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Lower Sternotomy Access for Congenital Heart Surgery

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Jeong Ryul Lee, MD, Ji Min Chang, MD, Cheong Lim, MD, Cheul Lee, MD,
Yong Jin Kim, MD, Joon Ryang Rho, MD

Department of Thoracic and Cardiovascular Surgery, Seoul National University Children's Hospital, Seoul National University College of Medicine, Seoul National University Clinical Research Institute, Seoul, Korea

ABSTRACT

Background: Minimally invasive cardiac surgery recently has been applied in the management of a variety of cardiac lesions. As our experiences accumulated, we were able to expand the minimal access approach to the repair of more complex congenital heart lesions.

Methods: From July 1997 to December 2000, 494 patients with congenital heart disease underwent T or J-shaped lower sternotomy by thoracic entry. Cardiac diagnosis consisted of ventricular septal defect (n = 322), atrial septal defect (n = 118), and more complex anomalies (n = 54). The approach consisted of a 4-10cm cephalad skin incision starting from the costoxyphoid angle, minimal dissection of the peristernal tissues, T or J lower sternotomy and a sternal opening using a self-retraction system of our own design. Conventional direct aortic and bicaval cannulation were used.

Results: Mean length of the skin incision was 6.2 ± 1.4 (range: 4.0-10) cm. Mean distance between the suprasternal notch and the upper most point of the skin incision was 4.4 ± 1.2 (range: 3.4-9.5) cm. All the patients showed an uneventful postoperative course. The mean total amount of analgesics used was 0.37 ± 0.98 mg of morphine. The mean duration of hospitalization after operation was 5.2 ± 5.0 days, and there were no wound complications or hospital deaths.

Conclusions: We found that the application of the minimal access technique by lower sternotomy on a selected group of congenital heart disease patients was feasible and more attractive in terms of cosmetic outcome. Our simple sternal opening method is both useful and effective.

INTRODUCTION

Minimal access approaches, which include limited lateral thoracotomy, partial sternotomies, and port access surgeries for repairing congenital heart defects, have recently been proposed to reduce postoperative pain and respiratory dysfunction, to obtain cosmetic benefits and to reduce hospital stay and cost [Moreno-Cabral 1997, Gundry 1998, Walterbusch 1998, Black 1998, Lin 1998, Doty 1998, Kappert 1999, Marianeschi 2000]. The so-called mini-sternotomies such as T-shaped, J-shaped and arrow-shaped sternal divisions have been applied by many cardiac surgeons. Although these approaches have been reported to have many potential advantages, repair and cannulation sites are difficult to view. Furthermore, unexpected events such as sudden cardiac arrest, ventricular fibrillation, and bleeding were found to be difficult to handle. As a result, many surgeons have tried to develop new techniques to overwhelm these limitations.

During the past 4 years, we have gained experience at undertaking minimal access approaches for the repair of congenital heart defects, using limited lower midline skin incision and the right lower unilateral (J) or bilateral trap-door type (T) ministernotomies. In this study, the safety and benefits of these approaches were reviewed and the technical tips described.

MATERIALS AND METHODS

From July 1997 to December 2000, 494 children underwent repair of congenital heart defects. J or T shaped lower sternotomy was selected as a surgical approach when transatrial repair was considered to be major and possible. Age and body weight at operation averaged 33.4 ± 43.8 (1-187) months and 14.5 ± 9.9 (3.0-40.0) kg. There were 256 males and 238 females. Lesions corrected were: 322 ventricular septal defect, 118 atrial septal defect, 30 tetralogy of Fallot, 6 partial atrioventricular septal defect, 4 Ebstein's anomalies, 4 partial and 3 total anomalous venous connections, 2 complete atrioventricular septal defects, 2 congenital mitral regurgitation, 1 cor triatriatum, 1 aortic regurgitation, and 1 pulmonary stenosis. Repair of additional lesions were performed in 55 patients (29 pulmonary artery angioplasty, 21 patent ductus arteriorsus closure, 1 aortic valve repair with subaortic muscle resection, and 1 mitral valvuloplaty).

