Operative Techniques in
Thoracic and
Cardiovascular Surgery

Aortic Valve Reimplantation According to the David Type I Technique

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Anatomy determines the close vicinity of the sinuses of Valsalva and the aortic valve leaflets. Therefore, the aortic valve has to be involved in any planning of surgery on the critically dilated aortic root. This is particularly true in patients with little or no structural changes of the valvular leaflets, because these valves can be considered potentially retainable regardless if they are tricuspid, bicuspid, competent, or regurgitant. The surgical challenge therefore resides in the need for a procedure that enables resection and replacement of diseased sinuses while preserving and/or restoring both function and anatomy of the aortic valve.

In 1993, we adopted a method for aortic valve reimplantation, which was described by T. David 1 year earlier. Meanwhile, we have used this technique in more than 300 patients with retainable aortic valves for 3 reasons:

1. It appears to provide long-term stability of the aortic annulus.
2. The procedure is relatively hemostatic.
3. The procedure is teachable to many surgeons with some interest in surgery on the aortic root.

With ongoing experience, we have expanded its use from patients with aneurysms of the aortic root to patients with aortic dissection too. The latter indication is still a matter of reasonable debate given the fact that aortic valve reimplantation takes somewhat more time compared with the implantation of a valved conduit or supracoronary replacement of the ascending aorta. On the other hand, this operation is probably the best treatment of the dissected aortic root, because most of the diseased vessel wall may be resected and replaced by a vascular graft while at the same time retaining the valve.

Likewise, many surgeons regard aortic valve reimplantation as the first choice for aortic root aneurysm in patients with Marfan syndrome who do not present with pronounced leaflet prolapse or extensive fenestrations in the valvular commissures. Whether this opinion will withstand the test of time is currently challenged by a prospective, multicenter clinical trial initiated by members of the National Marfan Foundation.

Using the original so called T. David type I procedure, we have remained resistant to the evolution, which this procedure has undergone in the meantime. However, our follow-up data well justify this attitude, because the incidence of reoperation for late valve failure has remained acceptable.

Operative Technique of the David Type I Procedure

The technique of aortic valve reimplantation can be used in many cases of aortic root aneurysm whenever the aortic valve is not stenotic and/or calcified. Central mild-to-moderate regurgitation can be corrected very often, whereas eccentric regurgitation may be more difficult to treat by this technique alone.

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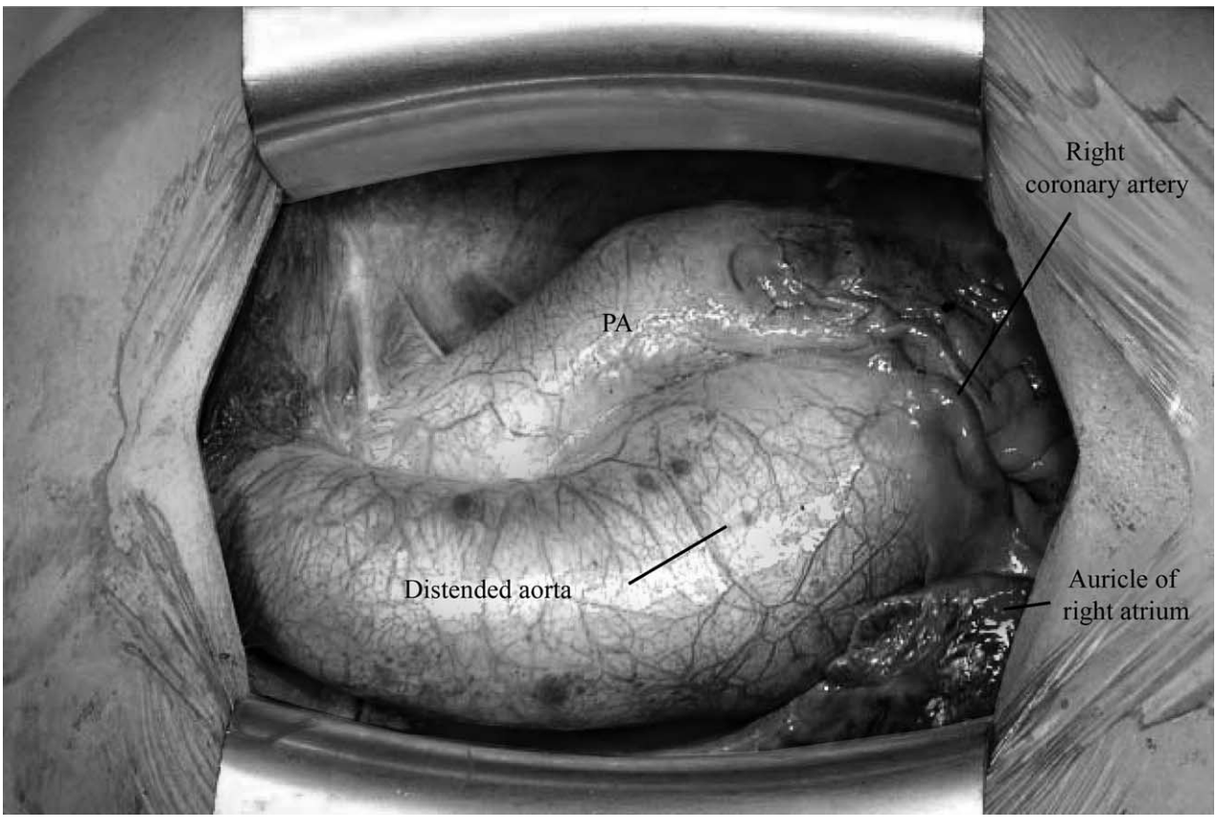

