Evaluation of Early Outcomes of Minimally Invasive Congenital Heart Surgery via Right Axillary Approach at the Heart Institute of Ho Chi Minh City

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ABSTRACT:

***Background**:* At our Heart Institute, the right axillary approach has been chosen for minimally invasive cardiac surgery for congenital cardiac patients in both adults and children.

***Objective**:* we evaluate the results of minimally invasive congenital cardiac surgery via the right axillary approach at the Heart Institute of HCM City.

***Method**:* descriptive study, case series.

***Results**:* From 11/2022 to 08/2024, 123 patients with congenital heart defects underwent complete repair via the right axillary minimally invasive cardiac surgery. There were 93 ASD (75.5%), 17 VSD (13.8%), 11 partial or intermediate AVSD (8.9%) and 2 Cor Triatriatum (1.6%). Concomitant procedures included: 2 PDA ligation (1.6%), 2 pAPVD repairs (1.6%), 12 tricuspid valve repairs (9.5%), 1 mitral valve repair (0.8%), and 1 resection of subaortic stenosis (0.8 %). There was no hospital mortality, the median time of ICU stay was 1 day and the median time of hospital stay was 7 days.

***Conclusion**:* minimally invasive cardiac surgery via the right axillary approach could be applied for simple congenital heart defects safely with low morbidity.

***Keywords**: MICS, congenital heart diseases, right axillary approach*

Introduction:

With the advancement of minimally invasive techniques in valve and coronary artery surgeries, their application in congenital heart disease has also become widespread among both pediatric and adult populations. [1-3].

In Vietnam, various cardiac centers have implemented such techniques for congenital cardiac surgery [4, 5]. At our Heart Institute, we have adopted the right axillary approach for minimally invasive surgery in both pediatric and adult congenital heart patients.

Objective:

To evaluate the early outcomes of minimally invasive congenital cardiac surgery via the right axillary approach at the Heart Institute of Ho Chi Minh City.

Methods:

Study design**:** descriptive study, case series

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***Received date**: 27/05/2025 **Revised date:** 26/06/2027*
***Accepted date:** 04/07/2025*

Study population: Patients with congenital heart disease underwent minimally invasive surgery via the right axillary approach, and direct vision, with or without video-assisted procedure.

Location**:** Heart Institute of Ho Chi Minh City.

Patient Characteristics:

From November 2022 to August 2024, 123 patients underwent surgery via the right axillary approach. The male-to-female ratio was 1:2.5. The median age was 29 years (range: 4 months to 61 years), and the median body weight was 50 kg (range: 4–75 kg). Twenty-eight patients were aged ≤15 years. All patients were in sinus rhythm preoperatively, with no case of cyanotic congenital heart disease.

The majority of cases were ASD, accounting for 93 patients (75.5%), followed by VSD in 17 patients (13.8%) (table 1). All patients had preserved cardiac function with moderately elevated pulmonary artery pressure (table 2).

All procedures were performed as open-heart surgeries under cardiopulmonary bypass (CPB). The method of CPB establishment depended on the patient's body weight: central cannulation was used in small children, and partial central or full peripheral cannulation was employed in older children and adults. No case required conversion to median sternotomy for the management of associated lesions during surgery.

The aortic cross-clamp time was relatively short (table 3).

The majority of procedures were atrial septal defect closures, often accompanied by tricuspid valve repair. In addition to isolated ASD closures, there were also cases where ASD closure was performed in combination with other congenital cardiac anomalies. For both ASD and VSD closure, the use of autologous pericardial patch was more common than direct suture closure — 49.2% vs. 33.6% in the ASD group, and 11.7% vs. 1.6% in the VSD group, respectively (table 4).

