Title: Redo Robotic-Assisted Transcatheter Mitral Valve Replacement in a Patient with Mitral Annular Calcification

Authors: James L. West, MD[1]; Andrew M. Frey, DO[1]; Clifton T. Lewis, MD[2]; Mustafa I. Ahmed, MD[2]; Kyle Eudailey, MD[2]; Panos N. Vardas, MD[2]

Corresponding Author:

Panos N. Vardas, MD
Division of Cardiothoracic Surgery
University of Alabama at Birmingham
1900 University Blvd
THT712
Birmingham, AL 35294
pvardas@uabmc.edu

Author Affiliations:

[1]Department of Surgery, Brookwood Baptist Health System, Birmingham, Alabama; [2]Division of Cardiothoracic Surgery, University of Alabama at Birmingham (UAB) Hospitals, Birmingham, Alabama;

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Abstract

Mitral valve replacement in the setting of mitral annular calcification (MAC) remains a surgical challenge fraught with several known complications. We present an innovative and hybrid approach involving robotic-assisted deployment of a SAPIEN S3 (Edwards Lifesciences, Irvine, CA) in the mitral position of a patient with severe MAC in the setting of previous sternotomy for aortic valve replacement. The robotic platform allowed avoidance of redo sternotomy, paravalvular leaks adjustment through excellent visualization from the right chest, and better assessment of the risk of left ventricular outflow tract obstruction. This report serves as an alternative technique for the management of mitral valve surgery associated with MAC in the era of transcatheter and minimally-invasive cardiac operations.

Keywords

Mitral Annular Calcification, Mitral Valve, Robotic Cardiac Surgery

Background

The surgical management of patients requiring mitral valve replacement (MVR) in the setting of mitral annular calcification (MAC) continues to be a challenge. Surgical replacement has well known complications, most notably paravalvular leaks (PVL), left ventricular outflow tract (LVOT) obstruction, and increased risk for atrioventricular disruption.[1,2,3] Strategies to address these complications have continued to evolve with further catheter-based delivery systems, transapical, and transseptal approaches. Increasingly, robotic mitral valve surgery has become an often utilized platform for complex mitral valve disease.[10] However, in MAC patients, who already tend to be older with multiple comorbidities[4], the need for redo operations and innovation remains. Here, we describe a case of a hybrid technique involving redo robotic-assisted surgery and transcatheter deployment of a SAPIEN S3 valve (Edwards Lifesciences, Irvine, CA) in the mitral position of a patient with severe MAC.

Case Presentation

A 79-year-old female with a history of previous surgical aortic valve replacement, atrial fibrillation, hypertension, and hyperlipidemia presented with progressive shortness of breath and fatigue. Pre-operative CT and transesophageal echocardiogram (TEE) revealed heavy MAC and severe mitral insufficiency (Figure 1). Her Society of Thoracic Surgeons Predicted Risk of Mortality for open surgical MVR was 5.46 percent. The patient was not a candidate for MitraClip (Abbott Vascular, Chicago, IL) secondary to heavy leaflet calcification and inadequate leaflet length for grasping. The patient had Carpentier Class IIIA valve dysfunction. Based on her preoperative CT scan and echocardiogram, it was felt that a trans-septal approach would have caused significant LVOT obstruction due to septal hypertrophy. Additionally, CTA was performed preoperatively with our institution’s transcatheter aortic valve replacement (TAVR) protocol to assess the severity of the MAC and post-operative LVOT size, for a possible transeptal mitral valve replacement approach, which was deemed too high risk for LVOT obstruction. In addition, the CTA provided an accurate assessment of the femoral vessels for peripheral cardiopulmonary bypass (CPB). After right groin cut-down, the femoral artery and vein were cannulated with TEE guidance. Robotic ports were inserted (Figure 2). A 1 cm stab wound was then created in the right fourth intercostal space lateral to the midclavicular line. A camera port was placed. Left, right, and third arm retractor 8 mm ports were placed. Retraction sutures to the pericardium and diaphragm were placed through angiocath punctures into the chest wall. The ascending aorta was then cross-clamped using occlusion intra-aortic balloon technology. The heart obtained a diastolic flaccid arrest with the administration of Del Nido cardioplegia.

