Original Article

Right Vertical Axillary Thoracotomy: Achieving Superior Results Without Adding Risk During Repair of a Wide Range of Congenital Cardiac Defects

Ihab Omar[1], Basem Aglan[2], Amira Nour[3], Dina Saad[2]

Departments of Cardiothoracic Surgery, Faculty of Medicine, [1]Beni Suef University, [2]Benha University, [3]Cardiology, Faculty of Medicine, Ain Shams University, Cairo, Egypt.

ABSTRACT

Background: Different incisions were tried to approach the heart rather than median sternotomy, targeting better cosmetic results without affecting the surgical outcome. However, most of these approaches added some risks that outweighed the desired benefits. We aimed to explain how vertical axillary thoracotomy could be an excellent alternative without adding surgical risk.

Patients and Methods: This Between May 2020 and January 2024, 118 patients with common congenital cardiac defects were corrected through right vertical axillary thoracotomy. Sixty-eight patients underwent atrial septal defect closure, repair of partial anomalous pulmonary venous drainage (17), ventricular septal defect closure (23), repair of partial atrioventricular canal (four), mitral valve replacement (three), and subaortic membrane resection (three).

Results: There were 76 females and 42 males with a mean age of 6.5 years and a mean weight of 20.2kg. The mean operative time was 227±42.5min, the mean cardiopulmonary bypass was 54.8±17.4min, and the mean aortic cross-clamp time was 37.4±22.5min. There was no need to convert to sternotomy in any case. We have no 30-day mortality. The most common complication was variable degrees of right lung atelectasis in 22(18.6%) cases. The mean intensive care unit and hospital stay times were 2.8±2.3 and 6.3±3.8 days, respectively. The mean scar length was 5.8±0.6cm. Few wound complications were observed during the follow-up period (6–24 months) with excellent cosmetic results.

Conclusion: In selected cases, the right vertical axillary thoracotomy is considered superior to median sternotomy regarding cosmetic results without inferior surgical outcome.

Key Words: Axillary thoracotomy, Cosmetic thoracic incisions, Minimally invasive cardiac surgery, Muscle-sparing thoracotomy.

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Corresponding Author: Basem Aglan, MD, Department of Cardiothoracic Surgery, Faculty of Medicine, Benha University, Benha, Egypt. **Tel.:** 00201008713556, **E-mail:** bassem.abdelgawad@fmed.bu.edu.eg

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INTRODUCTION

Partial sternotomy, as well as right-sided posterolateral or anterolateral thoracotomy, have been used for the repair of many congenital cardiac lesions. However, in female patients, impaired breast development after thoracotomy was reported. Furthermore, partial transection of large muscle groups is required for both the posterolateral and the anterolateral approach. The midaxillary approach may help avoid these side effects and improve the cosmetic result [1].

Although cardiac surgery is one of the critical surgeries with lots of feared complications, it is still defined by the patient or his relatives as an incision. Many alternative approaches to a standard sternotomy were tried to give better cosmetic results while ensuring a perfect repair. Furthermore, reducing the length of the mediastinal scar continues to be at a disadvantage as it attracts the stigma of being a cardiac patient. Moreover, the presence of a midline scar keeps a psychological consciousness of the scar.

The suggested advantages of the axillary incision include the following:

(1) The approach's muscle-sparing nature results in a shorter recovery time and returns to the functional activity of the right arm and shoulder, as only part of the serratus anterior muscle is split parallel to the ribs.

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(2) Being far away from the breast tissue, which is essentially important in young females.

(3) Given the absence of any visible landmarks, and a completely hidden scar by the resting arm, resulting in superior cosmetic results compared with other more visible thoracic incisions [2].

The objective of this study was to show how right vertical axillary thoracotomy (RVAT) is a safe and reproducible alternative to median sternotomy with better cosmetic results.

