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COMPARISON OF POSTOPERATIVE OUTCOMES FOLLOWING MINIMALLY INVASIVE CARDIAC SURGERY MITRAL VALVE REPLACEMENT AND MITRAL VALVE REPLACEMENT THROUGH MEDIAN STERNOTOMY

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ABSTRACT

Background: Mitral valve replacement (MVR) is conventionally performed through a median sternotomy. Right minithoracotomy minimally invasive cardiac surgery (MICS) has emerged as an alternative, but comparative data on early postoperative outcomes from resource-limited, rheumatic-predominant settings remain limited. We compared perioperative and early postoperative outcomes between MICS-MVR and conventional sternotomy MVR.

Materials and Methods: In this single-centre comparative study, 30 adults undergoing isolated MVR were analysed in two groups of 15 — MICS-MVR via right minithoracotomy and conventional median sternotomy MVR. Baseline, intraoperative and early postoperative variables were compared. Continuous variables were compared with the independent-samples t-test and categorical variables with the Fisher exact test; $p < 0.05$ was considered significant.

Results: Groups were comparable in age, sex, body mass index, functional class, etiology and ventricular function. Cardiopulmonary bypass (140.5 ± 15.7 vs 105.1 ± 10.4 min) and aortic cross-clamp times (89.7 ± 12.0 vs 68.5 ± 8.6 min) were significantly longer with MICS (both $p < 0.001$). MICS was associated with lower intraoperative blood loss (356.4 ± 67.5 vs 562.5 ± 166.5 mL), reduced 24-h chest drainage (368.0 ± 101.7 vs 585.0 ± 134.1 mL), shorter intensive care (2.5 ± 0.7 vs 3.1 ± 0.7 days; $p = 0.018$) and hospital stay (7.1 ± 1.5 vs 9.2 ± 1.9 days; $p = 0.002$), lower 24-h pain scores (3.5 ± 0.8 vs 4.9 ± 1.2; $p = 0.001$) and faster return to usual activity (32.6 ± 7.4 vs 49.2 ± 11.0 days; $p < 0.001$). One MICS case (6.7%) required conversion to sternotomy. Thirty-day mortality (0 vs 1; $p = 1.000$) and major morbidity did not differ significantly.

Conclusion: In this small comparative series, MICS-MVR achieved early mortality and major morbidity comparable to conventional sternotomy while offering less bleeding, less pain and faster recovery, at the expense of longer bypass and cross-clamp times. Findings are exploratory and require confirmation in adequately powered prospective studies.

Keywords: mitral valve replacement; minimally invasive cardiac surgery; minithoracotomy; median sternotomy; rheumatic heart disease; postoperative outcomes.

INTRODUCTION

Mitral valve disease remains a major contributor to the cardiac surgical workload in low- and middle-income countries, where chronic rheumatic heart disease continues to be the dominant etiology and frequently affects young, economically productive patients.[1] In contrast to the degenerative pathology that predominates in high-income settings, rheumatic disease commonly produces fibrotic, calcified and subvalvular-thickened valves that are less amenable to durable repair, so that mitral valve replacement

(MVR) rather than repair is performed in a substantial proportion of patients.[1-7]

Median sternotomy has been the standard access for mitral surgery for decades because it provides wide, familiar exposure of the heart, flexibility in myocardial protection and direct central cannulation. However, full sternotomy is associated with greater surgical trauma, a risk of sternal wound complications and mediastinitis, more postoperative pain, slower return to normal activity and a visible midline scar.[8-10] These considerations have driven sustained interest in less invasive access. Following the introduction of port-access and video-assisted techniques in the mid-1990s,[2] minimally invasive cardiac surgery (MICS) through a small right antero-lateral minithoracotomy has become an established approach at experienced centres, with reported repair and replacement results comparable to sternotomy.[3,6]

The accumulated evidence comparing minimally invasive mitral surgery with conventional sternotomy is dominated by observational cohorts and a smaller number of randomized trials, most of which address mitral repair for degenerative disease. Meta-analyses have consistently reported equivalent early mortality with the minimally invasive approach, alongside reduced transfusion, less atrial fibrillation, fewer sternal infections and shorter hospital stay, but at the cost of longer cardiopulmonary bypass and aortic cross-clamp times.[3,5,7,9] The UK Mini Mitral randomized trial subsequently confirmed that minithoracotomy repair is as safe and effective as sternotomy at one year, with faster early recovery, though it did not meet its primary 12-week physical-function endpoint.[10]

