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Minimally invasive cardiac surgery in low-resource settings: right vertical infra-axillary mini-thoracotomy without peripheral cannulation – the first 100 cases

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Abstract. – OBJECTIVE: Literature is scarce on minimally invasive cardiac surgery in adults with a right vertical infra-axillary thoracotomy approach without using peripheral cannulation. This study aimed to analyze the perioperative, early outcomes of minimally invasive cardiac surgery with direct vision using central aortic-venous cannulation through a right vertical infra-axillary thoracotomy, *vs.* standard cardiac surgery with median sternotomy.

PATIENTS AND METHODS: This retrospective study included the first 100 adult patients who were operated on *via* right vertical infra-axillary thoracotomy and central aortic and venous cannulation. The control group comprised 100 adult patients who underwent cardiac surgery through a median sternotomy and central aortic and venous cannulation.

RESULTS: The thoracotomy group was associated with prolonged aortic cross-clamp time, cardiopulmonary bypass time, and operation time. The amount of postoperative chest tube drainage and blood transfusion was higher in the sternotomy group. No difference was found between the groups in terms of postoperative morbidity and mortality rates. Despite a higher level of pain in the thoracotomy group on the first 3 postoperative days, patient satisfaction was higher in this group.

CONCLUSIONS: In a resource-limited setting, minimally invasive cardiac surgery with direct vision using central aortic-venous cannulation through a right vertical infra-axillary thoracotomy may help to establish minimally invasive cardiac surgery with better cosmetic results, and higher patient satisfaction compared to the median sternotomy approach. Outcomes during the learning curve were similar.

Key Words:
Minimally invasive, Cardiac surgery, Cardiopulmonary bypass, Central cannulation, Vertical infra-axillary thoracotomy.

Introduction

The use of minimally invasive cardiac procedures has expanded globally with excellent mid/long-term outcomes, and this has been proven to be a sufficiently safe and feasible alternative to median sternotomy (MS). Different approaches have been reported to reduce surgical trauma and postoperative morbidity, including mini-sternotomy, transxyphoid approach, mini-thoracotomy, endoscopic port access, and transaxillary incisions[1-4].

To perform operations through small ports, specially designed surgical instruments and thoracoscopic imaging systems are required. Moreover, in minimally invasive procedures, cardiopulmonary bypass (CPB) is established *via* cannulation of the common femoral artery/vein and the right internal jugular vein using peripheral cannulas. Endoscopic instruments, imaging systems, and peripheral cannulas are not readily available in all clinics[5]. Furthermore, the techniques used in this approach require a new skill set and are associated with a steep learning curve[6]. As a result of these factors, minimally invasive procedures have not become widespread. Simplified, reproducible, minimally invasive approaches have been described using conventional surgical instruments, cannulas, and devices with central aortic/venous cannulation[7,8].

One of these approaches is minimally invasive cardiac surgery through the right vertical infra-axillary thoracotomy (RVIAT) with central aortic and venous cannulation[8]. Through this access, procedures such as ASD (atrial septal defect), VSD (ventricular septal defect), myxoma excision, re-operations, AVR (aortic valve replacement), MVR (mitral valve replacement), double valve interventions, and ablation for atrial fibrillation can be performed[7-10].

There is a limited amount of literature on minimally invasive cardiac surgery in adults through RVIAT without peripheral cannulation[9,10]. This study aimed to analyze the perioperative and early outcomes of minimally invasive cardiac surgery with direct vision using central aortic and venous

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cannulation through RVIAT compared to the standard cardiac surgery with MS and to examine the effect of the learning curve on the outcomes.

Patients and Methods

Study Design

Approval for the study was granted by the Local Ethics Committee, and all procedures complied with the requirements of the Declaration of Helsinki. Data were collected retrospectively from the medical records of adult patients who underwent cardiac surgery between January 2015 and July 2019 at Gazi Yasargil Training and Research Hospital. The first 100 adult patients undergoing cardiac surgical procedures (MVR, tricuspid valve procedures, and ASD closure) with RVIAT and central aortic/ venous cannulation were included in the study. The control group comprised 100 consecutive adult patients who underwent cardiac surgery with MS and central aortic/ venous cannulation.