PATIENTS AND METHODS:

Study design: this retrospective study was conducted between May 2020 and January 2024. Ethics approval of the study protocol was obtained from the Ethics Committee of the Faculty of Medicine, Benha University. The need for informed consent was waived due to the retrospective nature of the study.

*Patient*s: 118 patients with common congenital cardiac defects were corrected through RVAT. Sixty-eight patients underwent atrial septal defect closure, repair of partial anomalous pulmonary venous drainage (17), ventricular septal defect closure (23), repair of partial atrioventricular canal (four), mitral valve replacement (three), and subaortic membrane resection (three).

During the preoperative preparation, the echo was reevaluated in detail in our center to avoid missing any defect or anomaly.

Exclusion criteria

We excluded complex anomalies in which surgical steps or decisions could vary, require prolonged operative time, or involve pulmonary artery manipulation. Furthermore, anomalies when reintervention is likely, such as complete atrioventricular canal repair or Glenn shunt, were also excluded.

Surgical technique

Because the field is deeper and the whole heart is far and not in your hands, it is essential to adopt new concepts to make it easy and safe. We have followed some rules to make the RVAT approach as easy and secure as the median sternotomy one.

(1) Move slowly to work fast: do not be frustrated by being slower than you used to be.

(2) Try to work single-handed (do not rely too much on the assistant) as the field is difficult for him to assist.

(3) Modify your instruments, cannulas, and even your direction of suturing to match the field.

(4) Do not go with dissection or pass any instrument beyond a point you cannot control.

All patients were intubated using a single-lumen endotracheal tube after general anesthesia. The paravertebral block was performed in all cases. The patient was placed with a lateral tilt of 45–60^{0} from the table, with the right side up. The right arm was abducted and placed or suspended over the head. An ~5–6cm vertical incision was made between the second and fifth ribs in the midaxillary line (Fig. 1). The subcutaneous tissue was carefully dissected to protect the long thoracic nerve and associated blood vessels.

The chest was entered through the fourth intercostal space, except for cases of subaortic membrane, where we preferred the third space. Two retractors were used; one was for rib spreading and the other was placed perpendicularly to retract soft tissues (Fig. 2).

A wet gauze or two was used to push the right lung posteriorly to facilitate approaching the pericardium. The right lobe of the thymus was removed with careful watching of the left innominate vein and reasonable control of thymic branches. The pericardium was opened 1.5–2cm anterior to the phrenic nerve, and several traction stitches were placed to help pull the heart more superficially (Fig. 3).

We start by applying a purse string to the right atrial appendage to help expose the aorta and superior vena cava (SVC) during the opening and closing of the atrium. After heparinization, we prefer the cannula after its purse strategy. We first place the cardioplegia purse to pull on the aorta for better exposure. Then, we put the aortic cannula purse as high as usual but slightly lateral. Keeping systolic arterial blood pressure between 80 and 100 mmHg is better during aortic cannulation. We have tried several types of aortic cannulas. However, using the Elongated One-Piece Aortic cannula (EOPA) (Medtronic: Minneapolis, MN 55432-5604, USA), with the pointed-tip trocar makes it easy to cannulate the aorta (Fig. 4). Moreover, its tip is fenestrated to allow for the Sildinger technique over a guidewire. Furthermore, the cannula is flexible and can be directed away from the field. The DLP pediatric one-piece arterial cannula (Medtronic) is similar but has a blunt-tip trocar, making it more difficult during the introduction (Fig. 5). Sometimes, when the aorta is far away, we hold the cannula with an artery forceps to facilitate its introduction.

After passing a snare around the SVC and taking its purse, we cannulate the SVC using a right-angle cannula. After that, we start bypassing to partially empty the heart and facilitate the inferior vena cava (IVC) cannulation.

We dissect the space between the IVC and the right lower pulmonary vein and pass a snare using a C-shaped vascular clamp. First, we pass the IVC cannula from outside through the sixth space below the original incision, which will be used later to place the chest tube (Fig. 6).

