Case Report

Minimally Invasive Ventricular Septal Defect Closure via Right Thoracotomy: The First Reported Case in Thailand

Noppon Taksaudom MD[1], Chanokporn Supasa BS[2], Pornwilai Tanachindawong BNS[3]

[1] Cardiovascular and Thoracic Surgery Unit, Department of Surgery, Maharaj Nakorn Chiang Mai Hospital, Chiang Mai University, Chiang Mai, Thailand

[2] Perfusionist Division, Cardiovascular and Thoracic Surgery Unit, Department of Surgery, Maharaj Nakorn Chiang Mai Hospital, Chiang Mai University, Chiang Mai, Thailand

[3] Operating Theater and Recovery Room Nursing Division, Maharaj Nakorn Chiang Mai Hospital, Chiang Mai University, Chiang Mai, Thailand

The present case report concerned a young woman who had a ventricular septal defect (VSD) that was unable to be closed by interventional approach. She had successfully undergone an anterior mini-thoracotomy to close the VSD directly. The thoracotomy approach was chosen as it would give a better cosmetic result for this patient without any subordination in comparison with the standard sternotomy approach. This is the first reported case of minimally invasive VSD closure via the right thoracotomy approach in Thailand.

Keywords: Minimally invasive cardiac surgery; Cardiac surgery; Ventricular septal defect; Minimally invasive congenital cardiac surgery; Congenital cardiac surgery

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Ventricular septal defect (VSD) is the most common congenital cardiac anomaly with an incidence of between 1.56 and 53.2 per 1,000 live births. The figures varied depending on the advances in imaging and screening of the infants[1]. In some cases, the VSD was left unclosed until adulthood. Indications for VSD closure during adulthood include signs of volume overload in the left ventricle, repeated episodes of infective endocarditis, progressive aortic regurgitation, and significant left-to-right shunt (Qp:Qs ≥1.5), but without Eisenmenger's physiology[2]. The most common type of VSD in adulthood is the perimembranous type, which constitutes 80% of all VSD cases in adults. Potential techniques for VSD closure are interventional closure with transcatheter devices and surgical closure. The perimembranous VSD is one of the most problematic in the case of transcatheter closure due to the conduction system being located at the inferior border of VSD. The application of transcatheter device closure in this area can result in a pressure effect in the surrounding structures and cause the conduction disturbance. The standard surgical approach in cardiac surgery is via a median sternotomy. Minimally invasive cardiac surgery (MICS) was proposed by Cosgrove et al in the late twentieth century[3]. One of the advantages of the minimally invasive concept for cardiac surgery is to avoid median sternotomy, which would not only avoid complications associated with sternotomy such as sternal wound infection, sternal dehiscence, and mediastinitis, but also give better cosmetic results especially for young women. Minimally invasive incisions such as lower hemi-sternotomy, upper hemi-sternotomy, and right anterior thoracotomy have been used as alternative incisions for VSD closure procedure. In Thailand, MICS has been an adopted practice since early twenty-first century. However, the most common application of MICS is in mitral valve surgery. The use of MICS for congenital cardiac surgery is still not widely accepted and few cardiac surgeons in Thailand perform this kind of operation with the exception of atrial septal defect (ASD) closure. In the authors' institution, the cardiac surgeons have tried to adopt MICS as an option in congenital cardiac surgery by using hemisternotomy or partial sternotomy in nearly all cases when MICS

Correspondence to:

Taksaudom N.

Cardiovascular and Thoracic Surgery Unit, Department of Surgery, Maharaj Nakorn Chiang Mai Hospital, Chiang Mai University, 110 Intawaroros Road, Si Phum, Muang, Chiang Mai 50200, Thailand.

