Repeat Sternotomy: No Longer a Risk Factor in Mitral Valve Surgical Procedures

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Background. The incidence of reoperative mitral valve (MV) surgical procedures is increasing, representing more than 10% of all MV operations in the United States. Previous clinical series have reported mortality rates of 5% to 18% and reentry injury rates of 5% to 10% for reoperative MV operations.

Methods. Between January 2004 and June 2012, 1,312 MV operations were performed on 1,275 patients. We excluded 234 patients who underwent small incision primary right thoracotomy, 11 redo operations with first or second operation other than sternotomy, and 10 emergent operations, leaving 1,056 MV operations for analysis (first-time sternotomy, 926 [88%]; repeat sternotomy, 130 (12%]). Preoperative computed tomography was performed for all repeat sternotomy patients. Patients at risk for reentry injury were identified, and protective strategies were applied systemically before resternotomy procedures.

Results. Among 130 patients undergoing reoperative MV operations, 35% (46/130) had prior coronary artery bypass grafting (CABG), 15% (19/130) aortic valve operations, and 61% (80/130) MV operations. Sixteen percent (21/130) had more than one previous sternotomy. Operative mortality was 4.6% (43/926) for first-time procedures and 4.6% (6/130) for reoperative MV operations. Intraoperative injury (innominate vein) occurred during repeat sternotomy in 2 (1.5%) patients. Stroke occurred in 3 patients (2%) who underwent repeat sternotomy and in 22 (2%) who underwent first-time sternotomy. On multivariable analysis, preoperative New York Heart Association function class, concomitant CABG, dialysis, and higher pulmonary artery pressures were associated with operative mortality, and repeat sternotomy was not.

Conclusions. With careful planning and execution, outcomes for reoperative MV operations in contemporary practice are favorable and are identical with those for first-time operations.

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Although the incidence of reoperative coronary artery bypass grafting (CABG) is declining (6% in 2000, 3.4% in 2009) [1], reoperative mitral valve (MV) procedures are increasingly common, representing over 10% of all MV operations in the United States [2, 3]. Repeat sternotomy is known to carry a finite risk of morbidity, including injury to the cardiac structures and previously placed coronary artery bypass grafts [3–7]. Previous clinical series have reported mortality rates between 6% and 18% for reoperative MV operations [3–7]. The incidence of intraoperative injury to cardiac structures has been reported to occur in 5% to 10% of resternotomies [3–8].

Several protective strategies have been described for reoperative MV surgical procedures, including femoral vessel exposure before sternotomy [6], prophylactic initiation of cardiopulmonary bypass (CPB) [6], and a right thoracotomy approach [9–12]. Preoperative computed tomography (CT) scanning is performed to visualize the relationship of the mediastinal contents to the sternum and to identify the patients at risk for injury during reentry [13]. Our preferred approach for MV operations in patients with previous cardiac operations is to perform redo sternotomy. On the basis of the proximity of the heart and great vessels to the sternum and the presence and location of patent bypass grafts, we systemically categorize patients into high-risk and low-risk groups and tailor operative techniques accordingly. The present report represents our experience with 130 patients who underwent repeat sternotomy for MV operation, and it compares the outcomes with those in a cohort undergoing first-time sternotomy. We hypothesized that reoperative MV operation is not a risk factor for adverse outcomes and that sternal reentry for MV operation can be performed with no increase in morbidity and mortality compared with first-time sternotomy.

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Material and Methods

Between January 2004 and June 2012, 1,312 MV operations were performed on 1,275 patients at our institution.

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Patients who underwent small incision right thoracotomy at initial (n = 241) or subsequent procedures (n = 4) were excluded (Fig 1). Two patients had a history of sternotomy and right lateral thoracotomy, and 1 patient had a history of left thoracotomy and sternotomy (not excluded). One patient required MV operation 2 days (same admission) after an aortic valve procedure and CABG (excluded).

Thoracic CT was performed in all patients to identify patients at risk for reentry injuries. Coronary artery catheterization was performed to identify the location and patency of previously placed grafts and native coronary arteries. Patients were categorized into two groups based on the risk of reentry injury (Fig 2). This retrospective study was approved by the institutional review board, and patient consent was waived.

