

Atrial Septal Defect Closure by Anterior Mini Thoracotomy with Total Peripheral Cannulation: A Step towards Establishing Mini Invasive Cardiac Surgery in a Developing Nation

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Abstract

Background: Atrial Septal Defect (ASD) closure is a common cardiac surgical procedure performed worldwide. Due to favourable clinical outcome, minimal invasive approach is becoming popular. Hence this study was conducted to compare the outcome of two surgical approaches, median sternotomy and mini thoracotomy with total peripheral cannulation, in a developing country Nepal. **Methods:** A prospective study of 62 ASD patients, randomized to undergo surgical closure either via right anterior mini thoracotomy or median sternotomy was conducted and followed up over three years. The clinical outcome parameters like intensive care unit stay, hospital stay, post-operative duration of ventilation, cardiopulmonary bypass time, aortic cross clamp time, mediastinal drainage, size of scar and complication were compared between two groups. **Results:** Cardiopulmonary bypass time and aortic cross clamp time were significantly longer in right anterior mini thoracotomy group as compared to median sternotomy group (43.97 min ± 12.70 min vs 34.42 min ± 10.42 min and 25.13 min ± 7.82 min vs 19.48 min ± 6.93 min respectively, p-value < 0.05). There was no significant difference in duration of surgery (2.75 hrs ± 0.43 hrs vs 2.56 hrs ± 0.41 hrs, p-value = 0.09), post-operative ventilation (2.90 hrs ± 1.22 hrs and 2.88 hrs ± 1.07 hrs, p-value = 0.96) between two groups. Post-operative mediastinal drainage was significantly less in right anterior mini thoracotomy group (214.52 ml ± 91.79 ml vs 284.03 ml ± 158.91 ml, p-value = 0.04). There was no significant difference in

ICU stay and hospital stay. **Conclusion:** Atrial septal defect can be safely closed by right anterior mini thoracotomy with a small, cosmetically acceptable submammary scar with less pain and bleeding.

Keywords

Atrial Septal Defect, Mini Thoracotomy, Total Peripheral Cannulation

1. Background

Atrial Septal Defect (ASD) is one of the common cardiac malformations, approximately 6.7% [1]. Although these malformations are often asymptomatic [2], if uncorrected, they may lead to irreversible pulmonary hypertension, progressively declining cardiac function and early death [3]. Median sternotomy (MS) has been the gold standard approach in cardiac surgery because almost all aspects of the heart can be reached and complex measures such as revascularization, valve surgery and procedures for arrhythmia can be executed. However, MS requires a large surgical wound around the sternum that can cause bleeding from bone marrow that occasionally requires blood transfusion and results in mediastinitis, which is often a critical complication although ASD itself is not a critical disease. In contrast, minimally invasive approaches like right anterior mini thoracotomy (RAMT) with cannulation of femoral artery, femoral vein and internal jugular vein delivers the benefits of smaller, less painful wounds, shorter hospital stay, more rapid postoperative recovery and cost reductions and has become a feature of cardiac surgery [4] [5]. Preferable results of minimally invasive ASD closure have been reported and Vida *et al.* had obtained excellent cosmetic results [6] [7] [8]. However, mini invasive cardiac surgery is in an early phase of development, in low resource countries. Hence this study was aimed to compare the clinical outcomes in ASD closure by RAMT with total peripheral cannulation and MS in a developing country like ours.

2. Methods

Sixty two patients of ostium secundum ASD, at Manmohan Cardiothoracic Vascular and Transplant Center, Kathmandu, Nepal from December 2014 to June 2016 were randomized into two groups (ASD closure via MS and ASD closure via RAMT with total peripheral cannulation), operated and followed prospectively. All the patients above 14 years of age, requiring ASD closure were included in the study. However, patients weighing less than 25 kg, those requiring other concomitant cardiac procedures and those with previous thoracic surgery/infection were excluded from study. Approval was obtained from institutional review committee for the study. In RAMT group, patients underwent standard general anesthesia, a right sub-mammary incision of 6 cm or less with anterior thoracotomy, internal jugular vein, femoral artery and femoral vein

cannulation, initiation of cardiopulmonary bypass (CPB), use of antegrade cardioplegia and ASD closure with autologous pericardial patch. An extra-pleural catheter was placed passing from 3rd to 5th space for analgesia (50 ml of fluid consisting of 44 ml of 0.9% normal saline, 1 ml of 50 micrograms of Fentanyl and 5 ml of 0.5% Bupivacaine). MS group differed from RAMT in having a standard median sternotomy, central cannulation of superior and inferior vena cava and aorta. Standard Intensive care was provided to the patients. All the vital parameters, amount of drain, inotrope requirement was recorded. Decision to transfer the patient out of intensive care unit and hospital was made by the operating team based on the general condition, amount of drain, inotrope requirement and X-ray findings of the patients. Wound was inspected for any local complications. All the study parameters (ICU stay, hospital stay, post-operative duration of ventilation, CPB time, Aortic Cross clamp (ACC) time, length of surgical scar, pain score (measured with numeric pain scale, in post-operative period after extubation, eight hours after extubation and whenever patients complained of pain), amount of drainage, complications) was recorded as per the proforma and analyzed. The data were analyzed using Statistical Program for Social Sciences (SPSS) version 23. Values were expressed as means \pm standard deviations or as frequencies and proportions. Quantitative parametric data were compared using an independent samples t-test. The p values of <0.05 were considered significant.

