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Conventional left atriotomy versus the superior atrial approach for mitral valve replacement

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Abstract

Background: The optimal atrial approach for exposing the mitral valve with optimized patient outcomes is still controversial. This study compared conventional left atriotomy with the superior atrial approach for mitral valve replacement (MVR).

Methods: A randomized clinical trial was conducted on 60 patients who underwent MVR during the period 2022-2024. Patients were randomized into: Group A (n= 30, left atriotomy) and Group B (n=30, superior atrial approach).

Results: The mean age in Group A was 43.17 ± 8.57 years, whereas that in Group B was 47.63 ± 10.35 years (P = 0.07). No significant differences in sex, smoking status or associated comorbidities were noted between the groups. Echocardiographic findings revealed no significant differences in left ventricular functions and dimensions. Preoperative laboratory data revealed no significant differences in hemoglobin levels, platelet counts, or INRs. The total cardiopulmonary bypass time was shorter in Group B than in Group A but did not reach a significant level (P= 0.08). The cross-clamp times were significantly shorter in Group B (64 ± 5.7 min) than in Group A (69 ± 9.5 min) (P = 0.02). There were no differences in the rate of postoperative complications or duration of hospitalization between the groups. Follow-up echocardiographic evaluations revealed no significant difference between Group A and B in regarding ejection fraction (β: -0.003, 95% CI: -0.04-0.03, P = 0.82). Similarly, the left atrial diameter decreased significantly over time (β-0.05, 95% CI: -0.07- -0.03, P < 0.001), with no significant difference between the groups (β: -0.11, 95% CI: -0.29- 0.06, P = 0.21). Changes in left ventricular end-systolic diameter decreased over time (β: -0.05, 95% CI: -0.06- -0.03, P < 0.001), with no significant difference between groups (β: -0.01, 95% CI: -0.21-0.19, P = 0.92).

Conclusions: The superior atrial approach provided comparable clinical and echocardiographic outcomes to those of left atriotomy for MVR, with shorter cross-clamp times. The superior atrial approach is a good alternative to left atriotomy with comparable safety and efficacy profiles.

KEYWORDS

Mitral valve replacement; Left atriotomy; Superior atrial approach; Atrial dome; Atrial fibrillation

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Introduction

Mitral valve replacement (MVR) is one of the most commonly performed cardiac surgical procedures [1]. The procedure is frequently performed for patients with rheumatic heart disease and degenerative mitral valve lesions, and recently, it has shown beneficial value comparable to that of repair in patients with ischemic mitral regurgitation [2,3]. Rheumatic heart disease commonly affects the mitral valve [4,5]. Currently, MVR is still the preferred procedure for severe rheumatic mitral valve lesions because of the durability of the outcome compared with that of repair, although mitral valve repair for rheumatic mitral lesions is preferred in some centers [6]. Thus, optimizing surgical exposure for MVR replacement is highly important for improving patient outcomes.

Several approaches can be used to expose the mitral valve for MVR. The atrial incision used to expose the mitral valve depends on the preference and expertise of the surgical team and combines procedures, in addition to the surgical approach, whether minimally invasive or through full sternotomy [7]. The left atriotomy approach through an incision in the Sondergard groove is considered the standard approach [8]. Left atriotomy has several limitations, including difficulty in visualizing the whole mitral valve and subvalvular apparatus, especially in patients with previous cardiac surgery, the small atrium and the deep thoracic cavity [8,9]. Transseptal approaches have been proposed to provide better exposure to the mitral valve; however, they are associated with postoperative atrial arrhythmia, which could compromise outcomes [10]. A third approach to expose the mitral valve is through the dome of the left atrium between the aorta and superior vena cava, namely, the superior atrial approach [11]. The technique provides direct exposure of the mitral valve, which could decrease the operative time. Furthermore, the approach could maintain left atrial geometry and atrial function postoperatively. However, this technique may not be optimal for repair because of the difficulty of exposing the subvalvular apparatus [12]. Furthermore, the superior atrial approach could be technically challenging in minimally invasive surgeries. Optimizing the balance between optimal mitral valve exposure for MVR and patient outcomes is a topic of ongoing research. Thus, this study aimed to compare the outcomes between MVR through left atriotomy and the superior atrial approach in patients who underwent MVR through full sternotomy.