Surgical Technique

The reoperations systematically followed the established protocols. Any patient who had previously undergone a cardiac operation received a CT scan (Fig 3) and coronary artery/graft catheterization. If the risk of reentry injury was considered high, the femoral vessels were exposed in case rapid institution of CPB became necessary. The sternum was reopened by use of an oscillating saw with continuous upward traction on the anterior sternum. Towel clips were placed in midsternum on both sides and were lifted with force vector completely toward the ceiling, with no lateral force applied. Once sternotomy was complete, dissection was started on the diaphragmatic surface of the heart. The goal was to expose the right atrium and aorta to allow central cannulation. Both pleural spaces were routinely opened to minimize tension on mediastinal structures and to allow the heart to rotate toward the left to improve exposure of the MV. In case of a noneventful reentry, CPB was instituted by use of central cannulation. Early in the series, patent internal mammary arteries were dissected and clamped, but as our experience grew and evolved, we left the mammary undissected to avoid injury. In these cases, the patient was cooled to 30°C. In all other cases, the lowest temperature on CPB was 35.5°C. Although it was not commonly required, we did not hesitate to decompress the heart by peripheral cannulation for further dissection [3, 6, 8]. We routinely plan for subsequent operations by using several strategies, including avoiding dissection of the plane between the aorta and the pulmonary artery, loosely reapproximating the pericardium, routing the internal mammary artery through a slit in the pericardium and under the left upper lobe (the shortest root from the origin of the left internal mammary to the left anterior descending) [14], and applying polyethylene glycol polymers (Coseal, Baxter Inc, Deerfield, IL) to the heart before chest closure in cases wherein the pericardium is inadequate or the risk of reoperation is considered elevated.

Intraoperative injury was defined as any injury to mediastinal structures. Operative mortality, defined as the greater of death in hospital or in 30 days after hospital discharge, was recorded. The primary endpoints of the study were injury during reentry, operative mortality, and morbidity.

Statistical Analysis

Analyses were performed with JMP 8.0 statistical software (SAS Institute Inc, Cary, NC). Continuous variables are reported as the mean ± standard deviation or median with the interquartile range. Categoric variables are presented as proportions. Patients' characteristics were compared with the χ^2 test, Fisher's exact test, Student's *t* test, and one-way analysis of variance. Logistic regression analysis of clinically relevant factors was performed to determine the independent predictors of operative mortality. Long-term survival was evaluated with the Kaplan-Meier method, and the log-rank test was used to compare groups.

Results

Overall, 926 primary MV operations and 130 repeat sternotomy MV operations were performed: 109 patients had a history of one sternotomy, 18 patients two sternotomies, and 3 patients three sternotomies. The incidence of repeat sternotomy MV operations has increased

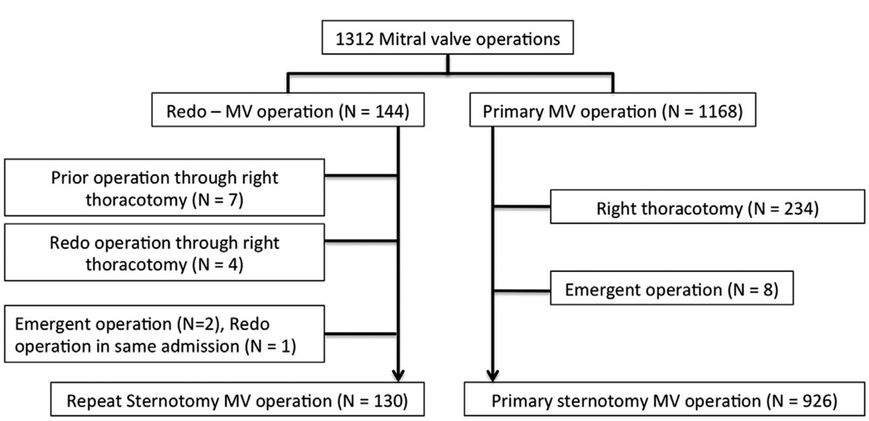

Fig 1. Patient population. (MV = mitral valve.)

