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Direct Vision Cardiac Surgery via Minimal Lateral Thoracotomy: Which Procedure is it Most Suitable for?

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ABSTRACT

Introduction: Minimal approaches have become popular in cardiac surgery in recent years worldwide; as in other surgical specialties, minimal right anterior thoracotomy (RAT) and minimal right lateral thoracotomy (RLT) techniques can be used for some cardiac procedures. This study compares and presents the operative and postoperative advantages and disadvantages of both techniques.

Methods: Between March 2021 and July 2024, a total of 40 patients underwent cardiac surgery via direct vision minimally invasive right thoracotomy approach at Cardiovascular Surgery Center of University of Health Sciences Türkiye, Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital. Eight of these patients underwent surgery with the RAT technique, and 32 underwent surgery with the RLT technique. Operative and postoperative outcomes were compared.

Results: One patient who underwent RAT died during the operative period, and two patients who underwent RLT died during the postoperative period. Cross-clamp and cardiopulmonary bypass times were longer for RAT during the operative period. While there was no difference in extubation times or intensive care stay durations, tube drainage times and hospital stays were shorter for RLT in the postoperative period.

Conclusion: These findings suggest a potential clinical advantage of direct-vision RLT; however, they require further validation in large-scale, prospective studies. The situation may be different in camera-assisted approaches.

Keywords: Cardiac surgery, minimal invasive, right anterior thoracotomy, direct vision, mitral valve surgery

Introduction

Over the past 70 years, various cardiac surgical techniques have been successfully used to treat cardiac pathologies, facilitated by cardiopulmonary bypass (CPB) and advances in myocardial protection (1). As in other surgical specialties, cardiac surgical techniques have been revised over time to reduce surgical trauma and to address cosmetic concerns (2). The number of patients undergoing minimally invasive cardiac surgery techniques has been steadily increasing. This trend can be attributed to both increased patient demand and physician preference (3). Today, minimal left anterior thoracotomy and robotic surgery can be used for coronary artery bypass grafting instead of a full median sternotomy (4,5). Minimal right anterior thoracotomy (RAT), minimal right lateral thoracotomy (RLT), and robotic surgery can be used for valvular and other cardiac pathologies [e.g., atrial septal defect (ASD), anomalous pulmonary venous return, cardiac myxoma, etc.] (2,5,6). Recently, transcatheter methods have also been used to treat coronary or valvular pathologies, or both (7). Numerous methods and technologies are currently available for the treatment of heart disease. This represents a new situation, especially for cardiac surgery, where there were few practical alternatives in the early stages (1).

In this study, cardiac surgical procedures performed with RAT and RLT were described, and their results were compared. The areas of use of these procedures in cardiac surgery, the CPB cannulation techniques, and their advantages and disadvantages were presented.

Methods

Between March 2021 and July 2024, a total of 40 patients underwent cardiac surgery via direct vision minimally invasive right thoracotomy approach at Cardiovascular Surgery Department of University of Health Sciences Türkiye, Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital. The mean age of the operated patients was 52.70±16.99 years, and 11 of the patients (27.5%) were male. The mean ejection fraction of the patients was 57.13±4.22%. Of these patients, 33 underwent [mitral valve replacement (MVR); mechanical MVR: 32 mechanical valves, 1 biological valve], 3 underwent ASD repair, and the remaining 4 patients each underwent one of the following

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procedures: ASD repair combined with correction of partial anomalous pulmonary venous return, left atrial myxoma excision, supracoronary aortic replacement (SCAR), and mitral valve repair (Table 1). Among the 34 patients who underwent mitral valve surgery, 24 had severe mitral regurgitation, 3 had severe mitral stenosis, and 7 had combined mitral regurgitation and stenosis. Of these patients, 8 underwent surgery via the RAT approach (7 for MVR and 1 for SCAR), while 32 underwent surgery via the RLT approach. In patients who underwent surgery via the RAT approach, arterial cannulation was performed via the right femoral artery, while venous cannulation was performed via both the right femoral vein and the right internal jugular vein. Only peripheral cannulation techniques were used for the RAT procedure; in contrast, some RLT cases required only central cannulation, while others required a combination of central and peripheral cannulation. The substantial difference between the numbers of patients undergoing RAT and RLT was primarily attributable to our preference to avoid routine peripheral cannulation, which is required for the RAT approach. Most patients were reluctant to undergo an additional femoral incision unless it was considered absolutely necessary. Consequently, our preference for central cannulation resulted in more patients being treated with the RLT approach. The operative and postoperative outcomes of the two minimally invasive techniques were compared.

