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Inferior Partial Sternotomy for Surgical Closure of Isolated Ventricular Septal Defects in Children

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ABSTRACT

Background: Surgical closure of isolated ventricular septal defect (VSD) through partial inferior sternotomy offers the advantages of a much shorter, cosmetically superior skin incision, potentially improved sternal stability, a lower rate of infection, and less postoperative pain. We report our technique and results of use of inferior partial sternotomy for closure of isolated VSD in children.

Patients and Methods: From July 2002 to July 2003, 24 consecutive patients with a median age of 4.5 months (range, 1 month–4.5 years) underwent partial inferior sternotomy for isolated VSD closure. The length of the incision ranged from 4 to 6 cm. Special features of the approach included T incision of the lower sternum (from the fourth intercostal space to the xiphoid), establishment of cardiopulmonary bypass with central cannulation, aortic cross-clamping, and cardioplegic arrest. All VSDs were approached through right atriotomy. Perimembranous VSDs were exposed after detachment of the anterior leaflet of the tricuspid valve and were closed with a continuous suture. Muscular VSDs were approached directly. Perioperative and postoperative echocardiographic findings were available for all patients. Follow-up was complete.

Results: There was no mortality or significant surgical morbidity. Median cross-clamping and cardiopulmonary bypass times were 43 and 103 minutes, respectively. All patients were in sinus rhythm. Perioperative and postoperative echocardiography confirmed the absence of any residual defects in perimembranous VSDs and the presence of a trace residual VSD in 4 patients with muscular VSDs. Optimal healing of the partial sternotomy was obtained in all patients.

Conclusions: Inferior partial sternotomy is less invasive than and cosmetically superior to full sternotomy. It provides excellent results when applied to isolated VSD with standard surgical techniques.

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BACKGROUND

Surgical closure of isolated VSD through partial inferior sternotomy offers the cosmetic advantage of a much shorter skin incision compared with the scar that follows conventional full sternotomy. In addition, it is assumed that avoidance of splitting the manubrium results in preserved sternal stability, a lower rate of infection, and less postoperative pain. A few groups of investigators have demonstrated that closure of VSD can be safely performed through inferior partial sternotomy with excellent cosmetic results in older children [Gundry 1998, Bauer 2000]. We report our technique and results of closure of isolated VSD through inferior partial sternotomy in a group of infants with a median age of 4.5 months.

PATIENTS AND METHODS

Between July 2002 and July 2003, 24 consecutive children (12 boys, 12 girls) with a median age of 4.5 months (range, 1 month–4.5 years) underwent surgical closure of isolated ventricular septal defect (VSD) through inferior partial sternotomy. The diagnosis of VSD was determined by echocardiography, which showed perimembranous VSD in 20 patients and muscular VSD in 4 patients. Transesophageal echocardiography (TEE) was routinely performed intraoperatively. Postoperatively transthoracic echocardiography (TTE) was performed during the stay in the intensive care unit and 3 months after hospital discharge.

Operative Technique

The skin incision was started at the fourth intercostal space and extended for a length of 4 to 6 cm. After careful mobilization of the subcutaneous tissue, an oscillating saw was used to "T off" the sternum at the level of the fourth intercostal space (Figure 1). The transverse cut was made first. It was slightly angulated at approximately 45 degrees to provide increased surface and improved stability of the fracture ends after osteosynthesis. A longitudinal incision was made, and the sternum was retracted with an orthostatic retractor, which places less traction on the skin. The pericardium was opened, and stay sutures were applied.

Cardiopulmonary bypass, cardioplegic arrest, and mild hypothermia (28°C-30°C) were used in all operations. Place-

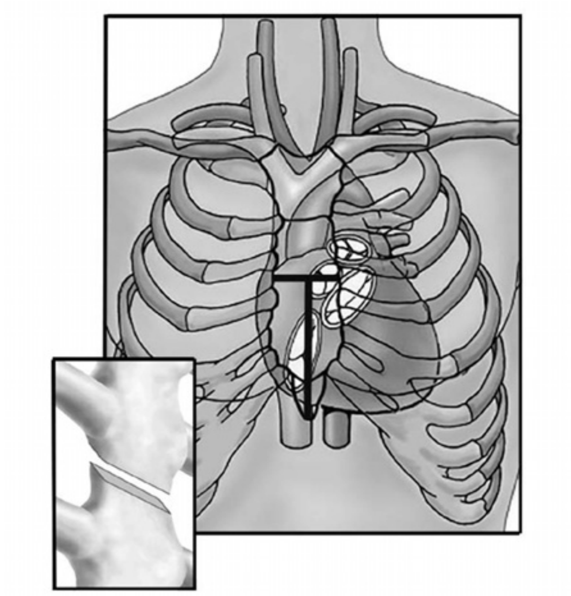

Figure 1. Partial inferior sternotomy. An oscillating saw is used to "T off" the sternum at the level of the fourth intercostal space. The transverse cut is made first and is slightly angulated at approximately 45 degrees to provide increased surface area and improved stability of the fracture endings after osteosynthesis (inset). The longitudinal incision is made, and the sternum is retracted with an orthostatic retractor.

