

3D-Video- and Robot-Assisted Minimally Invasive ASD Closure Using the Port-Access™ Technique

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ABSTRACT

Background: Video-assisted minimally invasive surgical methods with endovascular-based femoral cardiopulmonary bypass (CPB) and balloon occlusion of the aorta (Port-Access™ technique) were used to close an ostium-secundum atrial septal defect (ASD) in 7 patients.

Methods: Minor modifications were made to the system to provide drainage of the superior vena cava. The surgery was performed through a small (3.5–5cm) right anterolateral thoracotomy with 3D video and robotic arm assistance.

Results: The operative procedures were completely uneventful and the patients were discharged four days post-operatively in good condition and with excellent cosmesis.

Conclusion: Using the modifications described, the Port-Access™ surgical method can be recommended for minimally invasive closure of an ASD.

INTRODUCTION

Despite widespread interest in minimally invasive surgery in the fields of orthopedic, abdominal, and thoracic surgery, clinical interest in minimally invasive coronary artery bypass grafting (CABG) and valve surgery has only recently surfaced [Benetti 1996, Guliernos 1997, Stevens 1996]. Thoracoscopic ligation of patent ductus arteriosus and division of vascular rings have also been reported [Burke 1995]. Several methods of performing minimally invasive cardiac procedures have been described, including surgery on the beating heart with

pharmacologically-induced bradycardia and surgery on a still heart protected by cardiopulmonary bypass (CPB) with cardioplegic arrest [Benetti 1996].

In order to perform minimally-invasive cardiac surgery with the use of cardiopulmonary bypass and cardioplegic arrest, a project was started at Stanford University a few years ago focusing on a limited access surgical approach in combination with an endovascular CPB system (Port-Access™ Technique, Heartport, Inc., Redwood City, CA) [Stevens 1996]. This system uses a femoral arterial and venous access system for CPB and a transfemoral balloon catheter for endoaortic occlusion and administration of cardioplegia. This report describes the use of this endovascular bypass system for minimally-invasive closure of an atrial septal defect (ASD).

MATERIALS AND METHODS

Seven patients (3 male, 4 female, mean age 35.5 years, ranging from 16 to 62 years) were referred for evaluation of increasing symptoms of heart failure. Transthoracic echocardiography demonstrated an ostium-secundum ASD with no other abnormalities, and the patients were accepted for surgical repair. Before surgery, Doppler ultrasound was performed to rule out peripheral vascular disease of the pelvic and femoral vessels. Heart catheterization revealed a mean left ventricular ejection fraction of 68%, with no evidence of coronary artery disease or pulmonary hypertension. In addition, transesophageal echocardiography demonstrated normal aortic valve function and absence of major aortic atherosclerotic disease.

After induction of anesthesia, the patients were intubated with a double-lumen endotracheal tube to allow left-sided single-lung ventilation. The right internal jugular vein was accessed using a 15 Fr introducer system with subsequent percutaneous insertion of a 15 Fr arterial cannula for superior vena cava drainage (Medtronic GmbH, Düsseldorf, Germany). In addition, a double-lumen central venous catheter was inserted via the right brachiocephalic

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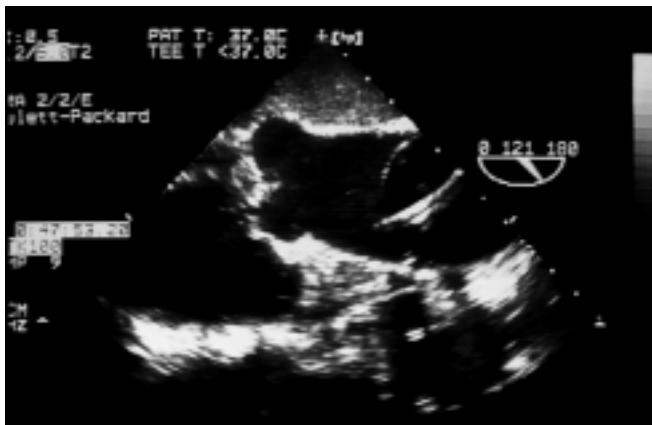


Figure 1. Placement of the endoaortic balloon for aortic occlusion about 2 cm above the competent aortic valve.

vein. The right and left radial arteries provided invasive blood pressure monitoring.