Surgical Techniques

In the RLT approach, a 6-7-cm skin incision is made along the right mid-axillary line. Subsequently, a thoracotomy is performed through the 4th or 5th intercostal space at a 90° angle to the incision. The surgical field is accessed using two thoracic retractors placed perpendicularly to each other (Figure 1).

For the RAT approach, a 5-6 cm skin incision is made over the 5th intercostal space, beginning 5-6 cm lateral to the right sternal border, under the breast. The surgical intervention is performed through this intercostal space using a single thoracic retractor (Figure 2).

In both techniques, standard surgical instruments available at our institution were used rather than dedicated minimally invasive surgical equipment.

Table 1. Distribution of surgical procedures performed via minimally invasive right thoracotomy (March 2021-July 2024)

Procedure	Number of patients
Mitral valve replacement	33
ASD repair	3
ASD repair + correction of partial anomalous pulmonary venous return	1
Left atrial myxoma excision	1
Supracoronary aortic replacement	1
Mitral valve repair	1
Total	**40**

ASD: Atrial septal defect

Figure 1. Postoperative right lateral thoracotomy incision (consent of the patient is taken)

Figure 2. Postoperative right anterior thoracotomy incision (consent of the patient is taken)

Ethics Committee Approval

Our study received ethical approval from the İstanbul Medipol University Ethics Committee on 30.04.2026 (decision number: 688). As our institution does not have an institutional ethics committee, ethical approval for this study was obtained from the Istanbul Medipol University Ethics Committee.

Informed Consent

As this was a retrospective study, informed consent was not required.

Statistical Analysis

Statistical analyses of the study were conducted using the trial version of the SPSS 22.0 software package (SPSS Inc., Chicago, IL, USA). The normality of the distribution of quantitative variables was assessed using the Kolmogorov-Smirnov and Shapiro-Wilk tests. For normally distributed variables, comparisons between independent groups were made using the independent samples t-test. For non-normally distributed variables, the Mann-Whitney U test was employed. Paired measurements that were normally distributed were analyzed using the paired-samples t-test, whereas those that were not normally distributed were analyzed using the Wilcoxon signed-rank test. The relationship between categorical variables was examined using the chi-square test. Descriptive statistics for normally distributed quantitative variables were presented as mean ± standard deviation, while those not normally distributed were presented as median (minimum-maximum). Descriptive statistics for categorical variables were expressed as frequencies (%). A p value of <0.05 was considered statistically significant.

Results

A total of 32 patients underwent surgery using the RLT technique, while 8 underwent surgery using the RAT approach. The mean age of patients who underwent the RLT procedure was 57.5 years, and 25 (78.1%) were female. The mean age of patients who underwent the RAT procedure was 60.0 years; 4 (50%) were female (Table 2). The mean cross-clamp time for the RLT and RAT techniques was 77.44±27.03 minutes (min.) and 94.25±26.90 min., respectively. The mean CPB times were 124.41±39.00 min. and 171.13±84.44 min., respectively. The mean cross-clamp and CPB times were shorter with the RLT technique. However, this difference was statistically significant only for CPB time. The preferred techniques for arterial-venous cannulation and left atrial approaches are presented in Table 3. Of the 34 patients with mitral valve disease, 32 underwent mechanical MVR, 1 underwent biological MVR, and 1 underwent mitral valve repair. Concomitant tricuspid De Vega annuloplasty was performed in 15 of these patients (Table 3).

Two patients who underwent surgery with the RLT technique died in the postoperative period, while one patient who underwent surgery with the RAT technique died intraoperatively.

In our study, no statistically significant differences were observed between the two techniques for extubation time and length of stay in the intensive care unit (ICU). Furthermore, the RLT technique was statistically superior in terms of postoperative chest-tube drainage duration and overall length of hospital stay. Additionally, no significant differences were detected in implanted valve sizes between the groups (Table 4).

When comparing preoperative and postoperative atrial diameters and pulmonary artery pressures for each technique separately, the RLT group demonstrated statistically significant reductions in left atrial apico-basal and medio-lateral diameters, as well as in pulmonary artery pressure. In the RAT group, no statistically significant changes were observed in atrial diameters and pulmonary artery pressures (Table 5).

