

Appendix 1 Detailed description of robotic-assisted cardiac surgery procedures in our center

Da Vinci robot-assisted off-pump coronary artery bypass surgery

In addition to routine examinations, 3D CT of the internal thoracic artery was performed to assess vascular quality. Specifically, patients underwent left chest elevation of 30° and right 1-lung ventilation; the left pleural cavity was filled with CO₂, and the pressure was set as 6–8 mmHg; besides, the left chest wall of the patient was punctured, the endoscopic hole was located between the midclavicular line and the anterior axillary line near the anterior axillary line in the 5th intercostal space, the left and right robotic arm holes were located in the 3rd and 7th intercostal spaces, and the 3 holes were set as a straight line (*Figure S1*). Subsequently, free skeletonization of the LiMA was performed by robots; and LiMA-LAD artery anastomosis was performed on the 5th intercostal mini-incision in the left.

Da Vinci robot-assisted ASD repair and/or concomitant tricuspid valvuloplasty

Patients were given intraoperative 16F jugular venous catheter drainage (*Figure S2*) and femoral arteriovenous cannulation for peripheral CPB. Then, the right 4th intercostal midclavicular line was opened about 3 cm laterally, a right atrial dissection was made after occlusion of the superior and inferior chambers under the beating heart, then the ASD was exposed with an atrial retractor via the 4th robotic arm, and a left heart drainage tube was placed. Finally, 4-0 prolene was used to suture the incision (*Figure S3*).

Da Vinci robot-assisted ventricular septal defect repair

One patient with mesangial defect was treated in our hospital (*Figure S4*). Through anesthesia, body position setting, and CPB, the same ASD was established, with the difference of blocking the ascending aorta.

Da Vinci robot-assisted resection of left atrial myxoma

After preoperative examination, anesthesia, body position setting, and CPB, the same ASD was established, and the difference was the presence of an upward 30° endoscope.



Figure S1 Overview of robotic-assisted cardiac surgery.

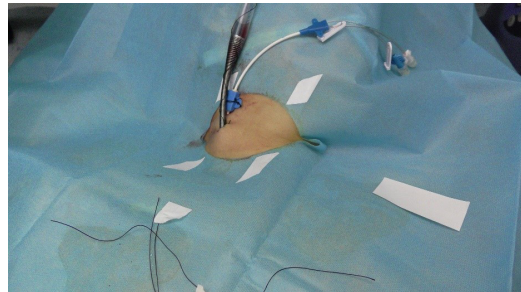


Figure S2 Percutaneous intubation of internal jugular vein.

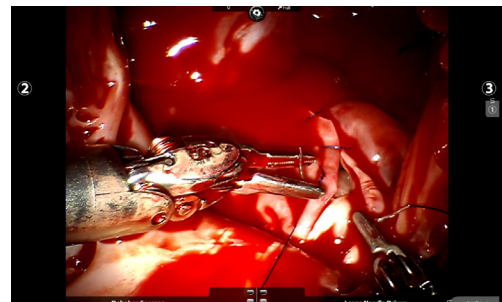


Figure S3 Endoscopic view of atrial septal defect repair.



Figure S4 Endoscopic view of ventricular septal defect correction.

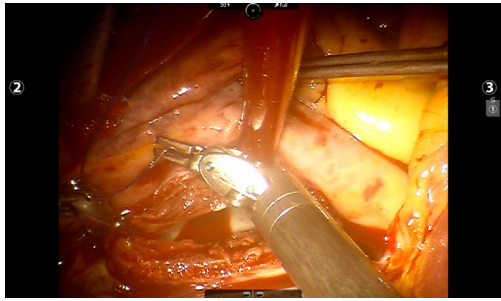


Figure S5 Endoscopic view of closure of the left atrial.

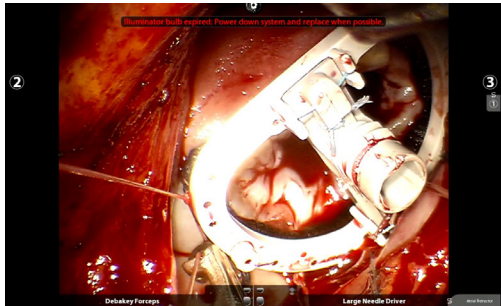


Figure S6 Endoscopic view of mitral valvuloplasty.

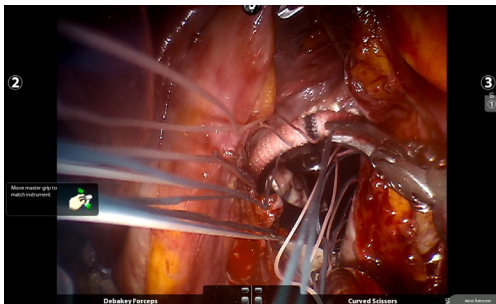


Figure S7 Endoscopic view of mechanical mitral valve replacement.

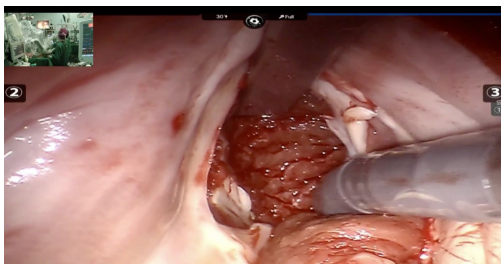


Figure S8 Endoscopic view of resection of the hypertrophic interventricular septum.

The superior and inferior vena cava were not occluded but the ascending aorta was occluded. The left atrium was incised along the interatrial sulcus approach to explore the pedicle of myxoma (*Figure S5*). After complete resection of the pedicle, the whole tumor was removed.

Da Vinci robot-assisted mitral valvuloplasty

Robotic surgery was the preferred choice for simple mitral regurgitation without coronary artery disease and other valvular. Previous work was the same as myxoma surgery. A left atrial retractor was applied to open the interatrial septum. Through exposure of the mitral valve, the leaflets and subvalvular apparatus were fully exposed (*Figure S6*).

Da Vinci robot-assisted mitral valve replacement

Previous preparations were the same as MVP. MVR was performed with standard interrupted suture to preserve the posterior leaflet as much as possible. Briefly speaking, the suture started at the direction of 1 o'clock, then was performed counterclockwise to 6 o'clock, finally clockwise to 6 o'clock along the direction of 1 o'clock. Generally, about 12–14 sutures were required. The assistant placed the prosthetic heart valve to the mitral valve and applied a knot pusher to knot through the work hole. Noticeably, routine exhaust needed to be performed before closing the left atrium (*Figure S7*).

Da Vinci robot-assisted hypertrophic obstructive cardiomyopathy correction

Preliminary preparations were the same as for MVR surgery. Firstly, hypertrophic interventricular septum was removed via anterior mitral leaflet incision. The extent, depth, and length of resection were determined based on preoperative MRI and transesophageal echocardiography (TEE). Rectangular septal dissection started from the lowest point of the right aortic cusp, continued in a counterclockwise direction toward the left fibrous trigone, and was kept away from the non-coronary leaflet. The excision extended from the bottom of the aortic valve cusp to the bottom of the anterior papillary muscle. The continuity of the resected muscle was maintained as much as possible so that a smooth and uniform interventricular septum could be formed (*Figure S8*).