

## Full sternotomy with limited skin incision for surgical treatment of atrial septal defect

*Atriyal septal defektin cerrahi tedavisinde sınırlı cilt kesisi ile tam sternotomi*

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**Background:** In this study, we report our experience with repair of atrial septal defects utilizing a minimally invasive surgical approach.

**Methods:** A full median sternotomy with mini skin incision was used in 29 patients (24 females, 5 males; median age 8 years; range 4 to 19 years) between November 2008 and August 2010. A midline chest incision was typically terminated at or near the nipple line, measuring approximately 6 cm in children and 7.5 cm in adolescents. Atrial septal defect was successfully treated through a mini skin incision in 27 patients. Skin incision was unavoidably enlarged in two patients due to technical challenges.

**Results:** None of the patients died and full skin incision was not performed. The mean cardiopulmonary bypass time was 57 minutes, while the mean aortic cross-clamp time was 35 minutes. The length of intensive care unit stay ranged from 1 to 2 days and the length of hospital stay ranged from 3 to 6 days (median hospital stay, 4 days). No reintervention for residual cardiac defects was required.

**Conclusion:** We consider that full median sternotomy with limited skin incision for the correction of atrial septal defects is safe and effective with improved cosmetic results.

**Key words:** Atrial septal defect; congenital heart surgery; cosmetic; ministernotomy; sternotomy.

**Amaç:** Bu çalışmada minimal invaziv cerrahi yaklaşımı kullanılarak yapılan atriyal septal defekt onarımı deneyimimiz sunuldu.

**Çalışma planı:** Kasım 2008 - Ağustos 2010 tarihleri arasında 29 hastada (24 kadın, 5 erkek; ort. yaş 8 yıl; dağılım 4-19 yıl) mini cilt kesisi ile tam sternotomi yöntemi kullanıldı. Orta hattaki cilt insizyonunun üst sınırı meme uçlarının hizası ya da bu hizanın hemen yakınında; çocuklarda yaklaşık 6 cm'de, ergenlerde 7.5 cm'de sonlandırıldı. Atriyal septal defekt 27 hastada mini cilt kesisi ile başarıyla tedavi edildi. Cilt kesisi iki hastada teknik zorluk yaşandığı için kaçınılmaz olarak genişletildi.

**Bulgular:** Hastalarda ölüm olayı görülmedi ve tam cilt kesisine dönülmedi. Ortalama kardiyopulmoner baypas zamanı 57 dakika, ortalama aortik kros-klemp zamanı 35 dakikaydı. Yoğun bakımda kalış süresi 1 ile 2 gün arasında, hastanede kalış süresi ise 3 ile 6 gün arasındaydı (medyan hastanede kalış süresi: 4 gün). Rezidüel kardiyak defekt için tekrar müdahale gerekmedi.

**Sonuç:** Atriyal septal defekt tedavisinde sınırlı cilt kesisi ile tam sternotomi yönteminin güvenli ve daha iyi kozmetik sonuçlarla etkili olduğunu düşünmekteyiz.

**Anahtar sözcükler:** Atriyal septal defekt; doğuştan kalp cerrahisi; kozmetik; ministernotomi; sternotomi.

The concept of minimally invasive surgical approaches has been introduced recently with the surgical treatment of congenital heart disease. These procedures include minithoracotomies and ministernotomies. Numerous variations of the ministernotomy approach have

been proposed; however, it must be noted that the characteristics of some of the approaches make it more feasible and more easily adoptable than others. Presence of some factors such as limited pathology groups (atrial septal defect, ventricular septal defect, etc.)



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and characteristics of patients (age, sex, weight, etc.), restricted the widespread application of this method.<sup>[1,2]</sup> Here we report our experience of a full median sternotomy with a limited skin incision for atrial septal defect (ASD) closure.

## PATIENTS AND METHODS

From November 2008 to August 2010, 29 patients (24 females, 5 males; median age 8 years; range 4 to 19 years) underwent minimally invasive surgery in our hospital for the correction of an ASD.

