Video-atlas of aortic valve repair

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Introduction

Reconstructive surgery of the aortic valve is a recent development in our center, based on old roots. In the 1950s and 1960s, the first aortic procedures were performed with neither adequate echocardiography nor clear understanding of aortic valve geometry; those early attempts were of limited clinical outcome. Meanwhile, the availability of valve substitutes enabled more reproducible and consistent results. Nowadays, with the help of transesophageal echocardiography, and the discovery of the limitations of valve substitutes, aortic valve repair has become an inspiration for many surgeons.

Our videos on aortic valve repair aim at showing our viewers the latest and most relevant techniques in aortic valve repair surgery, whether it concerns tricuspid or bicuspid valves.

Operative techniques

Every aortic valve repair surgery starts with a transverse aortotomy 1cm above the sino-tubular junction (STJ), followed by placement of three prolene 4/0 traction sutures through the three commissures (*Video 1*).

Reconstruction of the regurgitant aortic valve requires exact knowledge of the different pathologies leading to regurgitation as well as the normal anatomy. The aortic valve consists of the combination of cusps and aortic root, including the STJ, the sinuses, and the ventricular aortic junction (VAJ). The quality of the valve tissue, the free cusp margins, as well as the anatomy of the aortic root is then evaluated. Particular attention is paid to the presence of calcifications, fenestrations or dilatation.

Every successful aortic valve surgery requires a thorough assessment of the valve. An aortic valve could be quadricuspid, tricuspid, bicuspid or even unicuspid. Major pathological aspects of the aortic valve anatomy that should be monitored are the following. Starting by paying attention to prolapse, special interest should be insisted on the free margins. A free margin can be elongated, and show a transverse fold. This transverse fold, also called fibrous band, is a fold in the body of the leaflet running parallel to the free margin and corresponding to a discontinuity in the normal cusp's body curvature. Secondly, restriction in a cusp's motion is an essential factor. Usually, cusp restrictive motion can be related to root dilation.

When it comes to bicuspid valve assessment, the first step is determining whether the valve is bicuspid type 0 or type 1. In addition to the dilated root, type 0 bicuspid valves show a bisymmetrical disposition at 180°, with the commissures placed at diametrically opposite positions. Level of the free margins with respect to each other, will indicate absence or presence of prolapse. We differentiate the anterior or conjoint cusp from the posterior or non-conjoint one. The type 1 bicuspid valve however, shows a central raphé, resulting from the incomplete fusion of the left and the right coronary cusps, sometimes calcified. The commissures are positioned at a 240°/120° configuration, and thus no longer bisymmetrical.

In the rare cases, where one might stumble on a unicuspid valve, it can be characterized by the presence of one normally developed commissure and two raphés surrounded by fibrous thickening of the cusp.

Passing the assessment, the operative technique decision follows.

Tricuspid valve repair (*Video 1*)

In tricuspid valves, cusp repair concerns essentially valve prolapse. Cusp prolapse is the consequence of unequal free

margin length of one or more cusp. Simple shortening of the free margin and the adjacent tissue can eliminate the tissue redundancy and normalize cusp geometry.

Central free-margin plication technique

Central free-margin plication is the most frequent technique used to correct prolapse.

In our first case, the patient presents isolated right coronary cusp prolapse with a lower free margin compared to the adjacent cusp. Both non-coronary and left-coronary cusps are used as reference with a 7/0 stitch through the Arantius noduli. Central free margin plication is performed excluding the excess of free margin length. The radial fold created by this plication is compacted by a running locked 6/0 polypropylene suture.

In our second case, after valve sparing reimplantation technique, cusp assessment shows unequal free margin height of both the right coronary and the non-coronary cusps. Hence, the left coronary is used as reference; by a 7/0 stitch through the Arantius Nodulus. The excess length is evaluated by applying traction and approximating the reference cusp against the prolapsing cusp. In very thin tissue cusps, we use 7/0 stitches for central plication. The plication stitch is placed at a level facing the reference cusp's Arantius Nodulus, and reentered at a symmetrically opposite point on the other half of the free margin, and then tied. The same plication technique is repeated on the right coronary cusp. A water test usually follows every repair procedure to demonstrate valve competence. In cases where large plication is necessary, the protruding tissue is best resected, in order to avoid bulky scar tissue on the cusp.

In our third case of tricuspid valve prolapse, of both right coronary and non coronary cusps, after a central plication has been performed on the non-coronary cusp, a resection of the excess tissue is taken out on the right coronary cusp, followed by a running locked 6/0 suture, that will close the gap created by the triangular resection.

Free margin re-suspension technique

The other cusp prolapse repair technique, in tricuspid valves, is the free margin re-suspension technique. It is useful to close commissural fenestrations and reinforce free margin. We illustrate the technique in a patient with right coronary isolated cusp prolapse. First, a 7/0 Gore-Tex running suture is passed from one commissure to the other, over and over, along the free margin. A second identical running suture is then passed following the same path. By exerting a gradual tension on the suture, the free margin is shortened to the appropriate length and comparable level as the adjacent normal cusps, used as reference.