The study exclusion criteria were defined as reduced ejection fraction (EF <40%), patients who underwent emergent or salvage surgery, coronary bypass surgery, re-operative procedures, patients with dialysis-dependent renal failure, concomitant moderate to severe aortic valve regurgitation, those who required concomitant aortic valve intervention or concomitant coronary bypass, or those with body mass index (BMI) >35 kg/m^2, or severe chronic obstructive pulmonary disease (COPD). Patients not deemed appropriate for minimally invasive surgery in our clinic had been previously excluded from the study. According to the exclusion criteria, 77 patients were excluded from the study. A flow diagram of patients in the study is depicted in Figure 1. The preoperative clinical characteristics of the patients are presented in Table I.

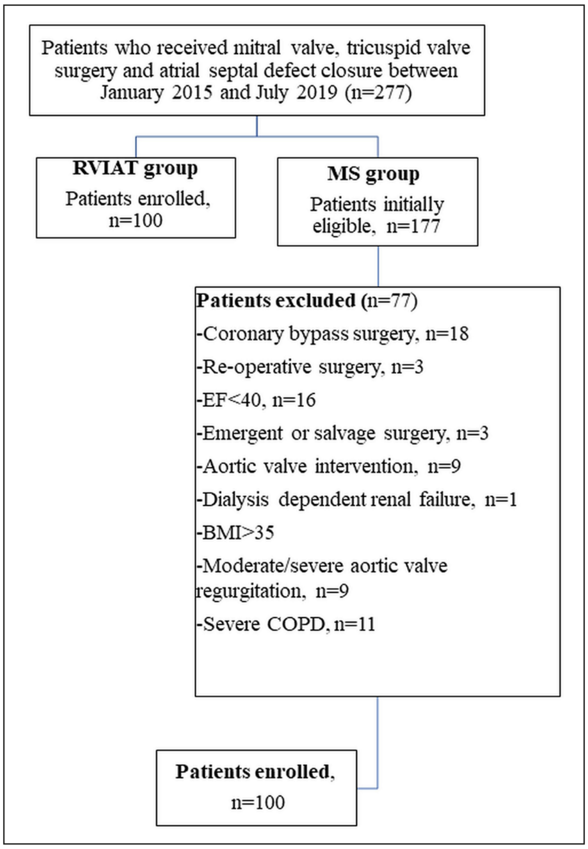

Figure 1. A flow diagram of patients in the study.

Table I. Baseline characteristics and comorbidities.

	RVIAT (n=100)	MS (n=100)	*p*-value
Age (years)	52.9±15.4	54.4±15.8	0.5
Male, n (%)	47	50	0.48
Smoking, n (%)	40	43	0.67
HT, n (%)	24	22	0.73
HL, n (%)	10	12	0.65
DM, n (%)	11	10	0.81
COPD, n (%)	10	11	0.82
PVD, n (%)	2	4	0.4
PHT, n (%)	21	18	0.59
History of CVE, n (%)	1	2	0.56
Renal dysfunction, n (%)	0	0	
EF	51.2±6.6	50.7±5.3	0.56
AF, n (%)	27	30	0.64

Values are presented as mean ± standard deviation, median (interquartile range), or n (%). $p<0.05$ was considered statistically significant. RVIAT, right vertical infraaxillary thoracotomy; MS, median sternotomy; HT, hypertension; HL, hyperlipidemia; DM, diabetes mellitus; COPD, chronic obstructive pulmonary disease; PVD, peripheral vascular disease; PHT, pulmonary hypertension; CVE, Cerebrovascular event; EF, ejection Fraction; AF, atrial fibrillation.

