Subject Area: Cardiothoracic Surgery

**Standard median sternotomy versus minimally invasive approach for atrial septal defect closure in adults**

Ahmed S. Ali  
*Department of Cardiothoracic Surgery, ahmed.shafeek.ali@gmail.com*

Ahmed G. Abd el Fattah Fahmy  
*Department of Cardiology*

Hatem K. Madkour  
*Department of Cardiology*

Reham M. Salah Eldin Ahmed  
*Department of Anesthesia*

Follow this and additional works at: https://jmisr.researchcommons.org/home

Part of the Medical Sciences Commons, and the Medical Specialties Commons

**Recommended Citation**  
DOI: https://doi.org/10.59299/2537-0928.1036

This Original Study is brought to you for free and open access by Journal of Medicine in Scientific Research. It has been accepted for inclusion in Journal of Medicine in Scientific Research by an authorized editor of Journal of Medicine in Scientific Research. For more information, please contact m_a_b200481@hotmail.com.
Standard median sternotomy versus minimally invasive approach for atrial septal defect closure in adults

Ahmed S. Ali a,*, Ahmed G. Abd el Fattah Fahmy b, Hatem K. Madkour b, Reham M. Salah Eldin Ahmed c

a Department of Cardiothoracic Surgery, National Heart Institute, Cairo, Egypt
b Department of Cardiology, National Heart Institute, Cairo, Egypt
c Department of Anesthesia, National Heart Institute, Cairo, Egypt

Abstract

Background: Atrial septal defects (ASDs) in adults and adolescents are not uncommon. Surgical ASD closure through a standard median sternotomy (SMS) has become less attractive approach in favor of minimally invasive techniques, especially in young female patients.

Objective: The aim was to compare early postoperative outcomes of surgically closed secundum ASDs through a SMS approach versus minimally invasive right anterolateral thoracotomy (MIRAT) approach in adults.

Patients and methods: The authors prospectively studied 60 adult patients who had their secundum ASD anomalies surgically closed at National Heart Institute between the period of September 2020 and February 2022. A total of 30 patients had their ASD closed through a SMS approach, whereas the other 30 patients underwent MIRAT approach. Early postoperative results were collected and compared with each other.

Results: There was no mortalities throughout the study, male: female ratio was similar in both groups with dominance of female patients, and patients in the minimally invasive group was younger (28.10 ± 8.73 years). The minimally invasive group had a significantly longer cardiopulmonary bypass time (106.53 ± 6.70 vs. 63.40 ± 4.68 min), longer cross-clamp time (84.06 ± 9.03 vs. 51.33 ± 4.55 min), and longer total operation time (158.13 ± 13.76 vs. 121.80 ± 7.15 min) than the standard group. The mechanical ventilation time (16.80 ± 4.07 vs. 14.70 ± 2.40 h), ICU stay (1.33 ± 0.46 vs. 1.13 ± 0.29 days) and total hospital stay (8.16 ± 1.74 vs. 6.33 ± 1.09 days) were significantly longer in the standard group compared with the minimally invasive group.

Conclusion: Surgical ASD closure via a MIRAT approach is safe and comparable to standard techniques.

Keywords: Atrial septal defect, Minimally invasive right anterolateral thoracotomy, Standard median sternotomy

1. Introduction

Adult congenital cardiac anomalies are not uncommon. As a general overview, atrial septal defects (ASDs) represent ~35% of all discovered adult congenital heart cases [1]. Although most patients passed unnoticed during childhood, treating medium to large ASDs is recommended to avoid long-term complications, in particularly progressive increase of pulmonary vascular resistance [2]. The treatment options for adult ASDs vary according to the type of ASD, whereas surgical closure is irreplaceable in treating sinus venosus, coronary sinus, and primum types of ASDs. Secundum ASDs have the option of percutaneous device closure, which has been introduced in recent years [3]. Although standard median sternotomy (SMS) approach was widely used for treating ASD anomalies in adults, it was associated with poor cosmetic appearance, especially in female patients [4]. Recently, different approaches with limited incisions have been introduced in many centers around the world to provide...
multiple advantages over the conventional median sternotomy approach. These advantages include improved cosmesis, early ambulation, decreased postoperative pain, and reduced overall hospital stay [5,6]. The current study compared minimally invasive right anterolateral thoracotomy (MIRAT) approach versus SMS approach in surgically treated patients with secundum ASD in terms of early postoperative outcomes.