The patients were placed in a supine position with the right shoulder elevated approximately 30 degrees. The right arm was positioned adjacent to the posterior axillary line. The patients were prepared and draped to expose the entire right chest and the sternum, in the event that a median sternotomy would be necessary. In addition, both groins were prepared and draped for surgical access.

At surgery, a small (3.5 to 5 cm) right submammary incision was performed and the fourth intercostal space was entered after left single-lung ventilation was started. The pericardium was opened about 2 cm anterior and parallel to the right phrenic nerve. Silk sutures were used to secure the pericardium to the skin margins. A soft tissue retractor (Heartport, Inc.) was used to open the intercostal space and to retract the subcutaneous tissue and underlying musculature, while the right femoral vein and artery were dissected and encircled with umbilical tapes. A 3D-endoscopic camera (Vista™ Cardiothoracic Systems, Inc., Westborough, MA) was inserted posterior to the thoracic incision. The camera was attached to a voice-controlled robotic arm (Aesop™, Computer Motion, Inc., Goleta, CA) for camera guidance.

After systemic heparinization, the 28 Fr Y-shaped femoral arterial return cannula was placed into the femoral artery via surgical cutdown and was positioned over a long (100 cm) guidewire using transesophageal echocardiography (TEE) control. The 28 Fr venous cannula was then inserted into the femoral vein over a guidewire for final positioning in the inferior vena cava with the tip just below the diaphragm. The endoaortic occlusion catheter was then positioned in the ascending aorta. Catheter and cannula placement was monitored in each case using TEE and fluoroscopy, if necessary. Venous drainage was augmented by a centrifugal pump connected to the heart-lung machine. Following initiation of CPB, the heart was electrically fibrillated to allow correct placement of the endoaortic balloon, about 2 cm above the aor-

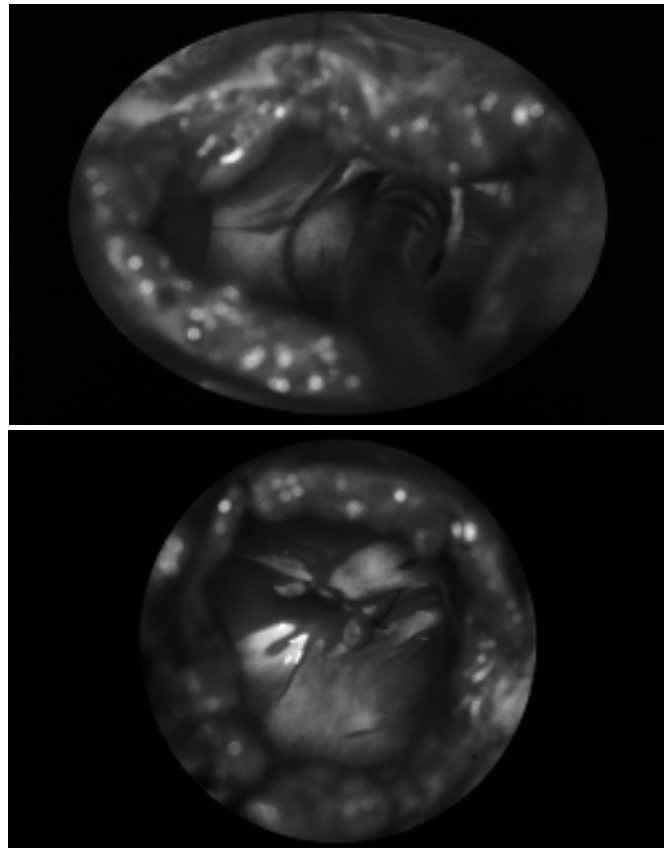


Figure 2. Endoscopic view of the ostium secundum ASD.

tic valve. During this process, right radial artery pressure was carefully monitored to detect and avoid occlusion of the brachiocephalic trunk by the endoaortic balloon (Figure 1 ●). After full inflation of the balloon, balloon and aortic root pressures were monitored continuously. Antegrade cardioplegic solution was then administered and cardioplegic arrest was achieved.