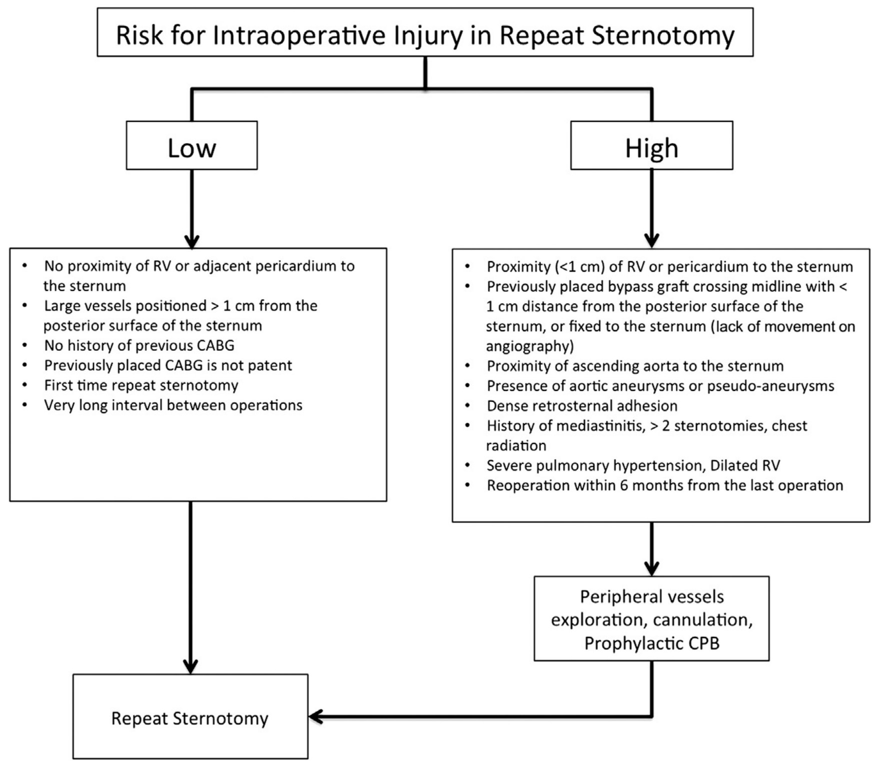

Fig 2. Protocol used for patients with a history of sternotomy undergoing mitral valve operation. (CABG = coronary artery bypass grafting; CPB = cardiopulmonary bypass; MV = mitral valve.)

over time (Fig 4). Of 926 patients who underwent primary MV operation at our institution, 2.5%(21/926) required subsequent repeat sternotomy MV operations and were included in both groups. A total of 130 repeat sternotomies were performed on 122 patients.

Most preoperative patients' characteristics were similar between the two groups (Table 1). However, patients in the reoperative sternotomy group were more symptomatic in comparison with the primary group.

The mean interval between reoperative sternotomy and prior cardiac operation was 7 ± 7 years. Among repeat sternotomy operations, 1.5% (2/130) had a history of chest radiotherapy and 0.7% (1/130) had a history of mediastinitis. A history of CABG was present in 35% (46/130), and 61% (80/130) had undergone prior MV operations (Table 2).

Operative Characteristics

The femoral vessels were exposed before repeat sternotomy in 37% (48/130) of patients who were classified as being at high risk on the basis of preoperative CT assessment. Cannulation of the femoral vessels was performed in 7% (9/130). In 5 patients, cannulation and institution of CPB was performed after sternotomy to decompress the heart to facilitate dissection in the