Patients associated with an additional congenital disease, such as ventricular septal defect (VSD), patent ductus artery (PDA), and atrioventricular septal defect (AVSD), were excluded. An echocardiographic examination and cardiac catheterization were performed for diagnosis. Three patients were catheterized due to the poor evaluation of partial anomalous venous return with echocardiography, and two patients with an enlarged right ventricle were catheterized to precisely calculate the Qp/Qs. The pulmonary-to-systemic flow ratio was  $2.3 \pm 0.3$  (range, 1.5-2.9), and the mean pulmonary artery pressure was  $21 \pm 3$  mmHg (range, 16-27 mmHg). Written consent was obtained from all patients and their family members before the surgery. The operative policy to use minimally invasive cardiac surgical techniques for the closure of ASD was approved by the appropriate hospital authorities.

### Operative technique

Anesthesia was carried out in the conventional manner. A transesophageal echocardiographic examination (TEE) was performed on all patients, with the probe being placed following the endotracheal intubation. A midline chest incision of approximately 6 cm in children (<10 years) and 7.5 cm in adolescents (>10 years) was typically terminated at or near the nipple line. The lower portion of the sternum was divided with a saw, the upper portion was divided with bandage scissors (Figure 1), and the sternum was completely divided



**Figure 1.** Bandage scissors.

(Figure 2). The apex of the sternal incision was retracted with an Army-Navy retractor.

After exposure and a longitudinal incision of the pericardium, traction sutures were placed at the right and left apical pericardial edge to displace the intrapericardial structures more anteriorly and laterally, thus allowing for better access to the aorta and right atrium. An aortic stay clamp was placed 1-2 cm above the aortic annulus, and the aorta was pulled inferiorly and anteriorly toward the skin incision (Figure 3). The aorta was then cannulated in the usual manner. Then the diaphragmatic attachments were mobilized laterally, particularly on the right side, to facilitate the cannulation of the inferior vena cava (IVC).

Cannulation of the superior vena cava (SVC) was performed directly using a metal-tipped, right-angle venous cannula, or through the right atrial appendage using a straight venous cannula. Since we performed the operation through a limited incision, SVC cannulation was more difficult and prone to complication, so we mostly used the right atrial appendage instead. This IVC cannula is usually (in patients <10 years old) brought out through a small skin incision, which is inferior to the caudal extent of the sternal incision. This serves to hold the cannula in a more inferior location, which improves exposure. At the conclusion of the operation, this small incision was used to place the chest tube, and the ascending aorta was cross-clamped directly via the mini skin incision (Figure 4). In the first group of our patients, the conventional cannulation time was longer due to the technical difficulty caused by the limited incision; therefore, the operation time was longer. However, after cross-clamping the aorta, the length of time it took for the cross-clamp procedure and cardiopulmonary bypass (CPB) was the same as for the conventional technique since no further difficulties were encountered.

