VENTRICULAR SEPTAL DEFECT'S CLOSURE VIA RIGHT THORACOTOMY: EXPERIENCES WITH 100 CONSECUTIVE CASES FROM VIETNAM NATIONAL CHILDREN'S HOSPITAL

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We evaluated the feasibility and effectiveness of the right vertical sub-axillary incision used for the closure of ventricular septal defect. 100 patients (55 males and 45 females) who consecutively underwent surgical repair of their ventricular septal defect at our institution from January 2020 to November 2021 were retrospectively reviewed. Technique considerations were right thoracotomy with a vertical mid-axillary line mini-incision, and central cannulation for cardiopulmonary bypass. Median age was 13 months; median weight was 8.7 kg. The mean cardiopulmonary bypass time and aortic cross-clamp time were 67 ± 16 minutes, 51 ± 15 minutes respectively. The ICU stay was 2.2 ± 1.2 days, mechanical ventilation time was 12.9 ± 28.2 hours, postoperative hospital stays was 9.9 ± 4.9 days. Morbidities were pneumonia (20%); surgical site infection (3%); subcutaneous emphysema (44%); transient arrythmias (10%). There was no conversion to another approach. There was no early or mid-terms mortality with a mean follow up of 15.8 ± 5.2 months. All patients are in a good health status. No significant residual defects were found on their last follow-up echocardiography. In conclusion, the ventricular septal defect's closure via right thoracotomy at Vietnam National Children's Hospital is a safe and feasible procedure with excellent cosmetic results.

Keywords: VSD (Ventricular Septal Defect), MICS (Minimally Invasive Cardiac Surgery), Mini incision.

I. INTRODUCTION

The first successful ventricular septal defect (VSD) closure were performed by C.Walton Lillehei on a 3-year-old boy utilizing cross-circulation in 1954.[1] Since then, open heart surgery has become gold standard of care for many congenital heart defects (CHD) with excellent outcomes. The goal of CHD management is to achieve an anatomic repair that ensures a normal survival and the best quality of life. With advancement of catheter-based interventional technique, some hole in the septum could be closed percutaneously by devices, but surgery remains an indispensable role in managing VSD patient.[2] While sternotomy continues to be identified as a standard approach for a perfect repair of a VSD, other approaches such as small incision with a full sternotomy, partical sternotomy, antero-lateral thoracotomy etc... have been explored and reported in order to reduce invasiveness of the surgery.[3,4]

With the support of Japan International Cooperation Agency (JICA), we have had several training courses about CHD both in academic objectives with lectures and in practice objectives with short rotation at Okayama University Hospital. Since, at Vietnam National Children's Hospital, the minimally invasive cardiac surgery (MICS) program was started by some first successful atrial septal

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Received: 28/10/2022
Accepted: 15/12/2022

defect's closures via right thoracotomy with vertical mid-axillary incision. Overcoming the learning curve, expertised with cardiac structure exposure and conventional cardiopulmonary bypass cannulation site, nowadays we routinely perform other heart defect's repair via this approach such as: partial atrio-ventricular septal defect, partial anomalous pulmonary veinous return, cor-triatiatum… Therefore, in this study, we aimed to evaluate the feasibility and effectiveness of the right vertical sub-axillary incision used for the VSD's closure.

II. METHODS

1. Subjects

100 consecutive patients operated for their ventricular septal defect using a vertical mid-axillary incision from January 2020 to November 2021 were enrolled in this study. We retrospectively reviewed all the medical record and the clinical and echography results of the last check-up. There were 45 females and 55 males. The data extracted from paper or electric medical records was collected by common form, analyzed by Stata 17.0. All results are expressed as percentage or mean ± standard deviations.

All patients had two echocardiography reports by two cardiologists to confirm the diagnosis prior to the surgery. Indications for VSD's closure were: left to right shunt VSD, dilated left ventricle, secondary lesion such as prolapse of the aortic cusp or aortic inssuficiency, RVOT obstruction, or with symptoms of congestive heart failure. At the beginning of MICS program, patients' bodyweight was chosen about 8 - 10kg and above. Then we gradually applied this technique for smaller infant. After discharge, all patients were scheduled to have 3 months, 6 months, and every 12 months follow up post surgery according to the patient's status. Information of each patient's check-up were stored using electric medical record software.