2. Patients and methods

This study was conducted between September 2019 and February 2022 after approval of the ethical committee. A total of 60 consecutive adult patients with secundum ASD and sought treatment at National Heart Institute, Cairo, Egypt, were studied prospectively. The studied patients were divided into two groups: group I included 30 patients who had their secundum ASD anomaly surgically closed through a SMS approach, and group II included 30 patients who underwent surgical ASD closure through the MIRAT approach. All preoperative, operative, and postoperative data of the participating patients were collected and compared with each other during the early postoperative period.

The participating patients were subjected to inclusion criteria, which included patients with isolated secundum ASD anomaly, both sexes, adult and adolescent patients 16 years old or above, first-do patients, normal ejection fraction patients (EF >55%), and patients willing to sign a written informed consent, and exclusion criteria, which included young patients less than 16 years old, patients with associated other congenital heart diseases, patients with associated other valvular or coronary artery diseases, redo patients, patients with pulmonary hypertension (pulmonary artery pressure, PAP >30 mm Hg), patients with low EF, and patients unable to provide a written informed consent.

2.1. Operative procedures

After full anesthetic state was achieved, the SMS group was positioned in the usual supine position with the chest slightly elevated by putting a supporting pad under the shoulders. A SMS incision was done with careful excision of an adequate piece of autologous pericardium, which will be used in ASD closure; aortobicaval cannulation was performed; and nylon tapes with snares were passed around both superior vena cava (SVC) and inferior vena cava (IVC) to facilitate opening of the right atrium safely. A vent cannula was inserted via the right superior pulmonary vein. Del Nido cardioplegic solution was delivered to the aortic root through a double-way cardioplegia cannula in an antegrade manner to ensure adequate myocardial protection during the procedure. After cross-clamping the aorta and arresting the heart, temperature was left to drift and the right atrium was opened after snaring both cavae. ASD was closed using autologous untreated pericardial patch by continuous (4-0) polypropylene sutures.

In the MIRAT group, supine position with the right side up was achieved by using supporting towels under the right side of the patient's back. The right inguinal region was sterilized and left exposed for direct cannulation of both femoral artery and vein. A small 3–4-cm transverse incision was made in the crease of the right inguinal region with exposure of femoral vessels. Two nylon tapes were passed around the femoral vessels separately, two halves for each vessel.

The common femoral vein was cannulated by either single or double-staged femoral venous cannula through a 6/0 prolene purse-string suture to the level of IVC under transesophageal echocardiography guidance so that the IVC tape can be snared without interruption. Another selective metal-tip venous cannula was used to cannulate SVC through a 5/0 prolene purse-string suture. This

![Image](image.jpg)
cannula can be passed either through the min-thoracotomy incision (Fig. 1) or through a separate 1-cm incision at the level of the second right intercostal space to descend directly over the SVC. The two venous cannulae were finally connected by Y connection to secure a single main venous line with adequate venous drainage.

The femoral artery was then directly cannulated using a reasonable size femoral arterial cannula through a 5/0 prolene purse-string suture according to Seldinger technique rules. An 8-mm PTFE tube graft was used in case of small or spastic femoral artery.

The main surgical incision was made simultaneously during femoral vessel exposure and before femoral cannulation to ensure clear operative field with the absence of lung and pericardial adhesions. It consists of limited anterolateral submammary incision 7–9 cm on an average (Fig. 2) with a targeted chest wall entrance at the level of the fourth right intercostal space. After femoral cannulation and establishment of minithoracotomy incision, commencing cardiopulmonary bypass will allow us to stop lung ventilation and decompress the heart which provide easier and more comfortable operative field to work on.