Phone: +66-53-936150, **Fax**: +66-53-935123

Email: drnoppon@hotmail.com

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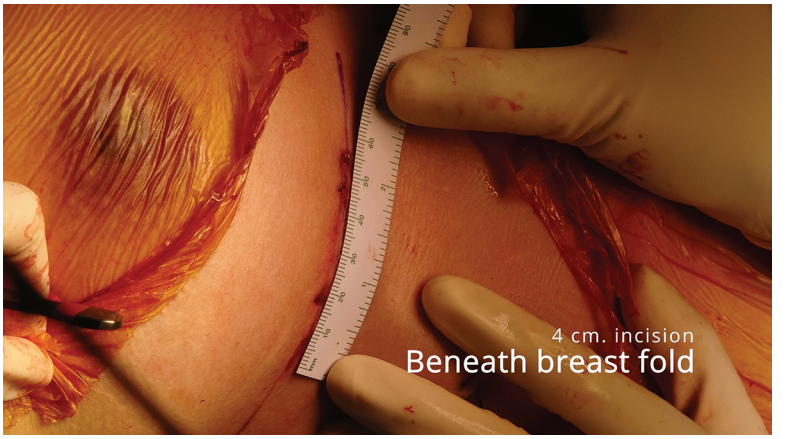

Figure 1. Shows the 4-cm incision beneath the mammary fold of right breast.

is a possibility. Selection of the most appropriate thoracotomy approach is still a challenging field in congenital cardiac surgery with the exception of ASD closure because of the difficulties associated with the cannulation technique, the difficulty of exposure to intracardiac structures, and the unfamiliarity of the surgeons with the operation.

The present report described the case of a young reproductive age female patient with untreated perimembranous VSD. The correction was conducted via right mini-thoracotomy, the first reported in Thailand.

Case Report

A 20-year-old women presented with an incidental murmur that was first diagnosed when she was eight years old. The patient was lost to follow up. Two years before this admission, the murmur was incidentally detected during her visit to the clinic about common cold, she was subsequently referred back to the authors' institution. She reported mild dyspnea (NYHA II) without cyanosis. On physical examination, vital signs were all stable with oxygen saturation of 98% at room air. A pan-systolic murmur grade IV was heard at the left lower sternal border with palpable thrill. The chest X-ray film showed no cardiomegaly and a cardio-thoracic ratio of 40%. The electrocardiogram showed normal sinus rhythm without significant cardiac chamber enlargement or conduction disturbance. The electrocardiogram also showed a small, 5mm, perimembranous VSD without pulmonary hypertension. The maximal pressure gradient across the VSD was 65 mmHg. The other intra-cardiac structures were normal without significant left ventricular dilation and an ejection fraction of 62.7%. Right heart catheterization was performed and revealed an isolated VSD with a left-to-right shunt with an Qp:Qs of 1.5 and mild precapillary pulmonary hypertension with a pulmonary vascular resistance index of 2.11 Wood units/m^2. According to the 2020 Guidelines for the Management of Adult Congenital Heart Disease[2], the present patient was suitable for VSD closure. Firstly, the cardiologists considered the option of closing the VSD using percutaneous device closure but there was a strong possibility of conduction disturbance in this young patient. The conclusion from the heart team discussion was to perform VSD closure with a minimally invasive technique.

The patient was scheduled for cardiac surgical closure two weeks after the discussion. The operative procedures were discussed extensively with the patient. All preoperative investigations were within normal limits. The surgery was conducted under general anesthesia with normal single-lumen intubation. The triple lumen catheter was inserted percutaneously via the left internal jugular vein. The right internal jugular vein was punctured with a 6-Fr vascular sheath for superior vena cava (SVC) cannulation during the operation. Transesophageal echocardiographic examination (TEE) was used as is routine in the present study institution. The patient was positioned in the supine position with an inflatable balloon bag placed beneath the right hemithorax, which enabled elevation of the right chest to facilitate better exposure. Standard antiseptic procedures were used in the prepping. A 4-cm. incision was made at the right sub-mammary skin fold to hide the scar beneath the breast. The incision was made more medially than the standard MICS incision for mitral valve repair (Figure 1). The skin flap was mobilized upwards to the fourth intercostal space. The chest was entered via the

