**Italian Journal of Medicine**

https://www.italjmed.org/ijm

**eISSN 1877-9352**

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***Please cite this article as:***

Nguyen TB, Nguyen TT, Luong LH, et al. **Minimally invasive *versus* median sternotomy for mechanical mitral valve replacement: a single-center comparative study of treatment outcomes and quality of life**. *Ital J Med* doi: 10.4081/itjm.2025.1963

*Submitted: 24-03-2025*
*Accepted: 23-05-2025*

# Minimally invasive *versus* median sternotomy for mechanical mitral valve replacement: a single-center comparative study of treatment outcomes and quality of life

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**Key words**: mechanical mitral valve replacement, quality of life, minimally invasive, sternotomy.

**Contributions**: NTB, TTN, designed the study; TTN, NCH, LNT, performed the surgeries and conducted clinical follow-up; LHL, NDH, KBG, conducted the statistical analysis; NTB, KBG, LHL, contributed to drafting the manuscript. All authors have read and approved the final version of the manuscript for publication.

**Conflict of interest**: the authors declare that they have no competing interests.

**Ethics approval and consent to participate**: the study was approved by the Ethics Committee of Hanoi Medical University, IRB00003121 and IRB-VN01001 (No. 106/GCN-HMUIRB, dated December 28, 2023). All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013.

**Informed consent**: informed consent was obtained from all participants included in the study.

**Patient consent for publication**: all patients provided written informed consent for publication of their data.

**Availability of data and materials**: the datasets used and/or analyzed during the current study are available upon reasonable request from the corresponding author.

**Funding**: none.

**Acknowledgments**: the authors would like to express their gratitude to the patients who participated in this study for their cooperation and valuable contributions.

**Abstract**
Mechanical mitral valve replacement (MMVR) is normally indicated for severe, irreparable mitral valve disease and is often performed through median sternotomy (MS). Compared with the traditional MS approach, the minimally invasive (MI) technique offers benefits like reduced trauma, faster recovery, and improved cosmetic outcomes. Because most studies focused on the MI approach in mitral valve repair, data on the outcome of MI MMVR are very limited. Thus, we conducted this study to compare treatment outcomes and quality of life in patients undergoing MMVR using MI *vs.* MS techniques. A total of 86 patients (43 MI, 43 MS) were recruited from 2019 to 2024, with follow-up at 36 months post-surgery. Cosmesis was assessed using the Scar Cosmesis Assessment and Rating Scale; quality of life was evaluated via the Short Form-36 questionnaire. The MI group had longer cardiopulmonary bypass and cross-clamp times but shorter ventilation times, intensive care unit stays, hospital stays, lower costs, and better cosmetic outcomes compared to the MS group ($p<0.05$). In conclusion, MI for MMVR is a safe technique that reduces short-term recovery times and costs, resulting in improved cosmetic and postoperative quality of life.

## Introduction

Mechanical mitral valve replacement (MMVR) is typically indicated for severe, irreparable mitral valve disease, especially when mitral valve repair is not feasible or is expected to yield poor long-term outcomes, or when there is a high risk of post-surgery valvular failure.[1,2] While valve repair involves repairing the existing valve, MMVR requires complete excision of the diseased valve, precise sizing, accurate positioning of the prosthesis, and secure fixation.[3]

Minimally invasive (MI) mitral valve surgery, first introduced in 1996, has been proven to be feasible and safe when performed in specialized centers.[4] By offering an alternative that aims to provide comparable or even improved safety and efficacy, these techniques offer several advantages, such as reduced trauma, better cosmetic outcomes, and shorter hospital stays.[5,6]

While previous meta-analyses have highlighted the advantages of MI surgery, such as reduced hospital stays and less bleeding, variations in surgical techniques and patient characteristics may have influenced these results.[6,7] Additionally, as the number of indications for mitral valve replacement has decreased over time, studies focusing on MI mitral valve replacement have become increasingly rare.[8] Therefore, evidence comparing MI mitral valve replacement to conventional median sternotomy (MS) is limited. Therefore, we conducted this study to compare the clinical outcomes and long-term quality of life between patients undergoing MI mitral valve replacement and those undergoing MS.

