Superior transseptal versus left atriotomy approaches in isolated mitral valve surgery

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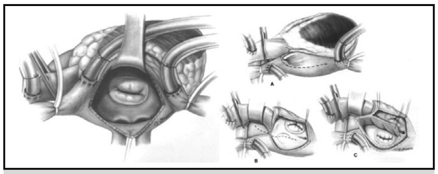
ABSTRACT

Objective: The superior transseptal approach to mitral valve surgery offers improved exposure compared with left atriotomy; however, concerns remain regarding postoperative arrhythmias and pacemaker placement. This study investigates intraoperative parameters and postoperative outcomes in these approaches.

Methods: Retrospective review of 259 adults undergoing isolated mitral valve repair or replacement over a 10-year period was performed. Exclusion criteria included previous history of permanent pacemaker placement and concomitant cardiac procedures. The primary outcome evaluated was postoperative permanent pacemaker placement. Secondary outcomes included postoperative new-onset atrial fibrillation, new-onset arrhythmias, major adverse cardiovascular events, length of stay, and mortality.

Results: Of 259 surgeries, 116 were performed via left atriotomy and 143 via superior transseptal approach. The overall incidence of postoperative permanent pacemaker placement was 3.0%, with similar rates (left atriotomy 1.7% vs superior transseptal 4.2%, $P = .30$). The incidence of new-onset atrial fibrillation (31.0% vs 42.7%, $P = .055$) and arrhythmias in general (37.1% vs 49.0%, $P = .06$) was similar. Rates of other secondary outcomes, such as major adverse cardiovascular events and mortality, were similar between cohorts. In addition, cardiopulmonary bypass and aortic crossclamp times did not differ. Interestingly, intensive care unit (55 vs 73 hours, $P = .04$) and postoperative length of stay (6.8 vs 9.0 days, $P = .002$) were shorter after left atriotomy.

Conclusions: The superior transseptal approach provides optimal exposure while preserving similarly low rates of postoperative morbidity and mortality to left atriotomy. There is no difference in the incidence of postoperative permanent pacemaker placement and new-onset arrhythmias. (JTCVS Open 2024;22:208-13)



Left atriotomy (*left*) and superior transseptal (*right*) approaches to mitral valve exposure. Figures derived from Pezzella et al. 1983.[1]

CENTRAL MESSAGE

The superior transseptal approach preserves similarly low rates of postoperative complications, mortality, and need for PPM as left atriotomy.

PERSPECTIVE

The goal of mitral valve repair is a perfect result, with no mitral regurgitation, no stenosis, and long-term freedom from reintervention. In our study, the superior transseptal approach offers similar freedom from PPM and adverse outcomes as left atriotomy. As such, surgeons should pursue excellent repair results, without compromising exposure or extent of repair, using the technique of their choice.

Mitral valve disease contributes up to 46% of all valvular heart disease.[2] It disproportionately affects elderly patients, with 10% of individuals older than the age of 75 years having mitral pathology.[3] Not only is it prevalent, but mitral valve disease also imparts a high morbidity if left untreated. Mitral valve regurgitation is associated with atrial fibrillation (AFib) and heart failure, with 10-year incidences of 30% and 63%, respectively, as well as an excess mortality rate of 6.5%.[4] This combination of incidence, untreated morbidity, and complexity often necessitates surgical interventions, such as mitral valve repair (MVr) and mitral valve replacement (MVR), to address this disease pathology.[5]

Given the posterior location of the left atrium, as well as the angled or sometimes inverted anatomic position of the mitral valve when viewed from the surgeon's perspective, proper exposure is integral for successful mitral valve surgery (MVS). A left atriotomy (LA) can be used for both open sternotomy and minimally invasive approaches, wherein an incision is made in the left atrium through the