Figure 1 The surgeon's view of the ascending aorta of a 26-year-old female patient with Marfan syndrome with a typical aortic root aneurysm 5 cm in diameter. The preoperative echocardiography revealed only mild aortic regurgitation. The onion-shaped aneurysmatic dilation is confined to the proximal ascending aorta, while its distal segment is not dilated. As with many ascending aortic aneurysms, the heart is rotated posterolaterally, which sometimes hides the right atrial appendage. The ascending aorta may now be cannulated. Venous drainage is accomplished by a 2-stage cannula, unless there is evidence of a shunt on the atrial level, which requires for bicaval cannulation to prevent from aspiration of air into the heart-lung machine once the aorta is opened. On full extracorporeal circulation, the heart is fibrillated before a vent catheter is introduced into the left ventricle through the right upper pulmonary vein to prevent from instant left ventricular over distension, which may develop due to aortic regurgitation. In addition, the vent catheter is very helpful to clear the operative field from residual blood flowing through the pulmonary veins. Then, the distal ascending aorta is cross clamped carefully before the aorta is opened and completely transected. Because of the distal progression of aortic root dilation, the sinotubular junction may sometimes have disappeared. In this condition, the aorta should be incised 3 to 5 mm distal to the estimated level of the former sinotubular junction to prevent from injury to both the right coronary ostium and aortic valve commissure between the right and the noncoronary sinus. This is particularly important in patients with Marfan syndrome, in whom both structures may have drifted surprisingly far downstream within the aortic root.

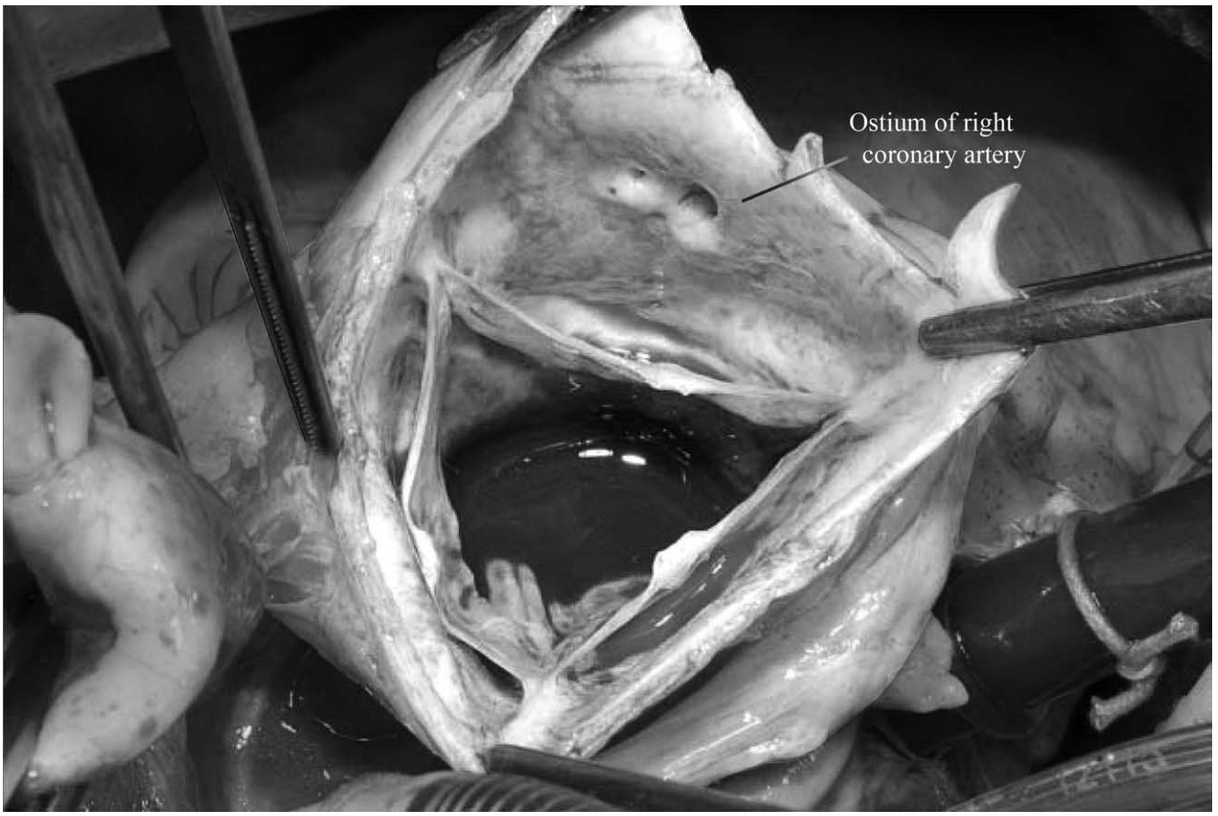

Figure 2 Once the ascending aorta is transected and its distal remnant is held cephalad by a stay suture, a frontal view to the aortic root facilitates its subsequent assessment. After antegrade application of cold blood cardioplegia, the aortic valve is inspected for structural integrity with regard to the number of leaflets, calcifications, and fenestrations at the valve commissures. Small fenestrations are found in many patients with aortic regurgitation and particularly in patients with Marfan syndrome. Their influence on the long-term stability of aortic valve–preserving surgery remains unclear. We prefer to leave them alone, avoiding attempts to reinforce the commissures by any kind of resuspension sutures. In case of extensive fenestrations, which are more frequently found in patients with an aortic root diameter beyond 5 cm, it may be more advisable to replace the valve.