Operative Features

All surgical operations were performed under a standard general anesthesia protocol, and all patients were intubated with a single-lumen endotracheal tube. Minimally invasive procedures were performed with RVIAT under direct view with central arterial/venous cannulation. A standard non-pulsatile roller pump and a membrane oxygenator were used in CPB. Retrograde autologous priming was performed to reduce the need for transfusion[11]. The CPB system was primed with Ringer lactate solution. CPB was established using bicaval cannulation and ascending aorta cannulation. Patients were administered 300-400 U/kg of heparin sodium to maintain activated clotting time (ACT) values >480 s. During CPB, non-pulsatile pump flow was maintained at 2.2-2.5 L/min/m^2. The body temperature was cooled to 28°C. The alpha-stat strategy was used for pH management, and normocapnic levels ($PaCO_2$=35-45 mmHg) were provided for each patient. Concentrated fresh erythrocyte suspensions (stored for ≤7 days) were used for priming volume if required to obtain hematocrit levels >25%, and the mean arterial pressure was stabilized between 50 mmHg and 70 mmHg during CPB.

Transesophageal echocardiographic monitoring was performed in all procedures.

Thoracotomy Incision

Each patient was positioned supine, and a pillow was placed beneath the right side of the chest to elevate it to 45°. The right upper extremity was abducted over the head and secured to a padded arm board. The skin, muscles, and mammary tissue were pulled to the assistant side using a drape. An 8-10 cm right vertical infra-axillary incision was made from the second to fifth intercostal space, extending along the anterior midaxillary line (Figure 2).

Flaps were created in the subcutaneous tissue to facilitate incision mobility. The layer under the pectoralis major muscle was dissected, and the pleural cavity was entered through the fourth intercostal space (Figure 2). Entry to the chest is shown by the red dotted line in Figure 2. Standard chest retractors were used, and an additional chest spreader was positioned perpendicular to the first one to provide optimal exposure (Figure 2). The retractor and the window formed by the skin incision were moved and fixed in a suitable position. (Figure 2)[12]. On entering the pleural space, pulmonary tidal volume decreased by about half of the tidal volume, and respiratory rate increased to 16-18 breaths per minute. The lung was retracted posteriorly with 5 to 6 pericardial stay sutures and wet sponges. These manipulations facilitate the exposure of the pericardium and eliminate the need for a double-lumen endotracheal tube or an endobronchial blocker. Under direct vision, the pericardium was incised parallel to and approximately 3-4 cm anterior to the phrenic nerve. Pericardial retraction raised the heart by 4-5 cm to the operative field. After systemic heparinization, a purse-string suture was placed at the base of the right atrial appendage. Traction on this suture allows exposure of the whole aorta, especially in patients with a markedly enlarged right atrium. Purse-string sutures were placed in a standard fashion. Arterial cannulation was performed directly in the ascending aorta using the Seldinger technique or in a conventional manner with a straight cannula secured to the surgical drapes. The aorta can be pulled downwards with a long clamp to aid exposure during cannulation. Next, the superior vena cava (SVC) was cannulated directly with a right-angled venous cannula, or SVC cannulation was achieved through the right atrial appendage. CPB was commenced after SVC cannulation, and once the heart was emptied, the inferior vena cava (IVC) was cannulated with a curved single-stage cannula. The IVC can be exposed by pushing the right ventricle posteriorly with a cardiotomy sucker. SVC and IVC snares were passed on CPB after the heart was decompressed. The lungs may be deflated during cannula insertions to aid exposure. To provide more working space, the IVC and SVC cannulas can be placed one or two spaces above or below the intercostal space which has been entered.

The ascending aorta was clamped through the incision using a standard cross-clamp. Adequate

Figure 2. An 8-10 cm right vertical infra-axillary incision made from the second to fifth intercostal space and extending along the anterior or midaxillary line. The entry location to the chest is indicated by the red dotted line.

