Successful Intracardiac Robotic Surgery
Initial Results From Japan

Go Watanabe, MD, PhD

Objective: The purpose of this study is to report our 2-year experience of performing endoscopic intracardiac procedures using the da Vinci Surgical System. Our teams at Kanazawa University and Tokyo Medical University groups began using the da Vinci Surgical System (Intuitive Surgical, Inc, Sunnyvale, CA) in 2005. This series represents the first Japanese application of robotic technology for totally endoscopic open-heart surgery.

Methods: From January 2008 to February 2009, 10 patients (mean age: 46.8 ± 16.3 years, 70% women) underwent endoscopic atrial septal defect closure and resection of the left atrial myxoma using the da Vinci Surgical System and peripheral cardiopulmonary bypass technique. Of the 10 patients, nine were classified as New York Heart Association class II and 1 patient exhibited atrial arrhythmias. In addition, two patients required mitral valve plasty (n = 2) and tricuspid annuloplasty (n = 1).

Results: Mean da Vinci Surgical System working time was 140.7 ± 57.4 minutes. Mean cardiopulmonary bypass and aortic cross clamp times were 103.1 ± 37.1 and 30.0 ± 16.9 minutes, respectively. There were no conversions to sternotomy or small thoracotomy. There were no hospital deaths. Mean intensive care unit and hospital stays were 1 day and 3.1 ± 0.3 days, respectively. All patients appreciated the cosmetic result and fast recovery.

Conclusions: Closed-chest atrial septal defect closure and myxoma resection performed using robotic techniques achieved excellent results and rapid postoperative recovery and provided an attractive cosmetic advantage over median sternotomy.

Key Words: Robotics, Atrial septal defect, Myxoma.

(*Innovations* 2010;5:48–50)

Recent advances in robotic instrumentation have facilitated endoscopic intracardiac procedures. In 1998, Carpentier et al[1] and Mohr et al[2] began performing endoscopic coronary artery bypass grafting (CABG) and mitral procedure using peripheral cardiopulmonary bypass (CPB) perfusion and the endoaortic cross-clamp technique. In 2005, we performed the first total endoscopic cardiac procedure in Japan using the da Vinci Surgical System. To date, we have performed >70 robotic cardiac procedures including mitral valve repair, multivessel small thoracotomy CABG with robotic internal thoracic artery harvest, and totally endoscopic CABG on the beating heart.

Herein, we report the initial Japanese experience with complete closed-chest atrial septal defect (ASD) closure and left atrial myxoma excision with the da Vinci Surgical System.

PATIENTS AND METHODS

Between January 2008 and July 2008, 10 patients (seven women and three men) underwent ASD closure (n = 9) and resection of left atrial myxoma (n = 1) using the da Vinci Surgical System after obtaining approval from the institutional review board and informed consent from all participants. The mean age of the patients was 46.8 ± 16.3 years (range: 24–70 years). The patients had echocardiographically confirmed ASD or left atrial myxoma, and two patients with ASD had moderate mitral as well as tricuspid valve regurgitation.

Surgical Technique

After induction of the general anesthesia with left lung ventilation, a transesopheal edocardiography (TEE) probe and arterial pressure monitoring line were inserted. Each patient was positioned with the right chest elevated ~30 degree. The patients were heparinized and femoral arterial and venous cannulations were performed. Bicaval venous drainages were performed through the jugular and femoral cannulas. The da Vinci endoscope was inserted through a 12-mm port in the fourth intercostal space (ICS) 2-cm lateral to the midclavicular line. A 20-mm service port was created lateral to the endoscope port in the same ICS. The two robotic instruments were inserted through the ports made in the third and the fifth ICS. Insufflation of carbon dioxide in the thorax was used. The pericardium was opened and excised for possible ASD repair. CPB was initiated. Aortic occlusion was performed with Chitwood cross-clamp through the third ICS in the midaxillary line. Antegrade cold blood cardioplegia was infused with a 14F angiocath. Carbon dioxide was insufflated continuously into the operative field for air displacement. A right atriotomy was performed, and the ASD was exposed. The ASD was closed directly with running suture of CV-4 Gore-Tex in eight patients and pericardial patch was used in one patient. Concomitant procedures included tricuspid valve repair using the De Vega technique in one patient and mitral reconstruction using a Cosgrove mitral band in two patients.

Accepted for publication September 10, 2009.
From the Department of General and Cardiothoracic Surgery, Kanazawa University, Kanazawa, Japan.
Address correspondence and reprint requests to Go Watanabe, MD, PhD, Department of General and Cardiothoracic Surgery, Kanazawa University, Takaramachi 13-1, Kanazawa 920-8641, Japan. E-mail: watago6633@gmail.com.