When the decision is made to reimplant the aortic valve according to T. David, the aortic root is mobilized as far proximal as necessary to reach a mentally created virtual horizontal plane near the base of the sinuses of Valsalva.

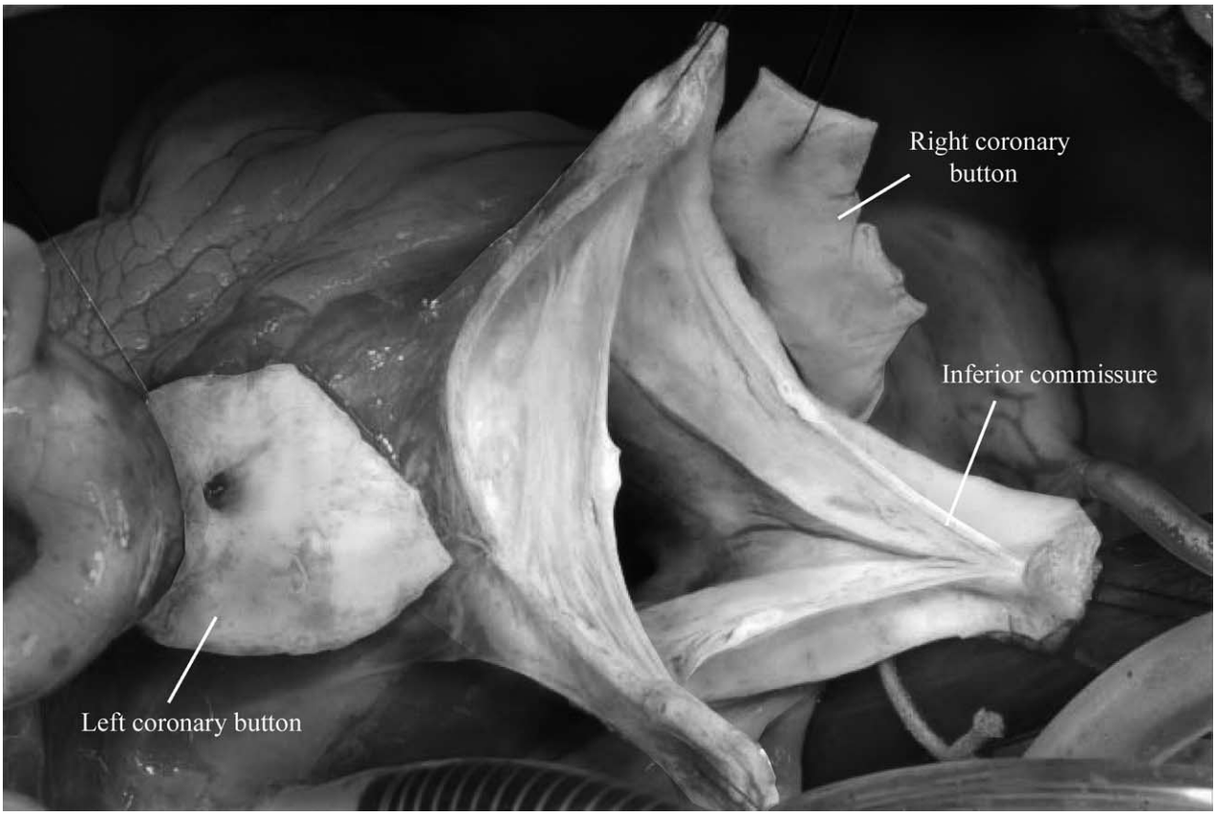

Figure 3 Before the sinuses carrying the coronary ostia are mobilized (in case of a tricuspid valve), both ostia are cut out of the aortic root as buttons, just like for any other type of aortic root replacement. With the ostia carefully held away with stay sutures, the aortic root is further mobilized beyond the level of the coronary ostia and near the left/right commissure. Although the dissection plane underneath the left ostium is easy to identify, preparation beyond the right ostium is to be done with utmost care so as not to accidentally open the right ventricle. In case this still happens, the defect usually may be closed with a double-armed 6-0 monofile transmuscular suture. Mobilization of the aortic root near the pulmonary artery requires a shallow incision of the membranous septum between the 2 vessels to get down to the appropriate plane which is required for later anchoring of the vascular graft.

When the mobilization of the aortic root is completed around its entire perimeter, a double-armed 4-0 monofilament suture is placed through the aorta from inside out right at the top of each commissure. Slightly lifting up the commissures by gently pulling on these sutures facilitates subsequent resection of the aortic sinuses, leaving a 4 to 5-mm remnant of the native aortic wall measured from the base of the aortic valve leaflets. At this stage, it is necessary to decide on the diameter of the vascular graft to be implanted. Sizing of the aortic root has been paid a lot of attention to. We believe that it is essential to size at this stage to allow for near anatomic reconstruction of the aortic root, thereby avoiding both stenosis on the one hand and insufficiency on the other. The sutures through the commissures are again lifted up to create a virtual cylinder around a conventional prosthetic heart valve sizer. If, for example, the use of a valve sizer for a 27-mm mechanical aortic valve results in a complete line of coaptation between the leaflets, a 30-mm vascular graft is very likely to reshape the near-original dimensions of the aortic root after reimplantation. The slight 2 to 3-mm oversizing of the vascular graft compared with the appropriate size of the valve sizer pays credit to the fact the aortic valve is *reimplanted* into the graft. Therefore, the graft needs to be slightly wider than suggested by the use of the sizer. This maneuver gives a good estimate of the appropriate vascular graft diameter to be implanted. In our experience in patients without Marfan syndrome, the majority of female patients needed a graft of 26-mm diameter, whereas male patients very often received a 28-mm graft. This experience, however, does not preclude the occasional use of wider grafts up to 34 mm in diameter or, very rarely, the use of a 24-mm graft. In the majority of patients with Marfan syndrome, who often present with a dilated aortic annulus, the implanted vascular grafts are usually 2 mm wider compared with those in patients without Marfan syndrome.