## Materials and Methods

### *Study design*

This comparative study examines the quality of life and surgical outcomes for patients who underwent MMVR.

### *Patients*

The study included 86 patients who underwent MMVR between January 2019 and May 2024 at the Cardiology Center – E Hospital. Of these, 43 patients underwent surgery *via* MS, while the remaining 43 underwent MI mitral valve replacement through a right thoracotomy approach. Patients in both groups were matched based on age to minimize selection bias and ensure comparability. All patients were followed up 36 months post-surgery. Preoperative and postoperative data were collected from the Cardiology Center's database.

### *Technical procedures*

Surgery was indicated and performed following the 2020 American College of Cardiology/American Heart Association guidelines for mitral valve disease management.[1]

### *Minimally invasive procedure*

Patients were anesthetized with double-lumen intubation and positioned at a 30-degree left tilt. A 4-5 cm right anterior thoracotomy incision was made at the fourth intercostal space. A trocar was inserted for camera access via the third intercostal space. Peripheral cardiopulmonary bypass was established using femoral artery and vein cannulation, with internal jugular vein access. The aorta was clamped using a Chitwood clamp through the fourth intercostal space. Myocardial protection was achieved with Custodiol solution, and the mitral valve was exposed and replaced. After surgery, incisions were closed, bypass was discontinued, and drainage tubes were placed.

### *Sternotomy procedure*

Patients were anesthetized with single-lumen intubation. MS was performed, and cardiopulmonary bypass was established centrally. Myocardial protection was provided with custodiol solution, and the

mitral valve was replaced. After surgery, incisions were closed, bypass was discontinued, and drainage tubes were placed.

***Aesthetic outcomes and quality of life assessment***

Aesthetic outcomes were assessed using the Scar Cosmesis Assessment and Rating Scale (SCAR), which includes 8 questions: 6 components were assessed by clinicians (covering scar spread, erythema, dyspigmentation, track marks, and hypertrophy), and 2 components were self-reported by patients (pain and itch). Higher scores indicate poorer aesthetic outcomes. Two trained doctors independently evaluated the surgical site and gave their scores, which were then averaged together with 2 patient-report components to get the final SCAR score. Quality of life was assessed using the Short Form-36 questionnaire (SF-36), which evaluates eight health domains: physical functioning, role limitations (physical and emotional), vitality, mental health, social functioning, bodily pain, and general health. Scores range from 0 to 100, with higher scores indicating better health.

***Statistical analysis***

Data were analyzed using IBM SPSS Statistics 24.0 (Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation and compared between groups using independent t-tests. Categorical variables were presented as frequencies and percentages, and comparisons were made using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

**Results**

Table 1 presents the baseline preoperative characteristics of the MI and MS groups. There were no significant differences between the two groups in terms of age or gender distribution. However, comorbidities, including hypertension, chronic obstructive pulmonary disease, diabetes, and preoperative atrial fibrillation, were significantly more prevalent in the MS group ($p<0.05$). No significant differences were observed in left ventricular function or echocardiographic parameters between the two groups.

***Postoperative outcomes***

The MI group had longer cardiopulmonary bypass and cross-clamp times (167.24 minutes *vs*. 124.00 minutes, $p<0.05$). However, the MI group demonstrated significantly shorter ventilation time (14.12 hours *vs*. 23.95 hours), intensive care unit (ICU) stay (3.47 days *vs*. 5.33 days), hospital stay (12.16 days *vs*. 14.72 days), and lower hospitalization costs ($4,203 *vs*. $4,654, $p<0.05$). Postoperative complications, such as atrial fibrillation and bleeding, were more common in the sternotomy group, but there was no significant difference in mortality (Table 2).