ISSN: 1556-9845/10/0501-0048

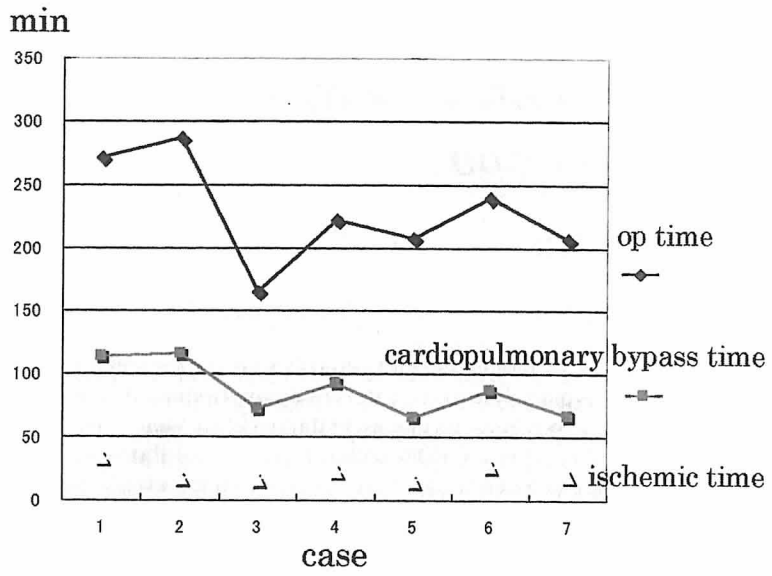

FIGURE 1. Case by case operative time, cardiopulmonary time, and aortic cross clamp time of this series. After the second case, these parameters decrease and were stable.

Left atrial myxoma was resected in one patient by left atrial approach (Fig. 1). Exploration of atrial myxoma was through a left atriotomy anterior to the pulmonary veins. Left atrial myxoma was visualized by placing two traction sutures at the left atriotomy and pulling upward. Excision was achieved by dissecting a plane through the atrial muscle at the point of attachment. Tumors were grasped by the tissue margins and extracted through the service port. The septum was then repaired. The atriotomy was closed with running suture of CV-4 Gore-Tex. After cross-clamp release, the patient was weaned from CPB. Data are shown as mean ± SD with P values of <0.05 considered significant (Fig. 2).

RESULTS

Successful resection of left atrial myxomas and ASD repairs were performed in all patients with the da Vinci Surgical System. The procedures were performed by the same console surgeon and patient-side surgeon. The median CPB time and aortic cross-clamp time were 103.1 ± 37.1 minutes and 30.0 ± 16.9 minutes, respectively. None of the patients received transfusions. The median ventilation time for the group was 2.2 ± 0.9 hours. Total length of intensive care unit stay for patients was 0.5 to 1.0 day. The length of hospital stay for all patients was 3 to 4 days (3.1 ± 0.3). The postoperative follow-up TEE showed no residual interatrial shunt. All procedures that were started with the da Vinci system were completed with robotic assistance. There were no device-related complications and no adverse events. There were no postoperative complications or operative deaths. All the patients were discharged and cosmetic results were excellent in all cases.

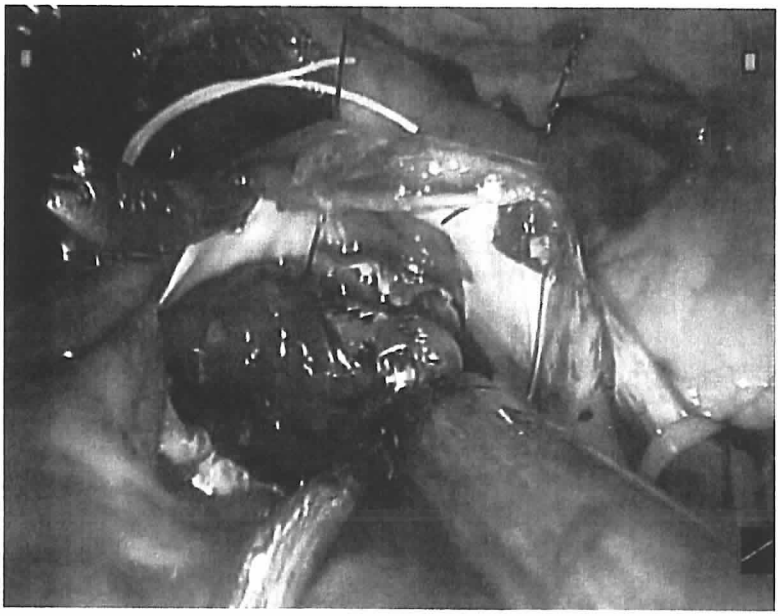

FIGURE 2. Resection of myxoma using the da Vinci Surgical System. Left atrial myxoma was resected by left atrial approach.

DISCUSSION

In recent years, computerized surgical robotic systems have been rapidly developed. The da Vinci Surgical System (Intuitive Surgical, Inc, Sunnyvale, CA) has assisted the surgeon by telemanipulation through a master-slave activation principle with a 3D imaging. Remote access perfusion and robotics have enabled totally endoscopic CABG, intracardiac repair such as ASD closure, mitral valve plasty, tricuspid valve repair, and other cardiac procedures.[1,2] Torracca et al[3] first reported a series of patients undergoing closed-chest ASD closure using a robotic device in Europe. Later, in the series of Argenziano et al,[4] robotic ASD repairs supplemented this experience. This represented the first U.S. application of robotic technology for totally endoscopic open-heart surgery. Recently, Wimmer-Greinecker et al[5] reported 10 cases of ASD repairs with good clinical results. Chitwood[6] showed that endoscopic mitral valve surgery can be performed safely and with "gold standard" results. Surgical robotic systems seem to be the ideal method for operating accurately through small incisions and in restricted deep spaces.