After accessing the left atrium through the Waterson's groove, a thorough and segmental assessment of the mitral valve was performed. There was severe annular calcification (mostly in the posterior annulus) and the leaflets were thickened and the corde retracted. Due to the thickened and calcified valvular and sub-valvular apparatus, a repair was deemed not feasible. In addition, the annulus had asymmetric calcification and this was extending into the atrial tissue and beyond the annulus. It was felt that a standard MVR would be of a risk for atrioventricular groove disruption and para-valvular leak, so the decision was made to proceed with a transcatheter direct deployment of an TAVR valve in the mitral position. We resected most of the anterior leaflet of the mitral valve, leaving a third of the leaflet behind and attached the calcified annulus. We then balloon sized directly in the annulus and selected a 26mm SAPIEN S3. Direct open measurement, as opposed to CT measurements preoperatively, allowed for a more accurate sizing. Prior to crimping the valve, a 1 cm wide Felt strip was sewn to the valve and around the ring and extending inferiorly into the skirt. The valve was then crimped. It was placed on the delivery device and advanced through the trocar. Under direct visualization with the robotic camera, the valve was guided into place and deployed. The valve was balloon-dilated once post-deployment.

Multiple pledgeted 2-0 Ethibond (Ethicon Inc., Somerville, NJ) sutures were then placed between the annulus (when feasible) or more often the atrial muscle and the edge of the sewing cuff of the S3 to reinforce the sealing and prevent PVL. Sutures were secured with COR-KNOT (LSI Solutions, Victor, NY). Next, the valve was tested with saline irrigation to ensure that all leaflets coapted and there was no PVL. The left atriotomy was closed and the patient was weaned from CPB uneventfully. TEE showed a well seated mitral valve, with no PVL and no LVOT obstruction. Total cardiopulmonary bypass time was 85 minutes and cross clamp time was 60 minutes.

The patient's postoperative course was uneventful, and she was discharged home on postoperative day five. Patient has continued to do well now three years postoperatively. The most recent echocardiogram showed well seated valve with expected and normal gradient, no PVL and no LVOT.

Discussion

The surgical treatment of mitral valve disease is complicated by the presence of MAC. Moreover, the MAC patient population is at a higher surgical risk due to the associated comorbidities of MAC.[5] MAC has been shown to be associated with advanced age, obesity and end stage renal dysfunction.[4] Furthermore, there are anatomical issues with mitral valve replacement, such as absence of a rigid annulus to stabilize a prosthesis and the possibility of LVOT obstruction by displacement of the anterior mitral valve leaflet. Extensive or circumferential MAC may actually help the previously mentioned annulus issues by providing a more rigid platform to deploy the valve. However, the presence of this calcium ring increases the rate of PVL.

Early data from transseptal and transapical mitral valve replacements in MAC has shown a high incidence of PVLs and LVOT obstruction.[3, 5] Furthermore, LVOT obstruction after transcatheter valve placement appears to have an extremely high mortality: Guerrero et al reported 116 patients undergoing balloon-expandable transcatheter mitral valve replacement, with only 2 of the 13 patients that had postoperative LVOT obstruction surviving at the 1 year follow up.[3]

In this setting, multiple techniques were used to decrease the chance of PVL, including the felt skirt sutured around the sewing cuff of the prosthesis. Robotic deployment of the valve also allows for reinforcement sutures, similar to open technique. We used pledgeted Ethibond (Ethicon Inc., Somerville, NJ) to secure the valve to the annulus. The valve is inspected and tested with saline for leaks prior to CPB wean. Additionally, our technique potentially decreases the risk of LVOT obstruction by resecting the anterior mitral leaflet with the sub-valvular attachments. Russell and colleagues published a case series of 8 patients that underwent open transatrial deployment of a SAPIEN valve. They used a felt skirt and resected the anterior leaflet via a sternotomy or a mini-thoracotomy[6]. To our knowledge, a robotic approach of this technique has not been described yet. The robotic assisted technology adds a superior visualization with the 3D image representation and adds surgical precision through the ergonomic movements of the robotic arms.

Transseptal approaches are less invasive than open deployment of the valve, but they do not address potential LVOT obstruction or PVL.[7,8] The robotic approach not only addresses these issues, but also provides a less invasive approach resulting in decreased transfusion rates, decreased wound infection rates, shortened length of stay, and earlier return to full activity compared with traditional sternotomy or thoracotomy-transatrial deployment of a balloon expandable valve.[9,10] As experience grows with primary interventions, more complex and reoperative surgery utilizing the robotic platform will continued to expand allowing the avoidance of reoperative sternotomy. This case serves as an alternative approach to a challenging and high-risk surgical setting.

