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Original Article

Experience of Minimal Invasive Cardiac Surgery for repair of Atrial Septal Defects- A Single Center Study

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Abstract:

Background: *Atrial Septal Defects (ASD) can be closed surgically using conventional midline sternotomy or minimal invasive technique. This study was done to evaluate the outcome and safety of the minimal invasive cardiac surgical (MICS) approach using right vertical infra axillary incision (RVAI) for the repair of ASD.*

Methods: *We performed a prospective observational cross-sectional analysis on 50 patients who were diagnosed as ASD of various types and not amenable to device closure. Their surgery was done RVAI using central cardiopulmonary bypass. Outcome of the study was evaluated using the following variables: length of the incision, satisfaction of patients, mortality, infection of surgical site, blood transfusion, duration of total operation, intensive care unit (ICU) stay, mechanical ventilation, hospital stay and aortic occlusion. Operations were done between December 2013 to December 2020. All the recruited patients were treated through RVAI as per patient's choice.*

Results: *Mean age was 11.4± 6.4 years. 18(36%) were male and 32(64%) were female. Body weight ranged from 10 to 65 kg. Mean length of incision was 6.2±0.8 cm. Mean aortic occlusion time was 42±14 min. ASD closed directly, using autologous treated pericardial patch or dacron patch. Mean total operation time was 4.08±0.6 hours and mean mechanical ventilation time was 8.3±5 hours. Average ICU stay was 35.6±6 hours and total hospital stay was 7.2±0.9 days. There was no significant blood loss. Only 10 patients required intravenous (IV) analgesics in the post-operative period. One patient required re-exploration, one conversion to median sternotomy and one suffered from superficial skin infection. There were no operative or late mortalities. Patient satisfaction was excellent.*

Conclusions: *MICS technique using RVAI for surgical repair of ASD revealed a safe procedure and could be performed with excellent cosmetic and clinical outcomes. It provided a good alternative to the standard median sternotomy.*

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Introduction:

Congenital heart surgery has constantly developed and matured since the ûrst intracardiac repair of an atrial septal defect by Lewis and Varco in 1952.[1] Although a median sternotomy was considered the routine approach for an open-heart operation, the scar was regarded as unsightly and displeasing, and may evoke psychological distress, especially in young, female patients.[2] Nowadays, increasing attention is paid to the cosmetic results of surgery.

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During the past decades, minimally invasive cardiac surgery techniques, such as a right posterolateral thoracotomy,[2,3] right anterolateral (submammary) thoracotomy,[4,5] partial sternotomy[6,7] and right axillary transverse incision[1,8] have been increasingly used in both adult and pediatric patients.

In recent years, the right vertical axillary straight incision approach has been employed for both paediatric and adult patients with atrial septal defects at Ibrahim Cardiac Hospital & Research Institute. In this study, we have explored the surgical and cosmetic results of right vertical infra-axillary mini-incision approaches for surgical repair of ASDs.

Methods:

This was a prospective observational study, taken place in the Department of Cardiac surgery, Ibrahim Cardiac Hospital & Research Institute. All patients included in this study were diagnosed as ASD by physical examination, chest X-ray, electrocardiogram and echocardiography. Cardiac catheterization was performed in patients with severe pulmonary hypertension to check the pulmonary vascular resistance (PVR) and reversibility. We included the patients who are not amenable to device closure. All the patients were operated by the same surgeon.

50 patients underwent ASD closure by MICS technique using RVAI from December 2013 to December 2020. This study was designed for evaluating the efûcacy and safety of the RVAI approach. Patients or their parents were explained about the procedure before surgery. All ASD patients were accepted for the study regardless of the types of ASDs, which were not amenable to device closure.

40 were ostium secundum ASD, three were sinus venosus ASD and 7 cases were primum ASD. The median weight of the patients was 30 kg (range from 10 to 65kg) and median age of the patients was 10 years (ranged from 2 years to 27 years).

Exclusion criteria were body weight less than 10 kg and more than 70 kg, presence of other cardiac, thoracic or systemic abnormalities. History of pulmonary tuberculosis (PTB), pleural effusion, pericardial effusion, endocarditis or rheumatic fever were also taken as exclusion criteria. Patients with patent ductus arteriosus (PDA) were also excluded from the study. Patient not willing to accept two incisions in case of failed procedure were excluded from the study.

