

Atrial Septal Defect Closure Via Mini Thoracotomy and with Peripheral Cannulation

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ABSTRACT

Background: Atrial septal defect is one of the most common congenital cardiac disorders requiring intervention. We compared a minimally invasive method for atrial septal defect closure that included total peripheral cannulation and an anterior mini-thoracotomy incision of 5 cm or less with a median sternotomy approach.

Methods: This was a retrospective cross-sectional study among patients with Atrial Septal Defect. The preoperative variables, intraoperative data, and postoperative outcomes of patients undergoing minimally invasive atrial septal defect closure with total peripheral cannulation and atrial septal defect closure via median sternotomy were collected and compared.

Results: Fifty-five patients underwent minimally invasive closure of the atrial septal defect with total peripheral cannulation and 55 patients that underwent surgery by median sternotomy were included for comparison. There were 61.81% (34) female and 38.18% (21) male in the mini-thoracotomy group while there were 52.72% (29) female and 47.27% (26) male in the median sternotomy group. The mean age at surgery was 23.4 and 28.6 years in mini-thoracotomy and median sternotomy groups of patients respectively. The most common symptom was exertional shortness of breath in both groups. The mean length of stay in the intensive care unit was 1.8 and 2.5 days in mini-thoracotomy and median sternotomy groups respectively, and the length of stay in the hospital was 4.5 days and 4.8 days in mini-thoracotomy and median sternotomy groups respectively. There was a significant association was found between the mini-thoracotomy and median sternotomy group in relation to mean size of the incision, average time for cardiopulmonary bypass, average cross-clamp time, and fluid drained on the first day after surgery.

Conclusions: Atrial septal defect closure with a mini-invasive approach is safe and cost-effective with very few perioperative complications and good patient satisfaction.

Keywords: Atrial septal defect; Nepal; sternotomy; thoracotomy; total peripheral cannulation.

INTRODUCTION

Median sternotomy is the most common approach in cases of open-heart surgery. However, the method is less efficacious due to the large incision, poor appearance, and the possibility of sternal malunion or deformity in some individuals.¹ In recent years, minimally invasive open-heart surgery has received a lot of attention across the world.² The minimally invasive surgery of the internal jugular vein, femoral vein, and femoral artery, which uses a right anterior thoracotomy with a smaller incision and TPC of the internal jugular vein, femoral vein, and femoral artery, requires no large-scale equipment and is relatively simple.³ This method has a low complication rate and a shorter hospital and Intensive Care Unit stay. More importantly, the micro

thoracotomy technique for ASD closure appears to be a cost-effective surgical approach, with a shorter ICU stay and hospital stay. We aim to present our experience with a minimally invasive method for ASD closure that included complete peripheral cannulation (TPC) and an anterior mini-thoracotomy (MT) incision of 5 cm or less in a resource-limited setting, Nepal.

METHODS

The study was a hospital-based retrospective cross-sectional study conducted from May 2015 to September 2018. Patients with ASD admitted at Manmohan Cardiothoracic Vascular and Transplant Center (MCVTC) of Kathmandu were included in the study. We included all the patients with ASD that underwent ASD closure

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via mini-thoracotomy with peripheral cannulation. A total of 55 patients receiving ASD closure via median sternotomy were recruited into the study. A total of 85 data were approached and among them, 55 patients with full information were eligible for final study purposes.

All the patients above 14 years of age, requiring ASD closure via anterior mini-thoracotomy with total peripheral cannulation (MTTPC) 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 the study. Fifty-five patients undergoing closure via median sternotomy (MS) were also selected for comparison after age and sex matching.

Standard Intensive care was provided to the patients. All the vital parameters, amount of drain recorded. The decision to transfer the patient out of the intensive care unit and hospital was made by the operating team based on the patients' general condition, amount of drain, inotropic requirement, and X-ray findings. The operative site was inspected for any local complications.

The patients were kept in a supine position, anesthetized, and intubated. The anesthesiologist used the Seldinger technique under ultrasonic guidance to implant the right-sided internal jugular venous cannula. Then the patients were repositioned in a supine position with the right side up by 30 degrees. A sub-mammary incision of 5 cm or less was made on the right side and dissection was continued. Right pleural space was entered at 4th intercostal space. Heparinization was done and both femoral artery and vein were cannulated. A vertical pericardiotomy was made and a pericardial patch was prepared. Cardiopulmonary bypass was thus established. An aortic cross-clamp was applied. Antegrade cardioplegia was given and the heart was arrested in diastole. Both the cavae were snared. Right atrium was opened 2 cm lateral to the atrioventricular groove extending from right atrium appendage superiorly to anterior to the inferior vena cava inferiorly. ASD was closed with an autologous pericardial patch. The right atrium was closed in two layers. Root was vented and heart was de-aired. The heart was weaned off of cardiopulmonary bypass. Venous and arterial decannulation was done followed by securing hemostasis. The chest was closed over a right pleural drain and the groin wound was closed.