In the second case, we illustrate that free margin resuspension with Gore-Tex can be associated with central plication, in order to reinforce the free margin, or close fenestration.

Bicuspid valve repair (*Video 2*)

In bicuspid valves, cusp repair consists mainly of cusp prolapse and raphe repair.

Central free margin plication technique

In the first type 0 bicuspid valve with VAJ dilatation, the patient received a subvalvular circumferential annuloplasty. Once this was performed, cusp analysis showed anterior cusp free margin lower than the posterior one. The prolapse was repaired using a plication technique similarly to what was described in the tricuspid case. A 6/0 prolene suture was placed on either side of the excess tissue, and tied.

In the second bicuspid type 0 case of valve prolapse with root dilatation, valve-sparing reimplantation was performed beforehand. Both cusps show prolapse, mainly due to the VAJ and STJ correction by the reimplantation technique. Cusp assessment after the first part of the procedure demonstrates prolapse of both cusps, which are repaired using central plication. Note that in cases where no normal cusp can be used as reference, the mid-height of the Valsalva sinuses is used as reference. A 6/0 prolene suture is placed on either side of the excess tissue of the posterior cusp. Passing on to the anterior cusp, the posterior will serve as reference cusp. A 6/0 prolene suture is placed on either side of the excess tissue of the anterior cusp. Concerning the anterior cusp, excess tissue is too bulky, and thus resected. A running locked 6/0 suture will be used to close the gap.

Triangular resection

The video then continues with techniques of triangular resection. In the first patient with bicuspid type 1 valve and root dilatation, the conjoint cusp shows complete fusion with discrete fibrosis of the raphe and prolapse. The repair consists of a central plication of the conjoint cusp, associated with resection of the excess tissue, and resection of the fibrous raphe remnant.

In the second patient with a bicuspid type 1 valve without root dilatation, the conjoint cusp shows incomplete fusion and fibrotic restrictive raphe. The repair consists of

resection of the fibrous structure and direct closure, thus completing the fusion of the conjoint cusp.

Raphé management, tricuspidization and commissural patch reconstruction

The video concludes with several examples of commissural reconstruction in bicuspid and unicuspid valves. In the first type 1 bicuspid valve, following a true 240°/120° cusp configuration, the conjoint cusp shows incomplete fusion of the raphe with fibrous thickening inducing motion restriction. In cases where raphe debridement leads to extensive tissue defect, direct closure is not advised, and patch extension is required. When the valve shows a symmetrical geometry, a triangular patch is used to close the gap and the valve is kept bicuspid. However, when valve geometry is almost tricuspid, a patch is used to reconstruct a neo-commissure, thus tricuspidizing the valve. After reference sutures are placed for accurate geometrical analysis, an approximate size of the bovine pericardial patch is prepared, taking into consideration normal commissure height. The patch is primarily attached to the aortic wall with a running 6/0 suture starting from the cusp insertion point, to the tip of the neo-commissure. The locked running suture is continued along the right coronary cusp section edge, then along the left coronary cusp. A water test is performed to evaluate valve competence. Dynamic valve assessment shows excellent repaired cusp approximation and mobility.

Unicuspid valve repair (*Video 3*)

Commissurotomy and patch reconstruction

The third video clip demonstrates unicuspid valve repair techniques. A unicuspid valve, characterized by its normal commissure between the non-coronary and the left-coronary along with two raphes. Fibrous thickened tissue from the raphe is excised with a blade. As the raphe between the left-coronary and the non-coronary is less fibrotic and higher in its insertion, commissurotomy is performed with thinning of adjacent tissue. Neo-commissures are created with bovine pericardial patch, at the level of the right and left-coronary cusps. A running 6/0 polypropylene suture starting from the cusp insertion point to the tip of the commissure, fixates the patch to the aortic wall. The running suture continues in its locked form along the right and the non-coronary cusp section edges. The patch is then trimmed to correspond to the appropriate cusp sizes. Triangular resection is also performed on the left coronary cusp which presents prolapse. Finally, valve assessment is performed and shows satisfactory end result of the repair.

The last case shows a similar reconstruction in a pediatric patient with unicuspid aortic valve. After the bulky raphe between left and right-coronary cusps is resected, the incompletely fused raphe between the right and non-coronary is opened till the aortic wall. Because of the small size of the valve, thinnest material possible such as treated autologous pericardial patch is chosen to recreate the neo-commissure between right and non-coronary sinus. The patch is attached vertically to the aortic wall, from the base of the cusp insertion point, till the tip of the neo-commissure. After the approximate cusp size is cut, the running suture is continued along the right and the non-coronary cusp section edges. Valve assessment shows appropriate repaired valve configuration, with adequate coaptation.

Comments

Note that the aforementioned techniques are those used most frequently in our center. Several other techniques exist, that also could have been useful in these specific pathologies, but these are no longer used in our center for reasons of ease of procedure, better understanding and expertise of the aforementioned methods over others, and better experience with outcome with these specific techniques.

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