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Totally Endoscopic Atrial Septal Defect Closure with a Robotic System: Experience with Seven Cases

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ABSTRACT

Background: The development of minimally invasive cardiac surgery has shown good clinical results with shorter recovery time and better cosmetic results. The introduction of the robotic systems can further reduce the surgical trauma and improve the surgical dexterity.

We report seven cases of complete closed chest atrial septal defect closure using the "da Vinci"™ Surgical System (Intuitive Surgical, Mountain View, CA).

Methods: Following peripheral cannulation for cardiopulmonary bypass (CPB), aortic occlusion and cardioplegia delivery, five patients with atrial septal defect (ASD) and two patients with patent forame ovale (PFO) with atrial septal aneurysm (ASA) were successfully treated using the robotic system. Two robotic arms and an endoscopic camera were inserted through ports in the right hemithorax and an accessory port was placed for blood suction and ancillary instruments insertion. The defect closure was carried out with interrupted stitches in one patient and with a continuous suture in the others.

Results: Mean cardiopulmonary bypass and cross clamp time were 101.8 ± 39.6 and 63.4 ± 21.9 minutes respectively. Extubation was carried out within the seventh postoperative hour. All patients returned to normal lifestyle in one week.

Conclusion: Complete closed chest ASD closure can be carried out using robotic technique with rapid postoperative recovery and excellent cosmetic result.

INTRODUCTION

Minimally invasive cardiac procedures have become a part of routine cardiac surgery following the introduction of new surgical instruments, techniques for peripheral cardiopulmonary bypass (CPB) [Stevens 1996a, Stevens 1996b] and three-dimensional video assistance [Carpentier 1996, Chitwood 1997a, Chitwood 1997b]. To minimize surgical trauma and improve cosmetic results, different minimal invasive surgical approaches have recently been applied to the atrial septal defect (ASD) treatment with good clinical results [Massetti 1996, Black 1998, Levinson 1998, Byrne 1999].

Moreover, interventional cardiologists have developed percutaneous techniques for ASD closure in selected patients with different devices [Rome 1990, Rao 1994, Berger 1999, Ewert 2000]. The application of the robotic systems has led to the possibility to perform complete closed chest ASD closure. We present our initial experience with totally endoscopic ASD closure with the aid of a robotic device (da Vinci™ System, Intuitive Surgical Inc, Mountain View, CA) and of the Heartport™ system for CPB, aortic occlusion and cardioplegia delivery.

METHODS AND MATERIALS

The da Vinci™ Surgical system has been described elsewhere [Falk 1999a, Falk 1999b, Falk 1999c].

Clinical material

Adult patients with atrial ostium secundum (ASD) or patent forame ovale (PFO) with or without atrial septal aneurysm (ASA) were selected for surgical treatment with the totally endoscopic robotic technique. All patients were evaluated preoperatively by transesophageal echocardiography to exclude the presence of persistent left superior vena cava and anomalous pulmonary venous connection. The iliac and femoral arteries were evaluated by echo-color Doppler. Patients with aortic regurgitation, small femoral arteries or atherosclerotic disease of the aorta or the femoral arteries were excluded as a contraindication to the safe application of the Heartport system (Ethicon Inc., Somerville, NJ) for CPB. Five female and two male patients with a mean age of 41 ± 13 years were operated on. Mean ratio of pulmonary to systemic blood flow (QP/QS) was 2.8. Size of the defect ranged between 13 and 21 mm. Patients with ASD were asymptomatic, while patients with PFO and ASA had recurrent episodes of cerebral embolism. All patients were in sinus rhythm. Patients, older than 40, were studied with coronary angiography to exclude coexisting coronary disease. All patients signed an informed written consent form.

Surgical technique

All patients were intubated with a double lumen endotracheal tube. Central lines were inserted and both radial arteries were cannulated for arterial pressure monitoring. After

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heparinization a 14 Fr arterial cannula was inserted in the superior vena cava through the jugular vein with the Seldinger technique. A multiple plane transesophageal echocardiographic probe was inserted and left in place during all of the procedure to evaluate the position of the cannulas, the endoaortic balloon inflation and the cardioplegia delivery. External defibrillation pads were placed on the chest wall. The patients were placed in a supine position with the right hemithorax elevated 30 degrees and the right arm slightly beneath the posterior axillary line.

Following right lung deflation, the first port was inserted in the right fourth intercostal space between the nipple and the anterior axillary line for the introduction of the camera and the CO_2 insufflation. Two additional ports were created in the third and fifth intercostal spaces on the anterior axillary line for the introduction of the robotic instruments. An accessory port was located in the fourth intercostal space on the posterior axillary line for the access of ancillary instruments (Figure 1,). With appropriate robotic instruments the pericardium was opened 1.5 cm up to the frenic nerve. Both venae cavae were dissected and encircled by umbilical tapes. Moderately hypothermic CPB was established using the Heartport system after cannulation of the right femoral artery, inferior vena cava (through the femoral vein) and connection with the cannula in the superior vena cava. Both venae cavae were occluded closing the snare tapes and the venous drainage enhanced by a vacuum system. The endoaortic balloon was inflated to occlude the ascending aorta and cold blood cardioplegic solution was delivered. After cardiac arrest, the right atrium was opened and the superior edge fixed to the pericardium by a traction suture. Intracardiac anatomy was inspected and the interatrial defect was closed with a 2-0 Ticron suture.

After right atriotomy closure, with the patient in Trendelenburg position, the endoaortic balloon was deflated and suction was started in the ascending aorta. Cardiac activity resumed in sinus rhythm and the patients were weaned from cardiopulmonary bypass. After careful control of the hemostasis, a chest tube was inserted in the right pleural space through one of the ports.

RESULTS

All the procedures were completed endoscopically. No major intraoperative or postoperative complications were observed. Mean duration of cardiopulmonary bypass and aortic occlusion were 101.8 ± 39.6 and 63.4 ± 21.9 minutes respectively. Mean postoperative ventilation time was 5-6 hours. All patients had a regular postoperative course with minimal chest pain and discomfort. They were discharged on the sixth postoperative day and returned to a normal lifestyle after one week. Successful correction of the defect was assessed in all patients one month after the operation.

DISCUSSION

Different minimally invasive surgical techniques have been applied for ASD correction to correspond with the desires of young and otherwise healthy patients for cosmetically satisfying incisions. Recently, with the development of new interventional technology, the transcatheter closure of ASD has become a standard approach in some centers. Certainly the correction of the defect without incision and extracorporeal circulation is attractive, although rigorous patient selection is mandatory and the success rate is actually around 80% [Fischer 1999]. Recurrence of intracardiac shunt as well as dislodgment of the occluder has been reported [Bohm 1997, Hekmat 1997, Lambert 1997, La Rosee 1999, Windecker 2000]. With the introduction of computer-assisted robotic surgery a new option is available for ASD closure without opening the chest.

Preliminarily, we selected patients with ASD to close with direct suture, excluding the sinus venous type that requires a patch closure. The possibility for using this technique for treatment of every type of ASD, regardless of the size and location is realistic and particularly appealing. Unfortunately, the operation cannot be carried out in small children because the percutaneous cannulation is required.

The operating times are still exceeding those needed for a conventional procedure and a substantial learning curve has to be overcome. The lack of thoracotomy offers an excellent cosmetic result and seems to reduce the postoperative pain with a faster recovery and return to a normal life. Although the results presented here are encouraging, more clinical data are necessary to prove these concepts.

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