A long cardioplegia cannula is placed at the aortic root, and a long cross-clamp with an angled handle is applied. After cardioplegia, we proceed with the same surgical steps as in sternotomy. However, in some VSD cases, we have chosen to detach the septal leaflet of the tricuspid valve for better visualization of VSD borders. Before coming off the bypass, we place the pacemaker wire sutures.

RESULTS:

We have included 118 patients with common congenital cardiac defects that were corrected using RVAT. There were 76 females and 42 males with a mean age of 6.5 years and a mean weight of 20.2kg.

Patient data and pathological details are presented in Table 1.

The main operative and postoperative data are presented in Table 2.

The main postoperative complications are presented in Table 3.

There was no mortality, no conversion to another incision, and no breast or chest wall deformity in any patient. Wound infection was present in four (3.4%) patients who were only superficial with mild seroma and improved by frequent dressing. In the follow-up period, 12(10.2%) patients had hypertrophic scars in part or all of the wound.

Table 1: The patient's characteristics and pathology are presented.

Variables	Mean±SD (range) or *n*(%)
Age, years	6.5±5.3(0.8–16)
Weight, kg	20.2±12.7(8–62)
Female : male	76: 42(64.4: 35.6)
Pathology, no all cases	118(100)
ASD	68(57.6)
VSD	23(19.5)
PAPVC	17(14.4)
Partial AVC	4(3.4)
Mitral valve replacement	3(2.5)
SAM	3(2.5)

ASD: Atrial Septal Defect; AVC: Atrioventricular Canal; PAPVC: Partial Anomalous Pulmonary Venous Connection; SAM: Subaortic Membrane; VSD: Ventricular Septal Defect.

Table 2: Operative and postoperative data.

Variables	Mean±SD (range)
Total operative time, min	227±42.5(190–320)
Total bypass time, min	54.8±17.4(40–140)
Aortic cross-clamp time, min	37.4±22.5(20–120)
Incision length, cm	5.8±0.6(5–7)
Mechanical ventilation time, h	6.4±4.5(0–18)
ICU stay time, days	2.8±2.3(1–5)
Hospital stay time, days	6.3±3.8(4–17)

Table 3: Postoperative complications rate.

Variables	*n*(%)
Exploration for bleeding	2(1.7)
Lung collapse	22(18.6)
Pneumonia	3(2.5)
Phrenic injury	7(5.9)
Residual defects by echo	
Small VSD ≤3mm	4(3.4)
Mild tricuspid regurgitation	4(3.4)
Moderate tricuspid regurgitation	2(1.7)
Wound infection	4(3.4)
Hypertrophic scar	12(10.2)

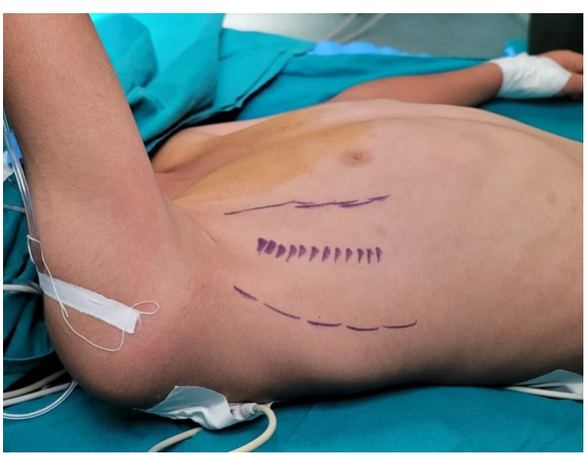

Figure 1: Skin incision mark before positioning.