Discussion

Mitral valve disease is a common cardiac condition requiring surgical intervention. Traditional sternotomy, while effective, is associated with significant morbidity and prolonged recovery (8). Minimally invasive approaches, such as RLT and RAT, have gained popularity due to reduced trauma and faster recovery (9). However, the optimal approach remains debated.

This research demonstrates that both RLT and RAT are safe and effective options for MVR. RLT provides greater visibility than RAT. On the other hand, although other previous studies have found that “By minimizing muscle dissection, RAT may facilitate more rapid postoperative recovery and consequently reduce both operative duration and length of

Table 2. Baseline demographic and clinical characterization

Total number of patients	**40**
Age, years, mean ± SD; [min-max]	52.70±16.99 [19-76]
Sex, male/female, n (%)	11 (27.5)/29 (72.5)
Presence of MS, n (%) Grade 1 Grade 2 Grade 3 Grade 4	14 4 1 1 8
Presence of MR, n (%) Grade 1 Grade 2 Grade 3 Grade 4	33 3 5 10 15
Presence of mitral pathology • Degenarative • Rheumatic	34 17 (50) 17 (50)
Ejection fraction, %, mean ± SD; [min-max]	57.13±4.22 [45-60]
Left atrium AP diameter, mm, mean ± SD; [min-max]	45.95±10.09 [30-50]
Left atrium AB diameter, mm, mean ± SD; [min-max]	58.43±12.41 [35-90]
Left atrium ML diameter, mm, mean ± SD; [min-max]	48.38±9.79 [29-77]
Right atrium AB diameter, mm, mean ± SD; [min-max]	44.08±10.90 [25-70]
Right atrium ML diameter, mm, mean ± SD; [min-max]	35.45±9.01 [19-59]
PAP, mmHg, mean ± SD; [min-max]	39.50±17.01 [12-78]
Presence of AF, n (%)	13 (32.5)
Presence of TR Grade 1 Grade 2 Grade 3	30 17 6 7

Data presented as n (%), mean ± SD and median (IQR) as appropriate. SD: Standard deviation, MS: Mitral stenosis, MR: Mitral regurgitation, AP: Anterior-posterior, AB: Apical-basal, ML: Medial-lateral, PAP: Pulmonary artery pressure, AF: Atrial fibrillation, TR: Tricuspid regurgitation, IQR: Interquartile range, min-max: Minimum, maximum

Table 3. Operational outcomes

n=40	RAT (n=8)	RLT (n=32)	p value
Age, years, median (min-max)	60.5 (5-72)	57.5 (19-76)	0.342**
Sex, female, n (%)	4 (50.0)	25 (78.1)	0.182*
Arterial cannulation, n (%) • Peripheral • Central	 8 (100) 0 (0)	 7 (21.9) 25 (78.1)	**<0.001***
Superior vein cannulation, n (%) • Peripheral • Central	 7 (87.5) 1 (12.5)	 1 (3.1) 31 (96.9)	**<0.001***
Inferior vein cannulation, n (%) Peripheral Central	 8 (100) 0 (0)	 2 (6.3) 30 (93.8)	**<0.001***
Atriotomy type, (n=39) Right, n (%) Left, n (%) Left + right, n (%) Transseptal, n (%)	 0 (0) 4 3 0	 5 (15.6) 13 (40.6) 7 (21.9) 7 (21.9)	0.101*
Mitral valve type, n (%) • Mechanical • Biological • Repair	 7 0 0	 25 1 1	N/A
Mitral valve size, mm, median (min-max)	29 (27-29)	29 (25-33)	0.232**
TDV, n (%)	3 (37.5)	12 (37.5)	0.999*
Xclamp time, min, mean ± SD	94.25±26.90	77.44±27.03	0.062***
CPB time, min, mean ± SD	171.13±84.44	124.41±39.00	**0.025*****

*chi square test, **Mann-Whitney U test, ***Independent sample t-test. RAT: Right anterior thoracotomy, RLT: Right lateral thoracotomy, TDV: Tricuspid De Vega annuloplasty, SD: Standard deviation, CPB: Cardiopulmonary bypass, min-max: Minimum-maximum, N/A: Not applicable

Table 4. Postoperative outcomes

n=37	RAT (n=7)	RLT (n=30)	p value
Extubation time, days, median (min-max)	0 (0-14)	0 (0-22)	0.212*
ICU stay, days, median (min-max)	2 (1-14)	1 (1-24)	0.185*
Drain time, days, median (min-max)**	5 (3-7)	3 (2-12)	**0.005***
Hospital stay, days, median (min-max)	8.5 (6-98)	6.0 (4-17)	**0.004***