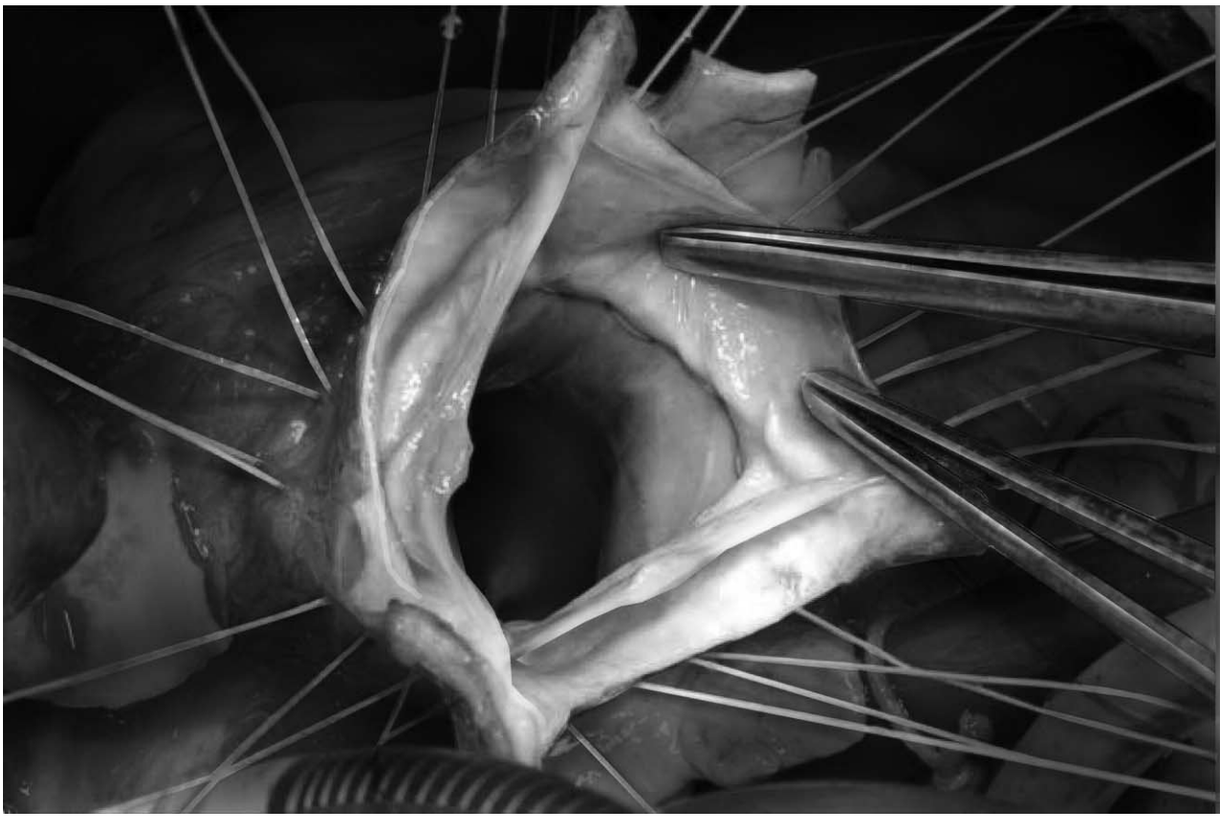

Figure 4 When the aortic root is completely mobilized and after the decision for a specific diameter of the vascular graft, 9 to 13 double-armed polyester sutures are placed transmurally from inside the left ventricular outflow tract out. The first stitch is positioned underneath the commissure between the left and the noncoronary sinus at the hinge line of the anterior mitral valve leaflet. Then, sutures are placed clockwise, keeping the horizontal subvalvular plane that was mentioned previously. Care is taken not to pass the needles accidentally through the bottoms of the remnants of the sinuses of Valsalva.

Figure 5 Now, the vascular graft is shortened to the estimated length of the ascending aortic segment to be replaced. In case of an isolated aneurysm of the aortic root, a length of 6 to 7 cm is usually appropriate. Then, its perimeter is divided into 3 segments by marking the expected position of the commissures with a line drawn with a sterile pencil (2 segments in case of a bicuspid valve). After transferring the stay sutures at the commissures into the lumen of the graft without fixing them at this point, the sutures previously placed in the horizontal subvalvular plane are stitched out of the cardiac end of the graft perimeter at corresponding sites.

