Robotic mitral valve repair: algorithmic approach in degenerative mitral valve disease

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Submitted Oct 27, 2016. Accepted for publication Oct 31, 2016.
doi: 10.21037/acs.2016.11.07
View this article at: http://dx.doi.org/10.21037/acs.2016.11.07

Clinical vignette

Degenerative mitral valve disease is the most common reason for surgical referral of patients with mitral regurgitation (MR) (1). The most recent guidelines strongly recommend mitral valve repair (MVR) over replacement because of higher survival, better preservation of left ventricular function and greater freedoms from endocarditis, thromboembolism, and anticoagulant-related hemorrhage (1). Robotic MVR was introduced in the late-1990s with the goal of improving technical precision of less invasive surgical mitral valve reconstruction. When compared to other less invasive approaches, the advantages of robotic MVR include three-dimensional views of the valve pathology and better maneuverability of the endoscopic instruments.

A 69-year-old lady was referred to our institution for evaluation and management of mitral and tricuspid valve regurgitation (TR). She had been experiencing worsening shortness of breath over the previous 6 months, and she was in New York Heart Association (NYHA) functional class II at the time of surgery. Her past medical history was significant for basal cell carcinoma of the lower lip; however, there was no history of concomitant cardiovascular disease. Physical examination revealed blood pressure of 135/73 mmHg and pulse of 85 BPM. A V/VI holosystolic murmur was detected at the fifth left intercostal space (ICS) radiating to the axilla. Transthoracic echocardiography (TTE) demonstrated a mildly dilated left atrium, normal left and right ventricles with a left ventricular ejection fraction (LVEF) of 63%, and right ventricular systolic pressure (RVSP) of 22 mmHg. There was 4+ MR and 3+ TR with normal aortic and pulmonary valves. The patient underwent thorough perioperative screening for potential robotic mitral and tricuspid valve repair, including coronary angiography to exclude coronary artery disease, thoraco-abdominal computed tomography (CT) scan to ensure feasibility and safety of peripheral perfusion and intraoperative transesophageal echocardiography (TEE) to delineate mitral valve anatomy in detail.

Surgical techniques

Preparation

The patient was positioned supine on the operating table. Induction of general anesthesia was achieved and a double lumen endotracheal tube, routine monitoring lines and a TEE probe were placed. Standard 3D reconstructed imaging on TEE demonstrated a 4+ anteriorly directed regurgitant jet resulting from prolapse, flail, and excessive leaflet motion of the P2 segment of the posterior mitral leaflet with 3+ functional TR due to annular dilatation.

Exposure and cardiopulmonary bypass

The right femoral artery and vein were exposed and found to be suitable for cannulation. The port placement was performed using standard robotic MVR protocol (2). The endoscopic camera port was placed in the infra-mammary crease (4^{th}–5^{th} ICS). The working port incision was placed in the 4^{th} ICS 4 cm lateral to the camera port. The left instrument port was placed one interspace above and approximately halfway between the shoulder and the camera port. The right instrument port was positioned two interspaces below the working port and near the anterior axillary line. The 4th robotic port for the atrial retractor instrument was placed in the 5th ICS medial to the camera port. After cannulation of the superior vena cava (SVC) and femoral vein/inferior vena cava (IVC) and institution of cardiopulmonary bypass, a pericardiotomy was performed anterior to the phrenic nerve. The heart was arrested by occluding the ascending aorta with a Chitwood clamp and administering antegrade cold blood cardioplegia using the del Nido solution.

Operation

A standard left atriotomy incision was made anterior to the right pulmonary veins and the intuitive surgical EndoWrist atrial retractor was positioned to elevate the atrial septum. A small suction vent was positioned in the left atrium to clear the surgical field of blood (*Video 1*).

The mitral valve was exposed and the normal chordae on either side of the prolapsing portion (P2) were identified to determine the extent of resection. A triangular segment of the middle scallop of the posterior mitral leaflet was excised and a running 4-0 prolene suture with ventricularization technique (3) was employed to close the defect in the leaflet. A cleft between the P2 and P3 segments was also closed using running 4-0 prolene suture. The repair was completed using a flexible 35-mm Duran annuloplasty band placed with a running suture technique. The repair was deemed competent following assessment with saline insufflation to fill and pressurize the left ventricle. The left side of the heart was de-aired and the left atriotomy was closed with a running polytetrafluoroethylene (PTFE) suture and several interrupted prolene sutures for reinforcement.

The caval cannulas were backed into the SVC and IVC and the caval snares were tightened down. A right atrial incision was made and a 25-mm Duran annuloplasty band placed with running technique around the tricuspid valve. The right atrium was then closed in two layers with PTFE, the caval tapes were released and the cross-clamp was removed.

Completion

The integrity of the repair (≤ mild residual MR) and adequacy of de-airing was confirmed with the patient off cardiopulmonary bypass before de-cannulation. Once the heart was beating (and preliminary evaluation of the repair by TEE appeared satisfactory), the antegrade cardioplegia catheter was removed from the aorta and the puncture site was closed with a pledget-reinforced 4-0 prolene suture. Intraoperative TEE evaluation demonstrated trivial MR and TR. The postoperative hospital course was without complications. The patient stayed overnight in the intensive care unit (ICU) and had a 4-day hospital length of stay. The TTE at discharge demonstrated normal RV and LV function (LVEF =58%), trivial MR, trivial TR, normal aortic valve, and RVSP of 25 mmHg.

Comments

Robotic MVR is the least invasive type of mitral valve surgery and aims to replicate a high quality, sternotomy based approach. Several recent series have demonstrated excellent outcomes including a hospital mortality rate of <0.9%, stroke rate of 0.6–1.7%, re-exploration for bleeding of 2.2–4.7%, and very low rates of chest wall infections (4). Furthermore, the incidence of iatrogenic aortic dissection, phrenic nerve palsy, and groin infections are approaching 0%. This technique is also associated with a shorter hospital length of stay and quicker return to work when compared to sternotomy; the total hospital cost associated with the use of robotic MVR is now comparable to conventional open operation (30,606 *vs*. 31,310 USD), particularly in high-volume centers (4,5). Furthermore, concomitant Cox-Maze IV procedures (using cryoablation) and tricuspid valve repair can be performed with relative ease. Although several studies confirm these advantageous features of robotic surgery, this approach has not become standard. This is attributable, in part, to certain patient characteristics, including mitral annular calcification, aortic regurgitation and aortoiliac atherosclerosis which serve as relative contraindications to robotic mitral valve surgery. While many of these limitations are grounded more in perception than in reality, each requires careful consideration, and represent opportunities for innovation and improvement that may enable safe and effective use of the surgical robot (4).

In summary, robotic MVR is a safe and effective approach for correcting MR with nearly 100% success in selected patients. Safety and efficiency improve with experience, and algorithm-driven patient selection further enhances clinical outcomes and procedural efficiency.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Cite this article as: Javadikasgari H, Suri RM, Gillinov AM. Robotic mitral valve repair: algorithmic approach in degenerative mitral valve disease. Ann Cardiothorac Surg 2016;5(6):586-588. doi: 10.21037/acs.2016.11.07