Surgical technique

A 4-8cm lower midline skin incision was made starting from the costoxyphoid angle toward the suprasternal notch. A midline longitudinal sternotomy was performed from the base of the xyphoid process to the right sternal border of the 2nd intercostal space. Care was taken not to enter the

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Address correspondence and reprint requests to: Dr Jeong Ryul Lee, Department of Thoracic and Cardiovascular Surgery, Seoul National University Children's Hospital, 28 Yongon-dong, Chongro-gu, Seoul, 110-744, Korea, Phone: +82-2-760-2877, Fax: +82-2-765-7117, Email: jrl@plaza.snu.ac.kr

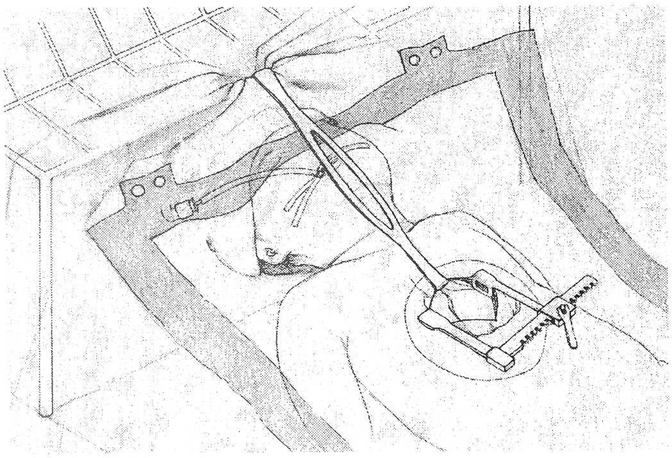

Figure 1. An illustration of self cephalad-traction method using an Army-Navy retractor. The cephalad-end of the Army-Navy retractor was hooked over the transverse bar of the drape-holding metal grid.

intrathoracic cavity during this procedure. We found that sternal scissors were a more useful tool than the sternal saw to symmetrically divide a narrow sternum in small patients. A pinpoint hole was made at the right sternal border of the 2nd intercostal space using a right-angled clamp with finger-guided protection of the undersurface of the sternum. The sternal scissors-tip was passed through the hole to cut the sternum transversely. We believe that this technique is a very safe way of preventing injury to the internal mammary artery. With anterolateral traction of the partially divided sternum, an arrow head-shaped oblique transverse-sternotomy was made either unilaterally (J) or bilaterally (T) using a sternal scissors. This arrow head-shaped transection allowed us a better view of the ascending aorta. A sternal retractor and an Army–Navy retractor were used to open the sternum and elevate the intact upper sternal edge anteriorly and superiorly (Figure 1, ◉). For effective retraction, we placed the patient's sternal notch 20-24 cm caudal to the edge of the bar, which was specially designed for this purpose, before draping. By hooking the intact upper sternum over the bar and using either the short or long blade of the Army-Navy retractor, depending on the length of the intact sternum, even the distal ascending aorta was readily approachable. This simple cephalad traction using an ordinary device (Army-Navy retractor) allowed us to obtain an excellent surgical field, which was to that obtained using a full-sternotomy approach. The thymic tissues are dissected as little as possible, without thymectomy, to achieve just enough space for a pericardiotomy. We have observed that minimal dissection reduces postoperative bleeding thus allows early chest tube removal. Furthermore, a smaller sized drainage tube could be used to obtain a better cosmetic outcome. The pericardium was entered through a median vertical incision and traction sutures were placed only on the right free edge of the pericardium to obtain a better view of the systemic veins.