Despite this body of work, data specifically describing MVR (rather than repair) performed minimally invasively are comparatively sparse, and evidence from rheumatic-predominant populations is limited. Whether the recovery advantages observed for degenerative repair translate to a replacement population with rheumatic valves, longer ischaemic times and frequent mechanical prostheses is not well established. Rheumatic valves are typically more fibrotic and calcified, the left atrium is often enlarged with dense adhesions, and replacement rather than repair is the rule, so the operative challenge — and potentially the balance of risks and benefits — may differ from the degenerative repair cohorts that dominate the published trials. We therefore undertook a single-centre comparative study to evaluate perioperative and early postoperative outcomes of MICS-MVR via right minithoracotomy versus conventional median sternotomy MVR, with particular attention to bypass and cross-clamp times, bleeding, recovery metrics, early morbidity and 30-day mortality.

MATERIAL AND METHODS

Study design and population: This was a single-centre comparative study of 30 consecutive adult patients who underwent isolated MVR. Patients were allocated to one of two groups according to surgical access: the MICS-MVR group (n = 15), operated through a right antero-lateral minithoracotomy, and the conventional group (n = 15), operated through a standard median sternotomy. Adults aged 18–65 years with severe mitral valve disease (stenosis, regurgitation or mixed lesion) requiring replacement were eligible. Patients requiring concomitant coronary, aortic or complex multi-valve procedures, those with prior cardiac surgery, severe peripheral vascular or aorto-iliac disease, significant pulmonary disease precluding single-lung ventilation, or emergency presentations were excluded so that the two groups were broadly comparable. The study was conducted in accordance with the principles of the Declaration of Helsinki; institutional ethics committee approval and written informed consent were obtained [to be completed by the authors].

Operative technique: All operations were performed under general anaesthesia with the patient supine. In the conventional group, MVR was carried out through a full median sternotomy with central aortic and bicaval cannulation, and the mitral valve was approached through a standard left atriotomy. In the MICS group, a 5–6 cm working incision was made in the right fourth or fifth intercostal space, with femoral arterial and venous cannulation for peripheral cardiopulmonary bypass and CO_2 field flooding. Myocardial protection was achieved with antegrade cardioplegia and the cross-clamp applied through the thoracotomy or with a trans-thoracic clamp; the valve was exposed via a left atriotomy through the interatrial groove. In both groups, the diseased valve was excised with appropriate preservation of subvalvular apparatus where feasible, and a mechanical or bioprosthetic prosthesis was implanted with pledgeted sutures according to standard practice and patient factors.[2,6] Conversion from minithoracotomy to sternotomy, when required for exposure, bleeding or haemodynamic instability, was recorded as an outcome.

Outcomes and definitions: The intraoperative variables of interest were cardiopulmonary bypass time, aortic cross-clamp time, total skin-to-skin operative time, estimated intraoperative blood loss and conversion to sternotomy. Early postoperative outcomes comprised duration of mechanical ventilation, intensive care unit (ICU) stay, total postoperative hospital stay, cumulative chest tube drainage in the first 24 hours, units of packed red blood cells (PRBC) transfused, proportion of patients receiving any transfusion, a 24-hour pain score on a 0–10 visual analogue scale (VAS) and self-reported time to return to usual activity. Postoperative complications recorded were new-onset atrial fibrillation, pneumonia, surgical site (sternal or thoracotomy) infection, re-exploration for bleeding, stroke and acute kidney injury (defined by KDIGO stage ≥ 1). The primary safety outcome was all-cause 30-day mortality.

Statistical analysis: Continuous variables are presented as mean ± standard deviation and were compared between groups using the independent-samples (Welch) t-test. Categorical variables are presented as frequencies and percentages and were compared using the Fisher exact test, which is appropriate for the small sample size and low expected cell counts. A two-sided p-value < 0.05 was considered statistically significant. Given the limited sample, analyses were unadjusted and should be regarded as exploratory; no imputation was undertaken as the dataset was complete. Analyses were performed using standard statistical software.