ment of the purse-string suture, aortic cannulation, and insertion of an aortic root cannula were performed after gentle downward movement of the vessel and anterior traction of the proximal sternum with a Langenbeck retractor. The right atrial appendage was cannulated, and cardiopulmonary bypass was instituted to empty the heart. The superior vena cava and inferior vena cava were then easily cannulated and snared. The aorta was cross-clamped, and cardioplegic arrest was achieved by infusion of cold hyperkalemic blood into the aortic root. At this time, no vent was inserted in the left ventricle. The atrial venous cannula was gently moved across the tricuspid valve to empty both ventricles (the right one directly and the left one through the VSD). After this cannula was removed and the right atrium opened, a vent was inserted in the left ventricle through a patent foramen ovale, an atrial septal defect (ASD) secundum, or, when the atrial septum was intact, a small stab incision in the septum secundum. A purse string or suture was secured around the vent to allow closure by simple knotting. The other atrial defects were closed, usually directly.

Three retraction sutures (6-0 polypropylene [Prolene]) were placed around the tricuspid annulus (at the 9, 12, and 3 o'clock positions) and gently pulled. The anterior leaflet of the tricuspid valve was detached from its annulus, as already described by our group, to clearly expose the border of the perimembranous VSD [Maile 2003]. A patch of Gore-Tex or xenopericard material was sutured on the right side of the septum with a running stitch of 7-0 polypropylene (Figure 2). With this approach, the patch was exactly tailored to fit the defect without risk of wrinkles or excessive traction on the suture line. The patch was inserted with a continuous 7-0 polypropylene suture starting at the posterior limb of the septomarginal band. Along the ventriculoinfundibular fold, the patch was sandwiched between the tricuspid annulus and the anterior valve leaflet over 3 or 4 stitches. The rest of the anterior leaflet was readapted with a continuous resorbable 7-0 suture. During this readaptation, warm blood cardioplegia was delivered. At the end of leaflet suturing, cardiac action was reinitiated. The cross-clamp was removed, light aspiration was set on the cardioplegic line, and the vent was connected to the venous line for gravity drainage. Blood was no longer aspirated from the right atrium, and the lungs were gently hand and then machine ventilated. Time was allowed for the heart to recover sinus rhythm. The state of the left ventricle (mostly absence of dilatation) was continuously observed with TEE. After approximately 5 minutes, the left ventricular vent was clamped, and the left ventricle further observed with TEE. When no dilatation was seen, the vent was removed and the residual ASD closed by knotting of the purse-string suture. The right atrium was closed with a running stitch of 7-0 resorbable suture. The venae cavae were not snared. Venous return was reduced, and the apex of the left ventricle was de-aired with a needle. The atrial venous cannula was reinserted into the appendage, and the superior and inferior vena caval cannulas were removed. After complete rewarming, cardiopulmonary bypass was terminated in the usual fashion. After placement of pacing wires and a 12F drain around the ascending aorta, the pericardium was completely closed with a resorbable suture, and the sternum was closed with 3 figure-8 sutures of 0 polyglactin 910 (Vicryl). Two additional polyglactin 910 sutures were placed longitudinally across the transverse sternal incision to obtain optimal readaptation of the sternum.

RESULTS

Mean cardiopulmonary bypass time was 103 minutes, ranging from 75 to 152 minutes. Mean aortic cross-clamp time was 43 minutes, ranging from 30 to 69 minutes. There were no perioperative or late deaths. The operative and postoperative courses were uneventful in all patients. The septal defects were closed in all patients without any significant residual defects. Echocardiography revealed trace residual defects in 4 patients, who had presented with muscular VSDs. All patients were in sinus rhythm. No patient had more than mild tricuspid valve insufficiency, and no subaortic obstruction occurred. Optimal healing was obtained in all patients, and there was no case of sternal infection or instability. Follow-up was complete and ranged from 7 to 19 months postoperatively.

DISCUSSION

The standard approach to closure of VSD is routinely performed through median sternotomy. However, the resulting full-length midline sternal scar is considerably cosmetically unattractive and can have negative psychological impact, especially in young female patients.

