Masters of Cardiothoracic Surgery

The Ross procedure with a bicuspid pulmonary autograft

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Clinical vignette

A twenty-four-year-old male with a history of hypertension and bicuspid aortic valve (BAV), presented with a one-year history of decreasing exercise tolerance and NYHA class II symptoms. Transthoracic echocardiography (TTE) demonstrated mild aortic stenosis with mean and peak gradients of 20 and 37 mmHg, respectively, and severe aortic insufficiency. The aortic cusps were quite dysplastic with areas of fibrosis and calcification. The pulmonary valve was functioning well with mild insufficiency. Left ventricular (LV) ejection fraction was 55% with severely dilated LV dimensions with end-systolic and end-diastolic diameters of 44 and 73 mm, respectively. Cardiac magnetic resonance imaging (MRI) suggested a dilated aortic annulus measuring 32 mm × 28 mm with a well-matched pulmonary root. Surgical options were discussed, and the planned preference was for aortic valve (AV) repair, and Ross procedure as backup considering his young age and reluctance to take warfarin.

Surgical techniques

Aortic root preparation

A midline sternotomy and central cannulation were employed. The aortic root and ascending aorta were skeletonized and a transverse aortotomy made just above the level of the sinotubular junction, allowing for antegrade cold Del Nido cardioplegia delivery. The AV was carefully examined revealing a dysplastic and mildly calcified unicuspid valve. We contemplated a bicuspidization repair strategy, but felt the anatomy was not ideal and that a pulmonary autograft would provide better long-term function and durability. Thus, the AV was excised *en bloc* and the annulus thoroughly debrided. We scalloped out the left and right main coronary buttons and placed direct ostial catheters within them. We preserved the non-coronary sinus and the bridge of aortic wall between the left/right sinus to be later incorporated into the anastomosis with the ascending aorta to provide external support for the pulmonary autograft.

Pulmonary autograft harvesting

The pulmonary artery was incised at its bifurcation and reflected anteriorly. Assessment of the pulmonary autograft identified a bicuspid pulmonary valve, Sievers type 1 morphology with two well-developed commissures and one raphe in the conjoint cusp. Nonetheless, the pulmonary cusps were pliable, without significant fenestrations and geometric heights of 20 mm each, making repair suitable.

The pulmonary autograft was harvested by inserting a right-angled forceps at the base of the anterior commissure and the pulmonary infundibulum incised 5 mm below the valve. Caution was taken in the posterior dissection, to avoid coronary injury. The pulmonary autograft was incised with a deep posterior commissure to match the well-developed posterior commissure in the unicuspid aortic annulus, and left the anterior portion of the pulmonary autograft largely planar to match the anterior planar shape of the unicuspid annulus.

Pulmonary autograft implantation: proximal anastomosis and aortic annuloplasty

A subannular row of six non-pledgetted, 2-0 Ethibond

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sutures were passed through the LV outflow tract (LVOT) to the exterior aspect of the aortic root. The autograft was implanted as a total root in a subannular position using interrupted 4-0 polypropylene sutures. This was achieved by placing suture bites 3–4 mm deep to the aortic annulus in the LVOT and on the pulmonary autograft, penetrating the suture 1 mm deep to the insertion of the cusp and exiting the suture 2–3 mm above the cusp insertion on the exterior aspect of the pulmonary autograft. We believe this technique ensures the pulmonary autograft will be implanted symmetrically deep within the LVOT and that the infundibular muscle is completely excluded, which is important for valvular competence. In this case, the pulmonary autograft was implanted with the commissures at 180 degrees from each other, with each cusp subtending 50% of the unicuspid aortic annulus.

Using the Schaefers repair caliper, we measured an effective height of 10 mm for the non-conjoint cusp and a prolapsing conjoint cusp; therefore, the conjoint cusp was centrally plicated with two 6-0 polypropylene sutures to achieve an effective height of 10 mm.

We returned our attention to the previously placed subannular Ethibond sutures and passed them through the base of a 30 mm straight Dacron ring graft to complete the extra-aortic annuloplasty. We routinely perform an external aortic annuloplasty for annular diameters of 27 mm or greater or significant aortic regurgitation to prevent late dilatation. Coronary buttons were reimplanted and excess pulmonary autograft trimmed.

Pulmonary homograft implantation and distal autograft anastomosis

The CryoLife SynerGraft 30 mm pulmonary homograft was trimmed distally and anastomosed to the pulmonary bifurcation using two running 5-0 polypropylene sutures. The proximal anastomosis to the right ventricle outflow tract was completed with running 4-0 polypropylene suture.

The pulmonary autograft was anastomosed to the ascending aorta with running 5-0 polypropylene suture, respecting the commissural orientation at 180 degrees to preserve autograft symmetry.

The patient was extubated the evening of surgery and transferred to the ward on the first postoperative day, where he recovered without complications allowing for his discharge home on the sixth postoperative day. At one-year follow-up, he was completely asymptomatic and ambulating without limitations. Repeat TTE revealed a normal functioning pulmonary autograft with no aortic insufficiency, normally functioning pulmonary homograft, and preserved LV function.

Comment

Although it could be argued to have simply replaced our patient's AV with a standard valve prosthesis, his young age posed a challenge with his longer anticipated life expectancy and higher cumulative risk of prosthesis-related complications. The Ross procedure, unlike standard bioprosthetic or mechanical AV replacement, restores expected survival equivalent to that of age and gender-matched general population (1).

A bicuspid pulmonary valve is considered a rare congenital anomaly with an estimated incidence of 0.1% and may be considered a relative contraindication for the Ross procedure (2). However, our patient had favourable bicuspid anatomic characteristics with pliable cusps, good commissural orientation, and geometric height of 20 mm, and we applied all the principles of BAV repair with symmetric commissural implantation, a tailored aortic annuloplasty and achieving an effective height of 10 mm to ensure a well-functioning bicuspid pulmonary autograft. We have employed this technique successfully in two patients. To our knowledge, only one previous paper presented a repair of a bicuspid pulmonary autograft valve, but this was for moderate aortic insufficiency noted five days after the Ross procedure (3). In this report, we present the concomitant repair of a bicuspid pulmonary autograft at the time of the index operation. We aim at drawing on the advantages of the Ross procedure for young patients while restoring the function of the bicuspid pulmonary autograft using common BAV repair techniques, thus extending the use of the Ross procedure to more patients who would otherwise be considered ineligible.

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Footnote

Conflicts of Interest: MWAC has received speaker's honorarium

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