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Abbreviations and Acronyms

ACC	= aortic crossclamp
AFib	= atrial fibrillation
ICU	= intensive care unit
LA	= left atriotomy
MACE	= major adverse cardiac events
MVr	= mitral valve repair
MVR	= mitral valve replacement
MVS	= mitral valve surgery
STS	= superior transseptal

interatrial groove (Figure 1).[1] This technique minimizes atrial tissue damage necessary for visualizing the mitral valve by obviating right atrial as well as transseptal incisions. However, direct visualization of the mitral valve during the operation can be obscured in the LA approach, as the surgeon is viewing the valve from the side or even from the bottom up.[6] Furthermore, this LA approach is not always plausible as the result of difficult anatomy, such as calcification of the mitral valve annulus, a small left atrium, a hypertrophic right ventricle, a deep thoracic cavity, or adhesions and scarring from previous cardiovascular operations.[7]

An alternative technique is the superior transseptal (STS) approach via sternotomy, wherein the surgeon makes a vertical incision in the right atrium, extending through the right atrial appendage to the superior portion of the atrial septum. Then, the fossa ovalis is incised extended to meet the right atrial incision at the superior septum and subsequently continued into the dome of the left atrium (Figure 2).[1,8] This technique improves exposure by creating a direct, unobstructed view of the mitral valve, especially when the left atrium is small.[8] However, this approach requires more dissection, raising concern for increased operative times, greater risk for bleeding, and the risk of disrupting the heart's intrinsic conduction system.[7] These alterations have been postulated to lead to an increased incidence of arrhythmias and subsequent pacemaker placement after the STS approach.[9]

There is no clear consensus whether either approach is superior to the other. Several studies have reported shorter cardiopulmonary bypass (CPB) time and aortic crossclamp (ACC) time during LA compared with STS.[10,11] However, data are inconsistent regarding whether the STS approach truly leads to a greater incidence of postoperative arrhythmias, such as AFib, and subsequent permanent pacemaker placement. Furthermore, most studies are confounded by an increased rate of concomitant tricuspid valve repair with the STS approach. Thus, further studies are needed to evaluate these 2 approaches. In this study, we compared postoperative outcomes between the LA and STS approaches with isolated MVS regardless of surgical access incision.

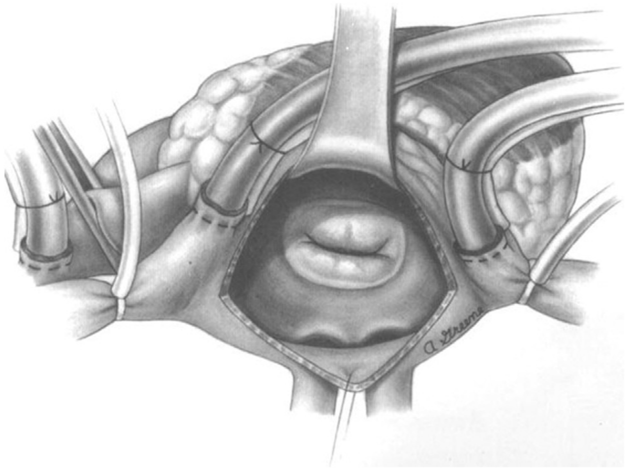

FIGURE 1. Left atriotomy approach. Depicted is the left atriotomy approach, in which a horizontal incision in the Waterson groove exposes the mitral valve. Figure derived from Pezzella et al. 1983.[1]

METHODS

We performed a retrospective review of patients who underwent MVS at our tertiary care institution from October 2012 to April 2023 (00089491; October 12, 2022). All operations were performed by the same group of 4 surgeons. Patients younger than the age of 18 years at the time of surgery were excluded. Only patients undergoing isolated MVS, defined as MVr or MVR via sternotomy or right minithoracotomy without concomitant coronary artery bypass grafting; tricuspid, aortic, and pulmonic valvular procedures; or aortic surgery, were included in the study.

Mitral valve repair techniques varied between the surgeons; however, they routinely involved the use of leaflet resection, select use of synthetic cord placement, as well as partial or full annuloplasty rings (Carpentier-Edwards or Medtronic SimuPlus and Simplici-T). Mitral valve replacement was most commonly performed for endocarditis and rheumatic mitral stenosis using Abbott Epic Plus, Edwards MITRIS, or St Jude Medical Epic, Epic Plus, and Masters prostheses depending on patient characteristics and surgeon preference.