The usual purse-string stitches were placed in the ascending aorta, as proximal as possible to leave just enough space for the aortic root cannula and the cross clamp. Usually, the aortic cannula did not need higher insertion. After making a vertical stab incision on the aortic wall, the aortic cannula secured by a Schnidtz clamp was inserted through the purse-string sutures. This proved a safe and effective way of inserting the cannula into the deep-seated ascending aorta (Figure 2, ◉). Cardiac chambers were emptied by starting a bypass just after the right atrial cannulation to make the subsequent procedures easier and safer. The inferior vena cava was cannulated with the straight venous cannula at the cavoatrial junction. Snare-tourniquets were placed for both SVC and IVC. The aorta was then cross-clamped and the heart arrested with a cold blood cardioplegia injected through the aortic root. A vent cannula was then inserted either through the right superior pulmonary vein or interatrial communication. Intracardiac repairs were performed via a standard right atriotomy, pulmonary arteriotomy or right ventriculotomy. On weaning, adequate de-airing through the aortic root with repeated gentle manual ventilation and cardiac massage was performed. Once the air ceased to flow out of the aortic root, the lungs were fully inflated and the aorta declamped. Patients were weaned from bypass in the usual manner. The sternum was then closed with standard peristernal wires. Additional vertical wires were placed from the manubrium to the 3rd intact intercostal space. Apparently, the intact upper sternum provided reliable stability and a solid base for the eventual sternal reunion. One small caliber chest tube (12-16F) for pericardial drainage and a Hemovac for substernal drainage were placed.

RESULTS

The mean length of the skin incision was 6.2 ± 1.4 (range: 4-10) cm, and the mean distance between the suprasternal notch and the upper-most point of the skin incision was 4.4 ± 1.2 (range: 3.4-9.5) cm. The mean aortic cross-clamp time and cardiopulmonary bypass time were 36.2 ± 16.2 (range: 11-82) and 71.2 ± 27.7 (range: 28-196), respectively. The mean total volume of postoperative blood transfusion was 77.0 ± 76.0 (range: 0-417) cc. All patients were extubated mean 17.5 ± 24.1

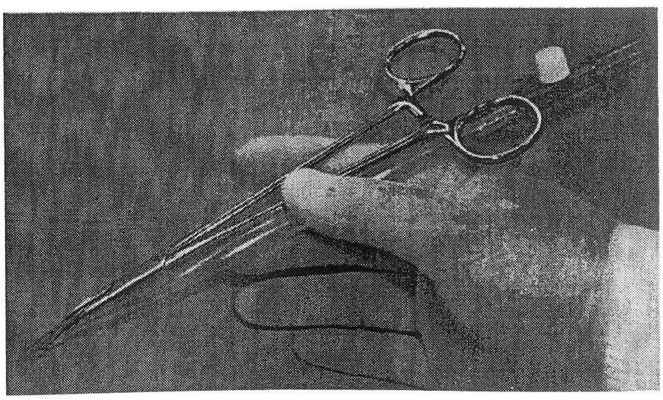

Figure 2. A photograph of an aortic cannula held by a Schnitdz clamp for an easy and safe insertion into the aorta.

Figure 3. A photograph of a patient's chest during the postoperative follow-up visit showing the scar on her lower anterior chest

(range: 1-148) hours after the operation. The mean total amount of analgesics used was 0.37 ± 0.98 (range: 0-14) mg of morphine or equivalent. The mean duration of stay in the intensive care unit and in the hospital were 45.4 ± 35.9 (range: 10-194) hours and 5.2 ± 5.0 (range: 3-27) days, respectively. No wound complications, no injuries to IMA and no hospital deaths were experienced, and there were no late deaths. Scarring was minimal and satisfactory to patients (Figure 3, ◉).

DISCUSSION

The traditional approach to open-heart surgery includes full median sternotomy, cardiopulmonary bypass, and myocardial protection. Using this approach, all the internal and external structures of the heart plus the great vessels can be simultaneously accessed, which is considered to be an essential procedural part in cardiac surgeries for providing sufficient surgical field. Nevertheless, various types of minimal access cardiac surgical approaches have recently been proposed in an attempt to minimize the surgical trauma and scars, and in order to reduce postoperative pain, the recovery period, hospital stay and eventually the cost [Moreno-Cabral 1997, Gundry 1998, Walterbusch 1998, Black 1998, Lin 1998, Doty 1998, Kappert 1999, Marianeschi 2000]. The cosmetic advantage of limited skin incision, is one of the most important reasons for introducing these techniques, and as such has received considerable attention. However, minimally invasive cardiac surgery cannot be considered as an established operation technique until the objective data on its safety can be reproduced and the results show no detriment compared to conventional operative methods.

