Robotic Trans-Mitral Septal Myectomy and Papillary muscle reorientation for HOCM combined with or without Mitral valve repair: Technical aspects – How we do it

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Abstract

Hypertrophic obstructive cardiomyopathy (HOCM) is one of the more common genetic disorders. The pathophysiology and natural history of the disease have been well studied. Left ventricular outflow tract (LVOT) obstruction and systolic anterior motion (SAM) of the anterior mitral leaflet can result in sudden cardiac death, progressive heart failure and arrythmias. Surgical septal myectomy for HOCM is the standard of care and is routinely performed through a median sternotomy. Septal myectomy has also been performed using the trans-atrial, trans-mitral approach either directly or with robotic assistance. In cases with severe LVOT obstruction in the setting of only mild to moderate proximal septal hypertrophy, intrinsic problems with the mitral valve contribute. Typically, these are hyper-mobile papillary muscles and or excessive height of the anterior mitral leaflet. Combining septal myectomy with reorientation of hyper-mobile anteriorly positioned papillary muscles has shown to prevent SAM and thereby additionally decrease the sub-valvular aortic outflow obstruction. Our extensive experience in both septal myectomy and robotic mitral valve repair has given us a different perspective in approaching the primary mitral regurgitation in HOCM patients where a combined septal myectomy, papillary muscle reorientation and complex mitral valve repair has been safely performed using the less invasive robotic-assisted approach. Our objective here is to discuss the technical aspects of the procedure.

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ABSTRACT

Hypertrophic obstructive cardiomyopathy (HOCM) is one of the more common genetic disorders. The pathophysiology and natural history of the disease have been well studied. Left ventricular outflow tract (LVOT) obstruction and systolic anterior motion (SAM) of the anterior mitral leaflet can result in sudden cardiac death, progressive heart failure and arrythmias. Surgical septal myectomy for HOCM is the standard of care and is routinely performed through a median sternotomy. Septal myectomy has also been performed using the trans-atrial, trans-mitral approach either directly [1, 2] or with robotic assistance [3, 4]. In cases with severe LVOT obstruction in the setting of only mild to moderate proximal septal hypertrophy, intrinsic problems with the mitral valve contribute.[5]Typically, these are hypermobile papillary muscles and or excessive height of the anterior mitral leaflet. Combining septal myectomy with reorientation of hypermobile anteriorly positioned papillary muscles has shown to prevent SAM and thereby additionally decrease the sub-valvular aortic outflow obstruction.

Our extensive experience in both septal myectomy and robotic mitral valve repair has given us a different perspective in approaching the primary mitral regurgitation in HOCM patients where a combined septal myectomy, papillary muscle reorientation and complex mitral valve repair has been safely performed using the less invasive robotic-assisted approach.

Our objective here is to discuss the technical aspects of the procedure.

SURGICAL TECHNIQUE

All patients undergo pre-operative CT angiography to rule out aorto-iliac atherosclerosis in order to substantially decrease the risk of stroke. Magnetic resonance imaging (MRI) assessment and multimodality echo are used for the surgical planning of the myectomy and mitral valve repair. After anesthesia, a trans-esophageal echocardiogram (TEE) is done to assess the safety of a robotic approach as well as to provide an accurate evaluation of the septal thickness in different areas. Routine robotic mitral valve surgical setup was used for all the cases as described by Gillinov and colleagues.[6]

After systemic heparinization, the femoral vein then artery are cannulated. An additional right internal jugular vein cannula is added according to the patient's body surface are as required. Once cardiopulmonary bypass (CPB) is instituted, both lungs are deflated. The pericardium is then opened approximately 2-3 cm anterior to the right phrenic nerve and tacked towards the chest wall. An antegrade cardioplegia cannula is inserted and secured. A transthoracic aortic cross-clamp is then inserted via a separate incision in the third or fourth intercostal space laterally, and carefully placed along the transverse sinus.

Once the aortic clamp is applied, del Nido crystalloid cardioplegia solution is given. The robotic arms (DaVinci systems) are docked to the ports.