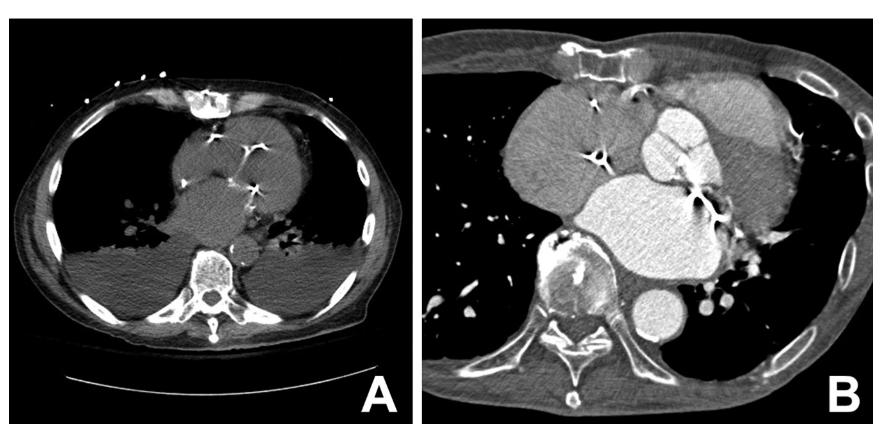

Fig 3. (A) Computed tomography scans of a patient at low risk and (B) a patient at high risk for intraoperative injury.

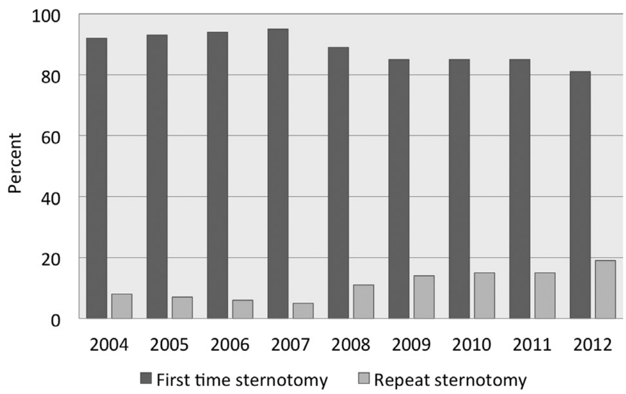

Fig 4. Percentage of primary and repeat sternotomy mitral valve operations.

presence of dense adhesions; in 2 patients, cannulation and CPB was performed before sternotomy; and in 2 patients, cannulation and CPB was performed after sternotomy as a result of injury during reentry. The operative characteristics are summarized in Table 3.

Outcomes

Operative mortality was 4.6% (43/926) in the first-time sternotomy group and 4.6% (6/130) in the repeat sternotomy group. The causes of death in repeat sternotomy patients included sudden cardiac death (2), tamponade (1), multisystem organ failure (2), and hemorrhagic shock (1).

Operative mortality was not significantly different between the second-time sternotomy (4.5%, 5/109) patients and those who had 2 or more prior sternotomies (4.5%, 1/22). Intraoperative injury (innominate vein) occurred during repeat sternotomy in 2 patients. One of the patients had a history of thymectomy. The innominate vein was injured upon reentering the sternum. The femoral vessels were immediately explored and cannulated. CPB was instituted, and the heart was decompressed. The bleeding site was controlled and repaired with multiple pledgeted sutures. The patient survived the operation and was discharged 5 days later. Another patient had a history of chest radiation and mediastinal tumor resection. The patient was considered to be at high risk for intraoperative injury, and therefore the femoral vessels were exposed before resternotomy. The adhesions were extremely dense, with a large calcified mass at the superior aspect of the incision. Sternal retraction caused a tear in the innominate vein. This was controlled with digital pressure. The previously exposed femoral vessels were cannulated, and CPB was instituted. The defect in the innominate vein was repaired with a bovine pericardial patch. The patient underwent a technically successful operation but died of respiratory failure and septic shock 2 months after the procedure.

The median operative times for the first-time and repeat sternotomy groups were 216 (IQR 175–271) minutes and 266 (IQR 230–309) minutes, respectively ($p < 0.0001$). No significant difference was observed between the two groups in terms of postoperative morbidities including stroke, reoperation for bleeding, prolonged ventilation, new postoperative atrial fibrillation, or dialysis (Table 4).

Actuarial survival in patients who underwent first-time MV operation at 1 and 3 years was 89% and 79%, compared with 85% and 71% in patients who underwent repeat sternotomy (Fig 5).

