VALVE AND AORTA SPARING ROOT TO ARCH REINFORCEMENT

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ABSTRACT

Bicuspid aortopathy carries indeterminate, elevated risks of potentially fatal complications, including Stanford type A, or less frequently, non-A non-B aortic dissection and rupture. Even so, available conventional modalities to prophylactically address progressive aortic root to arch dilatation, and/or a bicuspid aortic valve, are associated with not insignificant perioperative morbidity and mortality, in addition to long-term implications pertaining to the choice of aortic valve intervention.

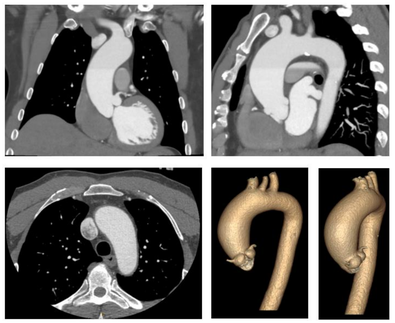
As a valve-sparing, beating heart alternative to traditional procedures, we utilized an innovative surgical technique that enables the personalized external aortic root support procedure to be extended distally to encompass the aortic arch, in two of the first successful live in-human cases worldwide. These techniques apply external reinforcement principles to preserve and biomechanically 'stabilize' the native aorta from the ventriculoaortic (VA) junction to the distal aortic arch, just beyond to the left subclavian artery (Ishimaru zone 0 to 2).

Early outcomes suggest stabilization or reduction of aortic dilatation within the prostheses, while mitigating the need for aortic valve replacement, cardiopulmonary bypass, cardioplegic cardiac arrest, circulatory arrest, interruption to cerebral perfusion, and resection of the native aorta. We consider that this novel technique could broaden the application of external aortic supports in selected patients to reduce the risk of aortic arch complications and the potential need for re-intervention.

METHODS

We sought to prospectively investigate the feasibility, safety, and outcomes of utilizing an external support to wrap the aorta from the aortic valve to the distal arch. Patients were eligible for the procedure if the aortic root to arch diameters were within the range of 40 to 59 milllimeters, recommended for prophylactic management based on patient-specific risks. Exclusion criteria included acute aortic syndrome, greater than moderate aortic valve dysfunction, low coronary artery to VA junction heights, irregular aneurysm geometry, severe aortic tortuosity, moderate to extensive aortic atherosclerosis or calcification, and difficult access to a posteriorly sited aortic arch.

Our initial case was a 66-year-old man, who was incidentally diagnosed with a Sievers Type 1 bicuspid aortic valve associated with moderate grade 2/4 aortic regurgitation, and progressive aortopathy involving his aortic root to arch over an 18-month period. Preoperative aortic dimensions demonstrated on computed tomography (CT) were as follows: trans sinus aortic root of 40mm, ascending aorta of 52mm, proximal arch of 45mm, distal arch of 34mm, and descending aorta of 30mm. His BMI was 26 and BSA of 2.21m^2.



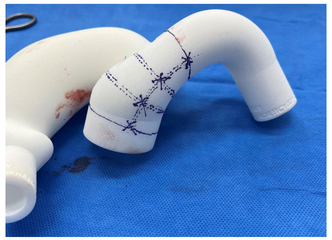
Preoperative computed tomography angiography of the thoracic aorta in coronal, sagittal, and axial views. Preoperative 3-dimensional reconstructions of the aorta rotated 55 LAO and in the anatomical position.

SURGICAL TECHNIQUE

The personalized external aortic root and arch support prostheses were pre-fabricated in the weeks prior to surgery using 3D printing technologies from reconstructions of CT or magnetic resonance (MR) aortograms.

Under general anaesthesia, patients were prepped with routine monitoring, transesophageal echocardiography (TEE), and a cardiopulmonary bypass machine on standby. Median sternotomy is performed. To facilitate aneurysm mobilization and prosthesis placement, the systolic blood pressure is intermittently lowered in the range of 60-80mmHg by the anesthesiologist.

The aortic root, ascending aorta and aortic arch are exposed and circumferentially dissected with the aid of peri-adventitial retraction sutures from the VA junction to the level of approximately one centimeter distal to the left subclavian artery. The ostia of the coronary arteries and arch vessels are partially mobilized at their bases and sequentially looped.