Our teams at Kanazawa University and Tokyo Medical University began using the da Vinci Surgical System in 2005. Essential steps for intracardiac repair, ASD closure, and CPB with aortic cross-clamp were inspired by our technique of internal thoracic artery harvesting used in >40 cases. And, we have attempted tricuspid annuloplasty, mitral valve plasty, and myxoma resection in a stepwise manner.[7,8] This series represents the first Japanese application of robotic technology for totally endoscopic ASD closure and myxoma resection. In our series, the robotic surgeries were performed safely and efficiently, with no operative deaths or conversions due to robotic system malfunction. Moreover, there were no incision conversions either to a thoracotomy or to a sternotomy. These patients benefited from minimal trauma, low transfusion rate, and early discharge.

An endoscopic approach to atrial myxoma is ideal, however, only if the surgical tenets of myxoma excision can be achieved. These include exposure of the attachment point of the tumor, allowing excision of adequate tissue margins, removal of the tumor without fragmentation, reconstruction of atrial wall defects, and ability to inspect the cardiac chambers for other tumors. Gao et al[9] was the first to report da Vinci myxoma resection through a left atrial approach. They demonstrated the importance of full-thickness resection with pedicle of the myxoma, which was loosely attached to the endocardium. In our case, the stalk of the myxoma was originated in the septum and we resected the stalk together with full-thickness septum. We found that the endoscopic left atrial exposure of the tumor was excellent and the identification of the tumor attachment point was superior to that achieved in patients previously approached through a median sternotomy. This exposure allowed excision with satisfactory margins with a nearly no-touch technique not possible with a conventional biatrial approach. Tumor embolization was not detected in our patient.

Despite these benefits, cross-clamp and perfusion times, and overall operative times may be acceptable in this group compared with the conventional sternotomy procedure. However, longer CPB time had no negative impact on intraoperative and postoperative outcomes. The learning curve demonstrated a progressive decline in cross-clamp, CPB, and overall operative times. In our experience, the length of the procedure time for robotic ASD closure taken by a specialized robotic surgeon was significantly shorter than the procedure time for standard ASD closure taken by fresh residents who normally perform these procedures. As surgical teams become even more skilled in using this device, perioperative time can be expected to decrease.

CONCLUSION

In conclusion, the da Vinci Surgical System has no limitations for the repair of large ASD and is applicable to left atrial myxoma resection. The system reduces surgical trauma. Surgical results are excellent, and this technology demonstrates 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.

REFERENCES

1. Carpentier A, Loulmet D, Carpentier A, et al. [Open heart operation under videosurgery and minithoracotomy. First case (mitral valvuloplasty) operated with success.] *C R Acad Sci III.* 1996;319:219–223.
2. Mohr FW, Falk V, Diegeler A, et al. Minimally invasive port-access mitral valve surgery. *J Thorac Cardiovasc Surg.* 1998;115:567–571.
3. Torracca L, Ismeno G, Alfieri O. Totally endoscopic computer-enhanced arterial septal defect closure in six patients. *Ann Thorac Surg.* 2001;72:1354–1357.
4. Argenziano M, Oz MC, Derose JJ, et al. Totally endoscopic atrial septal defect repair with robotic assistance. *Heart Surg Forum.* 2002;5:294–300.
5. Wimmer-Greinecker G, Dogan S, Aybek T, et al. Totally endoscopic atrial septal repair in adults with computer-enhanced telemanipulation. *J Thorac Cardiovasc Surg.* 2003;126:465–468.
6. Chitwood WR. Current status of endoscopic and robotic mitral valve surgery. *Ann Thorac Surg.* 2005;79:S2248–S2253.
7. Ishikawa N, Sun YS, Nifong LW, et al. Port-access atrium retractors for totally endoscopic mitral valve surgery: the Tornado Retractor, the Butterfly Retractor, and the Semiautomatic Butterfly Retractor. *Surg Endosc.* 2008;22:2088–2090.
8. Ishikawa N, Watanabe G, Iino K, et al. Robotic internal thoracic artery harvesting. *Surg Today.* 2007;37:944–946.
9. Gao C, Yang M, Wang G, Wang J. Totally robotic resection of myxoma and atrial septal defect repair. *Interact Cardio Vasc Thorac Surg.* 2008;7:947–950.

CLINICAL PERSPECTIVE

This report from Dr. Watanabe details his initial experience with endoscopic intracardiac procedures using the da Vinci surgical system. He reports on nine patients undergoing an atrial septal defect closure and one resection of a left atrial myxoma. The procedures had acceptable operative times, short length of stays and there were no complications or deaths. This report replicates similar successful series from the United States and Europe. While this is a very low risk group of patients in which one would not expect any complications, it clearly demonstrates the feasibility of using a surgical robotic system for these procedures and the excellent results that can be achieved by well-trained surgical teams.