On univariate analysis, repeat sternotomy was not a risk factor for operative mortality. Predictors of operative mortality on univariate analysis included diabetes, dialysis, infective endocarditis, peripheral arterial disease, prior myocardial infarction, concomitant CABG, concomitant aortic valve procedure, MV replacement, tricuspid valve procedure, New York Heart Association (NYHA) functional class III/IV, and preoperative systolic

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Table 1. Selected Preoperative Patient Characteristics

Characteristic	Overall (n = 1,056)	First-Time Sternotomy (N = 926)	Repeat Sternotomy (n = 130)	*p*
Mean age, y	62 ± 14	62 ± 14	62 ± 15	0.920
Male	569 (54%)	497 (53%)	72 (55%)	0.778
Diabetes	238 (23%)	207 (22%)	32 (24%)	0.736
Dialysis	71 (7%)	63 (7%)	8 (6%)	0.590
Previous MI	165 (15%)	146 (16%)	19 (15%)	0.797
Previous CVA	142 (13%)	118 (13%)	24 (18%)	0.053
AF	405 (38%)	347 (37%)	58 (44%)	0.123
NYHA				
Class I/II	467 (44%)	433 (47%)	34 (26%)	<0.0001
Class III/IV	589 (56%)	493 (53%)	96 (74%)	
SPAP (mean ± SD, mm Hg)	46 ± 16	46 ± 16	49 ± 21	0.384
EF	50% ± 15%	50% ± 15%	51% ± 12%	0.132

AF = atrial fibrillation; CVA = cerebrovascular accident; EF = ejection fraction; MI = myocardial infarction; NYHA = New York Heart Association functional class; SD = standard deviation; SPAP = systolic pulmonary artery pressure.

Table 2. Prior Operations in Reoperative Sternotomies (n = 130)

Variable	n (%)
Coronary artery bypass graft	46 (35%)
Number of bypass grafts	
1	5
2	16
3	18
4	6
5	1
Patent mammary	37 (77%)
Mitral valve operation	80 (61%)
Repair	39 (30%)
Replacement	41 (31%)
CryoMaze	3 (2%)
Aortic procedure	22 (17%)
Tricuspid valve replacement	1 (0.8%)
Other	7 (6%)

pulmonary artery pressure. On multivariable analysis, preoperative NYHA function class (class III/IV vs class I/II: OR = 3.67, 95% CI = 1.38–14.28, $p < 0.01$), concomitant CABG (OR = 2.20, 95% CI = 1.01–5.0, $p = 0.04$), dialysis (OR = 5.94, 95% CI = 2.36–14.15, $p < 0.01$), and preoperative systolic pulmonary artery pressure (OR = 1.02 per 1 mm Hg increment, 95% CI = 1.01–1.05, $p = 0.01$) were independently associated with operative mortality.

Comment

The key findings of this study include the following: (1) reoperative MV surgical procedures are increasingly common, with reoperation representing almost 20% of all MV operations in a contemporary practice; (2) repeat sternotomy MV operation can be performed with low perioperative mortality (4.6%) and low reentry injury rate (1.5%); (3) repeat sternotomy MV operation is not an independent risk factor for operative mortality or morbidity; and (4) the use of CT scanning in the setting of re-sternotomy is essential for optimal planning of operation.

Although the incidence of reoperative CABG has significantly decreased during the past 20 years [1], reoperative MV procedures have increased significantly in current clinical practice. In large series, more than 10% of patients undergoing MV operation have a history of previous cardiac operation [2, 3]. In the current study, 12% of MV operations were reoperations, and this percentage has increased over time (almost 20% in 2012). The incidence of reoperative MV procedures is increasing for several reasons. The survival of patients with prior CABG or aortic valve replacement has