fourth intercostal space. A skin protector device and the rib retractor were placed to maximize the operative view. The 1-cm. incision was made horizontally in the right groin and the common femoral vein and artery were identified and controlled. Patient was heparinized and peripheral cardiopulmonary bypass (CPB) was established as the standard procedure. The femoral arterial and venous cannulas were 17 Fr. and 20 Fr., respectively. Additional SVC cannulation was done with a straight 15 Fr venous cannula. Each vascular cannulation was performed cautiously using Seldinger's technique under TEE and fluoroscopic guidance. A small incision was made through the seventh intercostal space in the anterior axillary line. The left ventricular venting cannula was passed through this incision. After achieving full bypass, the ventilation was stopped, and the pericardium was opened longitudinally about 4 cm. anterior to the right phrenic nerve and extended up to SVC and downward to inferior vena cava (IVC) level. The pericardial hanging stitches were placed along the border of the pericardial incision. The right-side pericardial hanging stitches were brought out of the wall of the right side of the chest via the small stab incision using the snaring technique pulling the pericardial cavity laterally as much as possible. This maneuver enabled the heart to be moved laterally to the operative view. In other cases, if the exposure is still not adequate, additional pericardial stitches can be placed deeper and more traction applied. SVC and IVC were snared with umbilical tapes. A small surgical sponge was tied with heavy silk and packed into the aortopulmonary space to protect the left atrial appendage from the sharp teeth of the aortic cross clamp. A cardioplegic cannula was placed directly into the ascending aorta through the main incision. A Chitwood's aortic cross clamp was placed in a separate stab incision via the second intercostal space just behind the anterior axillary line. An aortic cross clamp was applied, and the heart was arrested by antegrade cold del Nido cardioplegia. A flexible tipped thoracoscope was used to enhance the surgical view by passing the camera directly via the main incision without any separate incision port. Both SVC and IVC snares were fastened. A left ventricular venting cannula was inserted via the right superior pulmonary vein. The right atrium was opened along the atrioventricular groove. The VSD was visually confirmed as being small and perimembranous and communication with the left ventricle was confirmed by probing the VSD then turning off the left ventricular venting cannula, letting the blood flood from the left ventricle. The VSD was closed directly with three horizontal mattress sutures with Teflon felt reinforcement. The right-side atrial interior was examined. The de-airing maneuver was performed as usual before removal of the aortic cross clamp. The patient was rewarmed. The right atrial wall was closed, the CPB was weaned off and discharged uneventfully, the pericardium was partially closed. All wounds were rechecked for bleeding with a thoracoscope, and one chest drainage tube was placed across the pericardium and right pleural cavity. The total operative time was 2 hours and 30 minutes, aortic cross clamp time and total bypass time were 23 minutes and 61 minutes, respectively. Intraoperative TEE results showed no residual defect with good cardiac function. The summary operative VDO clip had already been posted via this link (https://youtu.be/ZgpHbwHAiZ8). The patient was extubated four hours after arriving in ICU. She had normal convalescence without any complications. The chest drainage tube was removed at postoperative day 2.

The patient was discharged on postoperative day 4. She was clinically stable, and the postoperative echocardiogram showed no significant abnormality with good ejection fraction of 60%.

Discussion

During the late twentieth century, laparoscopic operations became popular for abdominal surgery. There were also attempts by cardiac surgeons to apply this minimally invasive method to cardiac surgery. In 1992, Cosgrove et al reported successful valvular surgery via right parasternal incision in 100 patients. The technique reduced the length of hospital stay and overall expense[3]. A few years later, in 1996, Carpentier et al started to use video-assisted technology to repair the mitral valve via mini-thoracotomy incision[4]. The technology developed rapidly then robotic surgery was used in cardiac surgery[5]. Numerous limitations in MICS were gradually overcome with better instruments, cannulas, and numerous techniques which were invented and developed by many committed surgeons around the world[6].

