and shorter hospital stays, without increasing major complications. Although MICS requires longer operative times and technical expertise, its postoperative benefits make it an attractive alternative. These findings align with global trends and suggest that MICS could be a viable option for AVR in Bangladesh and similar healthcare settings. Further research is needed to assess long-term outcomes and economic feasibility.

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Conflicts of interest

There are no conflicts of interest.

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