Feasibility and safety of robotic aortic root enlargement in conjunction with robotic aortic valve replacement

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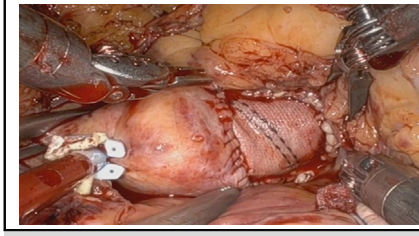

Robotic aortic root enlargement with polyethylene terephthalate patch augmentation.

Video clip is available online.

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CENTRAL MESSAGE

In patients with small or complex aortic anatomy, robotic aortic root enlargement may be safely performed concomitant to robotic aortic valve replacement.

Approaches to minimally invasive surgical aortic valve replacement (SAVR) include mini upper sternotomy, right anterior thoracotomy, and robotic-assisted aortic valve replacement (RAVR) performed via a 3-cm mini axillary line lateral thoracotomy.[1]

Aortic root enlargement (ARE) is commonly performed in the management of the small or calcified aortic root that may or may not be accompanied by annular enlargement. This is of particular benefit for patients with a potential for patient-prosthesis mismatch (PPM). At the time of sternotomy SAVR, ARE has been extensively described with reproducible outcomes.[2,3] The most common ARE technique without annular enlargement is the modified Nicks technique whereby the aortotomy is extended through the noncoronary sinus to, but not across, the aortic annulus, and patch augmentation of the root is facilitated by either pericardium or polyethylene terephthalate.

This is the first description of ARE using the robotic platform. Since our first case on May 12, 2020, we herein describe our experience with robotic ARE utilizing similar techniques used in open cases that include diamond patch augmentation of the noncoronary sinus with polyethylene terephthalate or pericardium, and a complete noncoronary to anterior root gusset enlargement. Three sample cases in which ARE was accomplished robotically concomitant to RAVR are shown. The study was approved by the Institutional Review Board of West Virginia University for retrospective analysis of de-identified clinical data (No. 2005016064; Approval date May 29, 2020; expiration date May 28, 2025).

CASE SCENARIOS

The first case was a 65-year-old man with severe symptomatic aortic stenosis (AS) and mild aortic insufficiency presenting with class III symptoms and normal ejection fraction. His body mass index was 41 with significant obstructive sleep apnea. RAVR was recommended by the heart team. As previously described,[1] RAVR was approached through a 3-cm minimally invasive nonrib-spreading right lateral thoracotomy, identical to the robotic mitral platform, at the level of the axillary line in the fourth intercostal space facilitated by the DaVinci Xi robot (Intuitive Surgical). After aortic crossclamping and cardioplegic arrest, the aortotomy was extended through the noncoronary sinus and the aortic valve was excised robotically. To avoid PPM, an upsized 25-mm mechanical prosthesis was implanted robotically. Much like we perform in open cases, ARE was commenced with a single pledgetted 4-0 polypropylene suture anchoring a polyethylene terephthalate patch in a horizontal mattress fashion

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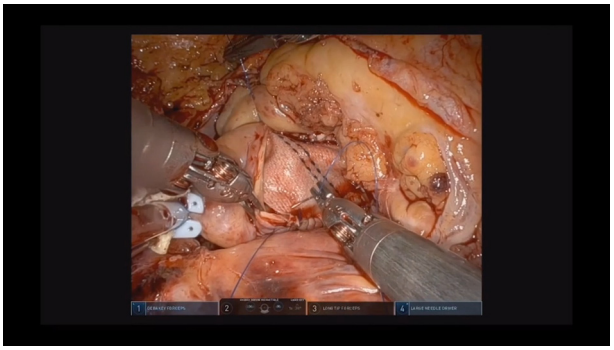

VIDEO 1. Robotic aortic root enlargement concomitant to aortic valve replacement. Video available at: https://www.jtcvs.org/article/S2666-2507(23)00369-3/fulltext.