Even though there are so many types of cardiac surgery associated with congenital heart disease, valvular heart disease, aortic disease, and coronary artery disease MICS is usually only used in valvular operations, especially in Thailand. Congenital heart disease is the field of cardiac surgery that has seen the least development in MICS method. In Thailand, the MICS for congenital heart disease is usually confined

to ASD closure. In the authors' institution, the cardiac surgeons also use MICS for congenital heart defects such as ASD, VSD, patent ductus arteriosus, and tetralogy of Fallot. However, these are all currently performed via partial sternotomy. The avoidance of sternotomy is one of the philosophies behind the use of MICS, which was proposed by Felger et al[7]. The lower partial sternotomy is also beneficial as it maintains the integrity of the claviculo-sternal joint improving the chances of a more rapid recovery and retention of normal arm movements in children[8].

The right thoracotomy was commonly used in teenagers who were more concerned about cosmetic problems. This approach can be effectively used when there is a requirement for a right sided lesion in cases such as ASD, VSD, and tricuspid valve. The poor exposure to intracardiac structure is still the main fallback of this approach. Another concern of thoracotomy is the risk of injury to the mammary gland that could lead to asymmetrical breast development especially in female patients. The incidence of this complication has a low occurrence of 5%[9].

The present case is the first application of MICS via thoracotomy for VSD closure in Thailand. This operation was performed in a mature teenage woman, therefore, the concern about breast development can be eliminated. The peripheral CPB was easily established via the femoral vessels, but the repair of the common femoral artery is a crucial part of this procedure. The risk of arterial stenosis or thrombosis is high in a young female patient who has small peripheral vessels. To minimize the chance of this, the cardiac surgeons used the open cut-down technique via small incision and repaired the vessel directly to avoid any purse-string effect from the purse-string sutures. The pulse of the ipsilateral limb was examined immediately after the operation and monitored throughout the hospital stay.

The concern regarding exposure was partially eliminated by using circumferential pericardial hanging stitches. This maneuver can bring the heart to the right side of the chest and up to the skin. However, this maneuver may not completely expose the deep intracardiac structures such as the VSD. Video-assisted thoracoscopy was used to increase the exposure of this area. However, the VSD that located on the right ventricular outflow tract such as outlet VSD or muscular outlet VSD may not be easily exposed via this approach, suggest using the lower sternotomy for right ventricular outflow tract septal defect lesions.

The present study operation was successful with satisfactory results without any significant complications. The operative time and aortic cross clamp time may be longer than in a usual standard sternotomy, but these times will decrease as the learning curve of the surgeons and the members of operative team increases.

Future developments need to focus on the increase in this technique in the pediatric demographic, which require direct cannulation and axillary thoracotomy that can not only avoid any visible scarring on the anterior chest, but also avoid the risk of mammary gland injury in female patients.

Conclusion

The use of a minimally invasive approach for VSD closure is feasible. The thoracotomy approach gives a better cosmetic result for reproductive woman without any unwanted outcomes compared with the standard sternotomy approach. The present operation will develop an interesting new field of treatment of congenital MICS in Thailand.

What is already known on this topic?

The minimally invasive VSD closure via the right thoracotomy was already proposed by studies with promising results. However, when comparing to the other fields of MICS, the congenital cardiac surgery has still not gained popularity. In Thailand, the minimally invasive congenital cardiac surgery is usually confined only for ASD closure.

What this study adds?

This case report is the first introduction of minimally invasive congenital cardiac surgery other than ASD closure in Thailand. This report will be the gateway for the next development of MICS in Thailand.

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Ethical approval and consent to participate

The present study was approved by the Ethic Committee of Faculty of Medicine, Chiang Mai University, and with the permission from the patient via the consent form for this report.

Conflicts of interest

The authors declare no conflict of interest.

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