3. Results

31 patients were included in each group. Maximum patients (54.01%) were in the age group of 14 - 24 years. The youngest patient with ASD was 14 years old and the oldest was 61 years old. Mean age of patients in MS group was 26.45 ± 11.59 years and that in RAMT group was 24.55 ± 10.82 years (p value = 0.50). The female: male ratio in MS group was 1.8:1 and it was 2.8:1 in RAMT group (**Table 1**). Majority of the patients presented with exertional shortness of breath; 20 (64.51%) in MS group vs 18 (58.06% in RAMT group) followed by occasional palpitation; 5 (16.12%) in MS group vs 7 (22.58%) in RAMT group. Intraoperative variables (**Table 2**) analyzed found the groups were comparable in relation to the ASD size.

Postoperative variables (**Table 3**) analysis did not find significant difference in postoperative ICU and hospital stay between the groups. Long term follow up of these patients revealed a hundred percentage survival and freedom from reoperation at 3 years. However, 3 patients in the MS group had hypertrophic scar with itching and infrequent paresthesia and all of the patients were concerned about having a sternal foreign body (steel wires) in the MS group. Patients in the RAMT group were satisfied with the cosmetic scar and absence of foreign body in their wound. Comparing the above findings, atrial septal defect closure by right anterior mini thoracotomy had some advantages over median sternotomy approach (**Table 4**).

Table 1. Demographics of the patients in two groups.

	MS group (N-31)	RAMT group
Gender: N, (%)	Male: 11 (35.48%) Female: 20 (64.51%)	Male: 8 (25.80%) Female: 23 (74.19%)
Age Distribution: N, (%)		
14 - 24 years	15 (48.38%)	18 (58.06%)
25 - 34 years	8 (25.80%)	8 (25.80%)
35 - 44 years	6 (19.35%)	4 (12.9%)
45 - 54 years	1 (3.22%)	0 (0.00%)
55 - 64 years	1 (3.22%)	1 (3.22%)
Chief presenting symptom N, (%)		
Exertional Dyspnoea	20 (64.51%)	18 (58.06%)
Palpitation	5 (16.12%)	7 (22.58%)
Asymptomatic	6 (19.35%)	6 (19.35%)

MS: Median Sternotomy; RAMT: Right Anterior Mini Thoracotomy.

Table 2. Intraoperative variables.

Variables	MS group (n = 31)	RAMT group (n = 31)	P value
Atrial Septal Defect size (cm)	2.51 ± 0.79	2.210 ± 0.71	0.11
Cardiopulmonary bypass time (min)	34.42 ± 10.62	43.97 ± 12.70	0.002
Aortic Cross Clamp Time (min)	19.48 ± 6.93	25.13 ± 7.82	0.004
Duration of Surgery (hrs)	2.56 ± 0.41	2.75 ± 0.43	0.09

MS: Median Sternotomy; RAMT: Right Anterior Mini Thoracotomy.

Table 3. Postoperative findings.

Variable	MS group	RAMT group	P value
Postoperative duration of ventilation (hrs)	2.88 ± 1.07	2.90 ± 1.22	0.96
Mediastinal Drainage (ml)	284.03 ± 158.91	214.52 ± 91.79	0.04
Pain Score	4.13 ± 0.49	3.42 ± 0.72	<0.01
ICU stay (days)	1.97 ± 0.75	2.06 ± 0.51	0.55
Hospital Stay (days)	3.74 ± 1.15	3.84 ± 1.12	0.74
Length of Scar (cm)	12.32 ± 1.04	5.06 ± 0.33	<0.01

MS: Median Sternotomy; RAMT: Right Anterior Mini Thoracotomy.

Table 4. Comparison of advantages of the approaches.

Variables	MS group	RAMT group
Scar length	Long	Short
Hypertrophic scar	Present	Absent
Mediastinal Drainage	More	Less
Pain Score	More	Less
Patient Satisfaction	Less	More

MS: Median Sternotomy; RAMT: Right Anterior Mini Thoracotomy.