Table 3. Operative Characteristics

Characteristic	Overall (n = 1,056)	First-Time Sternotomy (n = 926)	Repeat Sternotomy (n = 130)	p
MV pathology				
Leaflet prolapse	315 (30%)	304 (33%)	11 (8%)	<0.0001
Type I	199 (19%)	176 (19%)	23 (18%)	0.382
Functional	113 (11%)	109 (12%)	4 (3%)	0.001
Rheumatic	153 (15%)	140 (15%)	13 (10%)	0.142
Infective endocarditis	179 (17%)	151 (16%)	28 (21%)	0.135
Recurrence of MR	22 (2%)	-	22 (15%)	
Prosthetic valve degeneration	11 (1%)	-	11 (9%)	
Paravalvular leak	8 (1%)	-	8 (9%)	
Thrombosis in prosthetic valve	5 (0.5%)	-	5 (4%)	
Left heart mass	12 (2%)	11 (1.5%)	1 (0.7%)	
Other	11 (1%)	9 (1%)	2 (1%)	
NA	28 (3%)	26 (3%)	2 (1.5%)	
Mitral stenosis	107 (10%)	86 (9%)	21 (16%)	0.019
MV operation				
Repair	741(70%)	686 (74%)	55 (42%)	<0.0001
Replacement	315(30%)	240 (26%)	75 (58%)	
Concomitant procedures				
CABG	310 (29%)	293 (31%)	17 (13%)	<0.0001
Aortic valve procedure	152 (14%)	134 (14%)	18 (13%)	0.789
Tricuspid valve procedure	218 (20%)	179 (19%)	39 (29%)	0.010
CryoMaze	276 (26%)	256 (28%)	20 (15%)	0.002

CABG = coronary artery bypass grafting; MR = mitral regurgitation; MV = mitral valve; NA = not available.

Table 4. Operative Outcomes

Characteristic	Overall (n =1056)	First-Time Sternotomy (n = 926)	Repeat Sternotomy (n = 130)	*p*
Operative mortality	49 (4.6%)	43 (4.6%)	6 (4.6%)	1.000
Reoperation for bleeding	57 (5.3%)	52 (5.6%)	5 (4%)	0.534
Stroke	25 (2.3%)	22 (2.3%)	3 (2.2%)	1.000
Prolonged ventilation	261 (25%)	226 (24%)	35 (26%)	0.664
Pneumonia	39 (3.7%)	37 (4%)	2 (1.5%)	0.216
Atrial fibrillation	145 (14%)	128 (14%)	17 (13%)	0.892
Sternal infection	10 (0.9%)	8 (0.8%)	2 (1.5%)	0.353
Dialysis	41 (3.8%)	36 (3.8%)	5 (3.8%)	1.00
Cardiopulmonary bypass time, min: median (IQR)	121(94–155)	121 (94–154)	117 (94-160)	0.380
Cross-clamp time, min: median (IQR)	100 (75–124)	101 (76-125)	88 (72-119)	0.122
Length of stay, days: median (IQR)	8 (5–12)	7 (5–12)	9 (6–14)	0.311

IQR = interquartile range.

improved [15]. MV disease, predominantly mitral regurgitation, was not infrequently neglected at the time of prior operations in the majority of these patients. In addition, redo MV operation after a successful repair occurs at a linearized rate of 1% to 4% per year [16–18]. The use of bioprosthetic rather than mechanical valves has increased remarkably during the past decade (30% in 2000, 63% in 2007) [2]. The lifetime risk of reoperation for a patient 50 years of age undergoing bioprosthetic valve replacement is approximately 45% [19].

Despite the increased number of patients who require MV reoperation, a limited number of contemporary studies have reported the outcomes of reoperative MV procedures through sternotomy, with most published literature focusing on nonsternotomy approaches (Table 5) [20–23].

The current study confirms the favorable outcomes of reoperative MV operation with low intraoperative injury and perioperative mortality and morbidity rates. A reoperative MV procedure was not found to be a risk factor for operative mortality even though patients undergoing reoperation were more symptomatic and more frequently required multiple valve operations. The incidence of all major postoperative morbidities including stroke, atrial fibrillation, prolonged ventilation, and length of hospital stay were similar among the two groups.

It is still controversial whether reoperation is an independent risk factor in reoperative CABG or valve procedures [1, 7, 24]. Sabik and colleagues [7] compared the outcomes of 17,000 primary CABG in 4,500 reoperative patients. Those in the reoperative group were older, had more comorbidities, and were more symptomatic. Operative mortality was 1.5% for patients undergoing isolated CABG and 4.4% for reoperative patients. The authors concluded that the higher rate of hospital mortality among reoperative CABG patients was