RESULTS

Baseline characteristics: The two groups were well matched at baseline [Table 1]. Mean age was 43.6 ± 6.0 years in the MICS group and 39.1 ± 10.1 years in the sternotomy group (p = 0.155), and the proportion of women was similar (33.3% vs 46.7%; p = 0.710). Body mass index, preoperative haemoglobin and left ventricular ejection fraction did not differ significantly between groups. Rheumatic disease was the predominant etiology in both arms (80.0% each), reflecting the local disease pattern,[1] and the distribution of predominant lesion (stenosis, regurgitation or mixed) was comparable. Most patients were in New York Heart Association class III/IV (80.0% vs 66.7%; p = 0.682), and mechanical prostheses were implanted in the majority of patients in both groups (80.0% each), consistent with a young, rheumatic population.

Intraoperative outcomes: Intraoperative findings are summarized in [Table 2]. Both cardiopulmonary bypass time (140.5 ± 15.7 vs 105.1 ± 10.4 minutes) and aortic cross-clamp time (89.7 ± 12.0 vs 68.5 ± 8.6 minutes) were significantly longer in the MICS group (both p < 0.001), and total operative time was correspondingly longer (297.2 ± 24.2 vs 229.1 ± 22.3 minutes; p < 0.001). Despite the longer ischaemic and perfusion times, estimated intraoperative blood loss was markedly lower with MICS (356.4 ± 67.5 vs 562.5 ± 166.5 mL; p < 0.001). One MICS patient (6.7%) required intraoperative conversion to sternotomy; there were no deaths associated with conversion.[6]

Postoperative recovery: Early recovery metrics favoured the minimally invasive approach (Table 3). Although the duration of mechanical ventilation was numerically shorter with MICS, the difference did not reach significance (8.2 ± 2.9 vs 9.6 ± 4.4 hours; p = 0.317). ICU stay (2.5 ± 0.7 vs 3.1 ± 0.7 days; p = 0.018) and total hospital stay (7.1 ± 1.5 vs 9.2 ± 1.9 days; p = 0.002) were both significantly shorter after MICS. Cumulative 24-hour chest tube drainage was substantially lower in the MICS group (368.0 ± 101.7 vs 585.0 ± 134.1 mL; p < 0.001). The mean number of PRBC units transfused was lower with MICS (0.9 ± 0.9 vs 1.5 ± 1.1; p = 0.116) and the proportion receiving any transfusion was also lower (66.7% vs 86.7%; p = 0.390), although neither reached statistical significance. Patients undergoing MICS reported lower 24-hour pain scores (3.5 ± 0.8 vs 4.9 ± 1.2; p = 0.001) and returned to usual activity considerably sooner (32.6 ± 7.4 vs 49.2 ± 11.0 days; p < 0.001).

Complications and mortality: Postoperative complications and mortality are shown in Table 4. New-onset atrial fibrillation occurred less often after MICS (13.3% vs 33.3%; p = 0.390). Pneumonia (0% vs 13.3%), surgical site infection (0% vs 13.3%) and re-exploration for bleeding (0% vs 13.3%) were all observed only in the sternotomy group, although none of these differences reached statistical significance given the small numbers. Stroke (0% vs 6.7%) and acute kidney injury (6.7% vs 13.3%) were infrequent and comparable. There were no deaths in the MICS group and one death (6.7%) in the sternotomy group within 30 days (p = 1.000). Overall, the early safety profile of MICS-MVR was at least comparable to that of conventional sternotomy in this cohort.

Table 1: Baseline and preoperative characteristics of the study groups.

Variable	MICS-MVR (n=15)	Sternotomy-MVR (n=15)	p-value
Age, years (mean ± SD)	43.6 ± 6.0	39.1 ± 10.1	0.155
Female sex, n (%)	5 (33.3)	7 (46.7)	0.710
Body mass index, kg/m² (mean ± SD)	22.7 ± 2.1	23.2 ± 1.9	0.509
NYHA class III/IV, n (%)	12 (80.0)	10 (66.7)	0.682
Rheumatic etiology, n (%)	12 (80.0)	12 (80.0)	1.000
Predominant lesion — stenosis, n (%)	7 (46.7)	7 (46.7)	1.000
Predominant lesion — regurgitation, n (%)	4 (26.7)	5 (33.3)	1.000
Predominant lesion — mixed, n (%)	4 (26.7)	3 (20.0)	1.000
Preoperative LVEF, % (mean ± SD)	57.9 ± 6.6	55.0 ± 7.4	0.272
Preoperative haemoglobin, g/dL (mean ± SD)	12.3 ± 0.9	12.3 ± 1.6	0.944
Mechanical prosthesis, n (%)	12 (80.0)	12 (80.0)	1.000

Values are mean ± SD or n (%). NYHA, New York Heart Association; LVEF, left ventricular ejection fraction. Continuous variables compared with the independent-samples t-test; categorical variables with the Fisher exact test.

