

Right Anterolateral Thoracotomy versus Median Sternotomy in Tricuspid Valve Surgery

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ABSTRACT

Background: The tricuspid valve remains the least studied of the four cardiac valves, and there is still no consensus on the optimal surgical approach for its repair or replacement. A growing body of evidence favours minimally invasive access routes, which may reduce operative morbidity without compromising the quality of the surgical correction. *Aim:* To compare the early postoperative outcomes of isolated tricuspid valve surgery performed through a median sternotomy versus a right anterolateral thoracotomy.

Patients and Methods: This prospective, randomised clinical trial enrolled 40 patients undergoing isolated tricuspid valve repair or replacement at Kasr Al-Aini Hospital between July 2020 and August 2022. Patients were allocated equally to a median sternotomy group (Group 1, n = 20) and a right anterolateral thoracotomy group (Group 2, n = 20).

Results: Operative time was significantly shorter in the thoracotomy group than in the sternotomy group (232.15 ± 21.68 vs 294.85 ± 16.82 min; $p = 0.001$), a difference of approximately 63 minutes (21% reduction). Postoperative drainage was significantly lower in the thoracotomy group (632.5 ± 399 vs 1023.5 ± 439 mL; $p = 0.001$), a reduction of about 391 mL (38%). Hospital stay was significantly shorter after thoracotomy (6.05 ± 0.99 vs 7.50 ± 2.31 days; $p = 0.016$). Severe postoperative pain (Visual Analog Scale 7–10) occurred in 2 patients (5%) in the thoracotomy group versus 8 patients (20%) in the sternotomy group ($p < 0.05$). Total wound infection rate was also significantly lower with thoracotomy (2 patients, 5%) than with sternotomy (6 patients, 15%; $p < 0.05$), although re-exploration for bleeding (5% vs 15%), in-hospital mortality (5% vs 10%), bypass time, and cross-clamp time did not differ significantly between groups ($p > 0.05$ for all).

Conclusion: Right anterolateral thoracotomy is a safe and effective alternative to median sternotomy for isolated tricuspid valve surgery, offering shorter operative time, reduced postoperative drainage, less severe pain, fewer wound infections, and a shorter hospital stay. This approach may be particularly advantageous in patients with a prior sternotomy.

Keywords: median sternotomy, anterolateral thoracotomy, tricuspid valve surgery

INTRODUCTION

The tricuspid valve (TV), often referred to as the “forgotten valve,” has historically attracted far less scholarly attention than the mitral or aortic valve (1). Isolated tricuspid valve repair is uncommon, and surgical management of the valve is usually undertaken as a secondary procedure during other cardiac operations (2,3). This pattern, however, is beginning to change: recent reports

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show that isolated tricuspid valve surgery can be performed safely through a right mini-thoracotomy, an approach previously reserved for combined mitral-tricuspid procedures, thereby offering a dedicated option for patients who require an isolated tricuspid intervention (4).

Minimally invasive valve surgery offers several clinical advantages over conventional median sternotomy, including reduced surgical trauma, lower perioperative blood loss, and avoidance of full sternal exploration. These approaches have also been associated with less postoperative pain, shorter intensive care unit and hospital stays, and faster return to baseline functional status (5).

The aim of this prospective study was to compare the early outcomes of isolated tricuspid valve surgery performed via median sternotomy versus right anterolateral thoracotomy.

PATIENTS AND METHODS

Following approval from the local institutional ethics committee, 40 patients scheduled for primary or secondary repair or replacement of the tricuspid valve at Kasr Al-Aini Hospital were enrolled in this prospective, randomised, comparative study. Patients were allocated equally to two groups: Group 1 (n = 20) underwent surgery via median sternotomy, and Group 2 (n = 20) underwent surgery via right anterolateral thoracotomy. All patients underwent isolated tricuspid valve surgery, comprising either repair or replacement for primary or chronic secondary disease.