Personalized external aortic arch support model (centre).

The personalized external aortic root and arch support prostheses are prepared by creating apertures for the ostia of the coronary arteries and aortic arch vessels, which are connected to radial incisions in the prosthesis to create 'tabs'. Following application of liquid paraffin, the prostheses are sequentially positioned to encompass the aortic root to arch, with the aforementioned ostia lying within the apertures. The tabs and margins of the prostheses are re-approximated using non-absorbable sutures, taking care not to overly constrict the origins of the coronary arteries and arch vessels

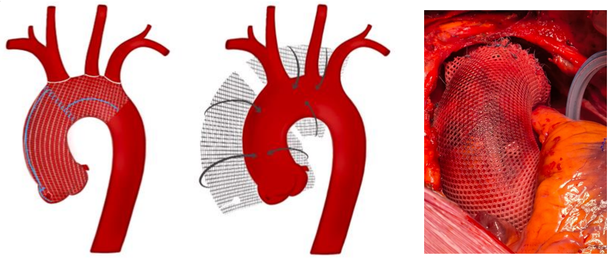


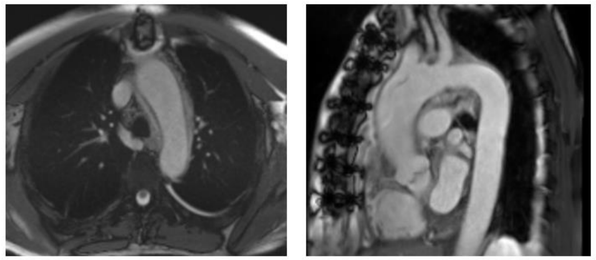
Illustration of the aortic root and aortic arch extension prostheses placement, and prostheses in situ.

Intraoperative TEE confirms seating of the prostheses, non-obstructed coronary arteries with no regional wall motion abnormalities, and stable aortic valve parameters. A drain is placed prior to routine sternal closure prior to transfer to the Intensive Care Unit. Post-operative care is as per the standard cardiac pathway with the addition of Colchicine for three-months and annual surveillance by either CT or MR thoracic aorta.

RESULTS

Our initial two cases demonstrate the feasibility of arch extension of the personalized external aortic root support prosthesis, using a valve-sparing, beating heart approach without the need for cardiopulmonary bypass or circulatory arrest. The operative duration and timing of extubation were non-inferior to standard cardiac operations (three and four hours respectively), while both patients have experienced no post-operative complications to date. Initial post-operative imaging demonstrated stable or reduced aortic dimensions, no aortic dissection, in addition to preserved aortic valve insufficiency, as demonstrated on the below table:

Maximum Aortic Dimension	Preoperative CT Aorta	Post-PEARS MR Aorta
Trans sinus (cusp to cusp)	40mm	40mm
ST junction	36mm	34mm
Ascending aorta	52mm	50mm
Proximal arch	45mm	40mm
Distal arch	34mm	30mm
Isthmus	32mm	27mm



Post-operative MR aorta with the aortic root and arch external supports in situ.

DISCUSSION

In select populations, the personalized external aortic root and arch supports may represent a novel, patient-specific approach to the prophylactic management of aortic dilatation prior to aortic measurements approaching the operative threshold size for traditional intervention. Further mid- and long-term data in a wider population is required to determine the efficacy, durability, reproducibility, risks, and target group for this procedure.

REFERENCES

1. Kenny LA, Austin C, Golesworthy T, et al: Personalized External Aortic Root Support (PEARS) for Aortic Root Aneurysm. Operative Techniques in Thoracic and Cardiovascular Surgery 26(2):290-305, 2021.
2. Takayama H, Hohri Y, Brinster DR, et al: Open, endovascular or hybrid repair of aortic arch disease: narrative review of diverse strategies with diverse options. European Journal of Cardio-Thoracic Surgery 65(6):ezae179, 2024.
3. Zanotti G, Reece TB, Aftab M: Aortic Arch Pathology: Surgical Options for the Aortic Arch Replacement. Cardiol Clin 35(3):367-385, 2017.