Table 2: Intraoperative variables.

Variable	MICS-MVR (n=15)	Sternotomy-MVR (n=15)	p-value
Cardiopulmonary bypass time, min	140.5 ± 15.7	105.1 ± 10.4	<0.001
Aortic cross-clamp time, min	89.7 ± 12.0	68.5 ± 8.6	<0.001
Total operative time, min	297.2 ± 24.2	229.1 ± 22.3	<0.001

Intraoperative blood loss, mL	356.4 ± 67.5	562.5 ± 166.5	<0.001
Conversion to sternotomy, n (%)	1 (6.7)	—	—

Values are mean ± SD or n (%). Conversion to sternotomy is not applicable to the sternotomy group. Continuous variables compared with the independent-samples t-test.

Table 3: Early postoperative recovery outcomes.

Variable	MICS-MVR (n=15)	Sternotomy-MVR (n=15)	p-value
Mechanical ventilation, h	8.2 ± 2.9	9.6 ± 4.4	0.317
ICU stay, days	2.5 ± 0.7	3.1 ± 0.7	0.018
Hospital stay, days	7.1 ± 1.5	9.2 ± 1.9	0.002
24-h chest tube drainage, mL	368.0 ± 101.7	585.0 ± 134.1	<0.001
PRBC transfused, units	0.9 ± 0.9	1.5 ± 1.1	0.116
Any transfusion (≥1 unit), n (%)	10 (66.7)	13 (86.7)	0.390
24-h pain score (VAS 0–10)	3.5 ± 0.8	4.9 ± 1.2	0.001
Return to usual activity, days	32.6 ± 7.4	49.2 ± 11.0	<0.001

Values are mean ± SD or n (%). ICU, intensive care unit; PRBC, packed red blood cells; VAS, visual analogue scale.

Table 4: Postoperative complications and 30-day mortality.

Variable	MICS-MVR (n=15)	Sternotomy-MVR (n=15)	p-value
New-onset atrial fibrillation, n (%)	2 (13.3)	5 (33.3)	0.390
Pneumonia, n (%)	0 (0.0)	2 (13.3)	0.483
Surgical site infection, n (%)	0 (0.0)	2 (13.3)	0.483
Re-exploration for bleeding, n (%)	0 (0.0)	2 (13.3)	0.483
Stroke, n (%)	0 (0.0)	1 (6.7)	1.000
Acute kidney injury, n (%)	1 (6.7)	2 (13.3)	1.000
30-day mortality, n (%)	0 (0.0)	1 (6.7)	1.000

Values are n (%). Acute kidney injury defined as KDIGO stage ≥ 1. Categorical variables compared with the Fisher exact test.

DISCUSSION

In this single-centre comparative study of isolated MVR in a predominantly rheumatic population, the minimally invasive minithoracotomy approach achieved early mortality and major morbidity comparable to conventional median sternotomy, while delivering meaningful advantages in bleeding, postoperative pain, intensive care and hospital stay, and return to usual activity. These benefits were obtained at the expected cost of significantly longer cardiopulmonary bypass, cross-clamp and total operative times. This pattern of trade-offs is highly consistent with the wider literature on minimally invasive mitral surgery.[3,5,7,9]

The prolongation of bypass and cross-clamp times we observed mirrors essentially every comparative analysis of the field. In their systematic review and meta-analysis, Modi and colleagues reported equivalent perioperative mortality but significantly longer bypass and cross-clamp times with the minimally invasive approach,[3] and the ISMICS consensus meta-analysis by Cheng and colleagues similarly found longer operative times alongside reductions in transfusion, atrial fibrillation, sternal infection and time to return to normal activity.[5] The longer ischaemic times reflect the technical demands of operating through a limited incision with peripheral cannulation, particularly in rheumatic valves with dense adhesions and subvalvular disease; importantly, the literature indicates that these longer times do not translate into increased early mortality, a finding reproduced in our cohort.[7]