Patients with a previous history of cardiac surgery or permanent pacemaker placement were excluded from the study. Cases were reviewed for preoperative characteristics, intraoperative parameters, and postoperative outcomes. Postoperative complications were defined as those having occurred from the time of surgery to within 30 days of discharge. The primary outcome assessed was permanent pacemaker placement. Secondary outcomes included new-onset arrhythmias, such as Afib, major adverse cardiac events (MACE), operative times, hospital lengths of stay, reoperation rates, readmission rates, morbidity, and mortality. Arrhythmias were defined as AFib, atrial flutter, atrioventricular nodal block, bundle branch block, junctional rhythm, or nonsustained ventricular tachycardia. MACE were defined as myocardial infarction, nonfatal stroke, or cardiovascular death.

Descriptive statistics, including means and standard deviations of continuous characteristics and frequencies and percentages of categorical factors, were computed overall and by surgical approach. Statistical tests for differences between surgical approaches were performed using t tests for continuous variables and χ^2 tests (or Fisher exact test in instances of expected cell counts <5) for categorical variables. Five-year mortality was examined by group using product-limit survival plots and differences were assessed using the log-rank test. All analyses were performed using SAS, version 9.4 software (SAS Institute).

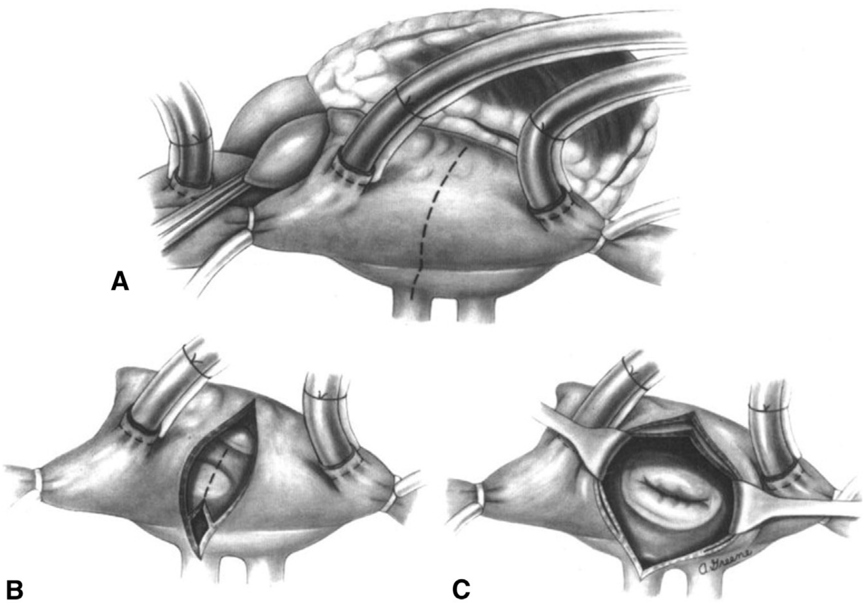

FIGURE 2. Superior transseptal approach. A, A vertical incision is made anterior to the sulcus terminalis. B, Then, a vertical incision is made through the fossa ovalis. C, Finally, the interatrial septum is retracted, exposing the mitral valve. Figure derived from Pezzella et al. 1983.[1]

RESULTS

In total, 259 patients met the inclusion criteria. The mean age was 58.9 (±14.4) years with 130 (50%) female patients. One hundred fifty-one (58%) had a history of hypertension, 88 (34%) dyslipidemia, 47 (18%) diabetes mellitus, and 91 (35%) coronary artery disease. Fourteen (5%) had previous myocardial infarction and 21 (8%) had cerebrovascular accident. One hundred thirty-nine (54%) were current or former smokers. Patient characteristics are summarized in Table 1.

Of the 259 mitral valve surgeries performed, 116 (44.8%) were performed via LA and 143 (55.2%) were performed via the STS approach. One hundred fifty-eight (61.0%) underwent median sternotomy, whereas 101 (39.0%) underwent right minithoracotomy. One hundred eighty-eight (72.8%) were MVr versus 71 (27.4%) MVR.