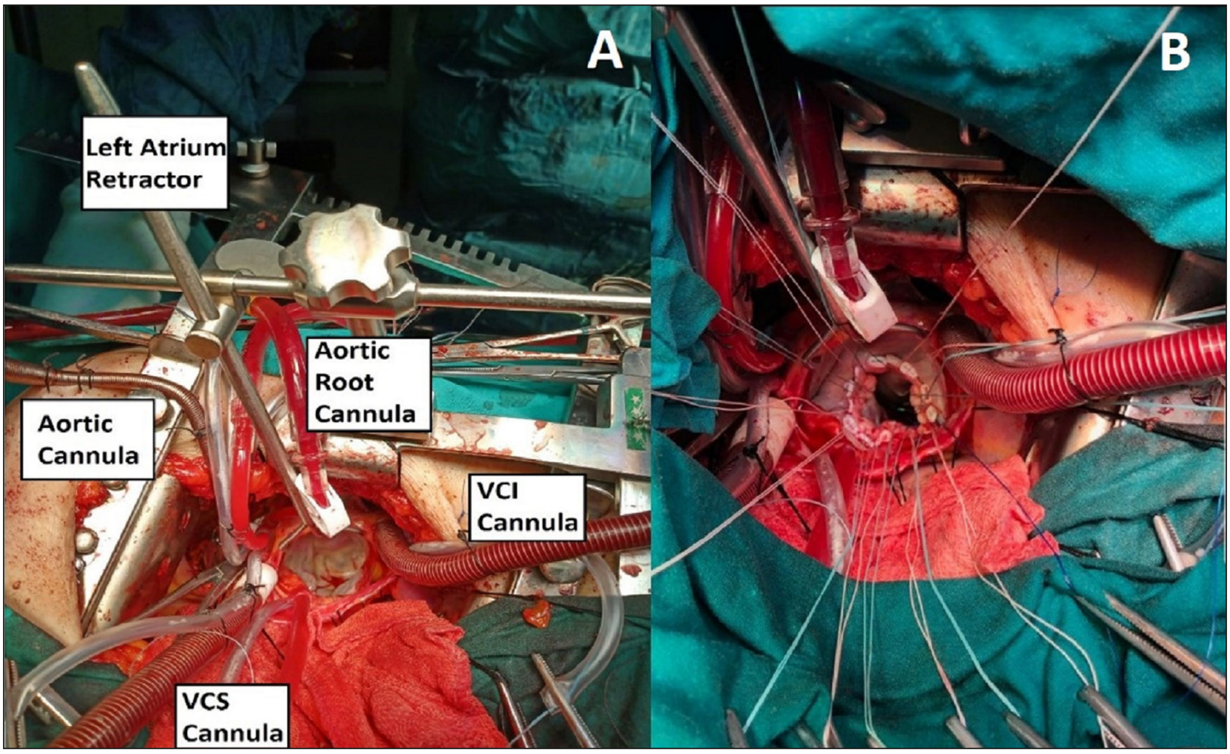

Figure 3. **A**, Exposure of the mitral valve with central aortic and bicaval cannulation within the same incision. **B**, Complete chordal-sparing mitral valve replacement through a right infra-axillary mini-thoracotomy.

myocardial protection was obtained with del Nido cardioplegia through a cardioplegia needle in the aortic root. Del Nido cardioplegia was prepared in the operating room at no additional cost. After cardiac arrest, the appropriate intracardiac procedures were performed (Figure 3 A-B, Figure 4). Defibrillation, when necessary, was administered through the regular internal defibrillator paddles, preferably with pediatric defibrillator paddles. The right pleural space and mediastinum were drained through the 6th or 7th intercostal space with two chest tubes, with one of the tubes placed into the posterior of the heart through the oblique sinus. The intercostal space was closed with three figure-of-eight pericostal sutures. A local nerve block was applied before the chest was closed. Continuous carbon-dioxide insufflation of the operative field was performed in all cases.