***Aesthetic outcomes and quality of life***

Table 3 shows that most aesthetic indicators on the SCAR scale were significantly better in the MI group compared to the sternotomy group, with statistically significant differences ($p<0.05$). The exceptions were dyspigmentation and pain, where no significant differences were observed between the two groups. Within 36 months post-surgery, the MI group reported significantly better general health scores (63.18 *vs*. 54.81, $p<0.05$), suggesting that they perceived their overall health to be better compared to the sternotomy group (Table 4).

**Discussion**

Over the past three decades, since Carpentier successfully performed the first MI endoscopic-assisted mitral valve surgery, the technique has been continuously refined and is now routinely practiced at many centers worldwide.[4] In Vietnam, this approach is available at major institutions, including the Cardiology

Center of E Hospital, primarily offered to younger patients who are not suitable candidates for valve repair.

Numerous studies have shown that mitral valve repair generally offers better outcomes and is recommended whenever feasible.[9] However, according to Rankin *et al*., only around 10% of patients with rheumatic mitral valve disease are eligible for valve repair, with an associated mortality rate of approximately 4%.[10] Our study also reflects this trend: the average age of patients undergoing MMVR was between 45 and 47 years (Table 1). Most valve lesions in our cohort were rheumatic in origin, characterized by thickened, fused valve leaflets, shortened chordae tendineae, and sub-valvular fibrosis. This pattern is consistent with the mitral valve disease profile seen in many developing countries and aligns with the younger average patient age compared to reports from other studies.[10,11]

Additionally, our data showed that over 50% of patients presented with preoperative atrial fibrillation, which was associated with higher rates of postoperative atrial fibrillation. Compared to Ayse *et al.*,[12] who reported a 38% incidence, our findings demonstrated higher rates, but they were comparable to the results of Chen *et al*.,[11] who reported 57%. Further investigation is warranted to determine if factors such as delayed access to healthcare or disease severity contribute to the high prevalence of atrial fibrillation in this patient population. Preoperative atrial fibrillation is clinically significant, as it increases the risk of thrombus formation and negatively impacts long-term outcomes following MMVR.

Regarding intraoperative metrics, our study showed that cardiopulmonary bypass time and aortic cross-clamp time were significantly longer in the MI group compared to the sternotomy group (Table 2). This is likely attributable to the technical challenges posed by limited surgical exposure, necessitating greater precision and operative time, findings consistent with previous studies.[13,14]

Early postoperative indicators such as mechanical ventilation duration, ICU stay, and total hospital stay are crucial markers of treatment success. Consistent with other reports, our study found that patients in the MI group experienced shorter ventilation times, ICU stays, and overall hospital stays compared to those who underwent sternotomy.[15-17] Several studies have highlighted that prolonged ICU stays can negatively affect patients' psychological well-being due to factors like constant noise, absence of normal circadian rhythms, and communication difficulties during mechanical ventilation.[16] Reducing ICU time, therefore, not only improves clinical outcomes but also enhances patient comfort and recovery.

Moreover, shorter ICU stays and hospitalizations contribute to lower healthcare costs. Our findings showed that the MI group incurred significantly lower treatment costs compared to the sternotomy group ($4203 *vs*. $4654, $p<0.05$). While MI surgery involves longer operative times and requires specialized, higher-cost equipment, the overall hospital expenses were reduced due to shorter recovery periods. These results are in line with an analysis by Iribarne and Grossi concluded that MI surgery is associated with lower total hospital costs compared to conventional sternotomy.[18,19] Optimizing postoperative recovery metrics like ICU stay and ventilation time is essential not only for improving clinical outcomes but also for reducing the financial burden on healthcare systems.

***Quality of life***

Although many studies emphasize the benefits of MI surgery, including faster recovery, reduced pain, and improved cosmetic outcomes compared to sternotomy, long-term evaluations of these benefits in Vietnam remain limited. Quality of life is a subjective measure influenced not only by surgical technique but also by factors such as disease severity, treatment adherence, and social circumstances. For patients undergoing MMVR, lifelong anticoagulation therapy is essential. However, this carries risks of thrombosis, bleeding, and embolism, which can negatively affect psychological well-being and overall quality of life.