Overall, 97 (37.5%) patients experienced new-onset postoperative AFib, and 113 (43.6%) patients experienced new-onset postoperative arrhythmias, including AFib. Eight (3.1%) patients required postoperative permanent pacemaker placement, and 1 (0.4%) patient required postoperative ablation therapy. Nine (3.5%) patients experienced postoperative MACE, 8 (3.1%) of whom experienced nonfatal strokes and 1 (0.4%) of whom experienced cardiovascular death. No patients experienced postoperative myocardial infarctions. Twelve (4.6%) patients required reoperation during index hospitalization, 10 (4.0%) of whom were re-exploration as the result of bleeding. Eight (3.1%) patients required anytime

TABLE 1. Preoperative characteristics

Preoperative characteristic	Overall n (%) or mean (SD)	LA n (%) or mean (SD)	STS n (%) or mean (SD)	*P* value
Age, y	58.6 (±14.5)	61.8 (±13.7)	56.1 (±14.7)	.002
Body mass index, kg/m^2	27.7 (±6.4)	26.6 (±4.9)	28.6 (±7.3)	.008
Male sex	129 (49.8%)	59 (50.9%)	70 (49.0%)	.76
Hypertension	151 (58.3%)	69 (59.5%)	82 (57.3%)	.73
Dyslipidemia	88 (34.0%)	72 (62.1%)	99 (69.2%)	.23
Diabetes mellitus	47 (18.2%)	23 (19.8%)	24 (16.8%)	.53
Coronary artery disease	91 (35.1%)	45 (38.8%)	46 (32.2%)	.27
Myocardial infarction	14 (5.4%)	5 (4.3%)	9 (6.3%)	.48
Cerebrovascular accident	21 (8.1%)	8 (6.9%)	13 (9.1%)	.52
Tobacco use	139 (54%)	62 (53.8%)	77 (54.2%)	.90

SD, Standard deviation; *LA*, left atriotomy; *STS*, superior transseptal.

mitral valve reoperation. Thirty-day, 1-year, and 5-year mortality rates were 0.4%, 4.0%, and 5.0%, respectively. The median time to last known follow-up was 2.6 (interquartile range, 0.4-5.2) years.

Of the 116 LAs, 101 (87.1%) were performed via right minithoracotomy and 15 (12.9%) were performed via median sternotomy. In the LA group, 91 patients (78.5%) underwent MVr and 25 patients (21.6%) underwent MVR. One hundred forty-three patients underwent STS approach, via median sternotomy. In the STS group, 97 (67.8%) patients underwent MVr and 46 (32.2%) patients underwent MVR. Mean operative times (190 [±77] vs 201 [±66] minutes, $P = .21$), CPB times (116 [±66] vs 116 [±28] minutes, $P = .97$), and ACC times (75 [±32] vs 78 [±22] minutes, $P = .44$) were similar between both groups. Intraoperative parameters are summarized in Table 2. Mean intubation duration was shorter in the LA group (12 [±10] vs 22 [±51] hours, $P = .02$). Mean intensive care unit (ICU) length of stay (2.3 [±2.0] vs 3.0 [±3.7] days, $P = .04$), postoperative length of stay (6.8 [±4.4] vs 9.0 [±7.0] days, $P = .002$), and hospital length of stay (8.2 [±7.2] vs 10.9 [±8.4] days, $P = .01$) were shorter after LA than STS.

Differences in the rates of new-onset postoperative AFib specifically (36 [31.0%] LA vs 61 [42.7%] STS, $P = .05$) and new-onset postoperative arrhythmias in general (43 [37.1%] LA vs 70 [49.0%] STS, $P = .06$) approached significance between groups. Rates of postoperative permanent pacemaker placement were similarly low between both groups (2 [1.7%] LA vs 6 [4.2%] STS, $P = .3$). Rates of postoperative MACE events (4 [3.4%] vs 5 [3.5%], $P = 1.00$), nonfatal strokes (3 [2.6%] vs 5 [3.5%], $P = .73$), and reoperation during index hospitalization (5 [4.3%] vs 7 [4.9%], $P = .82$), were similar between both groups. Rates of anytime mitral valve reoperation (6 [5.2%] vs 2 [1.4%], $P = .14$) were also similar between both groups. Thirty-day (1 [0.9%] vs 0 [0.0%], $P = .45$), 1-year (4 [3.4%] vs 6 [4.2%], $P = 1.00$), and 5-year (5 [4.3%] vs 8 [5.6%], $P = .64$) mortality rates were similar between both groups. Postoperative outcomes are summarized in Table 3.

