Two-Port Robotic Cardiac Surgery (TROCS) for Atrial Septal Defect (ASD) Using Cross-Arm Technique – TROCS ASD Repair –

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Background: We successfully performed totally endoscopic atrial septal defect (ASD) repair via 2 ports, and we named this procedure two-port robotic cardiac surgery (TROCS).

Methods and Results: A 51-year-old woman with secundum ASD underwent robot-assisted ASD repair under ventricle fibrillation without aortic cross-clamping. Two ports were placed in the right side of the chest, and 1 port was for the robotic endoscope. Two robotic instruments were inserted through another port and crossed while preventing them from colliding.

Conclusions: TROCS ASD repair using a cross-arm technique was achieved safely with good clinical results and excellent cosmetic results. (*Circ J* 2015; **79**: 2271–2273)

Key Words: Atrial septal defect; Congenital heart disease; Surgery; Ventricular fibrillation

For treatment of atrial septal defect (ASD), various minimally invasive surgical procedures have been developed to minimize the surgical incisions and cosmetic results, such as transthoracic approach transcatheter approach.^{1,2} Recently, a robotic surgical system has been developed to enhance the surgeon's ability not only in the field of laparoscopic surgery but also cardiac surgery,³ and the first total endoscopic closed-chest ASD repair using the da Vinci surgical system (Intuitive Surgical, Inc, Sunnyvale, CA, USA) was reported in 2001.⁴

The present study describes a case of total endoscopic cardiac surgery for ASD via 2 ports using a cross-arm technique, which we named two-port robotic cardiac surgery (TROCS).

A 51-year-old woman was diagnosed with secundum ASD. Preoperative 2D echocardiography revealed a pulmonary blood flow (Qp)-to-systemic blood flow (Qs) ratio of 1.9, and a diagnosis of secundum ASD (maximal diameter, 16.5 mm) with enough tissue surrounding the defect to enable transcatheter ASD repair. However, the patient preferred to undergo surgery, and we planned a minimally invasive robot-assisted ASD repair after consulting the institutional review board. Informed consent for this novel technique and the payment was obtained from the patient and her family before the operation.

Anesthesia was induced using a double-lumen endotracheal tube. The patient was placed in a left hemi-lateral decubitus

position. After systemic heparinization, a 16Fr outflow cannula was inserted transcutaneously into the right internal jugular vein, and a 18Fr Inflow cannula and a 25Fr outflow cannula were inserted into the right femoral artery and vein, respectively. The first 20-mm port for the robotic arms was made in the 4th intercostal spaces at the right anterior axillary line. The second 10-mm port for the robotic endoscope was inserted through the 4th intercostal space at the right mid-clavicular line.

Next, the da Vinci S surgical system was introduced from the left side of the patient. Both robotic instruments were inserted through the first port and crossed while preventing them from colliding with each other (**Figure 1A**). At the same time, the master-instrument association at the surgeon's console was set to the reverse of the default settings so that the right master would control the left instrument and the left master would control the right instrument.

Cardiopulmonary bypass (CPB) was initiated, and the superior vena cava were occluded with a small clamp. We performed the ASD repair with the 0 degree robotic endoscope and 5 mm robotic instruments using a cross-arm technique. Ventricle fibrillation (VF) was induced using a combined method of electrical fibrillator, injection of potassium and hypothermia without aortic cross-clamping. The ASD was directly closed with 4-0 Gore-Tex and a running suture (**Figure 1B**). After defibrillation, the patient was weaned from

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Figure 1. Intraoperative view of robotic atrial septal defect (ASD) repair. (A) da Vinci set-up for two-port robotic cardiac surgery (TROCS). (B) TROCS ASD repair.

CPB. The integrity of the ASD repair was confirmed by transesophageal echocardiography. Operation time was 137 min, CPB time was 75 min, and VF time was 16 min; the estimated blood loss volume was 10 ml. Extubation was performed in the intensive care unit by 2 h after the operation. She resumed a completely normal lifestyle on postoperative day 7, and the cosmetic result was excellent (Figure 2). Japanese National Health Insurance does not cover this procedure, so the patient paid all costs for the procedure.