Patients and Methods

Study Design and Settings

This prospective randomized, single-blinded, controlled clinical trial involved 60 patients who underwent prosthetic MVR at Banha University Hospitals from January 2022 to January 2024. The participants underwent MVR via either conventional left atriotomy or the atrial dome approach. The study received approval from the local ethical committees, and all patients provided informed consent prior to enrollment. Patients were blinded to their group assignment.

Groups

Patients were randomly assigned to two groups through blocked randomization. Computer-generated randomization numbers were securely enclosed in envelopes, with block sizes ranging from 4-6. Group A included patients who underwent MVR through conventional left atriotomy, and Group B included patients who had MVR via the superior atrial incision.

Inclusion and Exclusion Criteria

The inclusion criteria were as follows: 1) patients of both sexes, 2) underwent primary MVR, 3) had an ejection fraction greater than 50% and 4) were NYHA class I to III. The exclusion criteria were as follows: 1) patients who required redo surgery, 2) patients who underwent concomitant procedures, 3) patients who underwent emergency surgery, 4) patients with severe renal or hepatic dysfunction and 5) patients with heart failure or previous stroke. The study was reported according to the CONSORT guidelines [13].

Data collection and outcomes

Preoperative data collected included demographics (age, sex, smoking status), comorbidities (diabetes mellitus, chronic

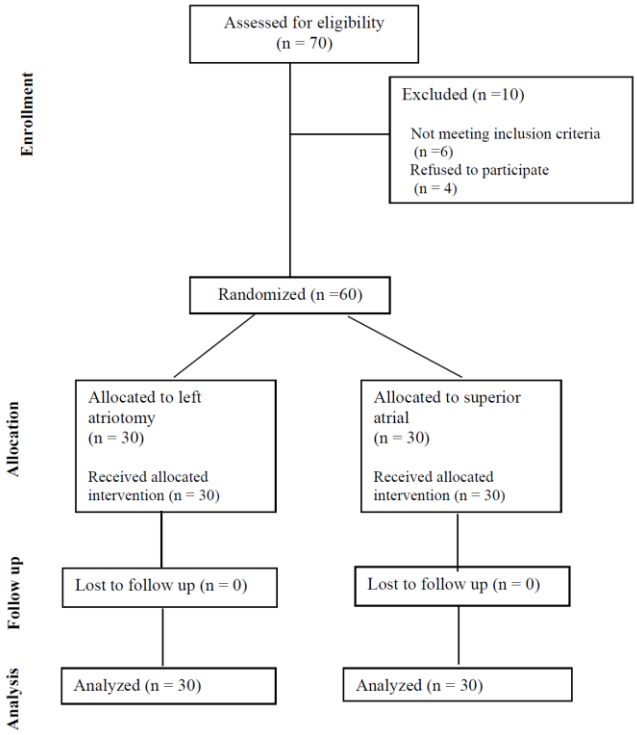

Figure 1: CONSORT Flowchart

obstructive pulmonary disease, atrial fibrillation, viral hepatitis), symptoms categorized by the New York Heart Association (NYHA) class, and laboratory data (international normalization ratio (INR), hemoglobin, and platelet levels). Echocardiographic data included ejection fraction (EF), left ventricular end-systolic diameter (LVESD), left ventricular end-diastolic diameter (LVEDD), left atrial diameter, and pulmonary artery systolic pressure (PASP).

Operative data included cardiopulmonary bypass (CPB) and ischemic times. The postoperative outcomes assessed were complete heart block, a vasoactive inotropic score (VIS), the duration of mechanical ventilation, the intensive care unit (ICU) admission duration, the length of hospital stay, new-onset atrial fibrillation, superficial wound infections and re-exploration for bleeding. VIS was calculated according to the following formula:

VIS= dopamine (μg/kg/min) + dobutamine (μg/kg/min) + 100 × norepinephrine (μg/kg/min) + 10 × epine (μg/kg/min) + 10 × milrinone (μg/kg/min).