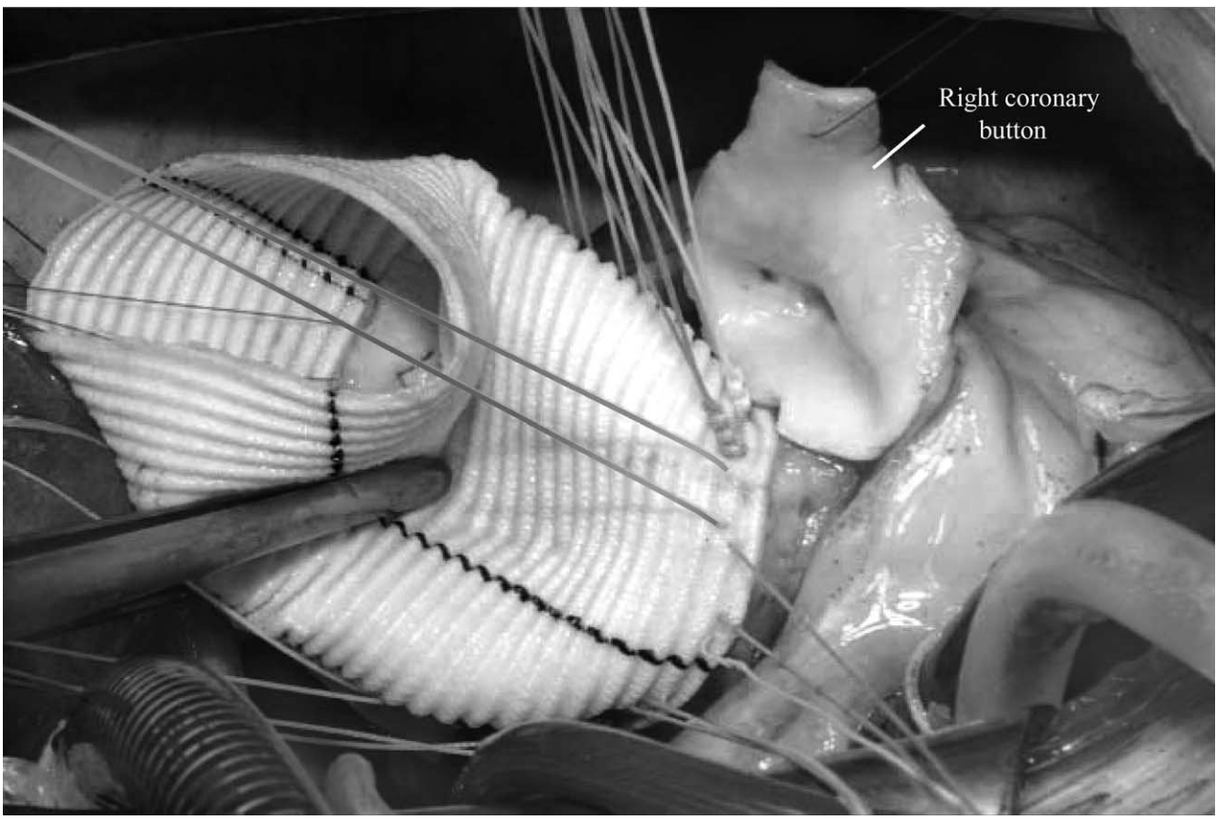

Figure 6 Then, the graft is anchored in the aortic root by tying the suture with the graft held in position by the assistant. We believe that it is key not to pull too much on these sutures while tying them, because this may result in unfavorable plication of both the graft and the annulus. Therefore, these knots should be tied like "wet toilet paper," and it should be kept in mind that this is not a hemostatic suture line.

