Masters of Cardiothoracic Surgery

Robotic aortic valve replacement and aortic root enlargement for optimal prosthesis selection

Ali Darehzereshki, Lawrence Wei, J. Hunter Mehaffey, Goya Raikar, Vinay Badhwar

Department of Cardiovascular and Thoracic Surgery, West Virginia University, Morgantown, WV, USA

Correspondence to: Ali Darehzereshki, MD. Department of Cardiovascular and Thoracic Surgery, West Virginia University, 1 Medical Center Drive, Morgantown, WV 26506, USA. Email: ali.darehzereshki@wvumedicine.org.

Keywords: Robotic aortic valve replacement (RAVR); aortic root enlargement (ARE); patient-prosthesis mismatch (PPM)

Submitted Dec 01, 2024. Accepted for publication Feb 14, 2025. Published online May 29, 2025.
doi: 10.21037/acs-2024-ravr-0183
View this article at: https://dx.doi.org/10.21037/acs-2024-ravr-0183

Clinical vignette

A 67-year-old female presented with severe aortic stenosis and New York Heart Association Class III symptoms. She had a body mass index (BMI) of 36 kg/m^2 and a history of long-standing persistent atrial fibrillation and left atrial thrombus on oral anticoagulation, permanent pacemaker implantation for sick sinus syndrome with high grade atrioventricular (AV) block, stage 3 chronic kidney disease, insulin-dependent diabetes, hypertension, hyperlipidemia, obstructive sleep apnea and moderate right carotid stenosis with recurrent transient ischemic attack (TIA). Echocardiogram showed a left ventricular ejection fraction of 60%, severe aortic stenosis and a small aortic root with an annulus measuring 18 mm. Cardiac catheterization showed non-obstructive coronary artery disease. Her calculated Society of Thoracic Surgery (STS) predicted risk of mortality was 4%. Despite several comorbidities, she was still independent and cared for her grandchildren. Concomitant robotic aortic valve replacement (RAVR) with aortic root enlargement (ARE) and biatrial Cox-maze cryoablation with left atrial appendage obliteration was recommended.

Surgical techniques

Preparation

Prior to induction of double lumen endotracheal anesthesia, patient received upper extremity arterial monitoring and intra-thecal injection of 0.1 mg morphine sulfate. The patient was positioned supine with a bumper under the right shoulder to facilitate a right lateral trans-axillary approach.

Exposition

The development, implementation and technical details of RAVR have been described previously (1). In summary, RAVR was approached through a 3 cm minimally invasive rib sparing right lateral thoracotomy at the level of the axillary line in the fourth intercostal space facilitated by the DaVinci Xi robot (Intuitive Surgical, Sunnyvale, CA, USA). Cardiopulmonary bypass (CPB) was initiated via peripheral cannulation established through right common femoral artery and vein and right internal jugular vein, as well as a 5-French distal perfusion catheter in the superficial femoral artery connected to the ipsilateral arterial cannula. An aortic root vent was then placed through the 3 cm working incision followed by a left ventricular vent through the right superior pulmonary vein via a separate chest wall stab incision. The DaVinci Xi robot was used with the camera port through the working incision (arm 2). Three additional ports included DeBakey forceps (arm 1), long-tip grasping forceps (arm 3) and scissors/needle driver (arm 4). A transthoracic aortic cross-clamp was then applied and antegrade cardioplegia solution was delivered via the aortic root.

Under full robotic assistance, a slightly modified transverse aortotomy at the sinotubular junction was extended down to the midpoint of the non-coronary sinus to provide excellent visualization of the aortic valve. The

aortic valve was then excised robotically. The steps for implantation of prosthetic valve include placement of circumferential interrupted 2-0 braided polyester sutures, valve sizing using conventional surgical aortic valve replacement (SAVR) sizers, passing the sutures through the sewing ring of the prosthesis, delivery of the valve through the working incision and securement using suture fasteners (Cor-Knot; LSI Solutions, Victor, NY, USA).

Operation

ARE was performed through a modified Nicks technique by extending the aortotomy through the mid-point of the non-coronary sinus to the aortic annulus. Following implantation of a 23 mm prosthesis, and similar to conventional open techniques, the ARE was commenced with a single pledgetted 4-0 polypropylene suture anchoring a Dacron patch in a horizontal mattress fashion (*Video 1*, case 3). The patch was then sewn to the aorta, proximally and distally, in a single running layer, to replace the non-coronary sinus and the entire anterior aorta as a gusset patch augmentation. Alternatively, a pericardial patch can be fashioned to facilitate this full augmentation. Less commonly, as shown in our initial series (2), a diamond shaped pericardial or Dacron patch is used to augment the non-coronary sinus with a transition suture at the mid-point of the aortotomy (*Video 1*, cases 1 and 2).

Completion

After completion of aortotomy closure, the repair and ARE patch were tested for hemostasis with antegrade cold-blood cardioplegia. In concomitant surgery for atrial fibrillation, a biatrial Cox-maze cryoablation and left atrial appendage obliteration is typically completed prior to RAVR ARE. The heart was then reanimated, the cross-clamp was released, the robot undocked and the patient was weaned from CPB, decannulated and closed.

Comments

Clinical results

Since the initiation of RAVR in January 2020, approximately 12.3% of patients underwent robotic ARE, which is similar in frequency to open SAVR ARE in our institution. Robotic ARE was performed due to a small or calcified aortic root, but most commonly to avoid patient-prosthesis mismatch (PPM) by valve upsizing. The average BMI was 30.9 kg/m^2 (range, 18–43 kg/m^2) and the mean prosthesis size was 23 mm (range, 21–27 mm). There were no mortalities, readmissions or reoperations for bleeding. Transthoracic echocardiogram at one month showed normal hemodynamics with physiologic valve gradients in all patients.

Advantages

PPM after SAVR has been well documented to be associated with worse outcome (3-5). Furthermore, the growing application of valve-in-valve transcatheter aortic valve replacement (TAVR) after SAVR underlines the importance of avoiding a 19 mm prostheses. This highlights the potential increased role of ARE during SAVR, particularly for patients at risk for PPM. Robotic ARE follows the same open surgical principles and could serve as a valuable complement to the well-established RAVR technique. Our standard approach to ARE is a modified Nicks root enlargement with full gusset patch augmentation of the non-coronary sinus and entire anterior aorta using Dacron or pericardium. A diamond shaped pericardial or Dacron patch with a transition suture at the mid-point of the aortotomy was used in our initial experience to augment the non-coronary sinus (2). Our series demonstrate robotic ARE at the time of RAVR is feasible, safe and may mitigate PPM in patients with small or complex aortic root anatomy.

Caveats

Robotic-assisted ARE requires technical proficiency in RAVR and careful patient selection. The modified Nicks technique applied in our series enlarges the aortic root, which allows for a one to two size larger valve to be inserted. An inverted Y-incision with rectangular patch may be performed to upsize the annulus by two to three sizes.

Acknowledgments

None.

Footnote

Funding: None.

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

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Cite this article as: Darehzereshki A, Wei L, Mehaffey JH, Raikar G, Badhwar V. Robotic aortic valve replacement and aortic root enlargement for optimal prosthesis selection. Ann Cardiothorac Surg 2025;14(3):238-240. doi: 10.21037/acs-2024-ravr-0183