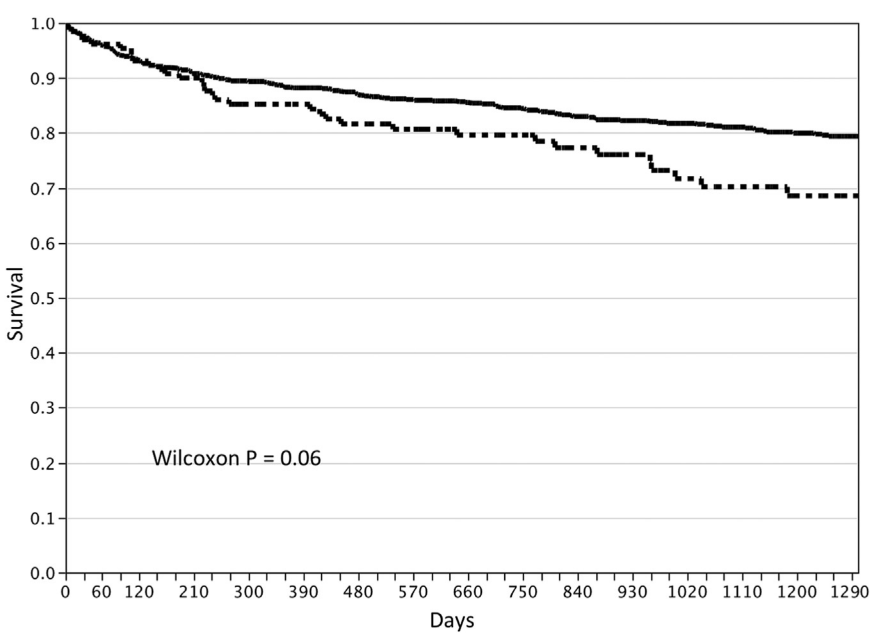

Fig 5. Kaplan-Meier analysis of survival in for patients undergoing first-time sternotomy mitral valve operation (n = 926) (continuous line) compared with those who underwent repeat operation (n = 130).

Table 5. Selected Published Studies in Contemporary Practice for Reoperative Mitral Valve Surgical Procedures[a]

Study	Technique	Key Results	Comments	Conclusion
Arcidi et al [11], 2012, n = 167, right thoracotomy	129: FA 39: AO/CPB 1: Both	Mortality: 3% Stroke: 2.4% Pneumonia: 10.8%	No comparison with sternotomy, concomitant CABG/AV procedures excluded	Right thoracotomy supplanted sternotomy as preferred approach
Romano et al [12], 2012, n = 450, right thoracotomy	134: FA 316: AO/CPB	Mortality: 7% Stroke: 2.4%	No comparison with sternotomy, concomitant CABG/AV procedures excluded	Redo right thoracotomy MV procedure on beating heart is safe, effective, associated with low operative mortality
Seeburger et al. [9], 2009, n = 181, right thoracotomy	140: FA 31: AO/CPB 10: Beating heart	Mortality: 6.6%, Conversion to sternotomy: 1.6%Stroke: 3.8% Reoperation for bleeding: 12%	No comparison with sternotomy, concomitant CABG/AV operation/ prior right thoracic excluded	Right thoracotomy is a safe alternative to redo sternotomy
Meyer et al [23], 2009, n = 107, right thoracotomy	75: AO/CPB 21: FA 11: Chitwood clamp	Mortality: 4.7% Stroke: 1% Aortic dissection: 1%	No comparison with sternotomy, concomitant CABG/AV operation excluded	Right thoracotomy may be preferred technique for reoperative MV procedure
Ricci et al [21], 2009, n = 241, right thoracotomy	AO/CPB	Mortality: 4.9% Conversion to sternotomy: 0.8% Stroke:5.8%	No comparison with sternotomy	Right thoracotomy is operation of choice for reoperations in contemporary practice

[a] All are retrospective studies.

AV = aortic valve; CABG = coronary artery bypass grafting; CPB = cardiopulmonary bypass; MV = mitral valve; FA = fibrillatory arrest; AO = aortic occlusion.

attributable to the higher risk profile of reoperative patients, not reoperation itself [7].