DISCUSSION

Given the evidence-based and guideline-driven shift in favor of MVr over MVR, achieving adequate exposure and visualization has become of even greater importance to ensure a perfect repair. Today, LA has largely become the predominant approach for performing MVS, in part because of the use of minimally invasive techniques. However, the average cardiac surgeon performs only a handful of mitral valve surgeries per year and may not routinely perform minimally invasive techniques, or may not have access to a robotic platform. As such, we demonstrate that both techniques are safe and effective, with low rates of complication and need for reintervention.[7,10,12]

The STS approach has been shown to provide better exposure and visualization of the mitral valve itself, increased ability to passively test valve repairs, and easier closure.[13] In addition, in cases requiring redo surgery, having knowledge of safely performing the STS approach provides surgeons with an additional tool for safe redo mitral valve surgery. Although sinus-node dysfunction remains the chief reservation associated with this technique, our data suggest that atrial arrhythmias are more common than sinus node dysfunction. It has been hypothesized that injury to the sinoatrial artery and anterior internodal tract or disruption of sinus node impulses by the incision in the right atrium may be contributing to such cases.[14,15]

Current literature demonstrates inconsistent results regarding postoperative new-onset arrhythmias and permanent pacemaker placement, as well as operative times. Although several studies report increased operative times and increased rates of postoperative arrhythmias after STS, these results are confounded by an increased rate of concomitant tricuspid valve repair with the STS approach.[5]

A recent meta-analysis compared the LA and the STS approaches for isolated MVS in order to minimize confounding factors.[5] Five studies were included, with a total of 1513 patients. The meta-analysis found no differences in rates of new-onset AFib and PPM requirement between both approaches. In addition, there were no differences in other outcomes, such as mortality and stroke, as well as in CPB and ACC times between the groups.

Similarly, our study demonstrates comparable rates of postoperative permanent pacemaker placement between LA and STS ($P = .30$). Although rates of new-onset postoperative Afib and arrhythmias in general were slightly greater in STS ($P = .055$ and $P = .06$, respectively), we have found that they

TABLE 2. Intraoperative parameters

Intraoperative parameter	Overall n (%) or mean (SD)	LA n (%) or mean (SD)	STS n (%) or mean (SD)	P value
Operative time, min	195.8 (±71.1)	189.7 (±76.8)	200.9 (±66.1)	.21
Cardiopulmonary bypass time, min	116.3 (±48.9)	116.2 (±66.0)	116.4 (±28.6)	.97
Aortic crossclamp time, min	76.7 (±26.6)	75.3 (±31.6)	77.9 (±21.7)	.44
Intubation duration, h	17.4 (±39.1)	11.5 (±10.4)	22.2 (±51.4)	.02

SD, Standard deviation; *LA*, left atriotomy; *STS*, superior transseptal.

TABLE 3. Postoperative outcomes (overall, LA, and STS)

Postoperative outcome	Overall n (%) or mean (SD)	LA n (%) or mean (SD)	STS n (%) or mean (SD)	*P* value
ICU length of stay, d	2.7 (±3.1)	2.3 (±2.0)	3.0 (±3.7)	.042
Hospital length of stay, d	9.7 (±8.0)	8.2 (±7.2)	10.9 (±8.4)	.0061
New-onset atrial fibrillation	97 (37.5%)	36 (31.0%)	61 (42.7%)	.055
New-onset arrhythmia	113 (43.6%)	43 (37.1%)	70 (49.0%)	.055
Permanent pacemaker placement	8 (3.1%)	2 (1.7%)	6 (4.2%)	.30
MACE	9 (3.5%)	4 (3.4%)	5 (3.5%)	1.0
Nonfatal stroke	8 (3.1%)	3 (2.6%)	5 (3.5%)	.73
Myocardial infarction	0 (0.0%)	0 (0.0%)	0 (0.0%)	–
Reoperation during index hospitalization	12 (4.6%)	5 (4.3%)	7 (4.9%)	.82
Bleeding requiring re-exploration	10 (3.9%)	5 (4.3%)	5 (3.5%)	.76
Readmission within 30 d of discharge	34 (13.1%)	14 (12.1%)	20 (14.0%)	.65
Anytime mitral valve re-operation	8 (3.1%)	6 (5.2%)	2 (1.4%)	.14
30-d mortality	1 (0.39%)	1 (0.9%)	0 (0.0%)	.45
1-y mortality	10 (3.9%)	4 (3.4%)	6 (4.2%)	1.0
5-y mortality	13 (5.0%)	5 (4.3%)	8 (5.6%)	.64
All-time mortality	17 (6.6%)	7 (6.0%)	10 (7.0%)	.76