Inclusion Criteria

Patients were eligible if they required primary or delayed secondary tricuspid valve intervention, either replacement or reconstructive repair, performed through median sternotomy or anterolateral/lateral thoracotomy, and limited to isolated tricuspid procedures.

Exclusion Criteria

Patients were excluded if they had compromised pulmonary function, prior right-sided thoracic surgery, a requirement for femoral artery cannulation that could not be met, or a need for additional concomitant cardiac procedures. All patients underwent the following evaluations.

Preoperative Parameters

Each patient underwent a comprehensive clinical

evaluation, including physical examination focused on signs of biventricular (left and right) heart failure, together with routine laboratory testing, electrocardiography, chest imaging, and Doppler echocardiography. Right-sided heart failure symptoms-dyspnoea, dyspepsia, and right hypochondrial or epigastric pain - and their duration were specifically recorded.

Operative Parameters

Surgical approach

In the median sternotomy group, access was obtained through a standard sternotomy, and the pericardium was retracted to the right using a silk traction suture. The right-sided cardiac

chambers and pulmonary artery were inspected by palpation. Systemic heparinisation was administered, followed by aortic and bicaval cannulation, with tapes placed around the superior and inferior vena cava before initiating cardiopulmonary bypass and aortic cross-clamping. Myocardial protection was achieved with antegrade cold blood cardioplegia, delivered every 30 minutes, supplemented by systemic hypothermia and topical ice slush. The tricuspid valve was approached through an oblique right atriotomy, 1 cm parallel to the atrioventricular groove, allowing systematic valve assessment and subsequent repair or replacement.

Right anterolateral thoracotomy

Patients in the thoracotomy group were placed under general anaesthesia and ventilated using a double-lumen endotracheal tube to allow selective single-lung ventilation. Patients were positioned in a 30° anterior oblique position referenced to the fourth rib, and external defibrillation pads were applied before the procedure began. Thoracotomy was performed through the right fourth intercostal space, using an incision of approximately 5-12 cm (*fig. 1*), after which standard cardiopulmonary bypass techniques were used to perform the required cardiac procedure.

Arterial and venous cannulation was established via the right femoral artery and vein (*fig. 2*), with position confirmed by transesophageal echocardiography. When required, an alternative configuration of femoral arterial access combined with central bicaval venous cannulation was used. Mild hypothermia (32-34°C) was maintained during cardiopulmonary bypass, with myocardial protection provided by antegrade cold blood cardioplegia.

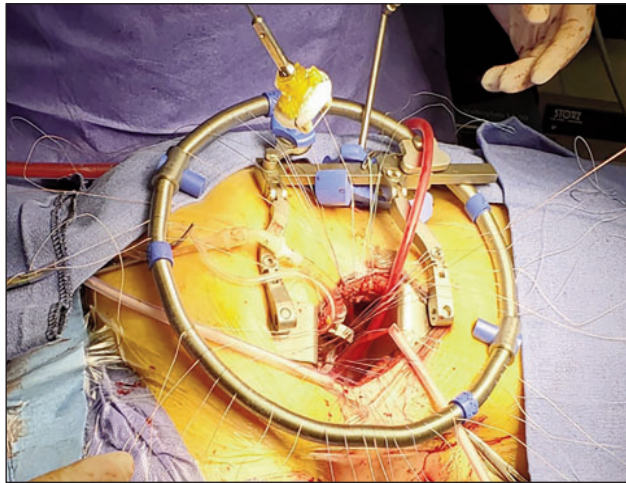


Figure 1 - Right anterolateral thoracotomy approach.