4. Discussion

Atrial septal defect is more common in females as compared to males. Our study also showed a female preponderance (Female: male-2.2:1), which is a finding similar to that seen in a study Bigdelian *et al.* [9]. In our study, the mean age of the patients was 25.50 ± 11.16 years. It was 26.45 ± 11.59 years in median sternotomy group whereas 24.55 ± 10.82 years in mini thoracotomy group with a *p* value of 0.507 signifying that the two groups were comparable in age factor. In a study by Tarek *et al.* the mean age of the patients was 15.6 ± 6.8 years and 18.3 ± 6.1 years in anterolateral thoracotomy and MS categories, respectively [10]. We found the mean length of surgical scar was 5.06 ± 0.33 cm in RAMT group whereas 12.32 ± 1.04 cm in MS group (*p* value < 0.01). Hu *et al.* found the length of incision in mini thoracotomy was 6.3 ± 1.1 cm, which was significantly shorter than 9.6 ± 2.5 cm long incision in sternotomy group [11]. Hence young females and those who are cosmetically conscious prefer mini thoracotomy to median sternotomy approach. In a meta-analysis conducted by Ding *et al.*, mini thoracotomy had significantly longer CPB time (8.00 min more, 95% CI -0.36 to 15.64 min, *p* = 0.04) [12]. The smaller incision, limited working space increase the CPB time and ASD closure time. In a retrospective Japanese study, ACC time was longer in the right thoracotomy group than in the MS group (45 ± 17 min vs 23 ± 9 min, *p* = 0.004) [13]. Adhikary *et al.*, found that the mean total operation time was 217.33 ± 21.65 min in ASD closure via thoracotomy [14]. RAMT requires compressing on the right lung to gain access to the pericardium and makes patients more prone to development of atelectasis. This may lead to longer duration of post-operative ventilation. However, this problem can be taken care of with positive pressure lung inflation during thoracotomy closure and adequate analgesia via extra-pleural catheter. Tarek *et al.* found the mean duration of ventilation was 12.1 ± 8.5 hours in thoracotomy group and 13 ± 8.4 hours in sternotomy group [10]. MS is theorized to have more mediastinal bleeding because of the long incision of the sternum with greater raw area in the bone whereas in mini-thoracotomy, there is small incision on the skin and muscles are divided with the use of electrocoagulation, thereby reducing the surface for bleeding. Ishida *et al.* found that significantly less intraoperative blood was

lost by the right thoracotomy group than the MS group (89 ± 53 mL vs 209 ± 142 mL, $p = 0.01$) [13]. However, the total amount and duration of blood drainage did not significantly differ between the two groups. Thoracotomy patients have the advantages of small incision, less pain, early extubation, less mediastinal drainage, early drain removal, early ambulation and hence they tend to have a shorter ICU stay and hospital stay. However in our study, no significant difference was found in the ICU stay and hospital stay amongst the groups. One study showed, the mean length of stay in the intensive care unit was 2 days and the mean length of hospital stay was 4.5 days [9]. The length of stay in the ICU and hospitalization did not significantly differ between the two groups in other studies [13]. In our study, pain management in RAMT group was done with infusion of analgesic solution (Bupivacaine, Fentanyl, and Normal Saline) through the extrapleural catheter and intravenous Fentanyl in SOS basis. In MS group, pain management was done by intravenous Fentanyl and Paracetamol in the first 24 hours. Then patients were switched to oral analgesics like Paracetamol and Ketorol. The mean pain score in thoracotomy group was 3.42 ± 0.72 and in median sternotomy group was 4.13 ± 0.49 (p value < 0.01). In a similar study by Baral *et al.*, no significant difference was found in the pain score in two groups [15]. The complication rate in our study was 11.29%. There were only three cases of superficial surgical site infection in patients undergoing ASD closure by median sternotomy and two cases of superficial surgical site infection in ASD closure via mini thoracotomy patients. In thoracotomy group, one patient had femoral vein thrombosis and one patient had femoral artery thrombosis for which thrombectomy had to be performed. There were no cases of breast deformity, re-exploration, limb loss and arrhythmia and in hospital deaths. In our previous experiences, patients with ASD closure used to have a longer stay in ICU and hospital. But with the progress of surgical experience and better intensive care facility the ICU stay and hospital stay have come down. Since the cost of the cannulae used, hospital stay and intensive care unit stay were similar in this study, there was no difference in the surgical expenses in two groups.

5. Limitations of the Study

This was a single hospital based study, done over a limited period with a small sample size. Quantification of pain is always a difficult matter. Although the use of numeric pain scale helps to quantify it, the subjective perception of intensity of pain varies amongst individuals.

6. Conclusion

We found a shorter surgical scar, less mediastinal drainage and lower pain score in RAMT group. There were no differences in postoperative ventilation duration, ICU stay and hospital stay. CPB and ACC time were significantly shorter in MS group. Although statistically insignificant, the operative time was less in MS group than RAMT group. Patients were satisfied with the smaller incision and

perceived that they had the better cosmetic results, besides having less pain in immediate postoperative period as well as in long term follow up. There was no mortality, limb loss or any other major complication. Hence we conclude that ASD can be closed safely by mini thoracotomy incision with total peripheral cannulation with a better long term cosmetic result.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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List of Abbreviations

ASD—Atrial Septal Defect
 ACC—Aortic Cross Clamp
 CPB—Cardiopulmonary Bypass
 ICU—Intensive Care Unit
 MS—Median Sternotomy
 RAMT—Right Anterior Mini Thoracotomy