The left atrium is incised. A left atrial retractor and cardiotomy suction are inserted. The mitral valve is exposed (Figure 1). The anterior mitral leaflet is incised superiorly a few millimeters away from its annular attachment and detached from commissure to commissure (Figures 2 and 3), and can be extended medially as required. This exposes the interventricular septum and the undersurface of the aortic valve (Figure 4). Septal Myectomy is performed using the robotic scissors, while taking great care not to damage the aortic valve (Figure 5). The resection is wide, carried out across the area opposing both fibrous trigones and extended towards the mid-cavitary portion, resulting in a smooth and even interventricular septum. The amount of resection is planned according to the pre-operative imaging from MRI and TEE.

The anterior mitral leaflet is then reattached to its annulus using continuous 4-0 polypropylene sutures, simultaneously reducing its height (Figure 6). Any abnormally oriented hypermobile anterior papillary muscle heads (Figure 7) are then re-oriented by fixing each to more centrally located, posterior papillary muscle sub-heads (Figure 8) using 3-0 polyprolylene sutures with polytetrafluoroethylene (PTFE) felt pledgets.

Typically, our surgical technique for mitral valve repair in degenerative mitral regurgitation utilizes Gore-Tex CV-4 (W. L. Gore & Associates, Flagstaff, Arizona) neo-chords, creating a more posteriorly positioned zone of coaptation. This is achieved by purposely making these neo-chords short, thereby moving the zone of coaptation well posteriorly, in order to decrease the risk of SAM. In myectomy cases, depending upon the LVOT and mitral valve, we sometimes complete the repair with annuloplasty using an appropriately sized mitral Medtronic Duran AnCore® Annuloplasty band System.

The left atrium is closed using Gore-Tex CV-4 after de-airing maneuvers. We use carbon dioxide throughout the procedure routinely to help us in de-airing the heart. A ventricular pacing wire is inserted onto the right ventricle. The aortic cross-clamp is then removed. We come off CPB initially with left lung ventilation to assess the LVOT gradients, mitral valve, aortic valve and ventricular contractility. Once satisfied with the result, we go back on CPB again to reinforce the left atrial suture line with 4-0 Prolene. The robotic arms are then undocked and the patient is finally successfully weaned off CPB.

DISCUSSION

The robotic assisted trans-mitral septal myectomy and papillary muscle re-orientation for HOCM is less invasive compared to the sternotomy procedure and can be safely performed when combined with complex mitral valve repairs.

Trans-aortic septal myectomy is a safe and reproducible technique for relief of LVOT obstructions due to HOCM. Done in expert hands the results are outstanding.[7] Maneuvers like papillary muscle reorientation are done concomitantly through the trans-aortic approach.[8] This approach also gives excellent exposure for mid-cavitary obstructions.[9]

Introduced by Dr. Chitwood, robotic assisted septal myectomy has proven itself as an alternate approach for myectomies[3, 4]. From our extensive experience in both robotic mitral repairs and trans-aortic myectomies, we found it appealing to approach patients needing both myectomies and primary mitral valve repairs robotically. The visualization of the interventricular septum is more direct and better magnified with the robotic assistance and the entire septum is well visualized. The aortic valve is not touched and hence the potential complications from a trans-aortic septal myectomy can be avoided. It is also easy to identify the papillary muscle heads with the direct maneuvering of the robotic camera and the retractor. The detachment of the anterior mitral leaflet and its subsequent reattachment shortens the very tall anterior leaflet which helps to prevent SAM. The ideal candidate is a patient with a combination of HOCM and primary mitral valve disease, which then both can be addressed robotically.

A longer robotic scissor would facilitate easier resection, and is a potential minor limitation of this technique. We need to study additional data on long-term outcomes in a larger cohort of patients. Nevertheless, our technique is a safe, reproducible alternative approach for a well-established procedure.

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Figure Legends:

Figure 1: Exposure of Mitral Valve through Left atrium

Figure 2: Incision line of the anterior mitral leaflet

Figure 3: Detachment of anterior mitral leaflet

Figure 4: Exposure of the interventricular septum

Figure 5: Septal myectomy using robotic scissors

Figure 6: Re-attachment of anterior mitral leaflet

Figure 7:HOCM and SAM from anterior papillary muscle. The planned resection line shown in dashes.

Figure 8: Re-oriented papillary muscle heads