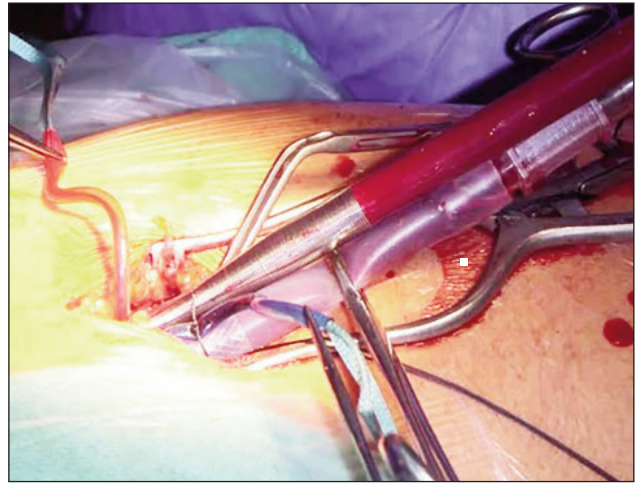


Figure 2 - Femoral-femoral cannulation for cardiopulmonary bypass.

Surgical Techniques

Tricuspid valve repair

The surgical technique was selected according to the pathophysiology and morphology of the tricuspid valve disease. Two repair techniques were used: suture annuloplasty (De Vega, modified De Vega, segmental annuloplasty, or pericardial strip/prosthetic band) and prosthetic ring annuloplasty, the latter performed in both groups.

Tricuspid valve replacement

Both bioprosthetic and mechanical valves were used for replacement (*fig. 3*). Patients were followed up postoperatively in the intensive care unit (ICU), the

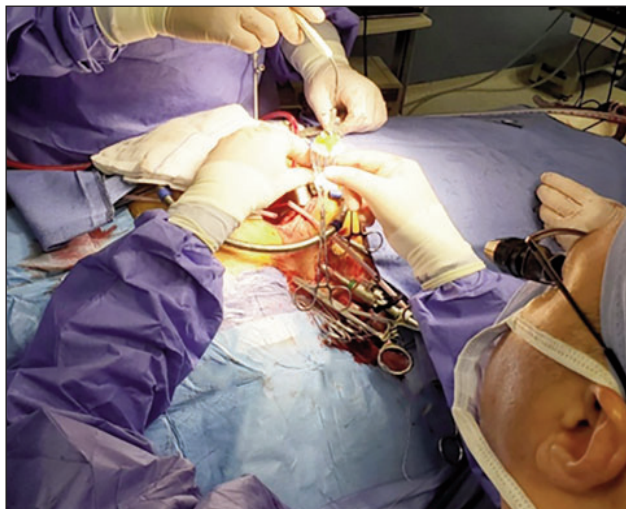


Figure 3 - Tricuspid valve replacement using bioprosthetic valve.

ward, and the outpatient clinic for one month after surgery. Recorded outcomes included total length of hospital stay (including ICU stay), incidence of re-exploration for bleeding, and other postoperative events. The need for mechanical ventilatory support, pharmacological inotropic support, and blood or fresh frozen plasma transfusion was also documented.

Postoperative pain was assessed using a standardised Visual Analog Scale (VAS), scored from 0 (no pain) to 10 (worst imaginable pain) and recorded by nursing and clinical staff at fixed postoperative intervals. Pain severity was categorised as mild (VAS 1–3), moderate (VAS 4–6), or severe (VAS 7–10). Pain was managed using a multimodal analgesia protocol comprising intravenous opioids, non-steroidal anti-inflammatory drugs (NSAIDs), and paracetamol, with the regimen adjusted according to the patient's reported pain score and clinical response. In-hospital mortality was also recorded

Statistical Analysis

Quantitative variables were expressed as means $\pm$ standard deviation and compared between groups using Student's t-test. Categorical variables were expressed as frequencies and percentages and compared using the Chi-square (χ^2) test or Fisher's exact test, as appropriate. A p-value < 0.05 was considered statistically significant, and a p-value < 0.01 was considered highly significant.

RESULTS

There was no statistically significant difference

between the two groups in mean age or sex distribution ($p > 0.05$ for both) (*table 1*).