The reductions in intraoperative blood loss and 24-hour chest tube drainage, and the lower transfusion requirement, are also concordant with prior reports. Avoidance of full sternal division reduces the raw bony bleeding surface and is repeatedly associated with less drainage and fewer transfusions in both meta-analyses and large registry analyses.[5,8,9] In a rheumatic population that is frequently young and may require future re-intervention, minimizing transfusion exposure and preserving sternal integrity are particularly attractive. The complete absence of surgical site infection and re-exploration in our MICS group, while not statistically significant, is directionally consistent with the well-documented reduction in sternal wound complications after minithoracotomy.[5,9]

Our recovery findings — shorter ICU and hospital stay, lower pain scores and faster return to activity — align closely with the randomized evidence. The UK Mini Mitral trial demonstrated that, although minithoracotomy repair did not improve physical function at 12 weeks (its primary endpoint), patients recovered physical function faster in the early postoperative period, spent less time in hospital and reported better early quality of life, with equivalent safety and efficacy at one year.[10] The faster return to usual activity we recorded (a mean difference of roughly two weeks) is clinically relevant in a working-age rheumatic population, where time away from employment carries a substantial socioeconomic cost.[1]

The comparable 30-day mortality and the lower observed incidence of new-onset atrial fibrillation are again consistent with pooled data, in which

minimally invasive access has been associated with equivalent mortality and a lower burden of postoperative atrial fibrillation.[5,9] It should be emphasised that minimally invasive mitral surgery is technically demanding and operator-dependent; published series from high-volume centres report very low conversion rates and excellent safety once the learning curve is overcome.[6] Our single conversion (6.7%) is somewhat higher than the rates reported by established programmes, which likely reflects a smaller case volume and is an expected feature of a developing programme.[6]

Several additional considerations are relevant to the adoption of MICS-MVR in a setting such as ours. First, although operative times are longer, the downstream reductions in ICU and ward occupancy, transfusion and wound complications observed here and in registry data may partly offset the higher intraoperative resource use, an argument that has been advanced for minimally invasive mitral surgery in cost analyses.[5,8] Second, the avoidance of a midline scar and preservation of sternal stability are of particular value to the young, often female, rheumatic patients who predominate in this population and for whom cosmesis, early mobilisation and quick return to domestic and occupational roles carry real weight.[1,10] Third, careful patient selection — excluding significant aorto-iliac disease, severe pulmonary dysfunction and extensive pleural adhesions — together with femoral cannulation expertise and transoesophageal echocardiographic guidance, is essential to keep conversion and vascular complication rates low, as emphasised in large minithoracotomy series.[6,9] A structured, mentored approach to the learning curve is therefore central to translating the outcomes reported by high-volume centres into a newer programme.[6]

Taken together, our results support the view that MICS-MVR can be offered as a safe alternative to sternotomy for appropriately selected patients with rheumatic mitral disease, provided the team accepts longer perfusion times and maintains a low threshold for conversion. The approach appears to shift the balance of early outcomes towards reduced bleeding, less pain and faster recovery without compromising early safety. These conclusions are necessarily provisional given the design and size of the study.

Limitations: This study has important limitations. It is a small, single-centre comparison of 30 patients with non-randomized allocation, so residual confounding by indication and selection bias cannot be excluded, and the analyses are unadjusted and exploratory. The modest sample size limits statistical power; several clinically meaningful differences in complications (for example, pneumonia, wound infection and re-exploration) did not reach significance and should not be interpreted as true equivalence. Follow-up was confined to the early postoperative period and 30-day mortality, so mid- and long-term outcomes — including valve-related events, durability, reoperation and survival — were not assessed. Outcomes such as conversion rate are also sensitive to the learning curve and surgeon experience. Adequately powered, prospective and ideally randomized studies with longer follow-up are required to confirm these findings in rheumatic MVR populations.

CONCLUSION

In this exploratory comparative study, MICS-MVR through a right minithoracotomy achieved early mortality and major morbidity comparable to conventional median sternotomy MVR, while offering less intraoperative blood loss and chest drainage, lower postoperative pain, shorter intensive care and hospital stay, and faster return to usual activity, at the cost of longer cardiopulmonary bypass and cross-clamp times. For appropriately selected patients with rheumatic mitral disease, MICS-MVR appears to be a safe and attractive alternative to sternotomy. Larger, prospective studies with longer follow-up are needed to confirm these early advantages and to define durability and long-term outcomes.

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