Huang *et al*. compared postoperative outcomes between MI and sternotomy mitral valve replacement patients.[20] They reported that, at 3 months post-surgery, patients in the sternotomy group experienced

significantly higher pain levels ($p<0.05$), while those in the MI surgery group showed better aesthetic satisfaction ($p<0.05$). In our study, we found that only General Health scores were significantly higher in the MI group, with no notable differences in other SF-36 quality-of-life domains. This divergence from Huang *et al.*'s findings could be attributed to the timing of our evaluation, conducted at 36 months postoperatively, by which point differences in postoperative pain and early recovery may have diminished. Our results are consistent with those of Rakesh *et al*.,[15] who reported no significant differences in pain scores between groups 12-24 months post-surgery. Similarly, Thomas *et al*. found that by 7 months after surgery, pain levels between the MI and sternotomy groups were comparable.[16] This suggests that while MI surgery offers advantages in reducing postoperative pain in the short term, long-term pain outcomes appear similar between the two approaches.

Interestingly, beyond 36 months post-surgery, our study observed higher vitality and role emotional scores in the MI group compared to the sternotomy group. However, overall quality of life scores between the two groups showed no statistically significant differences.

In Vietnam, no prior studies have systematically compared the quality of life and cosmetic outcomes between MI and sternotomy approaches. Nonetheless, it is acknowledged that MI surgery, with its smaller incisions that avoid sternotomy, offers better aesthetic results.[20] In our study, using the SCAR scale to assess cosmetic outcomes, we found that the sternotomy group exhibited more unfavorable characteristics such as scar spread, erythema, hypertrophy, and itching. In contrast, no significant differences were observed between groups regarding dyspigmentation, track marks, or pain. Overall, patients in the MI surgery group reported greater satisfaction with their cosmetic outcomes.

Additionally, when analyzing the relationship between the SF-36 quality of life scores and SCAR scores, we found that in the MI group, better cosmetic outcomes were positively correlated with vitality and social function. In the sternotomy group, aesthetic results correlated with mental health scores. However, these correlations were generally modest, suggesting that while aesthetics play a role in the general quality of life, they are not the dominant factor in the long term.

Our findings suggest that the advantages of MI, particularly regarding recovery speed and cosmetic outcomes, are more pronounced in the early postoperative period but gradually diminish over time. In clinical practice, we observed that as more time passes, patients tend to prioritize concerns such as disease progression, anticoagulation management, and the durability of the prosthetic valve, rather than cosmetic appearance. Further large-scale, long-term studies are necessary to determine when postoperative quality of life outcomes between the two surgical approaches converge. Such research will help guide follow-up care strategies, patient counseling, and anticoagulation management tailored to improving overall long-term well-being.

### *Study limitations*

The comparative design limited our ability to assess changes over time and analyze the short-term effects of mechanical ventilation, ICU stays, and hospital stays on quality of life. Future studies will focus on long-term survival outcomes and quality of life assessments.

## Conclusions

MI MMVR is associated with shorter mechanical ventilation times, reduced ICU stays, and shorter overall hospitalizations compared to MS, resulting in lower overall treatment costs. This study adds to the growing body of evidence supporting the safety and efficacy of MI valve replacement and may assist in guiding clinical decision-making and encouraging broader adoption of this technique in more medical centers.

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**Table 1. Preoperative characteristics.**

| Variable | MI group (n=43) | MS group (n=43) | p |
|---|---|---|---|
| Age (year; mean ± SD) | 47.98±7.92 | 45.79±7.37 | 0.18 |
| Male, n (%) | 12 (27.90) | 20 (46.51) | 0.07 |
| COPD, n (%) | 0 | 1 (2.32) | 0.31 |
| Diabetes mellitus, n (%) | 0 | 4 (9.30) | 0.04 |
| Hypertensive disease, n (%) | 0 | 2 (4.65) | 0.49 |
| Preoperative atrial fibrillation, n (%) | 22 (51.16) | 35 (81.39) | 0.003 |
| LVEF | 60.09±9.92 | 59.63±10.18 | 0.83 |
| LVDd (mm) | 48.02±7.40 | 48.98±8.82 | 0.58 |
| NYHA class I-II | 36 | 31 | 0.19 |
| NYHA class III-IV | 7 | 12 | |

MI, minimally invasive; MS, median sternotomy; SD, standard deviation; COPD, chronic obstructive pulmonary disease; LVEF, left ventricular ejection fraction; LVDd, left ventricular diastolic dysfunction; NYHA, New York Heart Association.

