Robotic mitral valve replacement for rheumatic mitral disease

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Clinical vignette

A 44-year-old woman presented with dyspnea on exertion. Her past medical history included rheumatic heart disease and she had been followed up for rheumatic mitral valve stenosis for the last 4 years. Her symptoms had worsened over the 3 months prior to her presentation. She was evaluated in the emergency department and electrocardiographic examination revealed atrial fibrillation. Sinus rhythm was achieved with medical treatment. A transthoracic echocardiogram revealed severe mitral valve stenosis (mitral valve area: 0.9 cm^2, mean mitral valve gradient: 14 mmHg), left ventricular ejection fraction of 60%, left ventricular end diastolic dimension of 4.7 cm and pulmonary artery systolic pressure of 55 mmHg. Coronary angiography demonstrated no critical stenosis. She was referred for surgical management and robotic mitral valve replacement was planned.

Surgical techniques

The patient was positioned in the supine position. After induction of general anesthesia, a double-lumen endotracheal tube and transesophageal echocardiography (TEE) probe were placed. A 17-Fr cannula (Medtronic Bio-Medicus, Eden Prairie, MN, USA) was placed percutaneously via the right internal jugular vein and the tip of this cannula was positioned in the right atrium. The right shoulder and the right side of the body were slightly elevated using a medium-sized chest roll. The right arm was placed below the level of the operation table (*Video 1*).

The common femoral artery (CFA) and common femoral vein (CFV) were explored through an oblique 2 cm incision in the groin. After systemic heparinization, the CFA was cannulated with an 18-Fr cannula (Medtronic Bio-Medicus, Eden Prairie, MN, USA) and the CFV was cannulated with a 24-Fr venous cannula (Medtronic Bio-Medicus, Eden Prairie, MN, USA) using the Seldinger technique and TEE guidance. The tip of the venous cannula was placed 1 cm superior to the cavoatrial junction.

A 3 cm incision was made between the anterior axillary line and midclavicular line at the fourth intercostal space. The right lung was deflated and a small soft tissue retractor (Applied Medical, Rancho Santa Margarita, CA, USA) was placed. The camera port was inserted through this soft tissue retractor. The right arm port was placed one or two intercostal spaces inferior to the soft tissue retractor, and the left arm port was placed one intercostal space superiorly. The sites for the two arms were placed in a line perpendicular to the incision at the fourth intercostal space. The left atrial retractor port was placed 3 cm medial to the soft tissue retractor in the same intercostal space. The robotic arms were connected to the ports. Carbon dioxide insufflation was applied at a pressure of 6 mmHg and a flow rate of 6 L/min.

After the institution of cardiopulmonary bypass, the pericardium was opened with an incision starting 2 cm anterior and parallel to the phrenic nerve. Two pericardial retraction sutures were passed through the lateral chest wall and fixed externally.

The transverse sinus of pericardium was controlled with the tip of a suction device for detection of any possible adhesions at the posterior wall of the ascending aorta. A transthoracic Chitwood aortic clamp was inserted through the chest wall in the direction of the transverse sinus. The inferior jaw of the clamp was placed in the transverse sinus. A temporary needle for cardioplegia was placed in the ascending aorta through the soft tissue retractor. The ascending aorta was clamped with the transthoracic clamp.

Cardioplegic arrest was maintained by using a single 2 L dose of crystalloid cardioplegia [histidine-tryptophan-ketoglutarate Bretschneider's solution (Custodiol, Essential Pharmaceuticals, LLC)]. After the arrest was accomplished, the cardioplegia needle was removed. The patient was cooled to 32 ℃.

The inter-atrial groove was dissected and a left atriotomy was performed. The left atrial vent and retractor were placed. The valve was assessed. There was fusion at both commissures and the leaflets were non-pliable, thickened and partially calcified. Thickening of the subvalvular structures was also present. The valve was grabbed with a prograsper and excised using curved scissors. The excised valve was used for sizing the valve prosthesis outside the thoracic cavity. Left atrial cryoablation was then performed with the probe deployed through the soft tissue retractor and positioned by the grasper. The left atrial appendage was also closed.

A total of 14 pledgeted sutures were implanted. The first suture was implanted at the 12 o'clock position and continued counter-clockwise to the 6 o'clock position. The rest of the sutures were then implanted starting from the 12 o'clock position continuing clockwise to the 6 o'clock position. Once all the sutures were completed, they were passed through the annulus of the valve prosthesis (29 mm Medtronic Mosaic Bioprosthetic Valve, Minneapolis, USA) outside the thoracic cavity. The valve was removed from its holder and deployed through the soft tissue retractor. The pledgeted sutures of the valve were secured with an automatic mechanical knot fastening system (Cor-Knot, LSI Solution, Victor, NY, USA).