The reported rate of intraoperative injury for patients undergoing reoperative cardiac procedures is between 7% and 10% [3, 6, 8]. Roselli and colleagues [6] studied 1,847 patients who underwent reoperative cardiac procedures and observed that 7% of patients had a life-threatening injury during reoperation. Risk factors for injury included chest radiation and multiple prior cardiac operations. Operative mortality was significantly higher if intraoperative injury occurred [6]. In another study, 2,555 patients who underwent repeat sternotomy for cardiac operations were investigated [3]. Intraoperative injury occurred in 9%. The overall operative mortality was 7.6% and was significantly higher if reentry injury occurred (6.5% vs 18.5%). In contrast to these results, Ellman and colleagues [4] found that intraoperative injury was not associated with adverse outcomes in a study of 612 resternotomies. The rate of intraoperative injury was 9%. The most common injured structures were patent coronary graft (46%) and right ventricle (21%). Operative mortality was 9% and was not significantly different between the cardiac injury group and the group that did not have an injury. The authors found that performance of CPB before sternotomy did not decrease the risk of intraoperative injury [4]. In contrast to these experiences, intraoperative injury was extremely uncommon in the current study, with no injury to previously placed coronary grafts and only two innominate vein injuries. One possible explanation is that the procedures followed the established protocols as described in the methods section of this article.

Potter and colleagues [8] reported the results in 106 patients who underwent MV re-replacement for failed MV prosthesis and compared the outcomes with those in 562 patients who underwent primary MV replacement. Operative mortality was similar for the reoperative (4.7%) and primary (4.1%) groups. The authors concluded that given the low operative risk of redo MV replacement, there should increased use of bioprosthetic rather than mechanical valves at the time of primary mitral operations [8]. This series was limited to patients with prior isolated MV replacements and did not include patients with prior CABG. Infective endocarditis was significantly less common in the experience of Potter and colleagues [8] (6%) than in the present series (21%). Others advocate a right thoracotomy approach for reoperative mitral operations as a safe alternative to conventional redo sternotomy [9, 10, 11, 12] (Table 5). Arcidi and colleagues [11] reported the outcomes in 167 patients who underwent small incision right thoracotomy for reoperative MV procedures. Fibrillatory arrest at 26°C was used for myocardial protection in most patients (77%). The 30-day operative mortality was 3%. Stroke occurred in 2.4% of patients and pneumonia in 10.8%. The authors concluded that small incision right thoracotomy is the preferred approach for reoperative MV procedures [11]. However, this study was limited to patients who required isolated MV operations. In addition, the patients were less symptomatic (NYHA class III/IV, 54%) than were those in the current study (72% of patients with severe heart failure symptoms).

Although the results of right lateral thoracotomy with fibrillatory arrest were satisfactory in the series by Arcidi and colleagues [11], in broader use fibrillatory arrest is associated with a substantially increased risk of stroke in primary and reoperative MV operations [25, 26].

Romano and colleagues [12] reviewed the outcomes in 450 patients who underwent redo right MV operation through a right thoracotomy. Fibrillatory arrest was used in 134 patients, and 316 patients underwent beating heart surgical procedures [12]. The core temperature during CPB for the beating heart group was 32°C, versus 26°C for the ventricular fibrillation group. The 30-day mortality was 7% and was similar for both techniques. Stroke rate was 2.6% for the beating heart group and 3% for the ventricular fibrillation group. The fibrillatory arrest group required substantially more blood products, had longer CPB times, and was intubated twice as long as the beating heart group. Fibrillatory arrest has risks of subendocardial hypoperfusion mismatch [12]; as a result, those authors favor the beating heart approach. Although this study was limited to patients who did not require simultaneous CABG or aortic valve replacement, the mortality rate was somewhat higher than that in the current series.

We acknowledge the limitations of this retrospective study with a diverse group of patients. The data for intraoperative injuries were obtained retrospectively from the operative notes. Although all operative notes were checked with the surgeon's personal notes, there is a possibility that some minor injuries may have not been recorded.

Conclusions

This study supports the safety of repeat sternotomy MV operation with low perioperative mortality and morbidity and low rates of intraoperative injury. With careful planning and execution, the outcomes in redo-sternotomy MV operations are favorable and are identical with those of first-time operation. Repeat sternotomy is the operation of choice for most patients with a previous sternotomy who require MV operation.

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