Preoperative right-sided symptoms, right-sided signs, and cardiac signs were comparable between groups, with no statistically significant differences ($p > 0.05$) (*table 2*).

Echocardiographic parameters—including tricuspid regurgitation, tricuspid stenosis, combined regurgitation and stenosis, pulmonary artery systolic pressure (PASP), right ventricular (RV) dimension, left atrial (LA) dimension, left ventricular (LV) dimensions, and ejection fraction (EF)—did not differ significantly between groups ($p > 0.05$) (*table 3*).

Total operative time was significantly shorter in the thoracotomy group than in the sternotomy group

(232.15 ± 21.683 vs 294.85 ± 16.816 min; $p = 0.001$), a mean difference of approximately 63 minutes. Bypass time, cross-clamp time, and the need for inotropic support did not differ significantly between groups ($p > 0.05$) (*table 4*).

During the recovery phase, the need for inotropic support in the ICU, requirement for blood or fresh frozen plasma transfusion, and incidence of re-exploration for bleeding were not significantly different between groups ($p > 0.05$) (*table 5*). Postoperative drainage volume, however, differed significantly: the sternotomy group had a mean drainage of 1023.5 ± 439 mL, compared with 632.5 ± 399 mL in the thoracotomy group ($p = 0.001$), a difference of approximately 391 mL.

Table 1 - Analysis of patient's age and sex.

	Group 1 (Sternotomy)	Group 2 (Thoracotomy)	p-value
Mean age (years)	44.75 $\pm$ 11.355	40.75 $\pm$ 9.973	0.244 (NS)
Male 12 (60%)	8 (40%)	0.206 (NS)	
Female	8 (40%)	12 (60%)	0.206 (NS)

NS = not significant ($p > 0.05$).

Table 2 - Analysis of preoperative clinical findings.

Parameter	Group 1	Group 2	p-value
NYHA Class II	8 (40%)	9 (45%)	0.349 (NS)
NYHA Class III	10 (50%)	11 (55%)	0.349 (NS)
NYHA Class IV	2 (10%)	0 (0%)	0.349 (NS)
Dyspepsia	4 (20%)	6 (30%)	0.46 (NS)
Right hypochondrial pain	11 (55%)	13 (65%)	0.52 (NS)
Neck vein congestion	15 (75%)	17 (85%)	NS
Liver enlargement (cm)	3.8 $\pm$ 0.76	3.95 $\pm$ 0.75	NS
Ascites	4 (20%)	3 (15%)	NS
Lower limb oedema	13 (65%)	15 (75%)	NS
TV murmurs	18 (90%)	17 (85%)	NS
Manifestations of pulmonary hypertension	16 (80%)	15 (75%)	NS
Manifestations of RV enlargement	20 (100%)	20 (100%)	—

NS = not significant ($p > 0.05$); RV = right ventricle.

Table 3 - Preoperative echocardiographic findings.

Parameter	Group 1	Group 2	p-value
Tricuspid regurgitation (TR)	13 (65%)	14 (70%)	NS
Tricuspid stenosis (TS)	4 (20%)	3 (15%)	NS
TR and TS combined	3 (15%)	3 (15%)	NS
PASP (mmHg)	62.50 $\pm$ 8.95	61.25 $\pm$ 10.24	NS
RV dimension (cm)	2.93 $\pm$ 0.37	2.99 $\pm$ 0.40	NS
LA dimension (cm)	7.10 $\pm$ 0.97	7.27 $\pm$ 1.00	NS
LVEDD (cm)	5.80 $\pm$ 0.64	5.72 $\pm$ 0.75	NS
LVESD (cm)	3.92 $\pm$ 0.36	3.90 $\pm$ 0.45	NS
Ejection fraction (%)	50.30 $\pm$ 3.13	52.35 $\pm$ 3.26	NS

NS = not significant ($p > 0.05$); PASP = pulmonary artery systolic pressure; RV = right ventricle; LA = left atrium; LVEDD/LVESD = left ventricular end-diastolic/end-systolic diameter.