LA, Left atriotomy; *STS*, superior transseptal; *SD*, standard deviation; *ICU*, intensive care unit; *MACE*, major adverse cardiac events.

include atrial flutter and bradycardia, which can be easier to manage postoperatively. In fact, a recent publication from our electrophysiology group looked at the STS cohort and described 8 examples of micro-reentrant right atrial flutters from slow conduction through this area of scar.[16] We hypothesize that the STS approach may increase the scar burden in the right atrium. Interestingly, for these cases, the ablations were performed from the RA not LA, with ablation usually combining CTI ablation and superior RA ablation between the SVC and the septal scar. This is in contrast to Afib ablation, which we generally approach as predominantly LA substrate.[16] Given these differences, it is incumbent upon electrophysiologists to be familiar with local surgical practices and make an effort to obtain operative reports before ablation of patients with a history of surgical atriotomy.

Rates of postoperative MACE events and mortality were similar in both groups ($P = 1.00$ and $P = .76$, respectively). With regards to intraoperative parameters, CPB time and ACC time were similar in both groups ($P = .97$ and $P = .44$, respectively). This is important to note, in that improved visualization with the STS approach does not prolong the operative time. We found slightly shorter ICU length of stay and total hospital length of stay after LA than STS ($P = .04$, and $P = .01$, respectively). This is likely attributed to the significant proportion of LAs performed via right minithoracotomy (87.1%) versus all (100%) of the STS approach cases being performed via median sternotomy. Both groups were routinely extubated within 24 hours of surgery, with the LA cohort spending 2 versus 3 days in the ICU and 8 versus 10 days in the hospital.

This study has associated limitations, including a retrospective observational approach, single-center nature, and limited sample size. The choice of access incision, namely full sternotomy versus minithoracotomy approaches, can confound the data; however, a larger incision should bias against the STS cohort and may explain the slightly greater rates of postoperative Afib and arrhythmias. Furthermore, surgical approach varied between operators. A larger, multicenter, controlled trial may yield more conclusive results. In addition, more thorough pre- and postoperative electrophysiology studies could provide data regarding preoperative sinus node function and subsequent arrhythmias. To further illustrate, "Afib" diagnoses after MVS may actually include macroreentry flutters, but because they do not have the typical CTI flutter electrocardiogram pattern, they may be misclassified as "Afib." Furthermore, there was a focus on short-term outcomes. Long-term follow-up may provide greater information regarding the durability and efficacy of each approach.

It should be highlighted that, to our knowledge, this study is one of the largest comparing the LA and STS approaches in patients undergoing isolated MVS. Thus, the effects of each surgical technique on outcome were evaluated without potential confounding concomitant cardiac procedures, such as tricuspid valve repair and coronary artery bypass grafting.

CONCLUSIONS

The STS approach preserves similarly low rates of postoperative complications and mortality as LA while simultaneously affording a greater field of exposure. Specifically, there are no differences in the incidence of postoperative permanent pacemaker placement, as well as new-onset AFib or arrhythmias in general. However, LA is associated with shorter ICU, postoperative, and total hospital length of stay times. Given these findings, the authors recommend cardiac surgeons employ their technique of preference between LA and STS when performing isolated MVS, in order to perform a near-perfect repair not constrained by surgical approach.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: mitral valve surgery, left atriotomy, superior transseptal, pacemaker, atrial fibrillation, arrhythmia, dysrhythmia