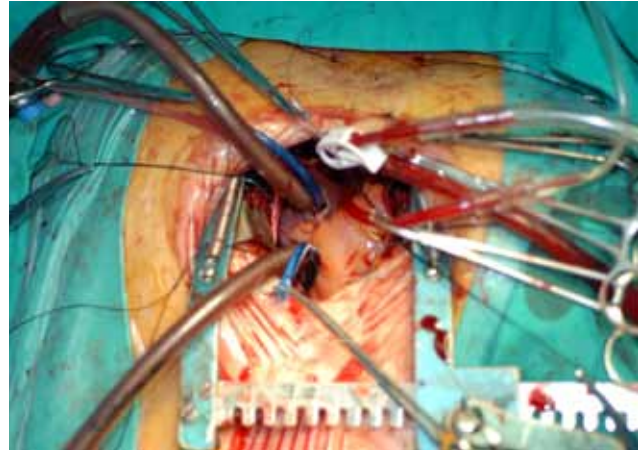


**Figure 2.** The sternum was completely divided with a saw and bandage scissors.



**Figure 3.** The aorta was pulled inferiorly and anteriorly towards the skin incision with a clamp.

On total bypass, the right atrium was entered through a conventional incision, and direct (4-0 polypropylene) or fresh-pericardial patch closure (5-0 polypropylene) was performed using over-and-over sutures with superficial suction through the defect. Before complete closure of the ASD, the air in the left ventricle was evacuated carefully by rotation of the operating table in all directions and expansion of both lungs. There was no obvious air bubble noted in the left atrium or left ventricle on the TEE. The aortic cross-clamp was then removed. Sinus rhythm recovered spontaneously, and cardioversion was not necessary in most patients. After termination of extracorporeal circulation, TEE was performed again in all patients.



**Figure 4.** The end of the aortic and bicaval cannulation.

A detailed physical examination was performed routinely every day until the patient was discharged from the hospital. A follow-up transthoracic echocardiographic examination was performed at five days and at one month after the operation.

## RESULTS

Patient demographics and postoperative data are shown in Table 1. Atrial septal defect closure was successful via a mini skin incision in 27 patients. The incision had to be enlarged by 1.5 cm in the other two patients due to the following technical difficulties: an inability to cannulate the aorta in one patient and an SVC-type sinus

**Table 1. Patient demographics and postoperative data**

	n	Median	Range
Age (years)		8	4-19
Weight (kg)		21	12-45
Gender			
Male	5		
Female	24		
High venosum atrial septal defect	2		
Secundum atrial septal defect	27		
Direct closure	6		
Patch closure	23		
<10 years skin incision (cm)		6	5.5-6.5
<10 years	13		
>10 years skin incision (cm)		7.5	7- 8
>10 years	16		
Cross-clamp time (min)		35	17-45
Cardiopulmonary bypass time (min)		57	35-65
Operation time (min)		152	124-215
Extubation time (min)		135	10-180
Intensive care unit stay (days)		1	1-2
Hospital stay (days)		5	3-6
Drain (ml)		210	50-500

**Table 2. Postoperative complication**

Complications	n
Wound dehiscence needing suture	1
Sternal dehiscence	0
Mediastinitis	0
Pleural effusion with thoracentesis	0
Pericardial effusion needing pericardiocentesis	0
Pericardial effusion needing medical treatment	1
Neurologic complications	0

venous ASD in the other. Conversion to a full sternal skin incision did not occur in any patients, and the ASD was closed by direct means in six patients and with the use of a patch in 23 patients.

There were no deaths, and all patients recovered without adverse events. The patients were fast-tracked and extubated after the end of the procedure, with two patients being extubated on the operating table. The maximum duration of ventilation was six hours. Intermittent atrial fibrillation occurred in one patient. The other patients remained in sinus rhythm, and no cardiac or neurological complications occurred. There were no cases of sternum dehiscence or infection, chylothorax, or pneumothorax, and no ventilation problems were reported (Table 2). Wound dehiscence occurred in one patient due to skin necrosis (Figure 5), and one patient required medical treatment for pericardial effusion (Table 2). No residual shunt or ventricular dysfunction occurred at the follow-up transthoracic echocardiographic examinations that were carried out at five days and one month postoperatively.

The mean follow-up of 6.9 months (range, 2 to 16 months) was completed for all patients, and the interval between the operation and return to normal activity was two to five weeks ( $3.3 \pm 0.5$  weeks). All patients were found to be in the New York Heart Association (NYHA) functional class I. One patient had pericardial effusion which was documented via echocardiography at the first follow-up assessment, and he was categorized as NYHA functional class II. This patient was managed medically with diuretics, and recovery was achieved. All patients were satisfied with the cosmetic healing of the mini skin incision.

## DISCUSSION

In this study, 29 patients had surgery to close an ASD with the use of a full sternotomy with a limited skin incision, and all recovered rapidly from the operation. The only limitation of this study is the lack of data in our series about the level of pain, which remains difficult to measure in the pediatric population.