The pericardium was then opened 2–3 cm above phrenic nerve and suspended with silk sutures through the chest wall and via incisions made for aortic cross-clamp insertion. Chest tube insertion was done at the end of the procedure. An adequate piece of autologous pericardium was secured for ASD closure. A long cardioplegia cannula was inserted in the aorta after securing double purse-string sutures. The SVC and IVC were surrounded with nylon tapes with snares in order to snare both cavae during ASD closure. The aorta was cross-clamped using Chitwood DeBakey Clamp from a separate incision in the anterior axillary line at the level of second intercostal space. The same type of cardioplegic solution (del Nido) was used in both groups with the same route of administration to ensure constant conditions during our study. After arresting the heart and opening of the right atrium, the ASD was closed in the same manner as in SMS patients. At the end of the procedure, the right atrium was closed with 5/0 prolene suture, the aortic cross-clamp was removed, weaning from bypass and de-cannulation procedures were performed using standard techniques, and chest and inguinal wounds were closed with special attention to cosmetic appearance.

2.2. Statistical analysis

Data were collected, tabulated, and statistically analyzed using IBM personal computer and Statistical Package for the Social Sciences (IBM SPSS) version 22.0 software (IBM Corp., Armonk, New York, USA). Two types of statistics were applied.

2.3. Descriptive statistics

Continuous variables were described as mean ± SD, and percentage, whereas categorical variables were expressed in number and frequency.

2.4. Analytic statistics

Student t-test was used to study association between two groups having quantitative variables. \( \chi^2 \)-test was used to study association between two qualitative variables. A \( P \) value of less than 0.05 was considered statistically significant.

3. Results

Patients in the minimally invasive group were younger (28.10 ± 8.73 years) compared with the conventional group (29.36 ± 8.06 years) without significant difference between the two groups. EF showed higher values in the minimally invasive group (61.73 ± 5.08) compared with the standard
group (58.56 ± 3.79), with no significant difference between the two groups. Other demographic and preoperative data showed no significant difference between the two groups (Table 1).

Intraoperative data revealed that the minimally invasive group had a significantly longer cardiopulmonary bypass time (106.53 ± 7.60 vs. 63.40 ± 4.68 min), longer cross-clamp time (84.06 ± 9.03 vs. 51.33 ± 4.55 min), and longer total operation time (158.13 ± 13.76 vs. 121.80 ± 7.15 min) than the standard group. We believe that this is in part was due to femoral cannulation and the other part was due to restricted operative field that accompany minimally invasive cardiac procedures (Table 2).

There were no mortalities among patients who participated in our study. The mechanical ventilation time (16.80 ± 4.07 vs. 14.70 ± 2.40 h), ICU stay (1.33 ± 0.46 vs. 1.13 ± 0.29 days), and total hospital stay (8.16 ± 1.74 vs. 6.33 ± 1.09 days) were significantly longer in the conventional group compared with the minimally invasive group. These results reflect the advantages of minimally invasive procedures in terms of early patient rehabilitation and faster return to normal activities. Other postoperative data such as chest tube drainage, residual ASD defects, re-operation for bleeding, neurological complications, and wound infection showed no significant difference between the two groups (Table 3).

4. Discussion

For decades, SMS approach has been practiced for ASD closure with excellent outcomes and minimal complications [7]. Most patients with ASD listed for surgery are young and healthy candidates who may discover their condition accidently during examination. Recently, the increased awareness toward minimally invasive open heart surgeries, especially among young and adult females, renders these surgeries preferable and more desired over conventional cardiac procedures. Although percutaneous devices may represent an alternative option for ASD closure in young adults, yet these devices are indicated for small secundum ASDs and are better avoided in case of large, deficient rim or sinus venosus type ASDs [8]. On the contrary, device complications such as migration, obstruction of systemic or pulmonary venous drainage vessels, thromboembolism, infective endocarditis, and neurological defects have been reported by several studies [9].