Follow-up occurred in the outpatient clinic, with echocardiography performed before discharge and at 3 and 6 months postoperatively. The follow-up measures included EF, LVESD, and left atrial diameter.

The primary outcome of the study was the duration of hospital stay, whereas secondary outcomes included hospital complications and echocardiographic measures during follow-up.

Surgical Techniques

Patient position and anesthetic techniques were similar in both groups regardless of the atrial incision. Both surgical techniques were performed via median sternotomy with aortobicaval cannulation. Cardioplegia arrest was achieved through an antegrade approach with an aortic root cannula. Blood cardioplegia or Custodiol was used as the preferred cardioplegia solution according to the discretion of the treating physician. The mitral valve was accessed through the atrial dome, where an incision was created to the left atrium between the aorta and superior vena cava in patients who underwent the superior atrial approach. For left atriotomy, the mitral valve was accessed along Sondergard's groove. Following the procedure, all incisions were closed via 3–0 Prolene sutures. Weaning from cardiopulmonary bypass and chest closure were performed in the standard way in both groups.

Sample size calculation

The average hospital stay was estimated to be seven days for the left atriotomy group and 8 days for the superior atrial approach group [8]. If the standard deviation was 1.5, the patient allocation ratio was 1:1, the type I error probability was 0.05, and the power was 0.8, 30 patients in each group were needed.

Statistical analysis

Statistical analyses were performed via Stata 18 Now (Stata Corp, College Station, TX). Continuous data were assessed for normality; normally distributed data are expressed as the means with standard deviations and were analyzed via t tests. Nonnormally distributed data are presented as medians (Q1-Q3) and were compared via the Wilcoxon test. Categorical data are reported as absolute numbers and percentages, with comparisons made via the chi-square test and Fisher's exact test. Random effects models were employed to evaluate changes in EF,

Table 1: Comparison of baseline and preoperative data between patients who underwent left atriotomy (Group A) and those who underwent the superior atrial approach (Group B)

	Group A (n= 30)	Group B (n= 30)	P value
Demographics			
Age (Years)- mean± SD	43.17± 8.57	47.63± 10.35	0.07
Female- no (%)	18 (60%)	19 (63.33%)	0.79
Smoking- no (%)	8 (26.67%)	9 (30%)	0.77
Symptoms			
New York Heart association class III/IV- no (%)	12 (40%)	13 (43.33%)	0.79
Comorbidities			
Diabetes mellitus- no (%)	8 (26.67%)	7 (23.33%)	0.77
Chronic obstructive pulmonary disease- no (%)	3 (10%)	5 (16.67%)	0.71
Atrial fibrillation- no (%)	8 (26.67%)	11 (36.67%)	0.41
Viral hepatitis (viral B or C)- no (%)	45(16.67%)	5 (16.67%)	>0.99
Echocardiography			
Ejection fraction (%)-mean± SD	62.7± 6.6	62± 6.5	0.89
End-systolic diameter (cm)- mean± SD	3.31± 0.52	3.27± 0.50	0.99
End-diastolic diameter (cm)- mean± SD	4.99± 0.63	4.95± 0.51	0.82
Left atrial diameter (cm)- mean± SD	4.9± 0.50	4.5± 0.47	<0.01
Pulmonary artery systolic pressure (mmHg)- mean± SD	55± 13	57± 13	0.50
Laboratory data			
Hemoglobin (mg/dl)- mean± SD	12.8± 0.63	12.77± 0.61	0.97
Platelets- median (IQR)	280 (250- 320)	280 (268- 320)	0.78
INR- median (IQR)	1.1 (1- 1.1)	1.1 (1.1- 1.2)	0.32

LVESD, and left atrial diameter both between and within groups, with β-coefficients and 95% confidence intervals reported. A P value of less than 0.05 was considered significant.