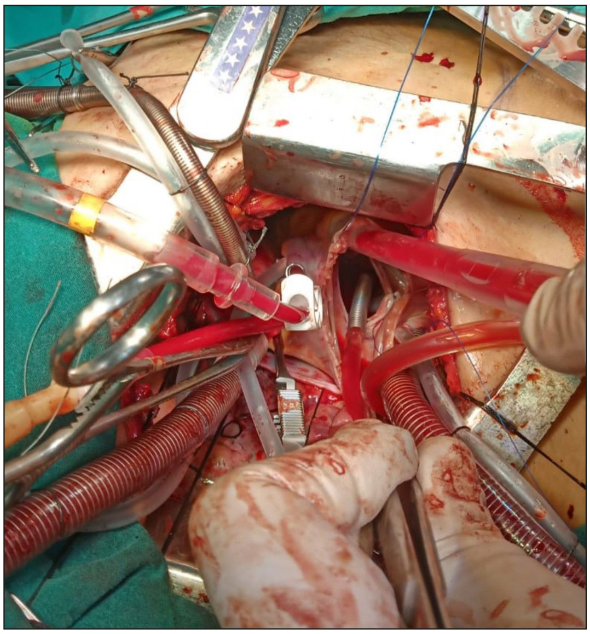

Figure 4. Exposure of the right atrium and the atrial septal defect through a right infra-axillary mini-thoracotomy.

Postoperative Pain Assessment

Pain intensity was measured 4 times using a self-reported visual analog scale (VAS): on postoperative days 1, 3, 5, and 15. Pain felt at rest (VAS1) and after coughing (VAS2) was recorded by a nurse.

Patient Satisfaction

A VAS to measure patient satisfaction was obtained on hospital discharge and in the second postoperative month. Patients were asked to mark their degree of satisfaction on a scale of 0 to 10, with 0 indicating least satisfied and 10 indicating most satisfied.

Statistical Analysis

All statistical analyses were conducted using SPSS Statistics for Windows software version 22 (IBM Corp., Armonk, NY, USA). All variables were investigated using visual (histograms, probability plots) and analytic methods (Kolmogorov-Smirnov test) to determine whether they were normally distributed. Continuous variables were reported as means and standard deviation for normally distributed variables and as medians and interquartile ranges for non-normally distributed variables. Categorical variables were presented using numbers and percentages. Comparison between the two groups was performed using the Chi-squared test or the Fisher's exact test for qualitative variables, the independent *t*-test for normally distributed continuous variables, and the Mann-Whitney U test for non-normally distributed continuous variables. *p*-values <0.05 were considered to indicate statistical significance.

Results

The clinical characteristics of the RVIAT (n=100; 47 males; mean age 52.9±15.4 years) and MS (n=100; 50 males; mean age 54.4±15.8 years) groups are shown in Table I. The RVIAT and MS groups were statistically similar in terms of demographic data, comorbidities, preoperative baseline, and clinical characteristics (Table I).

The operative and postoperative characteristics are shown in Table II and Table III, respectively. Total aortic cross clamp (ACC) time [60 (41-66.75) *vs.* 41.5 (23.25-48); *p*<0.001], CPB time [104.5 (73.75-117) *vs.* 81.5 (49-90); *p*<0.001] and operation time [185 (150-200) vs. 145 (111.25 - 155); *p*<0.001] were significantly higher in the RVIAT group. Postoperative drainage and blood transfusion rates were higher in the MS group (*p*<0.001 and *p*<0.001, respectively). There was no difference between the Wgroups in postoperative morbidity and mortality rates. There were no instances of mediastinitis in the RVIAT group. The length of ICU and hospital stay were similar in both groups. No patient in the RVIAT group required conversion to full sternotomy.

Postoperative Pain

VAS1 on postoperative days 1 [6 (5-7) *vs.* 5 (4-6); *p*=0.001] and 3 [5 (4-6) *vs.* 4 (3-5); *p*<0.001] was significantly higher in the RVIAT group. There was no difference between the groups in VAS1 on postoperative days 5 and 15. VAS2 was significantly higher in the RVIAT group on postoperative days 1 [8 (7-9) *vs.* 7 (6-8); *p*=0.001] and 3 [6 (5-7) *vs.* 5 (4-6); p<0.001]. There was no difference between the groups in VAS2 on postoperative days 5 and 15 (Table IV).

Patient Satisfaction

Patient satisfaction on discharge [8 (7-9) *vs.* 7 (6-8); *p*<0.001] and at postoperative month 2 [8 (8-9) *vs.* 8 (7-8); *p*<0.001] was significantly higher in the RVIAT group compared to the MS group (Table IV).

Discussion

The results of this study demonstrated that minimally invasive cardiac surgery through RVIAT

Table II. Operative characteristics.

