Totally robotic resection of myxoma and atrial septal defect repair

Changqing Gao*, Ming Yang, Gang Wang, Jiali Wang

Department of Cardiovascular Surgery, PLA General Hospital, 28 Fuxing Rd, Beijing 100853, China

Received 12 June 2008; received in revised form 6 August 2008; accepted 8 August 2008

Abstract

Resection of left atrial myxoma and large atrial septal defect repair were performed in 55 patients using the da Vinci S surgical system to evaluate device safety and efficacy. Fifty-five patients underwent resection of left atrial myxomas (n = 10) or secundum-type ASD (n = 45) repairs with three cases of concomitant tricuspid valve repairs, using the da Vinci S surgical system. Mean age of the patients was 38 ± 12.2 years (range 12–61 years). Cardiopulmonary bypass was achieved peripherally, aortic occlusion was performed with Chitwood cross-clamp, and antegrade cardioplegia was administered via anterior chest. Via four port incisions in the right chest and a 2-cm incision in the lower abdomen, the procedures were completed with the da Vinci robot. All patients had successful resection or repairs. The mean CPB times and aortic cross-clamp times were 108.6 ± 12.5 min and 45 ± 11.5 min, respectively. There were no operative deaths, strokes, or device-related complications. One patient was reexplored for bleeding. There were no incisional conversions. All the patients were discharged. da Vinci surgical system has no limitations to safe resection of left atrial myxomas and of ASD repairs, surgical results are excellent, and this technology is of reproducible value with excellent cosmetic results.

Keywords: Minimally invasive cardiac procedure; Robotics; Atrial septal defect; Myxoma; Tricuspid valve repair

1. Introduction

Traditionally, resections of left atrial myxomas and large atrial septal defect (ASD) repair, which are not suitable for cardiological interventional treatment, have been performed by median sternotomy with conventional cardiopulmonary bypass (CPB). Since 1995, improvement in perfusion technology and instrumentation has stimulated cardiac surgeons to investigate the efficacy of minimally invasive cardiac procedures. Cosgrove et al. [1] demonstrated that minimal access operations for both mitral and aortic valves improved patient outcomes and had economic benefits. These reports led others to investigate less invasive techniques for cardiac operations. In 1996, Carpentier’s group [2], Chitwood’s group [3] completed a videoscopic mitral valve repair using peripheral perfusion. Then, Mohr and his group [4] performed a similar operation using three-dimensional (3D) camera guidance displayed through a handheld monitor. Chitwood developed transthoracic aortic cross-clamps which enabled central aortic occlusion without using intraaortic balloon [5].

Since January of 2007, using the da Vinci S surgical system, our group [6–10] have performed 110 cases of robotic cardiac operations, including mitral valve repair, single-vessel small thoracotomy (SVST) or multivessel small thoracotomy (MVST) CABG with robotic IMA harvest, totally endoscopic coronary artery bypass (TECAB) on beating heart and ASD repair.

Robotic resection of left atrial myxomas or large ASD repairs has been performed on 55 patients in order to determine device safety and efficacy. This is the only heart center with the da Vinci surgical system in China to date.

2. Patients and methods

Between January 2007 and July 2008, fifty-five patients (female 38, male 17) underwent resection of left atrial myxomas (n = 10) or big secundum-type ASD (n = 45) repairs, using the da Vinci S surgical system (Intuitive Surgical Inc) with approval from the Institutional Review Board and with informed consent. The mean age of the patients was 38 ± 12.2 years (range 12–61 years) with echocardiographically confirmed left atrial myxoma or ASD with mild to moderate pulmonary hypertension and three ASD patients had moderate to severe tricuspid valve regurgitation. The mean myxoma body was 47 ± 6.0 cm³ (23 ± 36–43 × 74 cm³), and the mean ASD size was 3.2 cm (2.0–3.6 cm). All patients underwent a history and physical examination followed by a chest radiograph and transthoracic echocardiogram (TTE).