In this approach, a standard anterior midline incision was made from a suprasternal notch up to Xiphisternum. A vertical pericardiotomy was made and a pericardial

patch was prepared. Aortobicaval cannulation was done following heparinization and cardiopulmonary bypass was established. An aortic cross-clamp was applied. Ante grade cardioplegia was given and the heart was arrested in diastole. Both the cavae were snared. The right atrium was opened 2 cm lateral to the atrioventricular groove extending from the right atrial appendage superiorly to anterior to the inferior vena cava inferiorly. ASD was closed with an autologous pericardial patch. The right atrium was closed in two layers. Root was vented and heart was de-aired. The heart was weaned off cardiopulmonary bypass. Venous and arterial decannulation was done followed by securing hemostasis. The chest was closed over a right pleural drain and a pacing wire.

Data was compiled, edited, and checked daily to maintain consistency. The data was collected in Microsoft Excel (Ver. 2013). For statistical analysis, SPSS 21 (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.) was used. Descriptive analysis was done to identify the distribution of socio-demographic characteristics of patients.

Ethical approval was obtained from the Institutional Review Committee (IRC) of the Institute of Medicine (IOM). Official letters of cooperation from IRC were written to the respective study centre. Informed consent was obtained from all study participants to allow the use of anonymous personal and clinical data in research. Confidentiality of the information was maintained thoroughly by de-identification

RESULTS

Table 1. Demographical characteristics.

Variables	MT	MS
Gender		
Male	38.18% (21)	47.27% (26)
Female	61.81% (34)	52.73% (29)
Mean age (in years)	23.4	28.6
Symptoms		
Shortness of breath	69.09%	65.45%
Palpitation	63.64% (35)	54.45% (30)

Fifty-five patients underwent minimally invasive closure of atrial septal defects with total peripheral cannulation. Similarly, fifty-five patients undergoing closure via median sternotomy were also selected after

age and sex matching for the comparison. The mean length of stay in the intensive care unit was 1.8 and 2.5 days in the MT and MS group respectively while the mean duration of hospital stay was 4.5 and 4.8 days in the MT and MS group respectively.

About 61.81% (34) of the patients were female while 38.18% (21) were male in the mini-thoracotomy (MT) group. Similarly, 52.73% (29) of the patients were female and 47.27% (26) male among the median sternotomy (MS) group. The mean age of patients at the time of surgery was 23.4 and 28.6 years in the MT and MS groups of patients respectively. The age range of the patients was 16-40 years in both groups. Most of the patients presented with the symptom of exertional shortness of breath in both the MT (69.09%) and MS (65.45%) groups (Table 1). Palpitation was the second most common symptoms of the patients. In about 30.90% of the patients, there were incidental findings. 80% of the patients were in NYHA class I and the rest 20% of the patients were in NYHA class II in the MT group.

Table 2. Comparison among MT and MS groups.

Variables	MT	MS	p-value
Mean size of ASD (in mm)	22.4	22.6	>0.05
Mean size of incision (in cm)	4.9	12.8	<0.05
Average time for CPB (in minutes)	44	23	<0.05
Average cross clamp time (in min)	26	14.6	<0.05
Fluid drained on first day after surgery (in ml)	198	320	<0.05
Mean duration of stay at ICU (days)	1.8	2.5	>0.05
Mean duration of hospital stay (days)	4.5	4.8	>0.05

MT: mini thoracotomy; MS: median sternotomy; CPB: cardiac pulmonary bypass

The mean size of ASD among MT and MS group of patients was 22.4 mm and 22.6 mm respectively (range being 20mm -40mm). Similarly, the mean size of the incision was 4.9 cm and 12.8 cm in MT and MS respectively (range of 8-14cm in MS). The average time for cardiopulmonary bypass (CPB) was 44 minutes and 23 minutes in the MT and MS groups respectively. Similarly, the average cross-clamp time was 26.0 minutes and 14.6 minutes in the

MT and MS groups respectively. 198 ml and 320ml of fluid were drained on the first day in the MT and MS groups respectively. There was a significant association was found between the MT and MS groups in relation to mean size of the incision, average time for CPB, average cross-clamp time, and fluid drained on the first day after surgery. (Table 2) Peripheral to central cannulation conversions were not done. One patient among the MT group developed femoral vein thrombosis in the postoperative follow-up.

DISCUSSION

The mean length of stay in the intensive care unit was 1.8 and 2.5 days in MT and MS groups respectively, and the length of stay in the hospital was 4.5 days and 4.8 days in the MT and MS groups respectively. This is the first study in Nepal to study the ASD closure with a small thoracotomy and peripheral cannulation at a tertiary hospital.