List of abbreviations

MAC - Mitral Annular Calcification
PVL - Paraventricular Leak
LVOT - Left Ventricular Outflow Tract
TAVR - Transcatheter Aortic Valve Replacement
TEE - Transesophageal Echocardiogram
MVR - Mitral Valve Replacement
CPB - Cardiopulmonary Bypass

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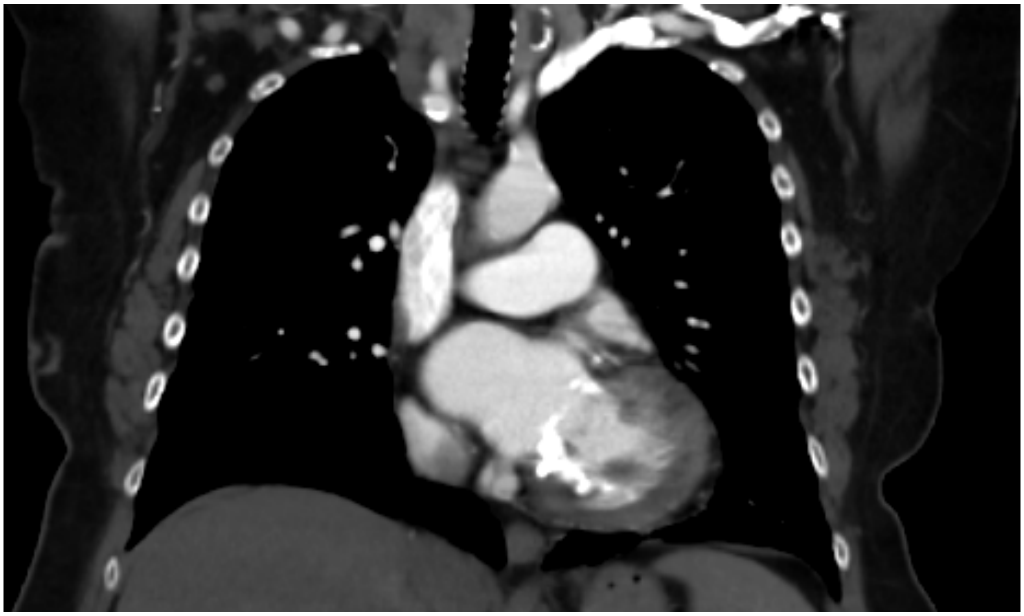

Figure 1: Visualization of MAC on preoperative CT

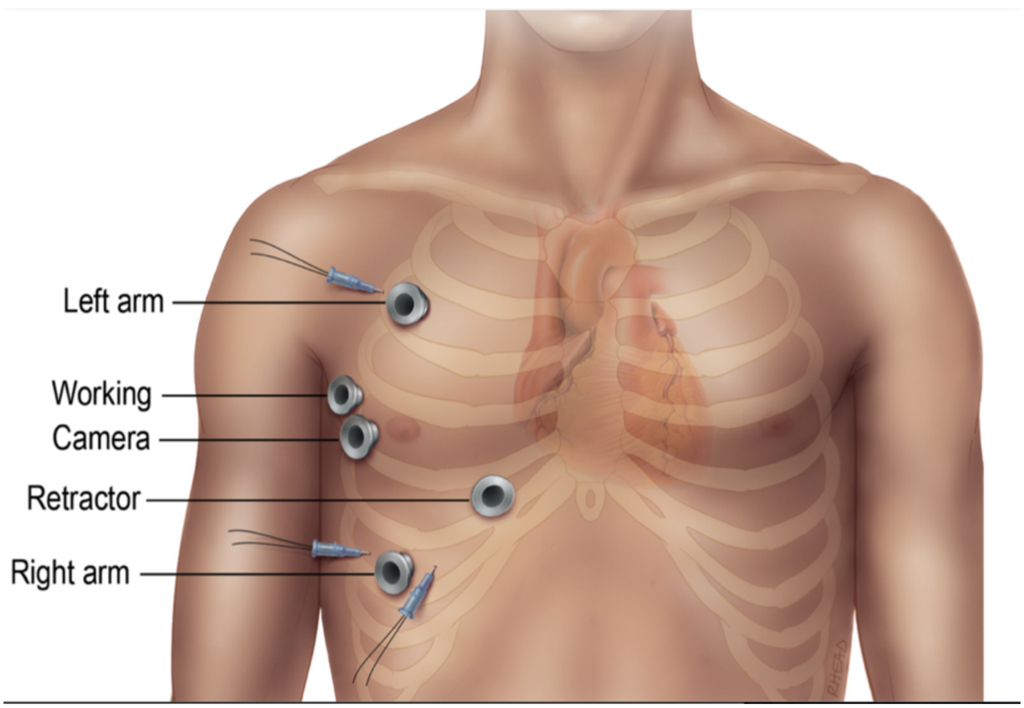

Figure 2: Schematic Illustration of Robotic Trocar Sites and functional use