In 1997, Moreno-Cabral introduced a mini-T sternotomy in cardiac patients with tracheostomy, and encouraged us to test the feasibility of using this technique [Moreno-Cabral 1997]. In addition, they reported that LIMA dissection as well as proximal aortic cannulation was possible by applying the T-shaped division of the lower sternum in combination with Rultrac and Favaloro retractors. It should be noted that this operation gave excellent cosmetic result because the scar is positioned on the lower side of the chest. Assuming that the upper sternum can be easily retracted toward the head, because of the flexibility of sternum and rib and of the wide movable range of the heart and surrounding structures in children, we applied this approach on relatively simple cases invloving ASD and VSD, and extended the indications as shown in Table 1.

Mini-sternotomy allows the use of standard retractors, standard cannulas, standard myocardial protection techniques, as well as the introduction of fingers to tie knots and large instruments to remove. Although several reports specify the minimum length of the skin incision, only a few authors have dealt with the level of the skin incision. We made a vertical mini-skin incision as low as possible on the anterior chest, starting from a point at least 4cm below the suprasternal notch, and aiming at the scarless-skin over the upper chest as widely as possible. This lower mini-skin incision proved to be cosmetically excellent and was well accepted by both patients and parents. The length of the mini-skin incision

Table 1. Diagnostic characteristics of the patients who underwent minimally invasive surgery

Diagnosis	Subgroup	Subtotal	Total
VSD	VSD only	227	322
	+ ASD	45	
	+ PS	18	
	+ PDA	15	
	+ LVOTO, AR	6	
	+ others	11	
ASD	ASD only	101	118
	+ PS	10	
	+ PDA	5	
	+ PDA + RPA stenosis	1	
	+ MR	1	
TOF			30
p-AVSD			6
Ebstein			4
TAPVC	Supracardiac	1	3
	Cardiac	1	
	Mixed	1	
PAPVC			4
Complete ECD			2
Congenital MR			2
Cor triatriatum			1
AR			1
PS			1
			494

VSD, ventricular septal defect; ASD, atrial septal defect; PS, pulmonary stenosis; PDA, patent ductus arteriosus; LVOTO, left ventricular outflow tract obstruction; AR, aortic regurgitation; TOF, tetralogy of Fallot; p-AVSD, partial atrioventricular septal defect; PAPVC, partial anomalous pulmonary venous connection; TAPVC, total anomalous pulmonary venous connection; ECD, endocardial cushion defect; MR, mitral regurgitation was reported between 3-10cm depending on the size of the patient. The mean length of the skin incision used in the present study was 6.2cm. As described by Walterbusch, we found that complete resection of the xyphoid process is a good way of minimizing the skin incision [Walterbusch 1998], and found that patient size, especially the anteroposterior diameter of the chest, and the length of the surgeon's index finger were important factors in determining the shortest possible length of the skin incision, because the surgeon's index finger should be able to reach the most posterior part of the chest to secure knots during the cardiac procedures. We made a 3 to 4cm skin incision in infants, a 5 to 6cm incision in children and a 7 to 8cm incision in adolescents, which created a skin opening large enough to allow the surgeon to reach any part of the chest with his fingertips.

Postoperative pain or discomfort was difficult to assess in our young patient group. However, for the limited lower sternotomy technique, femoral cannulation was not required, leaving the upper third of the sternum intact, which appeared to minimize postoperative discomfort. The small skin incision has been uniformly praised by parents and patients. To date, no wound complications have arisen. This, we believe is the most outstanding advantage of the smaller skin incision. Moreover, no complications, such as sternal deformity and no mortality were observed. Although it was difficult to be objective with the data, it appeared the parents were generally satisfied with the extent of scarring at follow-up. The total amount of analgesics used postoperatively was minimal, which was another advantage of this approach.

Despite our short-term experience, we have demonstrated the possibility and usefulness of applying the minimally invasive technique by lower sternotomy to a selected group of children with congenital heart diseases. In particular, in terms of the cosmetic aspects, we found it an excellent technique. We believe that our experiences will expand the operative indications. However, careful attention should be paid to any acquired deformity of the costal cartilage in young patients.

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