Results:

There was no in-hospital mortality (including deaths within 30 days postoperatively or during the index hospitalization). The median intensive care unit (ICU) stay was 1 day (range: 1–7 days), and the median postoperative hospital stay was 7 days (range: 5–26 days). There was one patient with a dehiscence of the pericardial ASD patch on postoperative day 4. Reoperation via the previous incision revealed suture disruption, the defect was successfully re-closed, and the patient was discharged 9 days after the second surgery. The longest hospital stay was 26 days, in a patient who developed a. third-degree atrioventricular block requiring multidisciplinary consultation for permanent pacemaker implantation.

There was a statistically significant increase in left ventricular dimension and overall cardiac function following surgery. In contrast, pulmonary artery pressure and right ventricular dimension showed a significant decrease postoperatively compared to preoperative values (table 5).

Statistical results also showed a significant change in the severity of tricuspid regurgitation before and after surgery (table 6).

Discussion:

Currently, minimally invasive cardiac surgery offers both effective treatment and superior cosmetic results for patients with congenital heart disease [2, 6]. The evolution of minimally invasive cardiac surgical techniques has progressed over many decades, in parallel

with the refinement of specialized surgical instruments. These advancements have made it possible to perform congenital heart surgeries through minimal incisions, enhancing aesthetic results while significantly accelerating postoperative recovery [7].

Several minimally invasive surgical approaches are commonly employed, including[1]:

1. **Ministernotomy:** This involves a skin incision of approximately 4 cm made in the midline below the sternum, with a partial opening of the lower one-third of the sternum.

2. **Right Anterolateral Thoracotomy:** A smaller incision compared to traditional approaches previously used in female patients with atrial septal defect. The skin incision, about 4 cm in length, is made horizontally below the right breast, avoiding the nipple in prepubertal girls.

3. **Right Posterolateral Thoracotomy:** A horizontal skin incision of approximately 4 cm is made below the scapula, entering the chest through the fourth intercostal space.

4. **Right Lateral Axillary Thoracotomy:** A vertical skin incision along the mid-axillary line from the axillary fold allows dissection of the pectoralis major muscle and access to the chest through the third or fourth anterior-lateral intercostal space. This approach permits near-complete access to the heart and aorta.

5. **Left Posterolateral or Lateral Thoracotomy:** Used for procedures involving the patent ductus arteriosus or closure of the ventricular septal defect in the infundibular region[1].

According to Emile Bacha and colleagues, the right anterolateral thoracotomy is commonly employed in adult patients, particularly in women with developed breast tissue, whereas the right lateral axillary approach is more frequently used in pediatric patients, as the heart is relatively distant from the anterior-lateral access point in this population. [8]. According to Jiaquan Zhu, the right lateral axillary approach is suitable for infants and young children, the right anterolateral thoracotomy is appropriate for older children and adults, and the left anterolateral thoracotomy is recommended for surgical closure of infundibular-type ventricular septal defects [9].

We adopted the right lateral axillary approach, as the skin incision is completely hidden from the anterior view, providing excellent cosmetic outcomes, particularly for female patients and young girls. We found that the right axillary approach allows access to most intracardiac structures, including the right atrium, right ventricle, aorta, and pulmonary artery. In the initial phase, lesions selected for this approach were primarily those easily accessible via the right atrium and right ventricle. Over time, as experience increased, more distant structures such as the pulmonary artery could also be effectively approached.

The intercostal space is typically identified and marked after patient positioning to avoid entering the incorrect intercostal level. Accurate marking is particularly crucial for the axillary approach, as the distance between the skin incision and the intercostal entry point may vary significantly and is often quite substantial (figure 1). After making a vertical skin incision along the mid-axillary line, approximately 3 to 4 cm in length depending on the type of lesion, we perform subcutaneous dissection to identify the fascia of the pectoralis major muscle. Dissection continues along the direction of the fascia toward the anterolateral chest wall. The appropriate intercostal space is then identified based on the

surgical target, and the intercostal muscles are incised to enter the right pleural cavity. Partial division of the pectoralis minor muscle is often required. Chest closure is performed meticulously in layers including the pectoralis minor, pectoralis major, subcutaneous tissue, and skin to minimize the risk of postoperative wound distortion and preserve cosmetic appearance.