Operative technique

In RVAI approach, after the induction of general anaesthesia, the patient was placed in the left lateral decubitus position with the right side elevated 45–60°. A vertical incision was made on the right midaxillary line skin from the second to the ûfth ribs, and the length of the incision was 4–5 cm in children and 8–11 cm in adults. Two sternal retractors were used to gain a better exposure. The surgical route was generally through the fourth intercostal space. Pre-operative chest X-ray was used as a guide in all cases to select the intercostal space of entry.

The thymus was partially blunt dissected, and the pericardium was opened 1–2 cm parallel and anterior to the phrenic nerve. After heparinization, the ascending aorta was ûrst cannulated, followed by both venae cavae, which were cannulated with a right-angled cannula. Aorta and IVC were cannulated through separate incisions in case of sinus venosus and primum ASDs for better exposure. Cardioplegia cannula was inserted in the root of aorta through the main opening and removed after arrest of the heart which aided better exposure. Angled or Chitwood aortic clamp was used depending on the surgeon's comfort for aortic occlusion. Separate incision was used for aortic and inferior venous cannula insertion in 18 cases to get a wide and comfortable working field. Under a mildly hypothermic (32°C) cardiopulmonary bypass (CPB), the ascending aorta was cross clamped, and cardioplegia was achieved by infusing a cold blood, Delnido cardioplegia solution into the ascending aorta root. A right atriotomy was performed for the closure of the heart defect, and according to the size of the defect, closure done by direct suture, using a Dacron patch or autologous glutaraldehyde treated pericardium. For the correction of sinus venosus atrial septal

defects, a double or single patch technique was used. Re-routing of partial anomalous pulmonary veins (PAPVD) done in required cases. The incision of the right atriotomy was extended to the superior vena cava (inclined to right side), and then the ASD was closed with a patch (the defect was expanded when necessary). After the air in the heart was eliminated and the cross-clamp was removed, the patient was rewarmed and CPB was discontinued gradually. A right pleural drain was inserted and the thorax closed in layers. In patients with PLSVC an extra sucker was inserted to the coronary sinus for blood less field. Carbon di oxide ($CO_{2)}$ was in all cases for deairing cardiac chambers.

After discharge, clinical data and colour Doppler echocardiography were evaluated after 3 months, 6 months and yearly thereafter. All 50 patients completed their 1st follow-up after 3 months but only 32 patients completed their 2nd follow-up after one year. As the patients remain asymptomatic, most of the patients were reluctant to come for follow-up after one year. Only 15 patients visited after one year. Special attention was paid to the cosmetic results of the scar. Each patient or their parents were evaluated for their satisfaction with cosmetic results of the procedure. Evaluation of satisfaction was done by direct questionnaire regarding their feeling about scar in comparison to a midline scar (If she or he would have a mid-line long scar instead of small regressing RVIA scar).

Variables:

The following variables were calculated: operating time (skin to skin); CPB and aortic cross clamp time; ventilation time; intensive care unit (ICU) stay; requirement of IV analgesics, re exploration, conversion to midline incision, volume of blood loss, duration of postoperative hospitalization, postoperative complications, mortality and satisfaction with the cosmetic results.

Results:

In our study, a total of 50 patients were included. 18 (36%) were male and 32 (64%) were female. The median weight of the patients was 30 kg (range from 10 to 65kg). Mean body weight was 31.8±13.8 kg. Median age of the patients was 10 years (ranged from 2 years to 27 years). Mean age was 11.4± 6.4 years and mean BSA was 1.01 ± .29 kg/m^2. 40 patients had secundum, 7 patients had primum ASD and only 3 patients had sinus venosus ASD in the series. Mean area of ASD was 4.8±3.4 cm^2. (Table I)

Table-I

Base line characteristics of the study population.