*Mann-Whitney U test, **Duration of postoperative chest tube drainage. RAT: Right anterior thoracotomy, RLT: Right lateral thoracotomy, min-max: Minimum-maximum, ICU: Intensive care unit

Table 5. Comparison of preoperative and postoperative changes in atrial diameters

n=37	RAT (n=7)			RLT (n=30)		
	Preop	Postop	p value	Pre-op	Post-opp	p value
EF	57.50 (50-60)	60 (50-60)	0.560*	60 (45-60)	60 (45-60)	0.520*
Left atrium AP diameter, mm, mean ± SD; (min-max)	44.67±6.02	44.33±9.22	0.942**	45.90±10.94	42.43±5.56	0.063**
Left atrium AB diameter, mm, mean ± SD; (min-max)	59.50±9.05	54.00±14.51	0.422**	57.97±13.26	53.13±10.73	**0.014****
Left atrium ML diameter, mm, mean ± SD; (min-max)	48.00±5.47	43.17±9.08	0.280**	47.50 (29-77)	44.00 (29-66)	**0.013***
Right atrium AB diameter, mm, mean ± SD; (min-max)	49.33±3.44	42.50±8.28	0.051**	42.77±11.79	40.17±9.75	0.200**
Right atrium AB diameter, mm, mean ± SD; (min-max)	37.83±4.46	34.00±7.29	0.252**	36 (19-57)	33 (22-60)	0.341*
PAP	48.83±19.65	37.33±18.04	0.329**	38.53±16.94	24.33±6.86	**<0.001****

*Wilcoxon t test, **Paired sample t-test. RAT: Right anterior thoracotomy, RLT: Right lateral thoracotomy, min-max: Minimum-maximum, EF: Ejection fraction, PAP: Pulmonary artery pressure, AP: Anterior-posterior, AB: Apical-basal, ML: Medial-lateral

hospital stay" (10,11) our study showed the opposite. Unlike previous studies, our findings show that RLT is associated with significantly shorter Xclamp and CPB times and a shorter hospital stay compared with RAT. This observation may be attributed to several intraoperative and postoperative factors that distinguish between the two techniques. These situations can be considered: CPB cannulation and decannulation for RAT being peripheral; RLT exposure being more visible compared to RAT; hemostasis being more difficult to achieve by direct vision in RAT since no camera is used; and being associated with longer tube drainage and hospital stay in the postoperative period. Although no statistically significant differences were observed between the groups in terms of extubation time or ICU stay, the prolonged chest tube duration in RAT patients appears to play a crucial role in extending hospitalization. One plausible explanation for this difference lies in the limitations of direct vision techniques employed in RAT. Without the enhanced visual assistance provided by a camera system, identifying minor bleeding foci that can contribute to prolonged drainage may be more challenging (Figure 3). RLT, on the other hand, offers superior visualization and exposure, allowing the surgeon to detect and manage even minimal sources of bleeding more effectively. This intraoperative advantage may lead to reduced postoperative drainage, thereby facilitating earlier chest tube removal and subsequent hospital discharge (12).

Figure 3. Surgical exposure of the right anterior thoracotomy (consent of the patient is taken)

