Case report - Congenital

Total endoscopic repair of a pediatric atrial septal defect using the da Vinci robot and hypothermic fibrillation

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Abstract

Computerized robotic enhancement has recently emerged as a promising technology to facilitate minimally invasive cardiac surgery. We report the first totally endoscopic closure of an atrial septal defect in a child using the da Vinci robot and hypothermic fibrillation.

Keywords: Congenital heart disease; Robotic; Pediatric; Minimally invasive surgery; Myocardial protection; Video-assisted thoracic surgery

1. Introduction

A 14-year-old female (weight = 35 kg, height = 150 cm, BMI = 15.6 kg/m²) presented with dyspnea on exertion, a new heart murmur and a transthoracic echocardiogram that revealed a large 4.5 × 3.5-cm secundum atrial septal defect (ASD). The patient was taken to the operating room and after placement of a double lumen endotracheal tube was placed in a left lateral decubitus position with the right hemithorax elevated. Initially, a 12-mm port was placed in the 4th intercostal space in the inframammary fold along the anterior axillary line. Furthermore, two 8-mm ports were placed at the 3rd and 5th intercostal spaces in the mid axillary line and a 10-mm port was placed in the posterior axillary line in the 4th intercostal space (Fig. 1). The da Vinci surgical robot (Intuitive Surgical) with three arms was used to complete the entire operation. Graspers and scissors were attached to electrocautery and used to isolate a 6.0 × 5.0-cm piece of autologous pericardium, which was fixed in gluteraldehyde. Next, the right femoral vessels were accessed through a 1.5-cm oblique incision along the inguinal crease. A 15 Fr Bio-Medicus arterial cannula was placed in the right femoral artery and a 21 Fr Bio-Medicus venous cannula was then inserted into the femoral vein and positioned in the inferior vena cava with transesophageal echocardiogram (TEE) guidance. Next, a 15 Fr Bio-Medicus venous cannula was inserted percutaneously into the right internal jugular vein and advanced into the superior vena cava. An endoaortic vent catheter was placed in the ascending aorta about 2 cm above the aortic valve through the left femoral artery. Once cardiopulmonary bypass was established, venous drainage was augmented using a centrifugal pump, cooling was initiated to 25 °C and the heart spontaneously fibrillated. Umbilical tapes placed around the cava were tied in a single knot and fixed in place with hemoclips (Fig. 2). The autologous pericardial patch was used to repair the ASD with a running 2.0 polytetrafluoroethylene (Gore-Tex®) suture followed by interrupted 2.0 Ethibond sutures that were robotically tied intracorporeally (Fig. 2). Before the patch sutures were tied de-airing was performed and the endoaortic vent was aspirated upon. After complete closure of the ASD rewarming was initiated and the heart spontaneously defibrillated. The atriotomy incision was closed with 2-0 Ethibond sutures. During reperfusion, TEE was used to facilitate de-airing and confirm repair of ASD. The patient was then weaned from cardiopulmonary bypass, cannulae were removed and protamine was administered. The thoracport incisions were then used for thoracostomy tube placement. The patient was extubated within six hours. Postoperatively, she developed right lower extremity edema secondary to the femoral venous cannulae and a residual hemothorax requiring thoracoscopic exploration. During exploration we identified a bleeder from the atrial suture line that was controlled with repair sutures on the atrial suture line. The patient was discharged home on postoperative day seven.

2. Discussion

ASD repair is routinely performed with excellent results via median sternotomy and cardioplegic arrest of the heart. In adults with the advent of minimal access cardiac surgery, goals have been to avoid the morbidity associated with a median sternotomy and cardioplegic arrest. Furthermore, in recent years the cosmetic sequelae following cardiac surgery has become more important, thus minimal access...
approaches with equivalent results and a nearly invisible scar have become the surgical goal [1–4]. Herein, we report the first case of totally robotic/endoscopic closure of an ASD in a child without a sternotomy, thoracotomy or cardiopulmonary arrest.

The advantages of totally endoscopic/robotic ASD repair combine improved precision and visualization with less associated pain and a better cosmetic result. Totally endoscopic robotic intracardiac procedures in children have been non-existent due to intercostal space limitation, smaller thoracic cavity, potentially longer ischemic times due to the additional suturing time needed by the robot as well as challenges with cannulation and delivery of cardioplegia.

In order to accommodate for the short distance between the chest wall and mediastinum, we placed a double lumen endotracheal tube and carefully positioned our ports to be directly triangulated around the ASD. Furthermore, when making the pericardiotomy we initiated cardiopulmonary bypass to decompress the enlarged right heart and discontinued mechanical ventilation to shift the mediastinum into the left hemithorax. In regards to the suture material, we used Gore-Tex since this is our preference for the conventional approach. An important technical aspect is that it requires multiple knots, to ensure that it will not become untied.

Minimizing ischemic time is of paramount importance in cardiac surgery. Historically, fibrillatory arrest of the heart combined with moderate hypothermia has been successfully utilized for re-operative mitral valve surgery with equivalent or better results than cross-clamp and cardioplegic arrest, according to some studies [5], and has been an especially useful strategy when longer operative times are required. Prior to conversion of a fibrillating heart it is of paramount importance to completely de-air the left heart. Chitwood (personal communication) advocates adequate de-airing occurs by simple agitation, filling the left side of the heart and draining via the atrial septal defect before completion of the closure. However, alternative techniques for de-airing include: (1) filling the left atrium and left ventricle with blood by avoiding suction of the blood from the left atrium; (2) expanding the lungs while rotating the operating table in all directions during air evacuation of the left atrium before complete closure of ASD; (3) monitoring with transesophageal echocardiographic examination for any residual air; and (4) keeping the patients in a head-down position after the aforementioned procedures before the heart starts beating. In our patient, we were able to place an endoaortic balloon suction catheter from the femoral artery to just above the aortic valve to further assist in de-airing.

Endoscopic repair requires a learning curve and significant endoscopic experience. Meticulous hemostasis is important to avoid the need for reexploration. Careful preoperative planning and awareness of potential cannulation complications are important.

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References