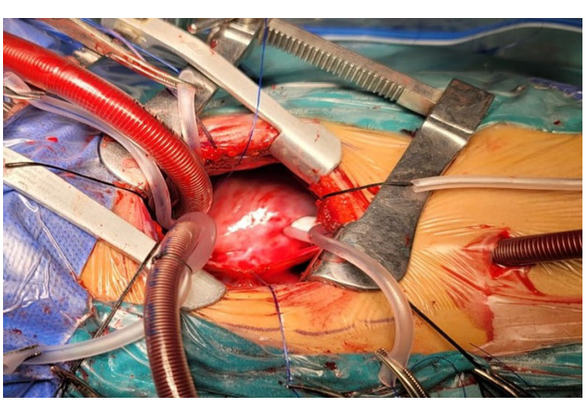

Figure 2: Exposing the field using two retractors with aortic and bicaval cannulation.

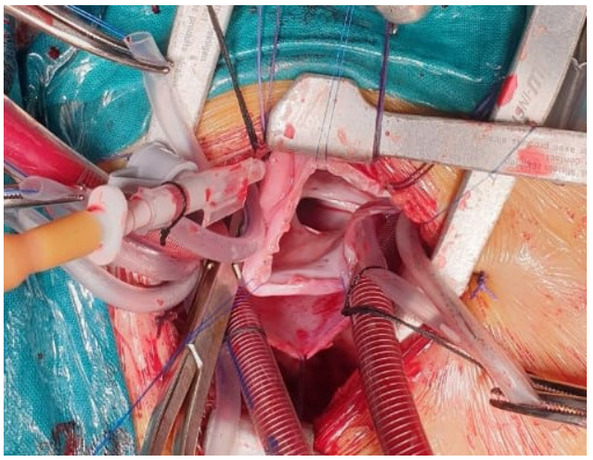

Figure 3: ASD through right atriotomy shows how superficial the heart field is.

Figure 4: Elongated one-piece aortic cannula (EOPA) (Medtronic).

Figure 5: DLP Pediatric one-piece Arterial Cannula (Medtronic).

Figure 6: Length of the skin incision (5cm) with the chest drain below it.

DISCUSSION

The psychological burden of a sternotomy scar should not be underestimated in children and teenagers. A visible mid-sternotomy scar is a lifelong stigma of a "heart problem" with deleterious psychosocial consequences [3].

Right anterolateral thoracotomy

Palma and colleagues have investigated the benefits of right anterolateral thoracotomy and have suggested in cases of undeveloped breasts to perform the skin incision in the fifth intercostal space to avoid breast deformity or cutting the pectoral muscle. However, in cases of developed breasts, the submammary groove was used for skin incision. Then a flap of breast tissue and pectoralis muscle was dissected from the underlying chest wall and retracted superiorly so that the chest cavity could be entered through the fifth intercostal space. The anterolateral skin incision was 5–7cm long [4].

However, in this approach, the patient is still having the risk of breast affection by infection or scarring, and significantly impaired unilateral development when performed in prepubertal patients [5].

Moreover, the muscle-cutting nature of this approach theoretically affects shoulder movement. Furthermore, entering the chest cavity through the fifth space makes it more challenging to place the aortic cannula.

Transverse axillary thoracotomy

Although aligned with Langer's lines, its extension is limited by the anterior axillary line and can only be extended posteriorly away from the heart. Widely opening the chest retractor sometimes ends in skin laceration into the breast tissue.

In the study of Prêtre and colleagues, they used an incision of 4–5cm long. However, they have performed cannulation of iliac vessels in most of their cases. This was avoided during the vertical axillary approach. Furthermore, they used ventricular fibrillation for ASD closure to save the space of the aortic cross-clamp but with added risk for neurological events secondary to air embolization in simple cases. Therefore, they stated that they had shifted the approach to the vertical incision along the midaxillary line [6].

Using the same incision with central aortic and venous cannulation, Lee and colleagues reported excellent outcomes in repairing a wider range of congenital anomalies. They had to use special endoscopic instruments to overcome the limited field such as an endoscopic needle holder, knot pusher, and special aortic cross-clamp. However, this small field makes it difficult for assistant surgeons to share parts of the operation or even perform the surgery independently with sufficient comfort and safety.