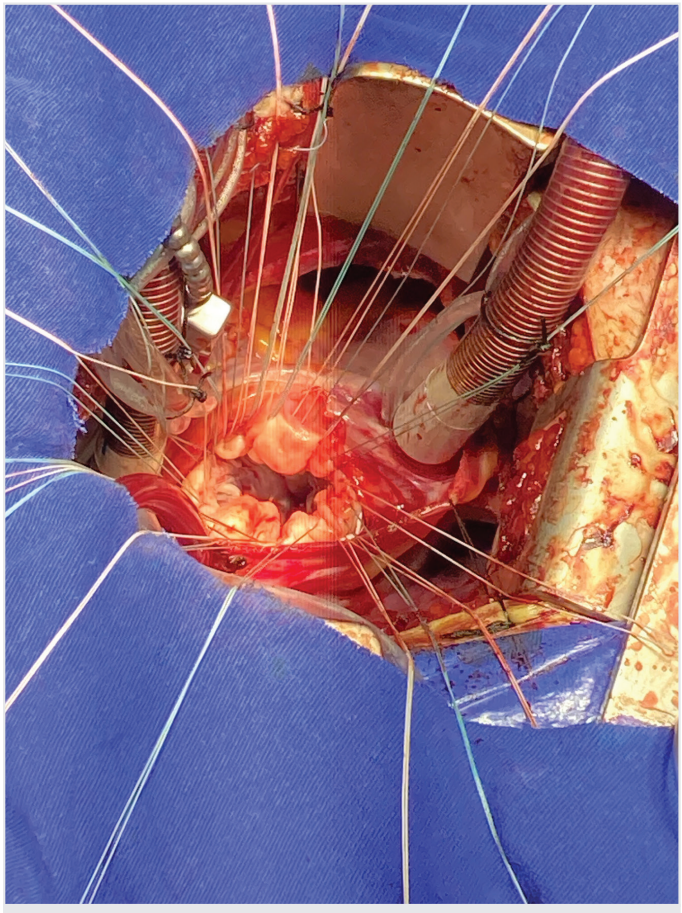

Figure 4. Surgical exposure of the right lateral thoracotom(consent of the patient is taken)

Direct cannulation of the ascending aorta for the RLT technique Figure 4 is effective in overcoming the challenges associated with peripheral cannulation, particularly in patients with peripheral artery disease. In situations where transesophageal echocardiography is not available in the operating room, blind peripheral cannulation may pose significant risks. However, the RLT technique eliminates this concern by enabling direct cannulation of the aorta and vena cava (13). Peripheral arterial cannulation is mandatory for the RAT technique. In contrast, peripheral arterial cannulation in RLT is at the discretion of the surgeon. If the surgeon believes that it will not hinder exposure and the patient's anatomy is suitable, central arterial cannulation may be performed. Peripheral arterial cannulation, in addition to the inherent complications of cardiac surgery, can introduce further risks. The most significant of these are femoral wound infection, seroma, hematoma, peripheral arterial stenosis, and peripheral venous thrombosis (14).

The decision to use RLT or RAT should be based on factors such as the patient's anatomy, the surgeon's expertise, and the institution's available resources. For instance, RAT might be the preferred option for patients with a high body mass index (the association of obesity with respiratory pathologies is particularly common in society) (15), where where lateral exposure is difficult (16). On the other hand, RLT could be more beneficial in reoperative cases or those requiring extensive mitral valve repair (17).

Study Limitations

This study has several limitations that should be considered. First, its retrospective, non-randomized, single-center design introduces potential selection bias, as the choice of surgical approach was based on surgeon preference and patient-specific anatomical factors. In addition, the relatively small sample size—particularly in the RAT group—limits the statistical power of intergroup comparisons and may have reduced the ability to detect clinically meaningful differences.

Second, procedural heterogeneity and technical differences between the two approaches may have influenced the perioperative outcomes. Variations in cannulation strategies, exposure quality, and the use of

direct vision without camera assistance, particularly with the RAT technique, may have affected operative times, control of hemostasis, and postoperative drainage. These factors should be taken into account when interpreting the comparative results of the two minimally invasive approaches.

The relatively small number of patients in the RAT group, compared with that in the RLT group, represents one of the major limitations of this study.

Conclusion

The superior intraoperative hemostasis and improved visualization provided by RLT during direct vision operations without camera assistance seem to contribute significantly to reduced postoperative drainage and shorter hospital stay compared with RAT. These findings suggest a potential clinical advantage of direct vision RLT and require further validation in large-scale, prospective studies. T he situation may be different in camera-assisted approaches. It would be beneficial for the surgeon to choose the technique he believes will be more successful and to complete the learning curve for that technique.

Ethics

Ethics Committee Approval: Our study received ethical approval from the İstanbul Medipol University Ethics Committee on 30.04.2026 (decision number: 688). As our institution does not have an institutional ethics committee, ethical approval for this study was obtained from the Istanbul Medipol University Ethics Committee.

Informed Consent: As this was a retrospective study, informed consent was not required.

Footnotes

Authorship Contributions: Surgical and Medical Practices - Y.Ö., M.Ş., Y.Ş., İ.K.; Concept - Y.Ö., Y.Ş.; Design - Y.Ö., M.Ş., İ.K.; Data Collection or Processing - Y.Ö., E.S.; Analysis or Interpretation - Y.Ö., M.Ş., Y.Ş.; Literature Search - Y.Ö., E.S., İ.K.; Writing - Y.Ö., E.S.

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