To allow access to the right atrium, the inferior vena cava was cross-clamped through the minithoracotomy under direct vision just above the diaphragm. A second straight vascular clamp was inserted through an additional small (0.5 cm) incision 2 cm above the minithoracotomy to occlude the superior vena cava just below the superior vena caval cannula. The right atrium was then opened through an oblique incision. Four stitches were placed to retract open the atrial incision. Direct closure of the ASD was performed using a continuous 5-0 polypropylene suture in 3 cases; an autologous pericardial patch was used in the remaining 4 cases (Movie 1 ●). Video-assistance was mandatory, since direct viewing of the defect was not possible in all cases (Figure 2 ●). Before the sutures were tied off, careful retrograde and antegrade (via the ascending aorta) deairing was done, the endoaortic balloon was deflated, and cardiac reperfusion was started. The hearts spontaneously defibrillated, and after a few minutes of reperfusion, normal sinus rhythm was reestablished in all

Table 1. Postoperative results

	Mean value	Range
Time of surgery	2.5 h	1.8 to 2.6 h
CPB	35.0 min	20 to 48 min
Cardiac Arrest	22.5 min	11 to 28 min
ICU-stay	8.0 h	2 to 12 h
Postop. Stay	4.0 d	3 to 5 d

cases. During reperfusion, TEE served for detection of air bubbles and deairing, and demonstrated complete closure of the ASD. The patients were then weaned from CPB. Both femoral cannulae were removed and protamine was administered. After hemostasis was achieved, a chest tube was inserted through the incision of the camera-port and the thoracic and femoral incisions were closed in layers.

RESULTS

The detailed results are listed in Table 1 (●); total surgery time was 2.5 hours on average, which included 35.0 minutes of CPB and 22.5 min of aortic occlusion. All patients were weaned from CPB without inotropic support. All patients were extubated on the table and spent 8 hours, on average, in the intensive care unit. PredischARGE TEE revealed good left ventricular function with no evidence of a residual ASD. Complaints about surgical pain were minimal, and postoperative cosmesis was excellent (Figure 3 ●). All patients were discharged four days postoperatively.

DISCUSSION

Median sternotomy is the routine surgical access for ASD closure. However, the use of a right thoracotomy has been recommended by several centers with the aim of avoiding sternotomy and its associated morbidity [Dietl 1992, Massetti 1996, Rosengart 1993]. However, inserting the aortic cannula via right thoracotomy can be difficult, particularly in patients with deep thoracic cavities. In addition the length of the thoracotomy usually exceeds 10–12 cm. For these reasons, we elected to use Port-Access™ minimally-invasive surgical techniques with endovascular-based CPB. Preoperative screening for evidence of peripheral vascular disease helped to avoid the potential danger of an aortic dissection as a complication of retrograde CPB [Reichenspurner 1998].

The Port-Access™ technique allowed us to perform the entire procedure through a 3.5 to 5 cm mini-thoracotomy while providing myocardial protection through catheter-based CPB with balloon occlusion of the aorta and cardioplegic arrest. These techniques offered good access to the right atrium and the ASD. Visualization of the defect and its repair was significantly improved by the 3D-endoscopic camera which was guided using a voice-controlled robotic arm. The entire peri- and postoperative course was completely uneventful and without any complications. The recovery of all patients was fast and the cosmetic result



Figure 3. Postoperative cosmetic result after Port-Access direct closure of an atrial septal defect.

was excellent. As an alternative technique of minimally-invasive ASD-closure, a subxyphoid approach has been published recently [Levinson 1998].

In conclusion, closure of an ASD can be recommended using 3D-Video-assisted Port-Access™ minimally invasive surgical techniques. In these cases, we modified the standard system to incorporate a transcatheter superior vena cava cannula inserted through the right internal jugular vein in order to get access to the right atrium.

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