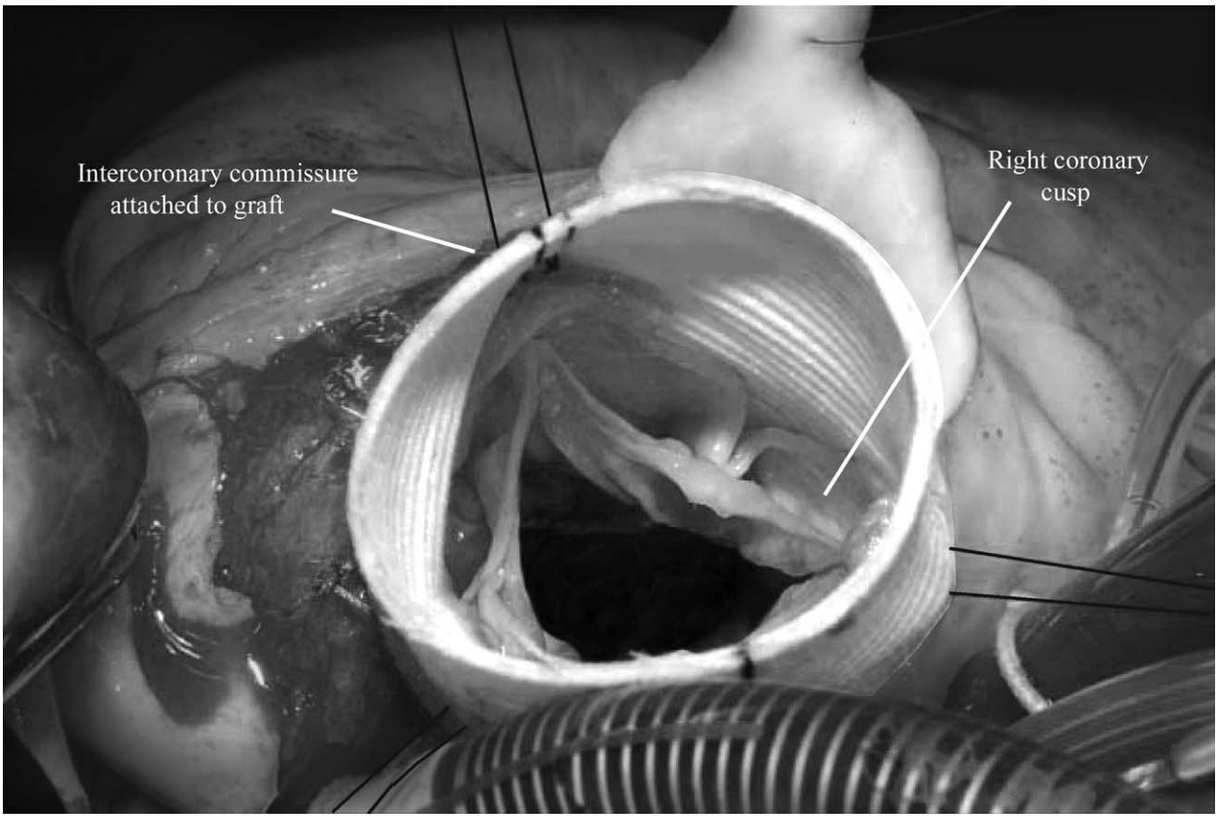

Figure 7 Once the graft is anchored in the aortic root, the commissures are trimmed by placing the stay sutures at the appropriate height inside the vascular graft. There is no need to tie these sutures at this point. The correct position of the commissures inside the graft is identified by slightly pulling on both the commissure and the vascular graft before stitching the sutures through the graft. At this moment, the graft should extend roughly by half of its maximum length at this segment. When the commissures are trimmed, the tissue remnants of the partially resected sinuses of Valsalva are reimplanted into the vascular graft using 4-0 monofilament running sutures starting from the depth of the left coronary sinus. The suture line then continues to the commissure between the left and the noncoronary cusp. A slight mismatch between redundant tissue of the neo sinus and the vascular graft can be easily compensated. In case the mismatch appears too big at this point, the remnant may be shortened by another 1 or 2 mm. If this is not the reason for a mismatch, the graft is probably too narrow and should be replaced by a wider one.

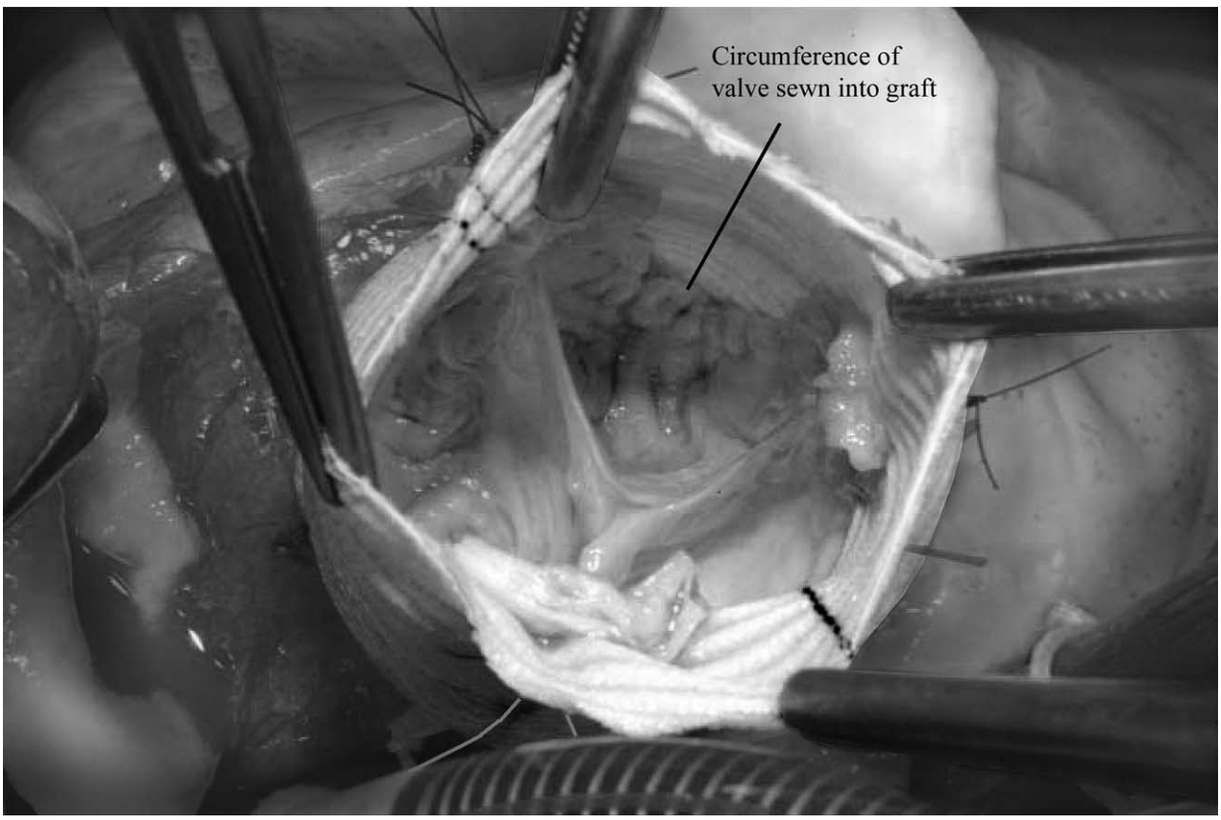

Figure 8 After reimplantation of the neo sinuses, the respective sutures are tied at the tip of the commissures. The initial stay sutures through the commissures are tied too. The aortic valve as a whole is now reimplanted into the vascular graft prosthesis and should present with a "mercedes star"-like configuration of the leaflets within the vascular graft. The prospective valvular competence may now be estimated by assessing the lines of leaflet coaptation and/or instilling some saline solution into the aortic root. Sometimes, small tissue segments may still prolapse into the lumen near the commissures. They may be either carefully resected or plicated to the graft by additional sutures.