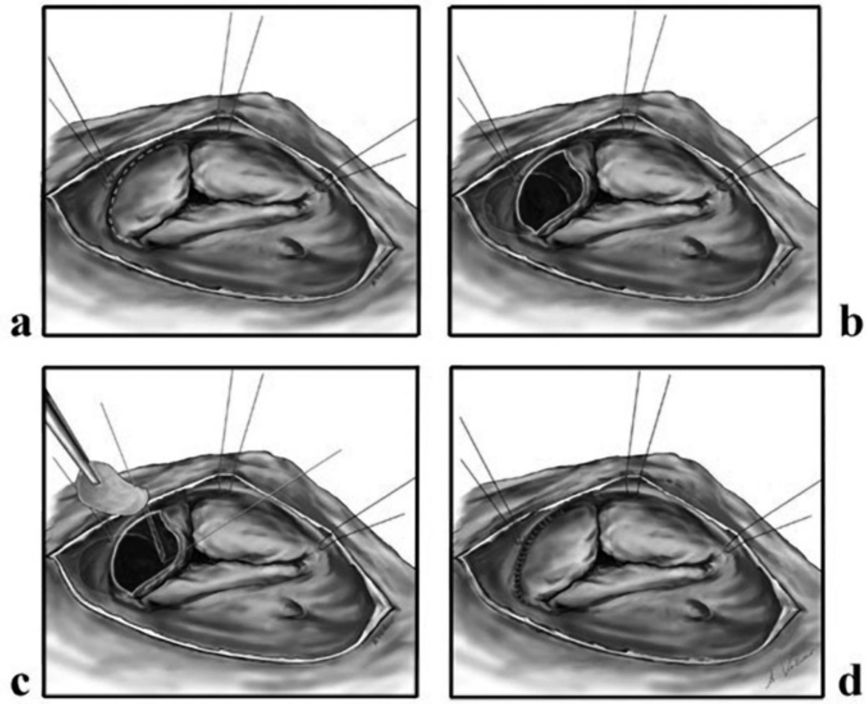

Figure 2. Perimembranous ventricular septal defect closure. The anterior leaflet of the tricuspid valve is detached from its annulus (A, B). A Gore-Tex patch is inserted with a continuous 7-0 polypropylene (Prolene) suture starting at the posterior limb of the septomarginal band (C). Along the ventriculoinferior fold, the patch is frequently sandwiched between the anterior tricuspid valve leaflet and the annulus. The anterior leaflet is reanastomosed by use of a continuous suture (D).

Several alternative minimally invasive approaches have been described for closure of VSD. These approaches include anterolateral thoracotomy, left parasternal minithoracotomy, full sternotomy with limited skin incision, and the transxiphoid approach. It appears that inferior partial sternotomy, as used for VSD closure in this study, presents several advantages [Gundry 1998, del Nido 1998, van de Wal 1998, Wu 1998, Bauer 2000, Hagl 2001]. This approach allows institution of cardiopulmonary bypass through the sternotomy. This method of bypass avoids additional groin incisions and subsequent potential peripheral vascular complications, such as malperfusion, infection, and lymph fistula. Exposure, especially of the great vessels, is not compromised and does not impair aortic cross-clamping or the application of cardioplegia, which may be encountered with the transxiphoid approach [van de Wal 1998].

Somewhat surprisingly, inferior partial sternotomy allows de-airing of the left ventricle through the left apex, a maneuver we have routinely performed. TEE enables additional control of residual air in the left chambers. All of our patients readily regained consciousness, and no neurological complications occurred.

Only partial splitting of the sternum may result in reduced sternal instability and subsequent infection. Given the very low rate of postoperative sternal instability observed in our pediatric patients, however, comparison with a group receiving full sternotomy does not appear reasonable.

Another advantage of using a midline approach is avoidance of the long-term complications following anterolateral and posterolateral thoracotomy, such as breast and pectoral muscle maldevelopment and scoliosis [Cherup 1986, Van

Figure 3. Postoperative result of ventricular septal defect closure through inferior partial sternotomy.

Biezen 1993]. Studies in adult cardiothoracic surgery have shown that midline sternotomy and ministernotomy are less painful than lateral thoracotomy and that respiratory discomfort is decreased in relation to that following lateral thoracotomy [Izat 1998, Hagl 1999]. Until now, however, a significant difference between lateral and midline access for congenital cardiac surgery had not been shown in terms of postoperative pain, length of intensive care unit, in-hospital stay, and costs [Laussen 2000].

The anterior leaflet of the tricuspid valve was routinely detached to fully expose the perimembranous VSD. We prefer this approach to detachment of the septal leaflet because of the excellent exposure of the periaortic annulus and the reduced risk of generating dysfunction of the atrioventricular node. Echocardiograms demonstrated perfect closure of the VSDs, good function of the tricuspid valve, and absence of left ventricular outflow tract obstruction in all patients.

In summary, inferior partial sternotomy can be safely performed for closure of isolated VSD in small children. The cosmetic results are excellent and superior to those of standard full sternotomy (Figure 3).

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