**Table 2. Postoperative outcomes.**

| Variable | MI group | MS group | p |
|---|---|---|---|
| CPB time (min) | 167.26±36.39 | 124.00±34.09 | **<0.001** |
| Cross clamp time (min) | 102.77±26.83 | 83.07±21.25 | **<0.001** |
| Ventilation time (h) | 14.12±9.48 | 23.95±22.61 | **0.01** |
| ICU length of stay (d) | 3.47±1.03 | 5.33±5.87 | **0.04** |
| Postoperative hospital length of stay (d) | 12.16±3.44 | 14.72±7.62 | **0.04** |
| In-hospital mortality | 0 | 0 | |
| Post-operation delirium (%) | 2.32 | 11.62 | 0.20 |
| Renal failure (%) | 0 | 2.32 | 0.31 |
| Re-opening for bleeding (%) | 2.32 | 6.97 | 0.61 |
| Surgical site infection (%) | 0 | 4.65 | 0.49 |
| Post-operation atrial fibrillation (%) | 39.53 | 62.79 | 0.03 |
| LVEF | 64.02±10.17 | 59.83±9.68 | 0.055 |
| LVDd (mm) | 46.37±6.14 | 48.0±7.75 | 0.28 |
| Hospital stay cost, mean (USD) | 4203.24±538.85 | 4654.14±1240.69 | **0.03** |

MI, minimally invasive; MS, median sternotomy; CPB, cardiopulmonary bypass; ICU, intensive care unit; LVEF, left ventricular ejection fraction; LVDd, left ventricular diastolic dysfunction

**Table 3. Description of aesthetic outcomes based on Scar Cosmesis Assessment and Rating scale Scores.**

| Variables (Mean ± SD) | MI group (n=43) | MS group (n=43) | p |
|---|---|---|---|
| Scar spread | 0 | 0.67±0.64 | **<0.001** |
| Erythemia | 0.95±0.37 | 1.42±0.54 | **<0.001** |
| Dyspigmentation | 0 | 0.05±0.21 | 0.15 |
| Track marks | 0.02±0.15 | 0.12±0.32 | 0.09 |
| Hypertrophy | 0.72±0.59 | 1.67±0.71 | **<0.001** |
| Itch | 0.05±0.21 | 0.3±0.46 | **0.002** |
| Pain | 0 | 0.05±0.21 | 0.15 |
| Overall impression | 0.02±0.15 | 0.23±0.42 | **0.003** |
| Total score | 1.77±1.10 | 4.35±2.28 | **<0.001** |

MI, minimally invasive; MS, median sternotomy

**Table 4. Comparison of Short Form-36 questionnaire quality of life components between minimally invasive and sternotomy groups**

| SF36 components | MI group | MS group | p |
|---|---|---|---|
| Physical function | 70.00±15.51 | 68.52±16.57 | 0.72 |
| Role physical | 44.70±43.19 | 37.96±43.50 | 0.55 |
| Role emotion | 86.87±33.27 | 88.89±32.02 | 0.81 |
| Vitality | 74.92±13.72 | 75.28±14.11 | 0.92 |
| Mental health | 76.36±16.04 | 77.33±13.76 | 0.80 |
| Social function | 80.68±15.96 | 81.01±21.19 | 0.94 |
| Bodily pain | 88.26±16.65 | 83.52±20.64 | 0.32 |
| General health | 63.18±10.14 | 54.81±13.90 | **0.01** |
| Physical component summary | 66.64±16.12 | 61.19±18.18 | 0.22 |
| Mental component summary | 79.82±14.26 | 80.74±15.03 | 0.80 |

SF-36, Short Form-36 questionnaire.