Surgical Procedures, n (%)	RVIAT (n=100)	MS (n=100)	*p*-value
Secundum type ASD repair	27	25	0.8
Sinus venous type ASD+PAPVC repair	3	2	0.9
Single valve replacement	44	46	0.8
- MVR	43	45	0.8
- TVR	1	1	
Double valve (MVR+Tricuspid repair) procedure	26	27	0.9
ACC time, min	60 (41-66.75)	41.5 (23.25-48)	<0.001
CPB time, min	104.5 (73.75-117)	81.5 (49-90)	<0.001
Operation time, min	185 (150-200)	145 (111.25-155)	<0.001
Conversion to full sternotomy	0		
Drainage, ml	250 (250-300)	500 (500-587.5)	<0.001
Transfused ES, unit	0 (0-1)	1 (0.25-1)	<0.001

Values are presented as mean ± standard deviation, median (interquartile range), or n (%). *p*<0.05 was considered statistically significant. RVIAT, right vertical infra-axillary thoracotomy; MS, median sternotomy; ASD, atrial septal defect; PAPVC, partial anomalous pulmonary venous connection; MVR, mitral valve replacement; TVR, tricuspid valve replacement; ACC, aortic cross clamp; CPB, cardiopulmonary bypass; ES, erythrocyte suspension.

Table III. Postoperative outcomes

	RVIAT (n=100)	MS (n=100)	*p*-value
Intubation time, hr	8.06±4.8	8.37±5.1	0.66
Drainage, ml	250 (250-300)	500 (500-587.5)	<0.001
Transfused ES, unit	0 (0-1)	1 (0.25-1)	<0.001
Re-exploration for bleeding, n (%)	0 (0)	2 (2)	0.5
Inotropic support, n (%)	5 (5)	6 (6)	1
IABP requirement, n (%)	0	0	
Perioperative MI, n (%)	0	0	
CVE, n (%)			
Major CVE	0	0	
Minor CVE	1 (1)	1 (1)	1
Respiratory failure requiring re-intubation, n (%)	1 (1)	2 (2)	1
Pneumonia, n (%)	1 (1)	1 (1)	1
Postoperative new AF, n (%)	18 (18)	21 (21)	0.7
Mediastinitis, n (%)	1 (1)	0 (0)	1
Wound infection, n (%)	4 (4)	4 (4)	1
Acute renal dysfunction, n (%)	0	0	
GIS complications, n (%)	0	0	
EF before discharge	50.5±6.7	49.5±5.9	0.29
EF by the sixth postoperative month	51.3±6.6	50.9±5.9	0.61
ICU stay (d)	1.1±06	1.2±0.8	0.4
Hospital stay (d)	5.6±1.5	5.7±2.4	0.67
In-hospital mortality, n (%)	1 (1)	1 (1)	1

Values are presented as mean ± standard deviation, median (interquartile range), or n (%). $p<0.05$ was considered statistically significant. RVIAT, right vertical infra-axillary thoracotomy; MS, median sternotomy; ES, erythrocyte suspension; IABP, intraaortic balloon pump; MI, myocardial infarction; CVE, cerebrovascular event; AF, atrial fibrillation; GIS, gastrointestinal system; EF, ejection fraction; ICU, intensive care unit.

without peripheral cannulation is a safe and feasible procedure associated with low morbidity and mortality rates. Furthermore, patient satisfaction was found to be higher in the RVIAT group than in the median sternotomy group. Surgical outcomes during the learning curve were similar in both groups.

There are several advantages of muscle-sparing RVIAT over anterior or lateral thoracotomy. The principal advantage of RVIAT is minimalized muscle transection due to muscle sparing. RVIAT conserves muscles other than the intercostal muscles. Thus, surgical injury is lower, allowing faster functional recovery[13]. In addition, RVIAT retains the long thoracic nerve. The incision is far from the costochondral junction and therefore does not negatively impact the chest wall development8. Moreover, the RVIAT incision is far from the breast tissue and avoids any interference in the development of breasts by preventing the sectioning of glands and nipple sensitivity[14].

Table IV. Postoperative pain assessment and patient satisfaction.