The debate regarding safety over cosmetic advantages of minimally invasive cardiac procedures is decreasing in concomitance with the outstanding results of limited approaches observed by many authors [10]. Modified sternotomy approaches may represent another treatment option for ASD closure but without any advantages over the conventional techniques [11]. In our study, we used the right minimally invasive anterolateral thoracotomy approach, which provides direct and easy access for secundum ASD closure. As shown in Table 1, there was no significant difference in the preoperative data of the patients between minimal and standard

<table>
<thead>
<tr>
<th>Table 1. Demographic and clinical characteristics of patients.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group I (n = 30)</strong></td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
</tr>
<tr>
<td>Male</td>
</tr>
<tr>
<td>Female</td>
</tr>
<tr>
<td>DM</td>
</tr>
<tr>
<td>COPD</td>
</tr>
<tr>
<td>Smoking</td>
</tr>
<tr>
<td>CKD</td>
</tr>
<tr>
<td>Hypertension</td>
</tr>
<tr>
<td>EF (%)</td>
</tr>
<tr>
<td>BSA (M2)</td>
</tr>
</tbody>
</table>

BSA, body surface area; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; EF, ejection fraction.

<table>
<thead>
<tr>
<th>Table 2. Intraoperative data.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group I (n = 30)</strong></td>
</tr>
<tr>
<td>CBP time (min)</td>
</tr>
<tr>
<td>CC time (min)</td>
</tr>
<tr>
<td>Total operation time (min)</td>
</tr>
<tr>
<td>MV time (hours)</td>
</tr>
<tr>
<td>ICU stay (days)</td>
</tr>
<tr>
<td>Chest tube drainage (ml)</td>
</tr>
<tr>
<td>Total hospital stay (days)</td>
</tr>
<tr>
<td>Residual defect</td>
</tr>
<tr>
<td>Re-operation for bleeding</td>
</tr>
<tr>
<td>Neurological complications</td>
</tr>
<tr>
<td>Renal failure</td>
</tr>
<tr>
<td>Respiratory failure</td>
</tr>
<tr>
<td>Wound infection</td>
</tr>
<tr>
<td>Postoperative EF (%)</td>
</tr>
<tr>
<td>In-hospital mortality</td>
</tr>
</tbody>
</table>

EF, ejection fraction; MV, mechanical ventilation.
groups except for the EF, which showed higher values in the minimally invasive group.

In our study, the preoperative data also revealed that the minimally invasive group contained more female population with younger mean age, representing the importance of postoperative cosmetic results among female patients trying to avoid the ugly median sternotomy scar, and this was similar to other studies, which exhibited similar patterns [12].

Although conventional approach for ASD closure is associated with excellent results, yet it is not free from disadvantages; wound infection and sternal dehiscence still represent one of the most common complications seen in this type of surgery. The minimally invasive techniques may avoid such complications due to limited incisions made away from sternum keeping sternal integrity untouched [13]. This comes in line with our results, which showed increased infection rates among the conventional group without significant differences between the two groups.

In the current study, our results revealed that the minimally invasive group (MIRAT) had a statistically significant shorter mechanical ventilation time, length of ICU stay, and total hospital stay duration (Table 3). This was similar to other studies with the associated early recovery and rehabilitation of minimally invasive patients during the early postoperative period [14]. However, there was no statistically significant differences regarding amount of bleeding, re-explorations, and neurological and renal complications.

In our research, we had no mortalities nor morbidities throughout the study, and also, there was no need for conversion to median sternotomy approach among minimally invasive patients (MIRAT) due to any cause. We used femoro-femoral cannulation together with selective SVC cannulation in all minimally invasive patients without any complications. This was unlike other studies who reported different complications such as bleeding, anatomical difficulties with aortic cross-clamping, severe pulmonary adhesions, aortic dissection, femoral artery injury, lower limb ischemia, and lymphocele [15,16].

In our series, intraoperative data showed that the minimally invasive group (MIRAT) had a statistically significant longer aortic cross-clamp time, cardiopulmonary bypass time, and total operation time (Table 2). We believe that femoral cannulation and limited operative field are time consuming and are the main causes for longer durations in this particular group of patients. Therefore, we used del Nido cardioplegic solution to ensure adequate myocardial protection during these long procedures.

Finally, routine postoperative echocardiography showed that there was no residual ASD defects in any of patients who participated in the study, with no significant difference between the two groups, and this was similar to other studies, which obtained same results during their research [17–19].

In conclusion, surgical ASD closure via the MIRAT approach is an excellent technique with comparable results to the SMS approach, especially in young adult females. The cosmetic benefits of this technique should be taken in consideration when dealing with such cases. However, adequate learning curve should be completed before this technique is routinely and widely applied.

Conflicts of Interest
None declared.

References