Table 4 - Comparison of intraoperative data.

Parameter	Group 1	Group 2	p-value
Operative duration (min)	294.85 ± 16.816	232.15 ± 21.683	0.001 (S)
Bypass time (min)	141.2 ± 28.2	161.5 ± 15.1	NS
Cross-clamp time (min)	91.7 ± 19.5	118 ± 13.6	NS
Inotropic support	16 (80%)	13 (65%)	NS

NS = not significant (p > 0.05); S = significant (p < 0.05).

Table 5 - Comparison of postoperative data.

Parameter	Group 1	Group 2	p-value
Re-exploration for bleeding	3 (15%)	1 (5%)	NS
Drainage (mL)	1023.5 ± 439	632.5 ± 399	0.001 (S)
Inotropic drug use in ICU	10 (50%)	8 (40%)	NS
Need for blood (units)	5 (25%)	4 (20%)	NS
Need for fresh frozen plasma	7 (35%)	5 (25%)	NS
Hospital mortality	2 (10%)	1 (5%)	NS

NS = not significant (p > 0.05); S = significant (p < 0.05).

Table 6 - Comparison of hospitalization variables.

Parameter	Group 1	Group 2	p-value
Mechanical ventilation (hours)	18.02 ± 25.385	17.55 ± 42.973	NS
ICU stay (days)	3.9 ± 0.96	3.6 ± 1.1	NS
Hospital stay (days)	7.50 ± 2.306	6.05 ± 0.999	0.016 (S)
Postoperative pain – Mild	1 (2.5%)	3 (7.5%)	NS
Postoperative pain – Moderate	11 (27.5%)	14 (35%)	NS
Postoperative pain – Severe	8 (20%)	2 (5%)	0.05 (S)
Wound infection (total)	6 (15%)	2 (5%)	<0.05 (S)
Superficial wound infection	4 (10%)	2 (5%)	NS
Deep wound infection	2 (5%)	0 (0%)	NS

NS = not significant (p > 0.05); S = significant (p < 0.05).

Hospital stay was significantly shorter in the thoracotomy group (6.05 ± 0.999 days) than in the sternotomy group (7.50 ± 2.306 days; p < 0.05). Regarding postoperative pain, the distribution of mild and moderate pain did not differ significantly between groups; however, severe pain was significantly less frequent in the thoracotomy group (5%) than in the sternotomy group (20%; p < 0.05) (table 6).

Wound infections were classified according to the depth of tissue involvement. Superficial wound infection was defined as involvement limited to the skin and subcutaneous tissue, presenting with local signs such as erythema, swelling, or discharge; these were managed with local wound care and oral or intravenous antibiotics as needed. Deep wound infection was defined as involvement of tissue deeper than the subcutaneous layer-muscle or the sternum itself in the sternotomy group, or the thoracic cavity, including the pleural space (e.g., empyema), in the thoracotomy group. Deep infections were managed more aggressively, with surgical debridement, drainage, and a

prolonged course of intravenous antibiotic therapy. The overall wound infection rate was significantly higher in the sternotomy group (6 patients, 15%) than in the thoracotomy group (2 patients, 5%; p < 0.05). When stratified by depth, however, neither superficial nor deep infection rates individually reached statistical significance between groups (p > 0.05 for both), most likely reflecting the limited sample size and the small absolute number of deep infections (2 cases, both in the sternotomy group).

DISCUSSION

The increasing number of cardiac valve reoperations - driven by the progressive nature of primary valvular disease, prosthesis-related complications, and a growing volume of initial repair surgery - has prompted the development of varied surgical access strategies for intracardiac procedures. Reoperative tricuspid repair, in particular, is known to carry a high mortality risk (6).