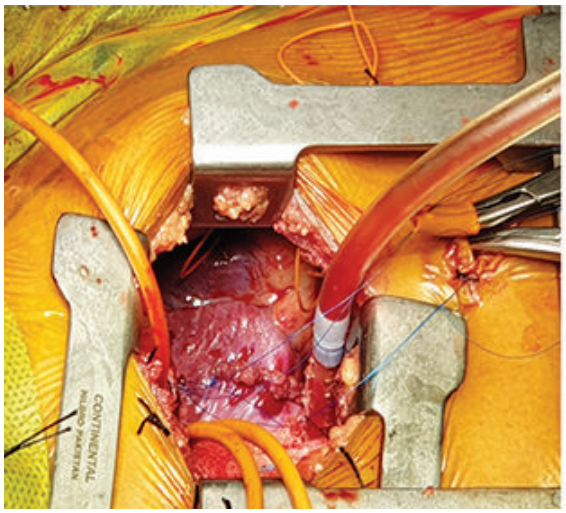
Variable	Mean ± SD	Number (%)
Age (yrs.)	11.4±6.4	
Sex		Male=20(40%) Female=30(60%)
Body weight (kg)	31.8±13.8	
PASP (mm Hg)	32.18±14	
BSA(m^2)	1.01±0.29	
Type of ASD		Primum=7 Secundum=40 Sinus venosus =3
Area of ASD (cm^2)	4.8±3.4	

Mean length of incision was 6.2 ± 0.8 cm. Mean aortic occlusion time was 42 ± 14 min. Mean cardio-pulmonary bypass time (CPB) time was 100±29 min. 25 patients had mild pulmonary hypertension (PAH), 14 patients had moderate PAH and rest 11 patients had severe PAH. Mean pulmonary arterial systolic pressure (PASP) was 32.18±14 mm Hg. Delnido cold blood cardioplegia was used in all the cases. Two patients required retrograde cardioplegia.

Eight patients had PLSVC opening to the right atrium. Only an extra sucker was used to manage it. Maximum patients cooled down up to 32^0C and one patient required to cool down to 24^0C and very low flow to get inferior vena cava (IVC) margin in view properly. In this case, IVC cannula was removed for some time.

Separate incision was used for aortic and inferior venous cannula insertion in 18 cases which facilitated a comfortable working field. 4th intercostal space was used for entry of pleural cavity in 42 cases and 3rd space in eight cases. Sinus venosus ASDs were closed through 3rd space. ASD closed directly in 4 cases as those were small. 22 cases closed with autologous treated pericardial patch and rest 24 cases were closed with Dacron patch. But all 7 primum, 3 sinus venosus and 12 secundum ASDs were closed with treated autologous pericardium.

Mean total operation time was 4.08±0.6 hours. Mean mechanical ventilation time was 8.3±5 hours. (Table II)



(a) Two sternal retractors are used for visualization through right 4th Intercostal space.

(b) Heart opened after cardioplegia and ASD in view.

(c) ASD closed with autologus pericardial patch.

(d) Final view and length of skin incision

Fig.-1: *Surgical orientation and view of MICS ASD closure*

Table-II

Operative variables in study population.

Variable	Mean ± SD
Aortic Occlusion time (min)	42±14
Total CPB time (min)	100±29
Total operation time (hours)	4.08±0.6
Mechanical Ventilation time (hours)	8.3±5

Mean blood loss was 182±118 ml and blood transfusion required in 6 (12%) cases. Intercostal tube was removed in 32.3 ± 10 hours. 3 patients developed small bronchopleural fistula and required re insertion of chest drain. Only 10 patients required IV analgesics in the post-operative period and other 40 were managed with only oral NSAIDs. (Table III)

Table-III

Post-operative issues and complications among the study population (N=50).

Variables	Mean±SD	Number (%)
Blood transfusion		6 (12%)
Chest drain removal(hours)	32.3±19	
Re exploration		1 (2%)
Requirement of IV analgesics		10 (20%)
Conversion to midline incision		1 (2%)
Infection		1 (2%)
Mortality		0 (0%)

Due to excessive blood loss re exploration was done in one case and revealed bleeding from a small branch of intercostal artery. It was also managed through axillary incision. Conversion to midline incision required in one case due to failed aortic cannulation through axillary incision and recovered without any complication. Superficial skin infection occurred in one case and could manage without any extra effort.

Table-IV

Outcome variables in the study population.

Variable	Mean ± SD	(%)
Total ICU stay (hours)	35.6±6	
Total hospital stays (days)	7.2±0.9	
Length of Incision(cm)	6.2±0.8	
Time to return to normal activity (days)	39±7.8	
Satisfaction		100%

Average ICU stay was 35.6±6 hours. Mean total hospital stay was 7.2±0.9 days. There were no operative or late mortalities and no special care in the ICU or re- hospitalization. Mean duration of return to normal life was 39±7.8 days. No signiûcant residual defects were found in follow-up. No asymmetrical development of the breast, thoracic deformity or scoliosis has been found during the follow-up. All the patients or the parents of young children (100%) were satisûed with the cosmetic results.