Congenital heart defects suitable for minimally invasive surgery via the right axillary approach**:** Atrial septal defect was the first heart defect for which this approach was applied, owing to its ease of access and straightforward repair. Subsequently, the technique has been extended to other simple congenital heart defects, including ventricular septal defect, cor triatriatum, and partial atrioventricular septal defect. Currently, it may be applicable in selected cases of more complex congenital lesions such as subaortic stenosis, pulmonary valve stenosis, and mild forms of Tetralogy of Fallot [10]. In general, the choice of intercostal space depends on the surgical approach. At the Heart Institute of Ho Chi Minh City, we have followed a similar progression. After an initial period applying the right axillary approach for atrial septal defect, we gradually expanded its use to other congenital heart defects such as ventricular septal defects, including perimembranous, infundibular types, and those associated with a muscular ridge causing subaortic stenosis; partial and intermediate forms of atrioventricular septal defects; cor triatriatum; and persistent ductus arteriosus. For congenital lesions accessible via the right atrium, we typically enter through the fourth intercostal space (figure 2). For lesions requiring access to the aorta or pulmonary artery, the third intercostal space is preferred. However, intercostal space selection should also be guided by preoperative evaluation using standard chest radiography to better assess anatomical relationships.

Cannulation strategy: In small children, central cannulation is generally preferred, with aortic cannulation becoming increasingly favorable as patient size decreases. In larger pediatric patients, peripheral cannulation is often necessary to provide adequate cardiopulmonary bypass support-either partially or fully, as in adult cases. Age and body weight are critical factors, along with the diameter of the femoral vessels, in determining whether to establish extracorporeal circulation via peripheral or central access [4, 11]. In this study, all patients underwent surgery via the right axillary approach. Therefore, we selected a central cannulation strategy for extracorporeal circulation in pediatric patients, while adults received peripheral cannulation through the right femoral vessels, with additional right internal jugular vein cannulation in cases requiring right atriotomy. Other studies have reported the feasibility of peripheral cannulation in children weighing more than 15 kg, although this requires specialized arterial cannulas appropriate for smaller body sizes. With ongoing advancements in minimally invasive surgical instruments, more complex congenital heart defects-such as Tetralogy of Fallot, and pulmonary atresia with ventricular septal defect-can also be addressed using either the right or left axillary approaches.[5, 12].

Conclusion:

Minimally invasive cardiac surgery via the right axillary approach can be safely applied to congenital heart defects such as atrial septal defect, ventricular septal defect, partial or intermediate atrioventricular septal defect, and cor triatriatum, with a low complication and mortality rate.

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Table 1: Preoperative Diagnosis

Diagnosis	Number	%
Atrial Septal Defect (ASD)	93	75.5
Isolated ASD	56	45.8
ASD with severe tricuspid regurgitation	34	27.6
ASD with mitral regurgitation	1	0.8
ASD with partial anomalous pulmonary venous drainage (PAPVD)	2	1.6
Ventricular Septal Defect (VSD)	17	13.8
Membranous VSD	13	10.7
Infundibular VSD	3	2.3
VSD with subaortic membrane	1	0.8
Partial Atrioventricular Septal Defect (pAVSD)	11	8.9
Cor Triatriatum	2	1.6

Table 2: Preoperative Echocardiographic Parameters

	Mean ± SD	Range	Z Mean
Left ventricular dimension (mm)	36.91 ± 6.07	19 – 56	-1.39
Right ventricular dimension (mm)	42.47 ± 9.16	16 – 65	9.27
Pulmonary artery pressure systolic (mmHg)	50.13 ± 16.92	25 - 105	
Ejection fraction (%)	66.68 ± 7.43	54 – 85	

Table 3: Surgical characteristics:

	Mean ± SD	Range
CPB time (minutes)	111.75 ± 38.8	35 – 205
Aortic cross-clamp time (minutes)	53.81 ± 26.45	12 – 131

