Masters of Cardiothoracic Surgery

Valve-sparing aortic root reimplantation and cusp repair in bicuspid aortic valve: with aortic insufficiency and root aneurysm

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Introduction

The text of this manuscript describes the surgical techniques demonstrated in our video, "Valve-sparing aortic root reimplantation in bicuspid aortic valve: with aortic insufficiency (AI) and root aneurysm" (*Video 1*).

This video shows our approach to valve-sparing aortic root reimplantation in bicuspid aortic valve (BAV) presenting with proximal dilation and eccentric aortic valve insufficiency. Understanding the aortic insufficiency classification system as conceived by the Brussels group under the direction of Gebrine El Khoury and published by Boodhwani *et al.* is important. This video is our approach to the combination type Ib/II BAV. This is the most common presentation and represents aortic root dilation with cusp prolapse.

The anatomy of the classically repairable type Ib/II BAV is characterized by lack of signification leaflet calcification, presence of eccentric AI, and dilated proximal aorta with sinotubular junction (STJ) effacement. Note that the actual sinus segment is mildly dilated only.

The main concepts of bicuspid aortic valve repair and root reimplantation are as follows: (I) leaflet/cusp free margin equalization, (II) annular stabilization and annular reduction, (III) raphe release (IV) optimization of the leaflet coaptation height to ensure elevation of this height above the annular plane, and (V) root reimplantation and coronary button reconstruction.

Operative techniques

The technical operation begins with a transverse aortotomy. This incision should be distal to the sinotubular junction and "high" enough so that surgeon is not "consigned" to a root procedure in case a simple subcommissural annuloplasty repair is more appropriate. The posterior ascending aorta is dissected free from the right pulmonary artery so that the full native root is exposed and mobile. After the aorta is transected but prior to any further dissection, the valve and root are inspected for reparability. An assessment of the sinus diameter, coronary ostial positions and the level of calcification is completed.

It is critical that the incompetent BAV be evaluated in the context of the native aortic root. This allows for analysis of the prolapsed leaflets, the amount of coaptation available, and the effective leaflet degeneration and calcification contributing to AI. In situations where there is effacement of STJ due to severe ascending aortic dilation, a proper aortotomy preserving the entire aortic root enables one to determine whether or not the root is truly aneurysmal and if the patient is a candidate for root preservation.

Leaflet repair proceeds according to five conceptual goals: (I) free margin equalization, (II) optimization of coaptation zone, (III) raphe release, (IV) annular stabilization and reduction and (V) if necessary, debridement of any annular or leaflet calcification for improved leaflet mobility.

An initial assessment of the BAV is used to accomplish free margin equalization. It is clear that we have excess free margin length in the raphed leaflet and therefore a resectional or plication method will allow us to achieve free margin equalization with requiring any further leaflet free margin augmentation in the contralateral cusp. Additionally, we have very satisfactory cusp mobility which will allow excellent opening and coaptation.

7-0 prolene sutures are used to mark the edges of both

free margins where they have equal length. The central portion the leaflet will be excess and require repair either with plication or excision. We precisely mark the distances necessary to ensure free margin equalization with the 7-0 prolene and proceed using a 5-0 prolene to plicate the redundant excess portion of the raphed leaflet accordingly. I then assess the proper equalization of this new free margin compared to the posterior or non-coronary, non-raphed leaflet.

The free margins of the two leaflets are now equal and the prolapse is corrected. Note that leaflet mobility is satisfactory after the 5-0 prolene plication.

This video is an example of a BAV raphe which needed excision instead of plication because there was a limited amount of calcification at the redundant raphe free margin. This calcified anatomy does not plicate well. Note the equalization of the free margin lengths.

The left coronary button should be dissected with attention to the valve annulus. The cut should be ideally half way between the coronary ostia and the valve annulus. Conceptually, we want to leave enough aortic tissue for the secondary suture line; however one does not want to sew a coronary button that is too small so that stiches are inside the coronary proper.

Occasionally in BAV anatomy the coronary button can be very close to the commissure. Careful attention must be applied in this instance. The same principles apply to the right coronary button as to the left. Careful attention to split the difference between the ostia and the annulus, leaving some aortic tissue to allow for a future easy secondary suture line is important.

Dissection with low cautery down to the annulus, adjacent to the right ventricular (RV) outflow muscle, can be tedious and must be precise as in any reimplantation procedure. In the common left/right raphe bicuspid valve anatomy, the right ostium is visually closer to the true commissure than the raphe.