The atriotomy was closed during rewarming using a premade loop suture. The left atrial vent was left in place. A 'Z'-type suture was passed through the previous cardioplegia needle site in the ascending aorta and a temporary needle for deairing and venting was placed again in the same point of cardioplegia delivery. The left lung was ventilated and the heart was loaded by partially clamping the venous line. After confirmation of deairing by TEE guidance, the cross-clamp was removed. When the systemic arterial pressures returned to within normal limits, the valve prosthesis was assessed using TEE. After confirmation of normal valvular function, the heart was unloaded, the venting needle was removed and the suture at this site was secured using a knot pusher. The left atrial vent was removed and atrial sutures were secured using a knot pusher. Hemostasis of the heart and pericardium was achieved and the robotic arms were removed before the patient was de-cannulated. After strict hemostasis of the thoracic wall, the drainage tube was placed through the right port incision and all incisions were closed in layers.

Comments

Rheumatic heart disease is a common cause of mitral valve disease. Rheumatic mitral valve disease is usually complex and may include severe calcifications affecting the annulus, leaflets and subvalvular apparatus. Thus repair may not always be achievable and the long-term durability of repairs remains questionable (1).

Currently robotic mitral procedures are performed with favorable outcomes and this technique has gained acceptance, especially for mitral repair operations (2). Robotic mitral valve replacement has also been demonstrated to be feasible and safe, particularly for patients with rheumatic etiology and pathology unsuitable for repair (3).

Robotic cardiac procedures have been performed since 2010 in our clinic. Currently mitral valve replacement operations account for nearly 30% of patients within the robotic program. Common features of these patients include echocardiographic demonstration of severe calcification of the leaflets, annulus or subvalvular apparatus, preventing any attempt at repair.

Contraindications for robotic mitral surgery include extensive coronary artery disease requiring bypass surgery, severe peripheral arterial disease precluding peripheral cannulation, redo operations and extensive mitral annular calcification that requires debridement.

The strength of robotic scissors usually precludes annular decalcification. Moreover, robotic mitral operations lack tactile feedback that may be required for determination of the extension of the calcification through the ventricle.

Results of our robotic program have been published (3). Early results demonstrated no mortality and equivalent or superior outcomes when compared to the open surgical technique (postoperative bleeding, intensive care unit length of stay, need for transfusion). Despite this data, the mean cardiopulmonary bypass and cross clamp times were approximately 40% longer when compared to open procedures in the initial phase. However, after approximately 50 cases, these times were no longer significantly different from those observed for open mitral surgery. Currently cross clamp time and cardiopulmonary bypass time for isolated robotic mitral valve replacement are 55–60 and 70–80 minutes respectively.

This operation can also be performed without a robot,

using an anterolateral thoracotomy and endoscopic instruments. However, robotic systems may provide better visualization and dexterity, especially for patients with difficult anatomy. Currently the Da Vinci Si and Xi systems are used for robotic operations. The main difference between these systems is that the latest Xi system provides a laser targeting feature and automated positioning of the device arms according to the type of operation planned. These characteristics standardize the arm positioning and help prevent collision of the arms during mitral operations. An additional important feature is the improved arm angle movement. This feature enables more practical use for cardiac surgery, since the arms are connected perpendicularly to the main shaft and come down directly to the port sites. Another feature of this latest Xi system is the availability of the camera to be used with any port implanted during the operation. This enables the surgeon to interchange the camera between different ports. This important feature enables hemostasis to be more practical.

With regards to operative technique, the main difference in mitral replacement when compared with mitral repair is the need for a 3 cm incision for the soft tissue retractor. We usually prefer a 2 cm working port and a separate camera port at the 4th intercostal space for mitral repair procedures. However an incision of at least 3 cm is required for the deployment of valve prosthesis into the thoracic cavity. In this setting we prefer to place the camera port through this incision.

Currently we use the Cor-Knot device (LSI Solution) for tying the valve sutures. This device offers standard and safe knot tying and helps to decrease cross clamp time (4). A gain of up to 30 seconds per knot can be achieved with this device. We also use handmade loop sutures (Leyla Loop) at both ends for atrial closure to save time (5).

In conclusion, although we have limited knowledge on the mid- and long-term outcomes of patients undergoing robotic mitral valve replacement for rheumatic mitral valve disease, our early results suggest that mitral valve replacement can be performed safely with the robotic technique. The main advantages of this technique over mini-thoracotomy include a smaller thoracotomy, better visualization and exposure of the valve and improved surgical dexterity, especially in patients with difficult anatomy.

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Footnote

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

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