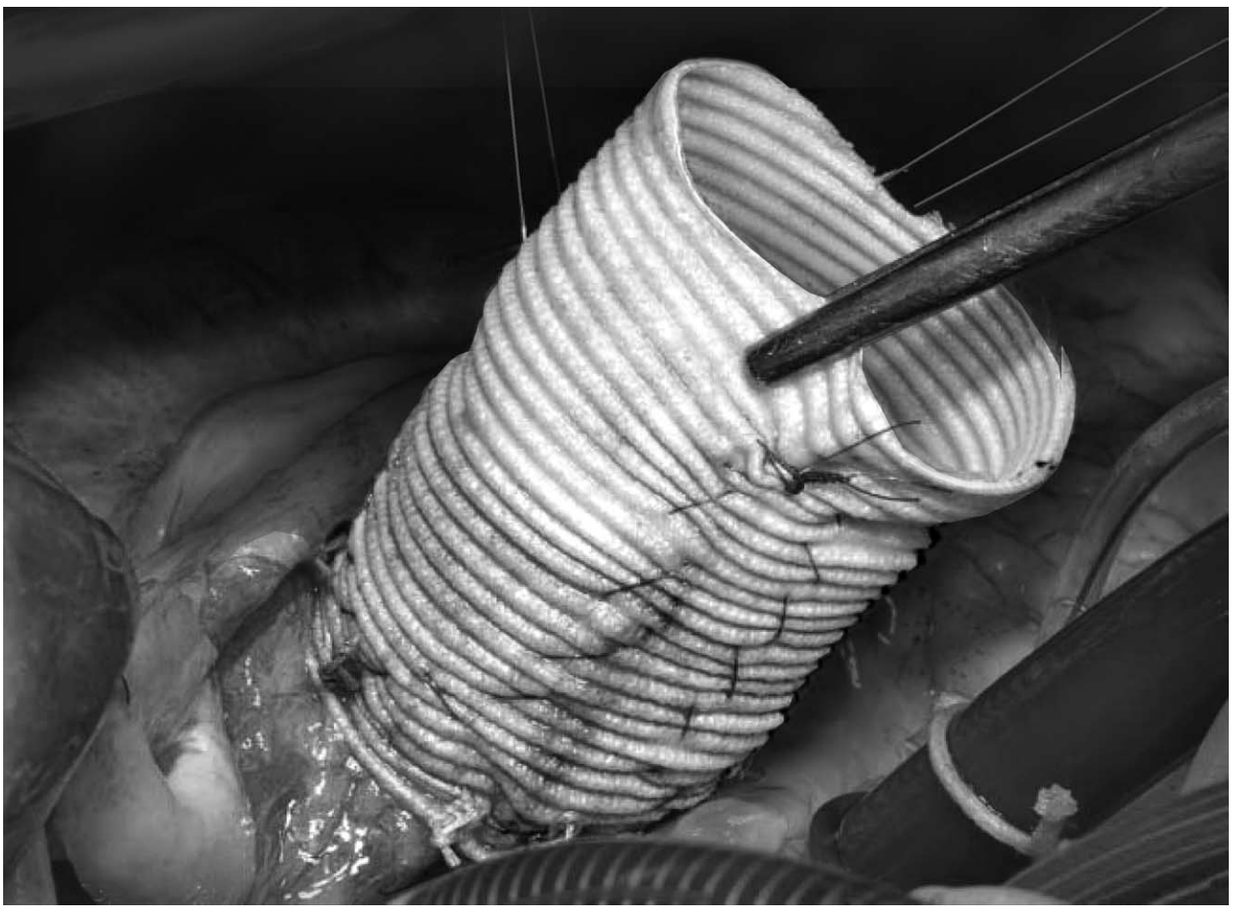

Figure 9 This figure provides the surgeon's view of the external aspect of the graft near the left neo sinus and the left/noncoronary commissure. The left coronary ostial button is seen in the lower left corner. The suture segments that can be seen on the external surface of the graft provide an impression on the remarkable height of the commissures inside the graft. We believe that it is important to reimplant the commissures as high as their individual anatomy suggests to prevent early postoperative valve failure.