Demographic data (age and sex)

The mean age in the sternotomy group and the thoracotomy group was 44.75 ± 11.355 and 40.75 ± 9.973 years, respectively, with no statistically significant difference between groups. Hanedan et al. (1) reported mean ages of 48.23 ± 9.54 and 53.29 ± 11.16 years in their cohorts. The predominance of middle-aged patients in both series is clinically reasonable, since isolated tricuspid valve repair is rarely the primary indication for surgery; most tricuspid procedures are performed as an adjunct to more extensive cardiac operations, with congenital anomalies such as Ebstein's anomaly being a notable exception. Clinically significant tricuspid regurgitation typically develops late in the course of myocardial or primary valvular disease, becoming an indication for surgery only once it reaches a severe stage.

Sex distribution was balanced overall, with the total study population evenly split between men and women. In the sternotomy group, 60% of patients were male ($n = 12$) and 40% were female ($n = 8$); in the thoracotomy group, the distribution was reversed (40% male, $n = 8$; 60% female, $n = 12$). This difference was not statistically significant. Population-based data suggest that women with valvular heart disease are often under-diagnosed relative to men, despite a similar overall disease incidence between sexes (7).

All patients in our cohort reported dyspnoea, graded using the New York Heart Association (NYHA) functional classification. In the sternotomy group, eight patients (40%) were NYHA class II, ten (50%) were class III, and two (10%) were class IV; the distribution did not differ significantly from the thoracotomy group. These findings are consistent with those of Hanedan et al. (1), who likewise reported no significant difference in NYHA class distribution between their re-sternotomy group ($n = 13$: six class II, six class III, one class IV) and their thoracotomy group ($n = 17$: five class II, eleven class III, one class IV). A higher NYHA class is typically associated with chronic left-sided heart failure, which can produce pulmonary hypertension, right ventricular dilation, and secondary tricuspid regurgitation that may overshadow primary tricuspid valve symptoms. Cardiac murmurs, hepatomegaly, ascites, and peripheral oedema are characteristic clinical features of tricuspid valve disease, and were correspondingly frequent in our cohort, with hepatomegaly, ascites, and lower-limb oedema present in 65%, 55%, and 77% of patients, respectively.

Ascites, peripheral oedema, and hepatomegaly reflect the clinical sequelae of advanced right-sided

heart failure, typically in the setting of reduced right ventricular systolic function (8). Doppler echocardiography remains the gold-standard diagnostic modality for tricuspid valve disease, allowing both aetiological characterisation and semi-quantitative grading of regurgitation severity (9), with colour-coded Doppler flow imaging providing high sensitivity and specificity for identifying the presence and cause of tricuspid pathology (10). This non-invasive modality has improved patient selection for surgical repair while avoiding the procedural risks associated with invasive catheterisation (11).

A statistically significant positive association was observed between the severity of tricuspid regurgitation and the degree of pulmonary hypertension, consistent with the findings of Mutlak et al. (12), who studied determinants of tricuspid regurgitation severity in 2,139 patients with pulmonary hypertension and identified systolic pulmonary artery pressure as an independent predictor of regurgitation severity.

Echocardiographic parameters such as left atrial dimension, left ventricular end-systolic and end-diastolic diameters, and ejection fraction were considered primarily indicative of residual left-sided heart failure rather than primary tricuspid pathology. Mean ejection fraction was similar between groups (Group 1: $50.30\% \pm 3.13$; Group 2: $52.35\% \pm 3.26$; $p > 0.05$), consistent with the preoperative ejection fraction values reported by Hanedan et al. (1). The distribution of surgical procedures was also similar between groups: in the sternotomy group, 12 patients (60%) underwent repair, 6 (30%) received a bioprosthetic valve, and 2 (10%) received a mechanical valve; in the thoracotomy group, 12 patients (60%) underwent repair, 7 (35%) received a bioprosthetic valve, and 1 (5%) received a mechanical valve. This difference in procedure type between groups was not statistically significant ($p > 0.05$).