Results

The Sample

A total of 60 patients were enrolled in the study, with 30 participants undergoing mitral valve replacement (MVR) through conventional left atriotomy (Group A) and 30 participants undergoing MVR via the superior atrial approach (Group B). Figure 1 shows the study flowchart.

Baseline Data

Table 1 summarized the baseline demographics and preoperative data of the participants. The mean age in Group A was 43.17 ± 8.57 years, whereas in Group B, it was 47.63 ± 10.35 years (P = 0.07). No significant differences were noted in sex distribution (Group A: 60% female; Group B: 63.33% female, P = 0.79) or smoking status (P = 0.77). Comorbidities such as diabetes mellitus (P = 0.77), chronic obstructive pulmonary disease (COPD) (P = 0.71), atrial fibrillation (P = 0.41), and viral hepatitis (P > 0.99) were similar between the groups. Echocardiographic findings revealed no significant differences in EF (62.7% ± 6.6 vs. 62% ± 6.5, P = 0.89), LVESD (3.31 ± 0.52 cm vs. 3.27 ± 0.50 cm, P = 0.99), or PASP (55 ± 13 mmHg vs. 57 ± 13 mmHg, P = 0.50). However, the left atrial diameter was

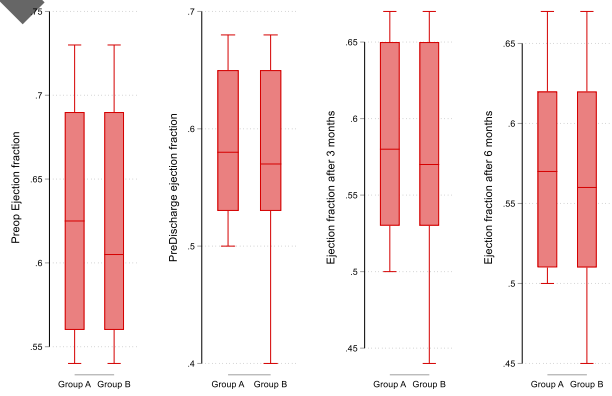

Figure 2: Changes in the ejection fraction at the 6-month follow-up in patients who underwent left atriotomy (Group A) vs. those who underwent the superior atrial approach (Group B)

Table 2: Comparison of operative and postoperative data between patients who underwent left atriotomy (Group A) and those who underwent superior atrial approach (Group B)

	Group A (n= 27)	Group B (n= 33)	P value
Operative outcomes			
Cardiopulmonary bypass time (min)- mean± SD	86± 11	81± 9	0.08
Cross-clamp (min)- mean± SD	69± 9.5	64± 5.7	0.02
ICU outcomes			
Vasoactive inotropic score- median (IQR)	14 (10- 20)	18 (14- 20)	0.07
Mechanical ventilation (h)- mean± SD	9.8± 3.7	11.5± 5	0.07
ICU stay (days)- mean± SD	3.8± 0.99	4.3± 1.5	0.20
Hospital outcomes			
Hospital stay (days)- mean± SD	9.7± 2.5	11.6± 3.5	0.02
New atrial fibrillation	2 6.670%)	2 (6.67%)	>0.99
New complete heart block	1 (3.33%)	2 (6.67%)	>0.99
Superficial wound infection	3 (10%)	2 (6.67%)	>0.99
Re-exploration for bleeding	2 (6.67%)	4 (12.12%)	0.35

significantly smaller in Group B (4.5 ± 0.47 cm) than in Group A (4.9 ± 0.50 cm) (P < 0.01). Preoperative laboratory data revealed no significant differences in hemoglobin levels (P = 0.97), platelet counts (P = 0.78), or international normalized ratios (INRs) (P = 0.32).