When compared to MS, minimally invasive therapies involving a thoracotomy appear to have some disadvantages. They may be insufficient for prolonged surgical exposure or complicated concomitant cardiac procedures like coronary, valve, aortic, and arrhythmia surgery. Cerebral infarction caused by retrograde perfusion using femoral artery inflow must be avoided, especially if the aorta is atherosclerotic, and peripheral arterial cannulation is linked to aortic dissection and lower limb ischemia.^{4,5}

We consciously picked the minimally invasive approach for ASD closure in this group of individuals. There is a reduced risk of stroke in individuals who require ASD closure since they are often young and do not have atherosclerotic lesions. As a result, we consider that femoral arterial cannulation with peripheral perfusion is appropriate. However, in these patients, there are two major issues with peripheral perfusion. One problem is that the femoral artery in young patients is smaller than in older patients. Hence, an appropriate size cannula must be used to maintain adequate blood flow during CPB. In this study, the mean basal surface area was $1.25 \pm 0.15 \text{ m}^2$, and a 16- or 18-Fr cannula was necessary to perfuse the whole body with blood flow. The vessel is required to be at least 6.5 mm in diameter to properly use a 16-Fr cannula. Alternative perfusion access was considered if the femoral artery was less than 6.5 mm in diameter. In such cases, the risk of lower limb ischemia should be considered. However, lower limb ischemia did not occur in this study. Arterial spasm, which happens more commonly in young patients

than in older patients, is another issue with peripheral perfusion in ASD closure. The femoral artery is dissected minimally without taping to prevent arterial spasm, and papaverine hydrochloride dispersion is administered suitably. Postoperative lymphoma is also avoided with minimal dissection. It's also crucial to monitor perfusion pressure to avoid femoral artery injury that leads to retrograde aortic dissection. When the pressure rises above 300 mmHg, a different perfusion route should be adopted.

The majority of our patients were females in the young age group. Similar to this a study by Bigdelian et al reported a higher number of females (85.71%).⁶ The mean age of patients at the time of surgery was 23.4 and 28.6 years in the MT and MS groups of patients respectively. In contrast to this, Jung et al reported the higher mean age as 26.4 years in the thoracotomy group and 38.4 years in the median sternotomy group.⁷ In a study by Hu et al, the length of incision in minimally invasive surgery (MIS) was 6.3 ± 1.1 cm, which was significantly shorter than 9.6 ± 2.5 cm long incision in the sternotomy group.⁸ Similar to this the mean size of the incision was 4.9 cm in thoracotomy group which was shorter than 12.8 cm in the MS group. In the same study, mean bypass times were 58 ± 19 minutes in the minimally invasive surgery group and 52 ± 19 minutes in the sternotomy group.⁸ In contrast to this our study reported an increased duration of CPB in the thoracotomy group than the sternotomy group.

Yoshimura et al reviewed the patients in whom the atrial septal defect was closed through a right anterolateral thoracotomy and found that the mean aortic cross-clamp time was 21 minutes (range 12 to 44 minutes).⁹ Similar findings were reported in our study among the MT group. Ishida et al found that significantly less intraoperative blood was lost by the MT group than the MS group (89 ± 53 mL vs 209 ± 142 mL, $p=0.01$).¹⁰

Shah et al showed that there was a significant decrease in ICU and hospital stay durations in ALT when compared to the sternotomy group ($p < 0.05$).¹¹ The mean stay in the intensive care unit (ICU) was 1.4 ± 0.5 days and 1.8 ± 0.7 days in the sternotomy group while the mean hospital stay was 3 ± 1.4 days in the ALT group and 4 ± 2.2 days in the sternotomy group. Postoperatively, the patients were extremely satisfied with the small sub-mammary incision. The costs of cannulas, oxygenators, medications used in both groups were almost the same. The expenditure incurred during surgery was fairly comparable around 1500 Euros in both groups. Hence, the two major factors affecting the overall cost were

found to be the ICU stay and hospital stay. Since the duration of stays was shorter in the MT group, it can be inferred that mini-thoracotomy is proving to be a cheaper approach in closing ASD in our setup.

There are limitations of this study. First, this was a cross-sectional study conducted in a single clinical facility; therefore, no causal relationship can be drawn from our findings. Second, the study participants were recruited over a relatively short period; therefore, the findings might be prone to selection bias. There was lack of several important variables due to the retrospective design of this study. Further, the date of the discharge depends on the surgeon's decision. Long-term follow-up was not done, as a result of which the complications could not be reported. In the future, a randomized controlled trial with long-term follow-up and a larger number of patients should be conducted to determine the most cost-effective strategy for ASD closure in the Nepalese setting.

CONCLUSIONS

The use of total peripheral cannulation with MT has shown to be a safe and excellent option in selected patients. It allows limited surgical chest incisions, reducing in this way the patient's surgical trauma, excellent clinical results that are comparable to classic and other minimally invasive approaches. TPC with the mini thoracotomy is providing both excellent functional and cosmetic results and proving to be a cheaper approach in closing ASD in our setup.

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