2. Operative considerations

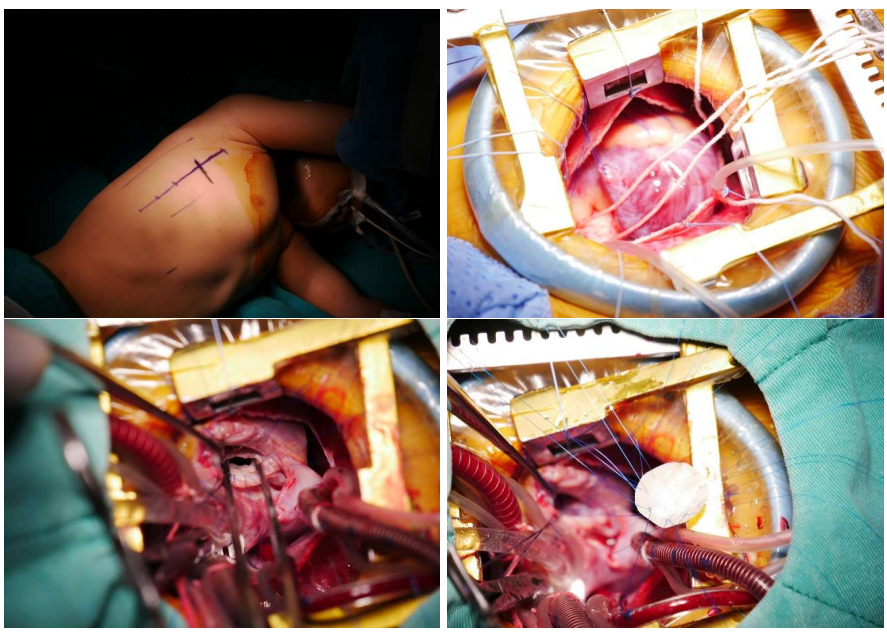

Figure 1. Operative procedure

(From left to right, from top to bottom: Patient position and incision marked, thoracotomy and exposure of the heart, interrupted suture for VSD closure, bovine patch for VSD closure)

We standardized the protocol for all patients underwent MICS (Fig. 1). The patient was under general standard anesthesia for open-heart surgery, specifically for VSD. The right lung was blocked for one lung ventilation during the surgery. The patient was placed in a left lateral with slight backward. The anterior, mid, posterior axillary line and 5th intercostal space were marked to guide the parameters for the incision. A vertical incision of 4 to 6cm was performed in the mid-axillary line. The latissimus dorsi was mobilized freely from the incision, and the serratus anterior overlying the thoracic cage was transected. An entry to the pleural cavity through the superior margin of the 6th rib was performed, and the pericardium was opened 1.5 to 2cm above the right phrenic nerve. Stay sutures were placed along both the margins of the pericardium and fixed to the surrounding drapes. The cannula were directly inserted into the aorta and two vena cava. Once cardiopulmonary bypass was established, the ventilation was stopped, the left heart vent was put through the right superior pulmonary vein, then the two vena cava were snared. The cold crystalloid cardioplegia solution was given after aortic cross-clamped. A right atriotomy was performed. Depending on the location of the VSD, the approach via the tricuspid valve or the pulmonary valve was selected. VSD was closed with a bovine patch and interrupted monofilament pledgetted 5/0 or 6/0 suture. Other additional procedures including ligation of a persistent ductus arteriosus, conus resection for release the right ventricle outflow tract obstruction, repair of the tricuspid valve were concomitant with VSD closure if persist. The heart was then deaired and filled. The aortic clamp was released. The right atriotomy or the pulmonary arteriotomy were closed with a running suture. After completion of the procedure, decannulation and hemostasis were performed. The opened pericardium was stitched with interrupted suture. An epidural catheter was placed in the posterior intercostal groove for post-operative pain management‘s infusion. A thorax drain was inserted, and the chest was closed in layers. Intraoperative transesophageal echocardiography or postoperative trans-thoracic echocardiography were performed for all patients while in ICU.

3. Research ethics

The study was approved by the Research Institute for Child Heath’s Ethical Board of Vietnam National Children’s Hospital (Issued date: 27 December 2021 / IRB00011976/ FWA00028418). The informed consent was taken only for surgery. Information, images, or video relating to the study’s subjects are confidential and used only for scientific purposes. Due to the retrospective nature of the study, complement informed consent is not necessary.

III. RESULTS

Through the vertical right axillary incision, the VSD could be exposed and closed completely in all patients. There was no need for conversion to another approach, nor additional surgery for revision of a residual lesion. Postoperative complications noticed were pneumonia (20%), surgical site infection (3%), subcutaneous emphysema (44%), transient arrythmias (10%) which had no need further electrophysiology intervention.

No early or mid-terms mortality with a mean follow up of 15.8 ± 5.2 months. No significant residual defects were found on the last follow-up echocardiography. At the most recent check-up, all patients are in a good health status (NYHA1) with good stomatic growth. There was no clinical deformity of the chest or the vertebral

column in any of these patients. The parameters of the cohort are shown in table 1, 2, 3 and 4.