Furthermore, the small incision may also contribute to longer bypass times reported in this study, which may place the patient at increased risk of morbidity, such as postoperative coagulopathy [7].

Vertical axillary thoracotomy

In the axillary approach, the thoracic development is normal as this incision is located in a muscle-free area. Therefore, the thoracic muscles are spared and the normal space between the ribs is retained. The placement of the chest wall retractor blades in the middle part of the ribs (midway between the anterior and posterior hinge points) means better rib spreading with a wider field in addition to minimal stress on the ribs or their articulation at the costochondral junction or the costovertebral one. Therefore, the ribs and their attachments are less liable for fracture or injury [8].

Another important advantage of the vertical axillary thoracotomy includes the feasibility of performing some procedures through the third space, such as SAM resection, aortic valve repair, and repair of PAPVC. Moreover, when the aorta looks far away from the fourth space, it is easy to do a double internal thoracotomy to cannulate the aorta through the third space and then shift again to the fourth space [9].

In our series, the length of the skin incision was between 5 and 7cm and was adequate to operate safely by trainee surgeons with excellent outcomes. Therefore, we consider the vertical right axillary approach the best teachable and reproducible alternative for median sternotomy.

Dodge-Khatami and Salazar evaluated patients' and parents' satisfaction and reported that the cosmetic results were highly appreciated. Furthermore, they agree with our experience where perfect results are achieved over time without compromising repair quality compared with a median sternotomy approach [2].

Heinisch *et al.,* [10] have used a 4–5cm vertical axillary incision with peripheral femoral vein cannulation instead of central IVC cannulation in 38(35%) cases with five cases complicated with venous thrombosis. However, we found that a vertical incision of ~6cm is enough to place all cannulas without obstructing the operative field. Furthermore, by going down by weight, the operative field is more superficial and a 4cm incision is adequate to operate efficiently in patients under 10kg. Our mean weight was 20.2±12.7 with the least 8kg in contrast to other studies [11].

In cases of PAPVC, we have chosen to perform the double patch repair in 13 cases and the Warden technique in four cases where anomalous pulmonary veins were high in the SVC. Although we used to perform the single patch technique in simple cases during sternotomy, in this approach, we tried to make it as wide as possible to eliminate the need for reintervention for SVC narrowing.

In contrast to many reports, we had a longer mean ICU (2.8±2.3) and hospital stay (6.3±3.8) times. This was attributed to right lung collapse and the requirement of more time for physiotherapy, especially in low-weight patients. We observed higher rates of phrenic palsy (5.9%), which did not require any intervention and resolved in most cases in the follow-up period. Furthermore, the rate of lung atelectasis was high (18.6%). However, most of these cases were at the beginning of our experience. Later on, we managed to avoid prolonged lung compression and focused on frequent lung recruitment and suction from the endotracheal tube before chest closure with adequate chest physiotherapy in the postoperative period.

In the follow-up period, 12(10.2%) patients had hypertrophic scars and were referred to the dermatologist for treatment. We could not find specific figures for the hypertrophic scar or keloid rate in children with either thoracotomy or median sternotomy.

The extension of this approach to include cardiac anomalies rather than ASD or VSD is still questionable as the possibility of reoperation is suspected in other lesions. Therefore, it was not wise to perform thoracotomy in the prospect of future suspected median sternotomy, especially when reintervention is likely.

CONCLUSION

Right vertical axillary approach is a safe and reproducible technique to repair many heart defects with superior cosmetic results and sound reduction of physical and psychological trauma associated with the median sternotomy approach.

LIMITATIONS

We did not apply a comparative study with median sternotomy cohorts and did not have the instruments used in minimally invasive cardiac operations. The follow-up period was short as most patients were referred from distant regions.

CONFLICT OF INTEREST

There are no conflicts of interest.

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