**Figure 5.** Complications included wound dehiscence requiring sutures in one patient.

It is a fact that cosmetic results are very important for pediatric patients who undergo cardiac surgery, but the most essential concerns remain the optimal correction of the cardiac anomaly and prevention of postoperative complications. Different approaches have been used over the years to correct congenital heart defects in the pediatric population.<sup>[2]</sup> A surgeon's main concerns are adequate exposure, safe application of CPB through a central site, effective myocardial protection, and de-airing before resumption of cardiac ejection.<sup>[3]</sup> Although several alternative incisions are currently available, our study group showed that access to the heart could be achieved by modifying the traditional ministernotomy by incorporating traditional cannulation techniques with a more limited exposure of the heart. In our preliminary experience with our 29 patients, there were no operative deaths, no neurological deficits, and no other complications. The incision length was significantly shorter, and all patients were satisfied with the cosmetic healing. All of this information indicates that this technique is a safe and effective procedure.

Approaches used for closure of ASD include a full sternotomy and different types of ministernotomies and minithoracotomies. The widespread introduction of minimally invasive techniques in various surgical disciplines has resulted in improved patient awareness and boosted the demand for minimally invasive procedures.<sup>[4]</sup>

There are several advantages of this technique over right minithoracotomies and inframammary incisions. First, the right atrium lies directly under the lower sternum; therefore, exposure is better and manipulation is more comfortable. In addition, it is easier to convert to a full sternotomy if necessary. Finally, it is less painful than a minithoracotomy.<sup>[4,5]</sup> Right minithoracotomies or inframammary incisions have been supported

particularly in female patients where the inframammary fold helps to cover the incision. The cosmetic results of these alternative approaches have been reported to be satisfactory, but specific complications related to the incision have been seen. Breast maldevelopment after an inframammary incision and paresthesia around the breast tissue have been documented.<sup>[6]</sup> Some other advantages of this approach are the use of intrathoracic cannulation along with the avoidance of the femoral artery and femoral vein cannulation.

An ASD can be also accessed through a partial divided sternum. This approach includes a lower partial midline sternotomy, a reverse 'J' sternotomy, and a T sternotomy. The advantage provided by full median sternotomy with limited skin incision is better exposure and manipulation. The main disadvantage of the T sternotomy and reverse 'J' sternotomy may be the need, under certain circumstances, to sacrifice one or both of the internal mammary arteries. In case there is a need to split the sternum more than usual, in rare cases, there may be an injury to one or more intercostal neurovascular bundles or instability in the anterior chest wall.<sup>[1,5,7]</sup> In our patients, we did not observe such complications.

Of course, the partial midline sternotomy, reverse 'J' sternotomy, and T sternotomy with limited exposure would make it more difficult to deal with intraoperative complications due to the difficulty of having sufficient time to split the whole sternum. For this reason, the success of this technique is related to the technical expertise of the surgeon.<sup>[8,9]</sup> Conversely, in a full median sternotomy with a limited skin incision for ASD closure, the size of the incision can be easily extended for better exposure within a few seconds, if necessary. However, a 6-7.5 cm skin incision was sufficient in 27 cases. In two patients, the skin incision had to be extended due to the technical difficulties of the aorta and SVC cannulation.

Another disadvantage of the T sternotomy is the need to rewire three separated segments of the sternum. This is in contrast with two segments that we used in our technique. In our patients, no sternal dehiscence was seen.

Finally, we demonstrate the safety and efficacy of a limited skin incision in the surgical repair of an ASD. Our experience confirms that this technique

offers satisfactory cosmetic results and affords stable sternal reconstruction, good surgical exposure, and a satisfactory recovery. There was no compromise in the technical repair and conversion to a full sternotomy can be done at any time during the procedure. Despite the small number of nonrandomized patients, we believe that this type of procedure with a limited skin incision does not compromise exposure of the great vessels and should be favored over other approaches.

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