Table 1. Demographic characteristics

Characteristics	n/ Mean ± SD (Min – Max)
Male	55
Female	45
Age (months)	30.6 ± 37.7 (3 – 159)
Weight (kg)	11.9 ± 8.2 (4.5 – 54)
Height (cm)	84 ± 23 (58 – 155)
BSA	0.52 ± 0.24 (0.27 – 1.55)
CPB times (min)	68 ± 17 (34 – 147)
XAo times (min)	51 ± 15 (28 – 127)
Operation times (min)	154 ± 25 (115 – 250)

Table 2. Operative findings and concomitant procedures

VSD locations	n (%)
Perimembranous & sub Ao	77
Inlet	1
Sub-pulmonary	22
Associated procedures	**n (%)**
PDA ligation	83
ASD closure	2
RVOTO (Parietal extension resection)	24

Table 3. Morbidity

Complications	n (%)
Bleeding	0
Pneumonia	20
Surgical site infection	3
Arrythmias (Bradycardia, extrasystole)	10
Pleural effusion	1
Pneumothorax	0
Subcutaneous emphysema	44
Phrenic nerve paralysis	0

Table 4. Postoperative characteristics

Characteristics	Mean ± SD (Min – Max)
Mechanical ventilation times (hours)	12.99 ± 28.25 (3 – 288)
Chest tube (hours)	35.27 ± 16.1 (12 – 72)
ICU stay (days)	2.2 ± 1.2 (1 – 12)
Hospital stay (days)	9.9 ± 4.9 (6 – 15)
Mortality	0
Follow-up (months)	15.8 ± 5.2 (8 – 30)
Functional status	Good, Gain weight,NYHA 1

IV. DISCUSSION

Median sternotomy has been widely accepted and applied to repair the VSD, but the sternotomy-related complications such as markedly visible midline scar, pectus carinatum or excavatum existed.[2] Other alternative approaches to standard sternotomy such as small incision with a full sternotomy, partical sternotomy, antero-lateral thoracotomy, posterior-lateral thoracotomy etc... have been explored.[3,4] In Vietnam, E hospital team were the first implementor of MICS for VSD's closure in children. They reported a cohort of 106 patients underwent VSD's closure via right anterolateral thoracotomy.[5] Their patients' mean age (1.1 years old) and mean weight at the surgery (7.6kg) seems to be smaller than our studied cohort, but the mean ICU stay (3.3 days) and hospital stay (12.4 days) seems to be longer while the bypass times (70 mins) and aortic crossclamp times (46 mins) were comparable to our study. However scar remained visible from the front. This approach could induce chest deformity and asymmetric development of breasts.[2,6] In the given period, due to the shortage of closed chest-drainage system, the subcutaneous emphysema occurred with quite high incidence, but not noticeable when supplies were available.

With nearly zero early morbidity and mortality, the quality of life of VSD patients especially cosmetic appearance have increasingly become the subject of consideration and should be discussed among healthcare provider and the family.[6] This incision, being in mid-axillary line, gives the best cosmetic result (remaining hidden underneath the resting arm) (Fig.2), and it does not interfere with the development of the chest or the breast. Since 2019, we have used this approach for repair simple intracardiac defects such as atrial septum defect, cortriatriatum, partial atrioventricular septal defect… with no need for conversion to another approach, meaning that provides a safe, reliable, and effective procedure. The cosmetic result of the scar is excellent (Fig. 2). At the last check-up, the thorax development has been normal. None of the girls in the cohort were in pubescence, so further follow-up of any breast or chest deformity are in need. We expect that the breast develops normally, because we divided only the serratus anterior muscle layer and not extend the incision over the anterior axillary line which avoid the potential breast bud area.

Figure 2. Post operative scar

13 months-boy who underwent VSD closure via this approach at the age of 5 months. Scar is hidden under the armpit. No chest deformity

A right axillary incision provides the best direct plane of vision to the atrial septum, AV valves and the membranous ventricular septum.[2] Additionally, the location of the scar being naturally covered by a resting arm provides excellent cosmetic result.[7] With an incision of 4cm for patient's weight below 15kg, and of 6cm for patient's weight above 15kg. By using the silicone wound retractor and 2 other retractors, we do find that this approach provide an adequate exposure to the heart and vessel without extending the incision. While approaching the intracardiac lesion, through the tricuspid valve, without detaching anterior leaflet or the Lancisi muscle, we obtained a good exposure of the VSD by using only one small retractor on the anterior commissure. Care is paid while suturing the inferior border of the peri membranous VSD in order to avoid the conduction system injury. No patient had significant residual shunt and no patient had permanent heart block in the postoperative course. No mortality and excellent cosmetic outcomes showed the feasibility and efficacy of this approach at our center.

Various authors reported the peripheral complication such as artery stenosis or aneurysm after the peripheral cannulation at the time of MICS.[2] In our experience, no patient is cannulated in the groin nor in the neck. Central cannulation through this vertical incision is easily etablished and do not put the peripheral vessel at risk especially, for the patient under 10kg whose peripheral vessel are not big enough for the cannula. Recently, we modified the cannulation technique by directly inserting

the IVC canula into a separate incision which would be the hole for the chest tube after the surgery. This modification helped shorten the main incision and provide wider surgical field. We highly recommended this approach with central cannulation for all pediatric patients.

V. CONCLUSION

At Vietnam National Children's Hospital, the vertical mid-axillary incision provided an adequate access to the heart for ventricular septal defectclosure without conversion to sternotomy or residual shunt after the surgery. Ventricular septal defect closure via this approach is a safe and feasible procedure. The surgery results in excellent clinical and cosmetics outcomes which would ensure the best quality of life of the patients and the caregivers.

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