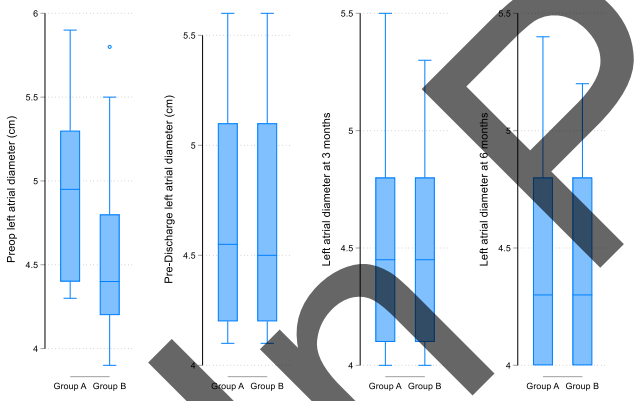

Figure 3: Changes in left atrial diameter at the 6-month follow-up in patients who underwent left atriotomy (Group A) vs. those who underwent the superior atrial approach (Group B)

Operative and postoperative data

Table 2 presents the operative and postoperative outcomes. CPB times were shorter in Group B (81 ± 9 min) than in Group A (86 ± 11 min), although this difference did not reach statistical significance (P = 0.08). The cross-clamp times were significantly shorter in Group B (64 ± 5.7 min) than in Group A (69 ± 9.5 min) (P = 0.02).

Postoperatively, the vasoactive inotropic score (VIS) was greater in Group B (18 [14–20]) than in Group A (14 [10–20]), although this difference did not reach statistical significance (P = 0.07). The duration of mechanical ventilation was longer in Group B (11.5 ± 5 h) than in Group A (9.8 ± 3.7 h), but this difference was also not statistically significant (P = 0.07). The mean ICU stay was similar between the two groups (Group A: 3.8 ± 0.99 days; Group B: 4.3 ± 1.5 days, P = 0.20). However, the total hospital stay was significantly shorter in Group A (9.7 ± 2.5 days) than in Group B (11.6 ± 3.5 days) (P = 0.02). The rates of new atrial fibrillation (6.67% in both groups), complete heart block (Group A: 3.33%; Group B: 6.67%), and superficial wound infections (Group A: 10%; Group B: 6.67%) were not significantly different (all P > 0.99). Re-exploration for bleeding occurred in 6.67% of Group A patients and 12.12% of Group B patients (P = 0.35).

Follow-Up

At the 6-month follow-up, echocardiographic evaluations revealed a significant decrease in the ejection fraction over time (β: -0.007, 95% CI: -0.008 to -0.006, P < 0.001), with no significant difference between the groups (β: -0.003, 95% CI: -0.04 to 0.03, P = 0.82) (Figure 2). Similarly, the left atrial diameter decreased significantly over time (β-0.05, 95% CI: -0.07 to -0.03, P < 0.001) with no significant difference between groups (β: -0.11, 95% CI: -0.29 to 0.06, P = 0.21) (Figure 3). Changes

in left ventricular end-systolic diameter decreased over time (β: -0.05, 95% CI: -0.06 to -0.03, P < 0.001) with no significant difference between groups (β: -0.01, 95% CI: -0.21 to 0.19, P = 0.92) (Figure 4).

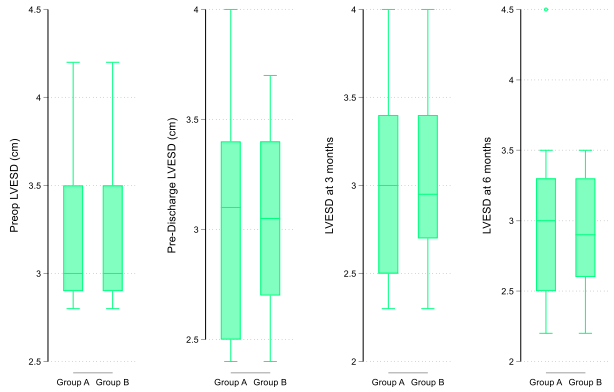

Figure 4: Changes in left ventricular end-systolic diameter at the 6-month follow-up in patients who underwent left atriotomy (Group A) vs. those who underwent the superior atrial approach (Group B)

Discussion

Summary

This randomized, single-blinded clinical trial aimed to compare outcomes between two surgical approaches for MVR: conventional left atriotomy and the superior atrial approach. A study of 60 patients over a two-year period revealed no significant differences in postoperative complications or echocardiographic parameters between the two groups at the 6-month follow-up. However, compared with left atriotomy, the superior atrial approach resulted in shorter cross-clamp times, but longer total hospital stays. Overall, both techniques were effective, but their outcomes varied in terms of surgical efficiency and recovery time.