Cosmetic results

No asymmetrical development of the breast, thoracic deformity or scoliosis has been found. All the patients or the parents of young children in our study group were satisûed with the cosmetic results. Even the midline conversion patient was also satisfied because our team has tried for them.

(a) No midline scar.

(b) Final scar under the axilla.

(c)No visible scar when hands are placed by the side

Fig 2: *Post-operative pictures 3 months after MICS ASD closure.*

Discussion:

Median sternotomy has been the standard approach used to correct non-complex congenital heart defects with excellent results.[1] However, deep sternal wound infection, which contributes to signiûcant morbidity, mortality and increased medical cost, is a rare but worrisome complication with this approach and remains a major challenge to cardiac surgeons.[9,10] Besides, it is much more important that the mid-sternotomy scar may evoke psychological distress of patients and guardans.[2]

It is beyond all doubt that the cosmetic result was crucial for the patients who underwent closure of ASDs. Non-surgical percutaneous trans-catheter closure of simple congenital heart defects has been used for more than 20 years and has been performed with excellent cosmetic results.[11] However, its safety still remains in debates because it might induce signiûcant complications such as device malposition, thrombosis, embolization, arrhythmias, cardiac perforation, hemo-pericardium with tamponade, signiûcant residual shunt, atrial and/or aortic injury or erosion.[12-14] Above all, we performed our study among those patients only who are not suitable candidate for device closure or unable to manage fund for device.

Both right anterolateral mini-thoracotomy and partial sternotomy can prevent femoral cannulation and be performed with acceptable clinical results. But the former might induce thoracic deformity or asymmetrical development of the breast,[15] and the later is not popular because of the midline scar, which would prevent some children from going swimming for fear of others' stares and sympathy.[1]

There were several advantages with the RVAI approach. First of all, the cosmetic result was excellent. The vertical incision of RVAI located on the right midaxillary line was small and in conspicuous (Fig 2). During the follow-up, all patients in our study group were satisûed with the cosmetic result and no asymmetrical development of the breast, thoracic deformity or scoliosis has been found. Furthermore, the surgical route through the fourth intercostal space and appropriate pericardial suspension provides enough exposure to the ascending aorta, both venae cavae and the operating ûeld of closure of the ASD through a right atriotomy. With neither operative nor late mortality, nor neither ICU nor hospital readmission in the RVAI group, and no residual defects were found during follow-up. The RVAI procedure did not need femoral cannulation and could prevent femoral artery stenosis in the future, and not required any specialized or expensive equipment.

Although all the patients were satisûed with the cosmetic results, the RVAI approach was more suitable for the patients with a body weight <40 kg according to our experience, and was not suitable for the patients with body mass index e"30 kg/m^2.[16] Because of the deeper thoracic cavity, the exposure of the operating ûeld would be poorer.

Complications included small broncho-pleural fistula in three cases which was treated with intercostal tube insertion. Although all three patients were cured and discharged, we should take particular care of the right pleural drain and the right lung of the patients after the RVAI procedure.

Our study may have potential limitations. As an observational prospective study and a single-institution survey, it needs to be conûrmed by expanding the sample and multicenter trials. Shorter follow-up time is a major limitation of the study. In fact, most of the patients were not interested for follow-up as they became asymptomatic after 3 months. In addition, the lack of data about the level of pain was another limitation.

There was no significant morbidity or any mortality in minimal invasive ASD closure as evidenced by literature review.[17-19] Moreover this RVIA approach was not associated with significant increased aortic occlusion time compared to conventional midline sternotomy technique.[1-4,8,17-19] So this RVIA procedure is equally safe as conventional midline sternotomy technique.

Conclusion

The MICS technique using right vertical axillary incision for ASD repair is a safe procedure with excellent cosmetic and clinical results, conferring psychological and social satisfaction upon patients. It is a good alternative to standard median sternotomy for all ASDs which are not amenable to device closure. Of course, learning curve is a major concern of the technique.

Conflict of Interest - None.

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