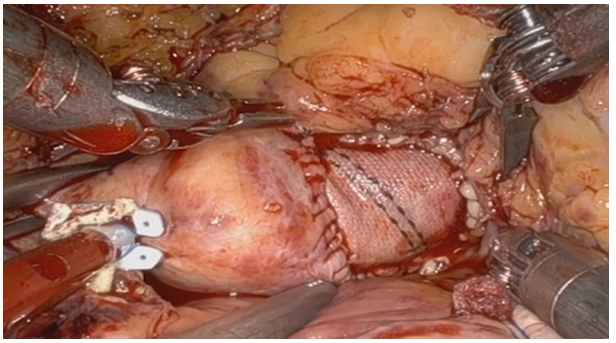

FIGURE 1. Robotic aortic root enlargement with polyethylene terephthalate gusset patch augmentation concomitant to robotic aortic valve replacement.

(Video 1). The patch was then sewn to the aorta in a single running layer, augmenting the noncoronary sinus. Next, the patch was cut in a diamond fashion and completed with a transition suture at the midpoint of the aortotomy. Following closure of the aortotomy from the lateral aspect using a separate 4-0 polypropylene suture in 2 layers, the closure and ARE were tested for hemostasis with antegrade cold-blood cardioplegia. Crossclamp and pump time was 137 and 183 minutes, respectively. Mean gradient at 30 days and 1 year was 5.9 and 5.0 mm Hg, respectively.

The second case was a 64-year-old obese man presenting with severe AS and an ejection fraction of 55%. He had a body mass index of 35 and insulin-dependent diabetes mellitus. RAVR with a 23-mm bioprosthesis and ARE with autologous pericardial patch was performed. The pericardial patch was harvested robotically, fashioned in a diamond shape, and secured to complete the ARE and aortotomy closure as outlined in the first case. Crossclamp and pump time was 140 and 192 minutes, respectively. Mean gradient at 30 days was 12 mm Hg.

The third case was a complex 67-year-old woman presenting with severe AS, normal ejection fraction, obesity, body mass index of 34, and long-standing persistent atrial fibrillation. She had a small aortic root with an 18- to 19-mm annulus. Robotic biatrial Cox-maze cryoablation and RAVR was performed. After completion of biatrial cryoablation, an upsized 21-mm bioprosthesis was accommodated by extending the aortotomy through the midpoint of the noncoronary sinus to the aortic annulus. Given the small aortic root, a gusset patch augmentation with polyethylene terephthalate, encompassing the entire anterior aorta was performed (Figure 1). Crossclamp and pump time was 222 and 282 minutes, respectively. Mean gradient at 30 days was 3 mm Hg. All 3 cases were either extubated in the operating room or within 4 hours postoperatively. All were discharged home with an uneventful postoperative course.

DISCUSSION

The association between PPM and worse outcomes following SAVR has been well documented.[2-4] In addition, the increasing application of valve-in-valve transcatheter AVR after SAVR further underscores the importance of avoiding 19-mm prostheses, and thus the potential augmented application of ARE at the time of SAVR to facilitate implantation of larger prostheses, particularly for those at risk for PPM.

RAVR is emerging as potential alternative technique to other surgical and transcatheter approaches to aortic valve disease.[1,5] Robotic ARE may complement the already established RAVR technique by following open ARE principles. Between January 2020 and April 2023, 170 consecutive RAVR operations were performed at our institution. Nineteen patients underwent robotic ARE (11.1%), in a similar frequency to our open SAVR experience. All patients had severe AS (6 bicuspid and 13 tricuspid). The average age was 66 years (range, 42-78 years) and body mass index was 33.3 (range, 23-43). The mean prosthesis size was 23 (range, 21-27), 3 of which were mechanical. Robotic ARE was performed due to a small aortic root in 5, calcified root in 3, and to avoid PPM by valve upsizing in 11. Patch reconstruction was done as a diamond in 11 and full gusset in 8 patients, facilitated by autologous pericardium in 6 and polyethylene terephthalate in 13 patients. The mean time to perform ARE was 48.5 $\pm$ 16.5 minutes. There were no mortalities or reoperations for bleeding. All patients were extubated within 8 hours, 13 (68.4%) in the operating room. Transthoracic echocardiogram at 1 month showed normal hemodynamic status with physiologic valve gradients in all patients.

Our series demonstrates robotic ARE at the time of RAVR is feasible and safe. By adapting techniques similar to open cases, robotic ARE may mitigate PPM in patients with a small or complex aortic root anatomy.

Webcast

You can watch a Webcast of this AATS meeting presentation by going to: https://www.aats.org/resources/robotic-assisted-aortic-root-enlargement-concomitant-to-aortic-valve-replacement.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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Key Words: aortic valve replacement, robotic cardiac surgery, aortic root enlargement