After induction of general anesthesia, all patients were intubated for single-lung ventilation. A TEE probe and arterial pressure monitoring line were inserted. Both a central venous catheter and a 15F venous drainage cannula were placed percutaneously into the right internal jugular vein. External defibrillator patches were placed to subtend the maximum cardiac mass. Each patient was positioned with the right chest elevated approximately 30° and with the right arm tucked at the side. Femoral arterial (17F or
20F) and venous cannulation (21F or 23F) were performed through a 2-cm transverse right groin incision by using the Seldinger guide wire method and TEE guidance. Bicaval venous drainage was instituted through the jugular and femoral/inferior vena cava cannulas. Caval snares were placed using the long-tip forceps and passed out of the working port. Cardiopulmonary bypass was initiated, with kinetically assisted bivaval venous drainage. Aortic occlusion was performed with Chitwood cross-clamp via the 4th intercostal space (ICS) in the midaxillary line. Antegrade cold blood cardioplegia was administered directly through anterior chest (3rd ICS) with 14F angio. Carbon dioxide was insufflated continuously into the operative field for air displacement. A right atriotomy was performed, and ASD was exposed with atrial retractor (Intuitive Surgical, Inc, CA) by the 4th arm. ASD was closed directly with 4-0 GoreTex in running suture in 31 patients, autogenous pericardium or Teflon patching was used in 14 patients, concomitant procedures included three ASD cases with tricuspid valve repair using De Vega technique, one with partial anomalous pulmonary venous connection. Eight of 10 myxomas were resected by left atrial approach (Figs. 1 and 2), two cases, by right atrial approach. The atriotomy was closed with 4-0 GoreTex in running suture. After cross-clamp release and meticulous intracardiac deairing, the patient was weaned from CPB and chest tubes were inserted (Fig. 3). Integrity of the septal closure was conformed by TEE.

The camera cannula was placed in the right, 2–3 cm lateral to nipple in the 4th ICS, 2–2.5 cm incision was used as a working port in the same ICS for the patient-side surgeon. da Vinci instrument arms were inserted through two 1-cm trocar incisions, in the anterior axillary line. The right instrument generally was positioned 4–6 cm lateral to the working port in the 6th ICS. The left instrument arm was positioned medial and cephalad to the right arm in the 2nd or 3rd ICS. The 4th arm trocar was placed in the midclavicular line in the 5th ICS (Fig. 4). All the resections of myxomas or ASD repair and the atrial closure were completed with the da Vinci robot.

Data are shown as mean ± standard error of the mean with P-values of <0.05 considered significant.

3. Results

All patients had successful resection of left atrial myxomas or ASD repairs with the da Vinci surgical system and were operated on by the same console surgeon and patient-side surgeon. The median CPB time and aortic cross-clamp time were 108.6 ± 12.5 min and 45 ± 11.5 min, respectively. (In the first 10 cases of our series, median values for CPB and cross-clamp times were 123.6 ± 19.2 and 56.2 ± 13.6 min, respectively; in the last 35 cases, median values for CPB and cross-clamp times were 100.1 ± 16.3 and 38.1 ± 17.9 min, respectively, P<0.05.) The 12 patients transfused with packed red blood cells (22%) required an average of 2.5 ± 0.5 units. The median ventilation time for the group was 4 ± 2.0 h. Total length of ICU stay for patients was 0.5–
1.0 days. The length of hospital stay for all patients was 4–5 days. The postrepair intraoperative and follow-up TEE showed no residual interatrial shunt.

There were no operative deaths, strokes, or device-related complications. One patient was reexplored for bleeding in the trocar sites. There were no intraoperative conversions to alternative surgical techniques, and there were no da Vinci system-related adverse events. All procedures that were started with the da Vinci system were completed with robotic assistance. All the patients were discharged, and cosmetic results were excellent in all cases.

4. Discussion

Over the last few years, computerized surgical robotic systems have been developed very fast. The da Vinci (Intuitive Surgical, Inc, CA) surgical robot has assisted the surgeon's work using tele-manipulation through a master-controller activation principle with a 3D intracardiac camera. Torracca [11] first reported a small series of patients undergoing closed-chest ASD closure using a robotic device in Europe. Later, Argenziano's series [12] of robotic ASD repairs supplemented this experience. This represented the first U.S. application of robotic technology for totally endoscopic open-heart surgery. Later, Wimmer-Greinecker [13] reported 10 cases of ASD repairs with good clinical results. Chitwood [14] showed that endoscopic mitral valve surgery can be performed safely and with 'gold standard' results. Surgical telemanipulation seems the ideal method for operating accurately through small incisions and in restricted spaces.