Table 4: Surgical procedures performed

Surgery	Number	%
ASD closure	106	82.8
Direct closure	43	33.6
Pericardial patch closure	63	49.2
Additional procedures		
Tricuspid valve repair with annuloplasty ring	7	5.6
Tricuspid valve repair with pericardial strip	5	3.9
Mitral valve repair	1	0.8
PAPVD repair	2	1.6
VSD closure	17	13.8
Direct closure	2	1.6
Pericardial patch closure	15	11.7
Additional procedures		
Patent ductus arteriosus (PDA) ligation	2	1.6
Right ventricular fibrous tissue resection	2	1.6
Subaortic membrane resection	1	0.8
Complete repair of partial AVSD	11	8.9
Cor triatriatum repair	2	1.6

Table 5: Echocardiographic outcomes

	Preoperative	Preoperative Z mean	Postoperative	Postoperative Z Mean	P
Left ventricular dimension (mm)	36.91 ± 6.07	-1.39	40.07 ± 6.65	-0.45	<0.001*
Right ventricular dimension (mm)	42.47 ± 9.16	9.27	38.15 ± 9.04	7.77	<0.001*
Pulmonary artery pressure (mmHg)	50.13 ± 16.92		33.9±11.03		<0.001*
Ejection fraction (%)	66.68 ± 7.43		68.76±7		0.016*

*** T- test**

Table 6: Tricuspid Regurgitation Severity.