Raphe release usually allows for improved leaflet mobility. The release should go down to the annulus but obviously not through the annulus. Excessive fibrous tissue can be excised carefully in necessary. Unlike in *Video 1* this usually release the raphe prior to free margin equalization. We have now completed the leaflet repair. We are assessing the mobility of the leaflets and the free margin as well as any suture lines. In this case, it appears we may not need to perform any contralateral plication but will be assessed after completion of the reimplantation. Note the ample residual aorta and leaflet insertion perimeter.

For proper reimplantation the dissection of the left ventricular outflow tract at the annular plane must proceed with caution and be carried out technically parallel to the outflow tract. Otherwise there can be easy and inadvertent entry into a cardiac chamber. The right dissection is tedious and needs to go to the annulus as close as possible -but not into the right ventricle. On the left, stay parallel to the left ventricular outflow tract (LVOT) and do not angle the cautery towards the left main. One can usually take the raphe more completely and deeper than initially contemplated.

In a typical raphed BAV, the annular perimeter and leaflet surface areas as noted earlier are most often asymmetrical and usually approximate 150 degrees and a total of 210 degrees for the right/left conjoined cusp. This is the geometry of our case.

We advocate respect for the native geometry especially when the orientation like this case is one where there is excess leaflet surface and prolapse. We do not force a 150 degree 210 degree geometry into a 180 degree 180 degree configuration in most reimplantation BAV repairs and believe this approach optimizes coaptation symmetry.

The subannular stabilization sutures for reimplantation are placed approximately two millimeters below the leaflet insertion sites. We usually use pledgets in these cases as the BAV annulus is usually quite large and there are minimal problems with subannular stenosis. In raphed 150 degree 210 degree BAV geometry we usually place three or four evenly spaced subannular sutures on the non-coronary and two each on the smaller right and left cusp for a total of four under the raphed leaflet.

The most difficult sutures are on the RVOT side and we try not to take super-sized bites into the RV. In this video the progression is from non-coronary to right coronary to left coronary. We do not place a suture across the commissures or raphed segment.

At this point the subannular sutures are in place and we have selected a Valsalva graft for reimplantation. We size the graft according to body surface area. The optimal annular reduction in most BAV cases is approximately 15-20 percent compared to initial annular diameter. This will usually guarantee an excellent coaptation height and minimize any residual aortic stenosis.

The marked neoroot is then placed over the retained valve complex after placement of sub-annular sutures, and the independent commissure sutures are pulled high as the new root is parachuted down to the sub-annular plane in classic reimplantation style. Note the good apposition in the

sub-annular area.

After tying the subannular sutures and fixing the commissures to the Valsalva graft just above or at the neo-sinotubular junction of the graft, the valve can be initially tested for competence. As the only functional aortic annular repair remains is the secondary suture line. The secondary suture line is the hemostatic suture line and needs to be completed with precision. We usually start at the nadir of the sinus and travel toward the height of the commissure.

The left main button cut or cautery on the graft must be done with precision as this must often be placed in a small or 150 degree pseudo sinus segment. The button must not be too close or interfere with commissure suture line. The button is parachuted down in a proximal into distal anastomotic onlay fashion. The most important concept is to keep the button free of the reimplanted valve so that no geometric distortion occurs.

The right main button follows along similar concepts as the left. It is usually placed higher on the neoroot just below or at the neo-STJ of the Valsalva graft. As on the left, the most important concept is to keep the suture line independent of the valve reimplantation suture line so that no distortion of the repaired valve occurs. The right button, like the left, will need to be placed on a small 150 degree suture line. Therefore careful attention must be paid particularly at the cut or cautery on the graft.

After completion of the repair, but prior to the distal suture line, one final inspection of the valve is important. Most important is to assess for any residual small prolapse of the leaflet and for free margin inequality. It is not uncommon to need a small free margin plication of the opposite cusp at this stage.

We often will have to perform a hemiarch procedure with the cusp repair and root procedure in BAV disease. In these cases, the final step of the procedure is the graft-to-graft anastomosis. The graft to graft suture line must be completely independent of the reimplantation procedure to minimize any distortion of the 3D functional aortic annulus. Note that this is the final opportunity to assess the valve repair, therefore competence of the valve should be tested.

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