	RVIAT (n=100)	MS (n=100)	*p*-value
VAS1			
-POD1	6 (5-7)	5 (4-6)	0.001
-POD3	5 (4-6)	4 (3-5)	<0.001
-POD5	1.98±0.7	1.86±0.7	0.23
-POD15	1.32±0.55	1.34±0.57	0.8
VAS2			
-POD1	8 (7-9)	7 (6-8)	0.001
-POD3	6 (5-7)	5 (4-6)	<0.001
-POD5	3.1±0.8	2.97±0.75	0.15
-POD15	2.1±0.79	2.03±0.77	0.47
Satisfaction at discharge	8 (7-9)	7 (6-8)	<0.001
Satisfaction at postoperative 2 months	8 (8-9)	8 (7-8)	<0.001

RVIAT, right ventricular infra-axillary thoracotomy; MS, median sternotomy; POD, postoperative day; VAS, visual analogue scale; VAS1, pain measurement at rest; VAS2, pain measurement after coughing.

The risk of scoliosis development is also reduced[15]. The RVIAT incision stays hidden under the resting arm, providing a superior cosmetic result compared to conventional incisions. There is no visible incision as in MS and anterolateral thoracotomy incision from the front view. Another advantage of RVIAT is that shoulder girdle motion is preserved after the operation, as reported in several studies[13-15]. In the immediate postoperative period, shoulder functions are maintained[13].

There are several advantages of RVIAT over MS. RVIAT preserves the thoracic osseous structures. Thus, there is no complication related to sternotomy, and the mediastinitis risk is lower than in MS. Incision and soft tissue dissection and the resultant surgical trauma are decreased in the RVIAT approach. Red blood cell (RBC) transfusion in patients undergoing cardiac surgery is associated with increased mortality, postoperative morbidity, and cost[16]. Previous studies[17,23,24] have shown that postoperative drainage is lower in patients undergoing cardiac surgery through mini-thoracotomy than in MS. The present study also found decreased postoperative bleeding and transfusion with a mini-thoracotomy approach. The disadvantages of this technique are increased cannulation time, CPB, ACC, and operative time compared to the MS approach. In the present study, although the CPB and ACC time were significantly higher in the RVIAT group, early in-hospital outcomes were comparable between both groups. The findings of this study confirmed the previous findings[18]. The prolonged CPB and ACC times in this series were thought to be due to the learning curve. We observed that ACC, CPB, and operation times decreased as our experience with this technique increased.

Compared to endoscopic port access RVIAT has several advantages. The techniques used in this approach are similar to those used in a conventional operation and can therefore be applied in all cardiac surgery clinics without additional specialized equipment, they do not require a new skill set and are not associated with a steep learning curve[3,17]. This technique can be performed without additional costs[3,17]. Anesthesia techniques are also conventional. Double-lumen endotracheal tube or endobronchial blocker placement is not necessary with this approach[18]. As a result of using a standard aortic clamp, potential complications of endovascular aortic balloon occlusion, such as endovascular balloon malposition and migration, are avoided[18]. Despite a longer incision, this strategy provides an acceptable cosmetic result and an invisible postoperative scar from the front view. CPB cannulation is usually obtained from the femoral artery and vein in minimally invasive procedures. A preoperative workup should be made to rule out aortoiliac disease and small femoral arteries. However, femoral artery cannulation can lead to retrograde dissection, embolization, stroke, ipsilateral limb ischemia, and arterial injury[19-21]. Moreover, femoral vein and internal jugular vein cannulation are associated with an increased risk of deep venous thrombosis and venous injury[19-21]. Although the skin incision is 3 to 5 cm longer than in a conventional minimally invasive technique, incisions for peripheral cannulation and aortic clamp and potential complications associated with peripheral cannulation are avoided with this approach and have the advantage of antegrade flow. Moreover, this technique does not require additional preoperative workup to rule out aortoiliac disease. On the other hand, RVIAT is associated with a longer incision and rib spreading associated with frequent concomitant rib fractures and bleeding. Therefore, pain is a significant component of this approach[22], and these patients may require strong analgesics after surgery. The current study results confirmed that postoperative pain was significantly higher in the RVIAT group on postoperative days 1 and 3 compared to the median sternotomy group, and although not at a significant level, postoperative pain on the 5th day was also higher in the RVIAT group. Scarring and surgical trauma are reduced with endoscopic port access surgery. Endoscopic port access surgery can be performed without rib spreading and is therefore associated with reduced incidence of postoperative pain, and bleeding, more comfortable recovery, and a shorter time to return to normal activities[3,17].