Severity	Preoperative	Postoperative	P
Mild	21	65	P<0.001 Phép kiểm T

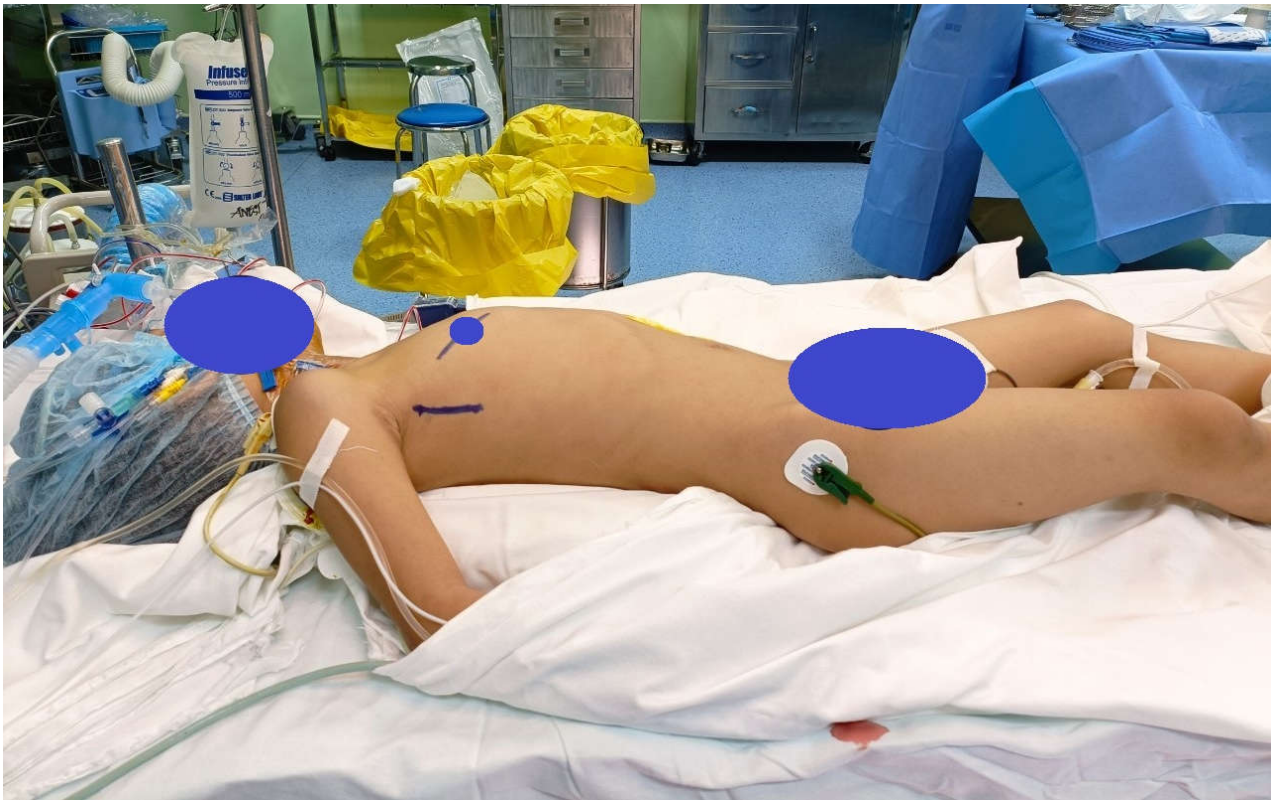

Figure 1: The pediatric patient was positioned appropriately, and the site for the skin incision was marked

Source: Heart Institute of Ho Chi Minh City

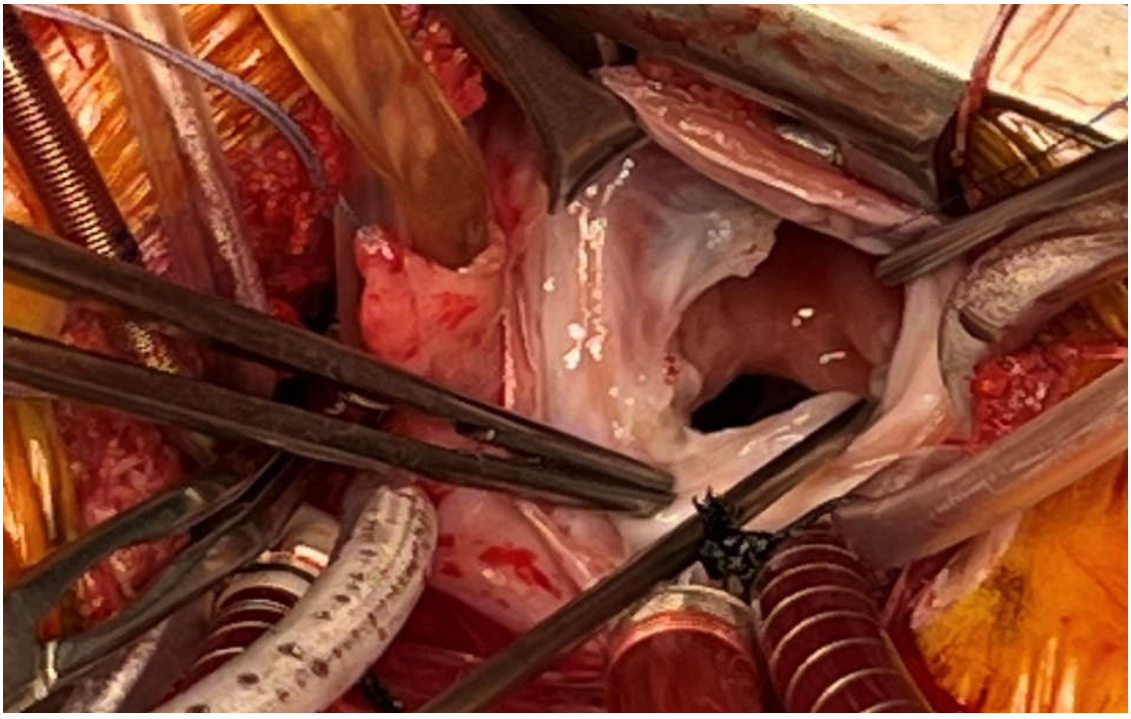

Figure 2: The perimembranous ventricular septal defect was exposed via the right axillary approach

Source: Heart Institute of Ho Chi Minh City

Figure 3: Surgical wound on postoperative day 2 following ventricular septal defect closure in a 2-year-old girl

Source: Heart Institute of Ho Chi Minh City