Discussion

Recent advances in transcatheter occlusion devices have resulted in a shift from surgical repair to interventional treatment for secundum ASD. However, the presence of a large ASD or multiple ASDs with insufficient surrounding tissue is associated with higher procedural failure rates. Recurrence of the intracardiac shunt, dislodgement of the occluder and breakage of the device have also been described.⁵⁻⁷ Therefore, rigorous patient selection is mandatory.

We used to perform robotic ASD repair with 4 ports on the arrested heart, and it was an established safe procedure. However, it still has several disadvantages, such as being time consuming for hemostatic confirmation of the cardioplegic opening and all ports, and risk concerns about aortic clamping. To avoid postoperative bleeding and complications, periaortic

Figure 2. The patient after TROCS ASD repair.

maneuvers and the number of ports should be reduced. The port of the left arm passing the vascular-rich mammary gland is at increased risk of bleeding in particular. In this procedure the first port includes the role of service port where sutures and suction device are inserted. Furthermore, we could avoid having the port for the Chitwood transthoracic clamp by operating under VF.

In the future, we plan to start single-incision ASD repair using this cross-arm technique, but we will need a 5-cm incision to avoid collision of both robotic arms and the endoscope. We are particular about a totally endoscopic procedure in robotic surgery to minimize wound pain. To overcome these problems we believe a smaller robotic endoscope and further artifice will be needed for procedures via a smaller incision. However, this TROCS is one of the most minimally invasive cardiac surgeries so far, and we believe not only single-incision ASD repair but also TROCS mitral valve repair will be performed in the future.

Intuitive Surgical Inc developed the single-site robotic platform, and it was approved by the US Food and Drug Administration for cholecystectomy in 2011. The dedicated curved instruments do not have wrist articulation and only 5 degrees of freedom; 2 degrees (inner and outer yaw of the wrist) less than conventional da Vinci instruments, which we do not think is suitable for cardiac surgery requiring quick suture and ligation.

In Japan, only radical prostatectomy has been approved by the Ministry of Health, Labour and Welfare (MHLW), and other da Vinci surgeries are not covered by National Health Insurance. Furthermore, use of the da Vinci system for cardiac surgery has not approved by the MHLW. Under such circum-

stances, da Vinci cardiac surgeries currently can only be performed either in a private practice where the patient pays all costs for the procedure; or for research purposes where the hospital shoulders all costs. The National Cerebral and Cardiovascular Center and Kanazawa University have finished clinical trials of da Vinci use for structural heart diseases, and we await the approval of the MHLW.

In conclusion, TROCS ASD repair using a cross-arm technique was achieved safely with good clinical results and excellent cosmetic results.

References

1. Black MD, Freedom RM. Minimally invasive repair of atrial septal defects. *Ann Thorac Surg* 1998; **65**: 765–767.
2. Ewert P, Berger F, Daehnert I, van Wees J, Gittermann M, Abdul-Khaliq H, et al. Transcatheter repair of atrial septal defect without fluoroscopy: Feasibility of new method. *Circulation* 2000; **101**: 847–849.
3. Ishikawa N, Watanabe G, Tomita S, Yamaguchi S, Nishida Y, Iino K. Robot-assisted minimally invasive direct coronary artery bypass grafting: ThoraCAB. *Circ J* 2014; **78**: 399–402.
4. Torracca L, Ismeno G, Alfieri O. Total endoscopic computer-enhanced atrial septal defect repair in six patients. *Ann Thorac Surg* 2001; **72**: 1354–1357.
5. Hekmat K, Mehlhorn U, Rainer de Vivie E. Surgical repair of a large residual atrial septal defect after transcatheter repair. *Ann Thorac Surg* 1997; **63**: 1456–1458.
6. Bohm J, Bittigau K, Kohler F, Baumann G, Konertz W. Surgical removal of atrial septal defect occlusion system-devices. *Eur J Cardiothorac Surg* 1997; **12**: 869–872.
7. Komar M, Przewłocki T, Olszowska M, Sobieć B, Stepniowski J, Podolec J, et al. Conduction abnormality and arrhythmia after transcatheter closure of atrial septal defect. *Circ J* 2014; **78**: 2415–2421.