Despite these and other successful minimally invasive operations, most surgeons have not embraced endoscopic methods for heart surgery. In fact, robotic technology can provide many potential benefits to cardiac surgeons and patients. Cutaneous incisions can be smaller because of improved optics and instrumentation. Our working port was only 2.0–2.5 cm. Wrist-like articulations transfer the dexterous actions of instrument tips to the plane of intracardiac procedures. With the addition of tremor filtration, there is improved precision in tight intracardiac spaces. Moreover, ambidexterity can become a reality for all surgeons.

New atrial retractor (Intuitive Surgical, Inc, CA) was an excellent device for interatrial exposure. Whether it was resection of myxomas or repair of ASD and/or tricuspid valve, exposure could be easily achieved by the 4th arm with atrial retractor (Figs. 1 and 2). With this device, we felt that resection of left atrial myxomas was approached more easily by an incision through the anterior wall of the left atrium than the right, especially when the stalk of myxoma did not originate in the septum, thus the stalk was easily found and totally resected in order to prevent the recurrence of the myxoma after operation. Our policy was to resect full thickness whenever possible. However, we found that some stalks of myxoma were loosely attached to the endocardium, which could be easily detached robotically because of magnification. When the stalk of myxoma originated in the septum, we resected the stalk together with partial or full septum, the septum was then repaired. Eight of our 10 patients with myxoma were operated on through left atrial approach.

Though there was a limited number of cases, we believe that robotic tricuspid valve repair was feasible and safe. The sites of arm trocar were very important for successful operations. We felt that arm trocar sites were maintained at least 6 cm apart at chest entry and the 4th arm trocar was placed in the midclavicular line in the 5th ICS.

Chitwood's aortic clamp technique [5] was safe and economical compared with remote access perfusion cannula with endoaortic balloon, which may cause complications and is more expensive. In our group, aortic occlusion was completed with Chitwood cross-clamp through the 4th ICS in the midaxillary line. Antegrade cardioplegia was administered directly through anterior chest, instead of the distal cannula port [11, 12], was feasible and safe. Therefore, the working port could become smaller.

Despite these benefits, cross-clamp and perfusion times were longer in the robotic operation. However, after the learning curve (in the first 10 cases of our series, the median value for CPB and cross-clamp times was 123.6 ± 19.2 and 56.2 ± 13.6 min, respectively; in the last 35 cases, the median value for CPB and cross-clamp times were 100.1 ± 16.3 and 38.1 ± 17.9 min, respectively P < 0.05), the overall operative times were slightly longer in this group compared with conventional sternotomy procedures. The learning curve demonstrated a progressive decline in cross-clamp, CPB, as well as overall operative times. We felt that the learning curve for operative time was steep. As surgical teams become even more skilled in using this device, perioperative time can be expected to continue to decrease. It is necessary to point out that in our series, two ASD patients had atrial fibrillation (AF), and we did not treat AF simultaneously, only aspirin was given after operation.

In our series, the robotic system performed safely and efficiently, with no operative death or conversions due to a system malfunction. Moreover, there were no incision conversions either to a thoracotomy or to a sternotomy. These patients benefited from minimal trauma, a low transfusion rate, and early discharge.
In conclusion, da Vinci S surgical system has no limitations to safe resection of left atrial myxomas and repairs of large ASD, and reduces surgical trauma. Surgical results are excellent, and this technology is of reproducible value with excellent cosmetic results. With the evolution of robotic surgical systems, surgeons and their patients can expect to gain the benefits shown in this study.

Acknowledgments

Lixia Li, Yue Zhao, Cangsong Xiao, Yang Wu, Jiachun Li, and Qi Zhou from the same department participated and made active contributions for the study.

References