Feasibility and Safety of Robotic Aortic Root Enlargement in Conjunction with Robotic Aortic Valve Replacement

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Abbreviations

ARE  Aortic Root Enlargement
AS   Aortic Stenosis
EF   Ejection Fraction
PPM  Patient-prosthesis mismatch
RAVR Robotic Aortic Valve Replacement
SAVR Surgical Aortic Valve Replacement
TAVR Transcatheter Aortic Valve Replacement

Central Picture Legend (63/90 characters): Robotic aortic root enlargement with Dacron patch augmentation.

Central Message (154/200 characters): In patients with small or complex aortic anatomy, robotic aortic root enlargement may be safely performed concomitant to robotic aortic valve replacement.
Introduction

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 Dacron. This is the first description of ARE using the robotic platform. Since our first case on May 12, 2020, we hereby describe our experience with robotic ARE utilizing similar techniques used in open cases that include diamond patch augmentation of the non-coronary sinus with Dacron or pericardium, and a complete non-coronary 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 (#2005016064; Approval date 05/29/2020; Expiration date 05/28/2025).

Case Scenarios

The first case was a 65-year-old male with severe symptomatic aortic stenosis (AS) and mild aortic insufficiency presenting with class III symptoms and normal EF. His BMI was 41
kg/m$^2$ with significant obstructive sleep apnea. RAVR was recommended by the Heart team. As previously described, RAVR was approached through a 3 cm minimally invasive non rib-spreading right lateral thoracotomy, identical to the robotic mitral platform, at the level of the axillary line in the 4th intercostal space facilitated by the DaVinci Xi robot (Intuitive Surgical, Sunnyvale, CA). After aortic cross-clamping and cardioplegic arrest, the aortotomy was extended through the non-coronary sinus and the aortic valve was excised robotically. To avoid PPM, an upsized 25mm 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 Dacron patch in a horizontal mattress fashion (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 mid-point of the aortotomy. Following closure of the aortotomy from the lateral aspect using a separate 4-0 polypropylene suture in two 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 mmHg, respectively.

The second case was a 64-year-old obese male presenting with severe AS and an EF of 55%. He had a BMI of 35 kg/m$^2$ 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 mmHg.

The third case was a complex 67-year-old female presenting with severe AS, normal EF, obesity, BMI of 34 kg/m$^2$, and long-standing persistent atrial fibrillation. She had a small aortic
root with an 18-19 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 mid-point of the non-coronary sinus to the aortic annulus. Given the small aortic root, a gusset patch augmentation with Dacron, 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 mmHg. All three cases were either extubated in the operating room or within four 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. In addition, the increasing application of valve-in-valve TAVR 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, particularly for those at risk for PPM.

RAVR is emerging as potential alternative technique to other surgical and transcatheter approaches to aortic valve disease. 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, 13 tricuspid). The average age was 66 years (range 42-78) and BMI was 33.3 (23-43 kg/m2). The mean prosthesis size was 23 (21-27), three 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 Dacron in 13 patients. The mean time to perform ARE was 48.5 ± 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 hemodynamics 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.
References


Figure and Video Legend

Central Figure  Robotic aortic root enlargement with Dacron gusset patch augmentation concomitant to RA V R.

Figure 1  Robotic aortic root enlargement with Dacron gusset patch augmentation concomitant to RA V R

Video 1  Robotic Aortic Root Enlargement Concomitant to Aortic Valve Replacement
Robotic Aortic Root Enlargement
*Concomitant to Aortic Valve Replacement*

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