There are very few clinical studies[8-10,12,20] related to minimally invasive cardiac surgery without peripheral cannulation through RVIAT in adults, and published studies[8-10,12,20] have not compared this technique with endoscopic port access surgery with peripheral cannulation. Wang et al[9] compared 192 patients who underwent MVR through RVIAT with 203 patients who underwent MVR using MS[9]. The RVIAT group had less chest drainage and required less blood transfusion. Postoperative mechanical ventilation time was also less in the RVIAT group. There were no statistical differences between the two groups in respect of ACC time, CPB time, and total operation time[9]. Tünerir et al[10] compared the use of RVIAT and conventional MS in 59 adults undergoing elective cardiac surgery[10]. Patients were randomized to the RVIAT group (n=29) or the MS group (n=30). In the RVIAT group, postoperative bleeding, analgesic requirements, blood transfusion requirements, extubation time, and hospital stay were significantly lower than in the MS group, and the CPB and ACC times were similar in both groups[10].

A few other studies[8,12,20] have claimed that minimally invasive cardiac surgery can be performed with regular instruments and cannulas without peripheral cannulation and have shown comparable results in adults. Although these studies have reported similar results, they did not have control groups. A few publications[4,14,24] have also reported good results with right mini-thoracotomy without peripheral cannulation in pediatric patients undergoing correction of congenital heart disease.

We found increased patient satisfaction with the RVIAT technique. The length of the scar in the RVIAT group is significantly shorter than in the MS group. Furthermore, the RVIAT incision stays hidden under the resting arm, providing a superior cosmetic result compared to conventional incisions. There is no visible incision as in MS and anterolateral thoracotomy incision from the front view. Hence, RVIAT is associated with superior cosmetic outcomes. Previous studies[17,24,25] also reported increased patient satisfaction in conventional minimally invasive cardiac surgery patients. Body image and self-esteem levels were reported to be negatively affected in patients who underwent cardiac surgery *via* median sternotomy[25].

Limitations

The present study had several limitations, primarily the retrospective and single-center design. Another limitation was that this approach was not compared with other minimally invasive techniques. A final limitation of this study was that high-risk patients were not included in the study. Further studies are needed to evaluate the outcomes in high-risk patients and compare the results with minimally invasive cardiac surgery techniques with peripheral cannulation.

Conclusions

Despite the learning curve of the RVIAT, the outcomes were similar in both groups. This approach may be a safe alternative to conventional sternotomy in non-high-risk patients, and it could help establish a minimally invasive cardiac surgery program in hospitals with limited resources as it provides good cosmetic results and high patient satisfaction, with reduced surgical trauma compared to the median sternotomy approach.

Conflict of Interest

All authors including spouses and other immediate family members have no financial relationships with commercial manufacturers, pharmaceutical companies, or other commercial entities that have an interest in the subject matter or materials discussed in this manuscript.

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Authors' Contributions

Hande Istar: conception and design of the study, acquisition of data, drafting the article, analysis, and interpretation of data; Utkan Sevuk: critical revisions of the manuscript, supervision, validation, and final approval of the version of the article to be published.

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Conflict of Interest

The authors declare that they have no conflict of interest to declare.

Data Availability

All data generated or analyzed during this study are included in this published article.

Ethics Approval

This study was approved by our Local Ethics Committee (University of Health Sciences Gazi Yaşargil Training and Research Hospital Clinical Research Ethics Committee) and complied with the requirements of the Declaration of Helsinki (Ethical Approval Number: 148).

Informed Consent

Informed consent is not applicable due to the retrospective nature of the study.

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