Comparison with the literature

Several atrial incisions have been described for mitral valve exposure [14]. The superior atrial approach offers rapid and easy access to the mitral valve, which does not require extensive dissection of the heart. Furthermore, the suture line after the incision is closed is readily visible, allowing good hemostasis [15]. Legare and associates compared three atrial approaches (left atriotomy, transseptal and superior atrial) for mitral valve repair in 131 patients and reported older patients and longer bypass times in patients with left atriotomy [12]. All the approaches were effective for mitral valve repair. These findings are consistent with our study in which patients who underwent surgery via the superior atrial approach had shorter bypass times. This may indicate that proper mitral valve exposure with the superior atrial approach results in faster MVR. Ahmed and Abdel Jawad evaluated the safety of the superior atrial approach for mitral surgery and resection of left atrial masses in 85 patients [16]. They reported an average ischemic time of 62 minutes, which is comparable to that reported in our study. Postoperative AF occurred in 2% of their patients, which was comparable to the 6% reported in our series. Utley and colleagues compared three atrial incisions for mitral valve surgery and reported a higher rate of atrial arrhythmia in patients who underwent the superior septal approach [17]. The risk of atrial fibrillation is substantial after MVR and is associated with increased morbidity and mortality [18,19]. Compared with conventional left atriotomy, the superior atrial approach was not associated with a greater risk of atrial fibrillation in our series. Few associates have evaluated the superior atrial approach for minimally invasive mitral surgery and reported adequate exposure of the mitral valve, with a mean cross-clamp time of 70 min [20]. Similarly, Alkady and Abouramadan reported the feasibility of the superior atrial approach for combined aortic and mitral valve surgery through minimally invasive and conventional surgical approaches [8]. Furthermore, the duration of mechanical ventilation and the need for blood transfusion were lower in patients who had a minimally invasive approach. The superior atrial approach has also shown beneficial outcomes when used for the resection of left atrial tumors [21].

Future Implications

These findings suggest that while the superior atrial approach may provide some advantages in terms of surgical time, it has patient outcomes similar to those of conventional left atriotomy. Future studies could explore larger sample sizes and longer follow-up periods to further assess the long-term effects of each approach on patient quality of life and functional recovery. Additionally, investigating the impact of surgeon experience and technique refinement on

outcomes may provide valuable insights into optimizing MVR procedures.

Limitations

Several limitations should be acknowledged in this study. The relatively small sample size may limit the generalizability of the findings. The short follow-up duration of six months might not capture late postoperative complications or long-term functional outcomes. Additionally, the study was conducted at a single center, which could introduce biases related to specific surgical practices or patient populations. Finally, the influence of surgeon experience and technique variability was not controlled, which may have affected the outcomes.

Conclusion

This randomized clinical trial comparing conventional left atriotomy and the superior atrial approach for mitral valve replacement demonstrated that both techniques yield similar postoperative outcomes and echocardiographic parameters at the 6-month follow-up. Notably, while the superior atrial approach was associated with significantly shorter cross-clamp times, this did not translate into differences in postoperative complications or hospitalization duration. Furthermore, both approaches effectively reduced the left atrial diameter and left ventricular end-systolic diameter over time, indicating improvement in cardiac function irrespective of the surgical method employed. These findings suggest that while the superior atrial approach may offer logistical advantages in terms of surgical efficiency, it has similar long-term benefits in terms of patient outcomes especially in mini sternotomy and small Lt atrium compared with the conventional method. Further studies with larger cohorts and longer follow-up periods may be warranted to fully elucidate the implications of each approach for patient recovery and cardiac performance.

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