Sarris-Michopoulos et al. (13) reviewed ten retrospective studies comprising 5,366 patients, comparing isolated tricuspid valve repair ($n = 779$) with replacement ($n = 628$), and reported superior outcomes with repair, including lower 30-day mortality (4.7% vs 12.6%; OR 0.34, 95% CI 0.18–0.66) and a lower rate of postoperative permanent pacemaker implantation (OR 0.37, 95% CI 0.18–0.77). The authors noted that, although stroke and reoperation rates also favoured repair, therapeutic outcomes are ultimately determined by appropriate patient selection, underlying pathophysiology, and the severity of regurgitation. This preference for repair where feasible is supported by Wang et al. (14), whose data showed that repair was

associated with lower in-hospital mortality, less renal dysfunction, and a reduced need for pacemaker implantation compared with prosthetic replacement.

Operative time was significantly longer in the sternotomy group (294.85 ± 16.816 min) than in the thoracotomy group (232.15 ± 21.683 min; $p = 0.001$). This difference is most likely explained by the technical demands of repeat sternotomy, which requires extensive dissection of adhesions and scar tissue-particularly relevant given that the majority of our patients had undergone previous cardiac surgery-whereas the right anterolateral approach avoids this step entirely. These findings are consistent with those of Hanedan et al. (1), who reported a similarly longer operative time with re-sternotomy compared with right anterolateral thoracotomy (298.08 ± 76.64 vs 246.76 ± 47.40 min; $p = 0.032$).

Re-exploration for bleeding occurred in three patients in the sternotomy group and one patient in the thoracotomy group; although this difference did not reach statistical significance ($p > 0.05$), the higher incidence in the sternotomy group may relate to the greater technical complexity of re-sternotomy. Post-operative drainage was significantly lower in the thoracotomy group (632.5 ± 399 mL) than in the sternotomy group (1023.5 ± 439 mL; $p = 0.001$), consistent with the findings of Maimaiti et al. (15), who similarly reported lower total drainage volumes with thoracotomy compared with sternotomy (1150 ± 803.5 vs 2270 ± 1920 mL; $p = 0.012$). Cardiopulmonary bypass time did not differ significantly between groups (141.2 ± 28.2 vs 161.5 ± 15.1 min for sternotomy and thoracotomy, respectively; $p > 0.05$).

Hospital stay was also significantly shorter in the thoracotomy group (6.05 ± 1.00 days) than in the sternotomy group (7.50 ± 2.31 days; $p < 0.05$), in keeping with the trend reported by

Maimaiti et al. (15). Both groups in our study recovered faster than patients in an earlier series, which reported hospital stays of 11.3 ± 7.9 days for median sternotomy and 10.1 ± 6.6 days for thoracotomy (16).

Limitations of the Study

The relatively small sample size ($n = 40$) limits the generalisability of these findings.

- The short follow-up period (one month) does not permit assessment of long-term outcomes such as valve durability or late complications.
- This was a single-centre study, which may introduce institutional bias.
- Although randomisation was performed, potential confounding related to patient selection and

surgeon experience cannot be entirely excluded.

Future multicentre studies with larger cohorts and longer follow-up periods are recommended to validate and extend these findings.

CONCLUSION

Right anterolateral thoracotomy appears to offer efficacy comparable to that of median sternotomy for isolated tricuspid valve surgery, without imposing additional cost on the healthcare system. Based on our analysis, we consider this approach a viable and safe alternative for isolated tricuspid valve repair, with the principal benefits being a shorter hospital stay, reduced operative time, less postoperative bleeding, and less severe postoperative pain.

Conflicts of Interest

The authors declare no conflicts of interest associated with this manuscript.

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Ethical Statement

This study was reviewed and formally approved by the Research Ethics Committee (REC) of the Cairo University Faculty of Medicine.

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