Aortic annulus elevation for aortic valve and root replacement

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January 14, 2022

Abstract

Aortic valve and root replacements require an in-depth understanding of the aortic root and annulus. Both structures can be asymmetric at times, and this needs to be recognized and taken into consideration when peforming valve-sparing operations or other root-replacement procedures. Moreover, the geometry of the aortic annulus can be altered, and when performing an aortic root replacement this can distort the geometry of a neo-aortic valve for instance, and lead to valve dysfunction, which is difficult to reverse. We are describing an altered aortic annulus, which required modification through annulus elevation before proceeding with aortic root replacement with a graft-reinforced pulmonary-autograft.

Introduction

The technique for aortic root replacement was first described in 1968 by Bentall and DeBono [1]. The method was further refined and additional valve-sparing operations, such as the remodeling and reimplantation technique, were introduced later [2-3]. Today, different options for aortic root replacement exist, ranging from valve sparing to valve replacing procedures. In 1967, replacement of the native aortic valve with the pulmonary valve was suggested[4]. Although mainly utilized in the pediatric population in the past, in recent years, it has gained more widespread acceptance in adults as well [5].

Nevertheless, all the above-mentioned techniques are surgically challenging and require a thorough understanding of the aortic root anatomy and function. There is wide variability in aortic valve phenotypes, which also affects the geometry of the aortic annulus and aortic root [6]. Herein, we are describing an abnormal aortic annulus of the left coronary sinus, which was displaced into the left ventricular outflow tract (LVOT), due to aneurysmatic changes of the left coronary sinus. This occurred in the setting of a severely calcified unicuspid aortic valve in an adolescent, with extension of calcifications onto the mitral valve (Figure 1). Although the annular displacement is a subtle finding, which can easily be overlooked (Figure 2A), it has the potential for serious consequences during an aortic root replacement, when not adequately addressed. We know from Ross procedures, that distortion of the neo-aortic valve, due to a prosthetic graft alone can lead to valve dysfunction [7]. This distortion can not only occur when the pulmonary autograft is seated into the prosthetic graft but can also occur when the prosthetic graft itself is distorted during placement onto the aortic annulus. We are therefore describing a surgical technique to remedy the displaced aortic annulus, through elevation of the aortic annulus to the level of the normal annulus, with a prosthetic graft in this case. This provided a geometrically balanced foundation for the pulmonary autograft, without subsequent distortion of the neo-aortic valve.

Technique

The surgical technique is illustrated in the Video (Video 1, supplementary material). After excision of a severely calcified unicuspid valve and debridement of aortomitral curtain calcifications (Figure 1), we noticed the asymmetric aortic annulus with significant displacement of the left coronary aortic annulus into

the LVOT (Figure 2A). The leftover graft of a 28mm Cardioroot graft (Getinge, Sweden), which was used for pulmonary autograft reinforcement, was sewn to the aortic annulus of the left coronary sinus with a 4.0 Prolene suture (Figure 2B). The autograft reinforcement technique has been previously described in detail [7]. The graft was sewn to the aortic annulus effectively from the left/right- coronary commissure to the non/left- coronary commissure. During the surgery, we started the suture line in the middle of the sinus (Figure 2B) and completed the suture line on the displaced annulus and towards each commissure. Once the graft was seated and tied, it was cut and the free margin of the graft was trimmed to align with the height of the normal annulus of the non- and right coronary sinus (Figure 2C). An additional commissural stitch was placed at each commissure to secure the graft at the 2 lateral edges (Figure 2D). Upon completion of this step, a balanced aortic annulus was created with an even horizontal plane (Figure 3A), which would match the horizontal plane of the graft reinforced autograft (Video 1).

The pulmonary autograft was then sewn to the neo-aortic annulus with a running 4.0 Prolene suture (Figure 3B,C). This allowed for seating of the pulmonary autograft to an even and horizontally balanced aortic annulus, without any graft or neo-aortic valve distortion (Figure 3D).

Comments

Aortic root surgery is among the most complex procedures in an already technically demanding surgical specialty of cardiac surgery. A thorough understanding of the anatomy, and subsequent appreciation of abnormal findings, with avoidance of potential pitfalls is critical. Knowledge and acknowledgement of these subtle details, however, comes with experience. Thus, we are sharing our experience and highlight our approach to restore a more physiologic anatomy, which allows for execution of a standard technique without the risk of failure related to this particular anatomic entity.

The underlying principle described here, is that we sewed the horizontal plane of the graft-reinforced pulmonary autograft, to a newly created horizontal and even plane of the aortic annulus. With this, we avoided distortion of the prosthetic graft with subsequent distortion of the neo-aortic valve. Distortion of the neo-aortic valve would lead to aortic regurgitation, due to prolapse or cusp restriction, and subsequent potential failure of the procedure despite a correct surgical execution. The potential culprit for failure here, is not a lack of surgeon skills, but an unusual anatomical detail, which potentially wasn't recognized or taken into consideration.

Moreover, when regarding the quality of the tissues in the left coronary sinus, it becomes evident that the tissues are quite thin and would not be able to adequately hold the sutures of the pulmonary autograft. It also lacks the ability to provide any annular support and may therefore also compromise durability of the repair. Thus, the annular elevation and reinforcement alleviates the weaknesses of the annulus and sinus wall. We most commonly observe these changes in the non-coronary sinus. But this case highlights the notion, that these changes can affect any of the aortic root sinuses.

The principles we presented here, do not only apply to the pulmonary autograft but are universally applicable to any aortic annulus or root technique. The only difference is that some techniques, such as prosthetic valve replacements for instance, are more forgiving. Despite that, even earlier generations of bioprosthetic valves required modifications from a horizontal plane of the sewing ring to a more scalloped formed ring. Hence, the scalloped sewing ring is anchored to a scalloped aortic annulus, the natural from of the aortic cusp insertion line. This allows for a more physiologic placement of the prosthetic valve and decreases the possibility for errors. Hence, the form of the bioprosthetic valve sewing ring was adjusted to better fit the natural anatomy of the aortic annulus. In this case however, we adjusted the aortic annulus to the root replacement substrate. We chose a graft reinforced autograft, which had an even plane to sew to. Of course, we could have also performed a Bentall procedure, but in young patients we prefer the pulmonary autograft due to the improved long-term survival and better quality of life [8].

Recognizing and understanding these subtle details, however, is important to avoid potential pitfalls when dealing with the aortic root and annulus.

References

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Figures

Figure 1. A. Severely calcified unicuspid aortic valve. **B.** *Blue arrows,* extension of calcifications onto the aortomitral curtain and anterior mitral valve leaflet.

Figure 2. A. *Blue arrows,* depict displaced aortic annulus of the left coronary sinus into the LVOT, and below the level of the aortic annulus of the right- and non-coronary sinus. **B.**Sewing of a prosthetic graft to the displaced aortic annulus between left/right- to non/left- coronary commissure. **C.** Trimming of the graft to align the cut free edge of the graft with the aortic annulus of the right- and non-coronary sinus. **D.** Anchoring of the lateral 2 edges of the graft to the commissures.

Figure 3. A. Elevation of the left coronary sinus annulus with prosthetic graft material. **B.** *Black and blue arrows* , depict the new aortic annulus. **C** . Graft-reinforced pulmonary autograft is sewn to the aortic annulus. **D.** Seated pulmonary autograft onto the neo-aortic annulus.

Supplementary material

Video 1. Aortic annulus elevation.