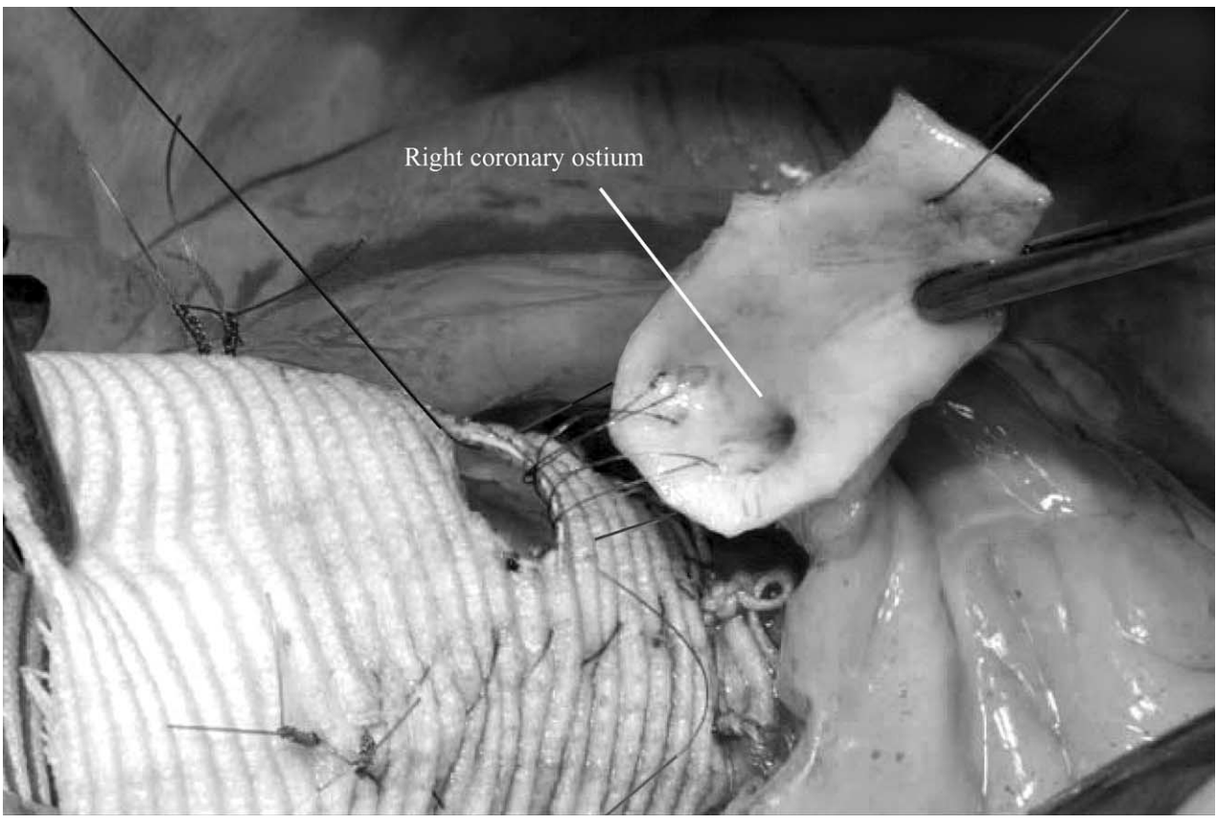

Figure 10 The coronary ostia are reimplanted anatomically in the left and the right neo sinus with a 4-0 or 5-0 monofilament running suture as in any other type of aortic root replacement. The stitches should rather pass through the rim of the ostium than through the aortic wall surrounding to prevent later aneurysmatic dilation of the ostial implantation site.

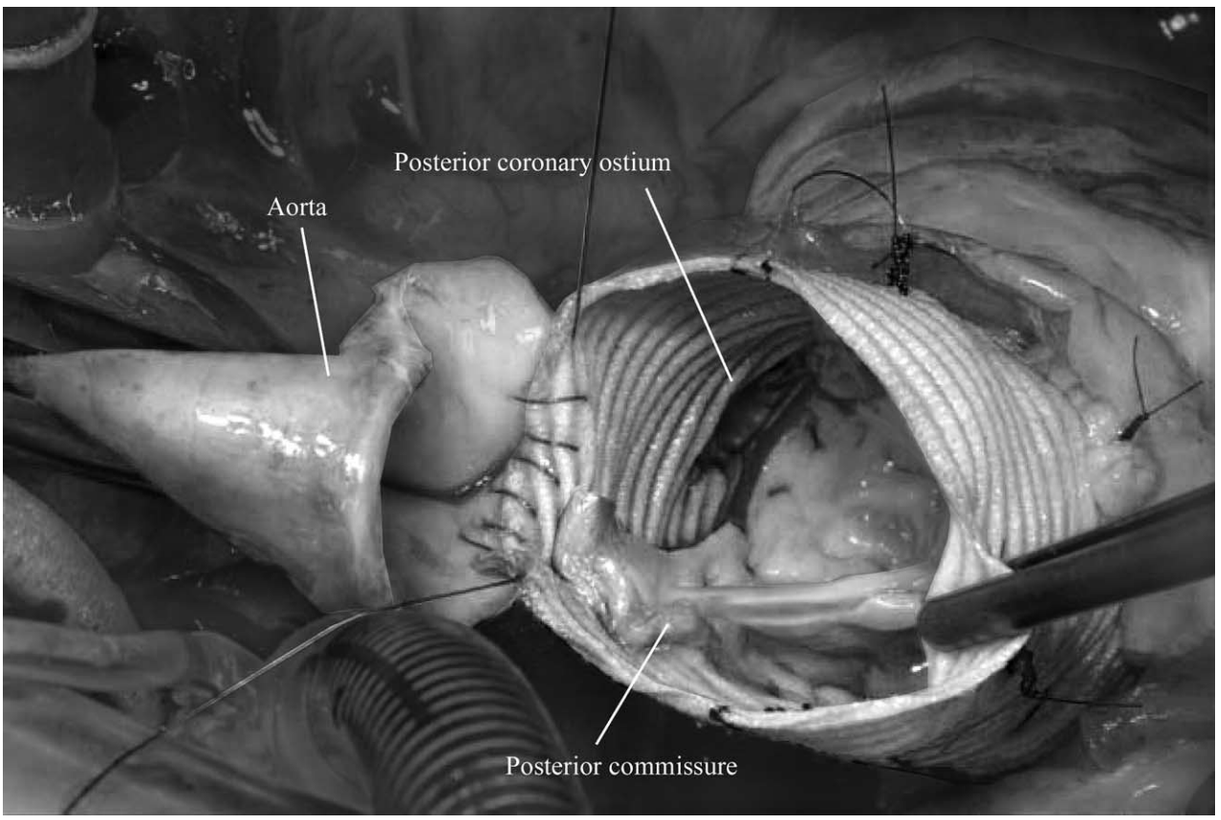

Figure 11 Before the prosthesio-aortic anastomosis completes the repair, both the native distal ascending aorta and the proximal vascular graft segment carrying the reimplanted valve need to be tailored in a way that allows for a tension- and torsion-free anastomosis. This may imply that the commissure between the left and noncoronary cusps is located very close to the anastomotic suture line. We avoid the use of a graft inclusion in patients with isolated repairs according to David, because we have made the experience that even a small rim of graft inclusion may cause malperfusion of the reimplanted left coronary artery.

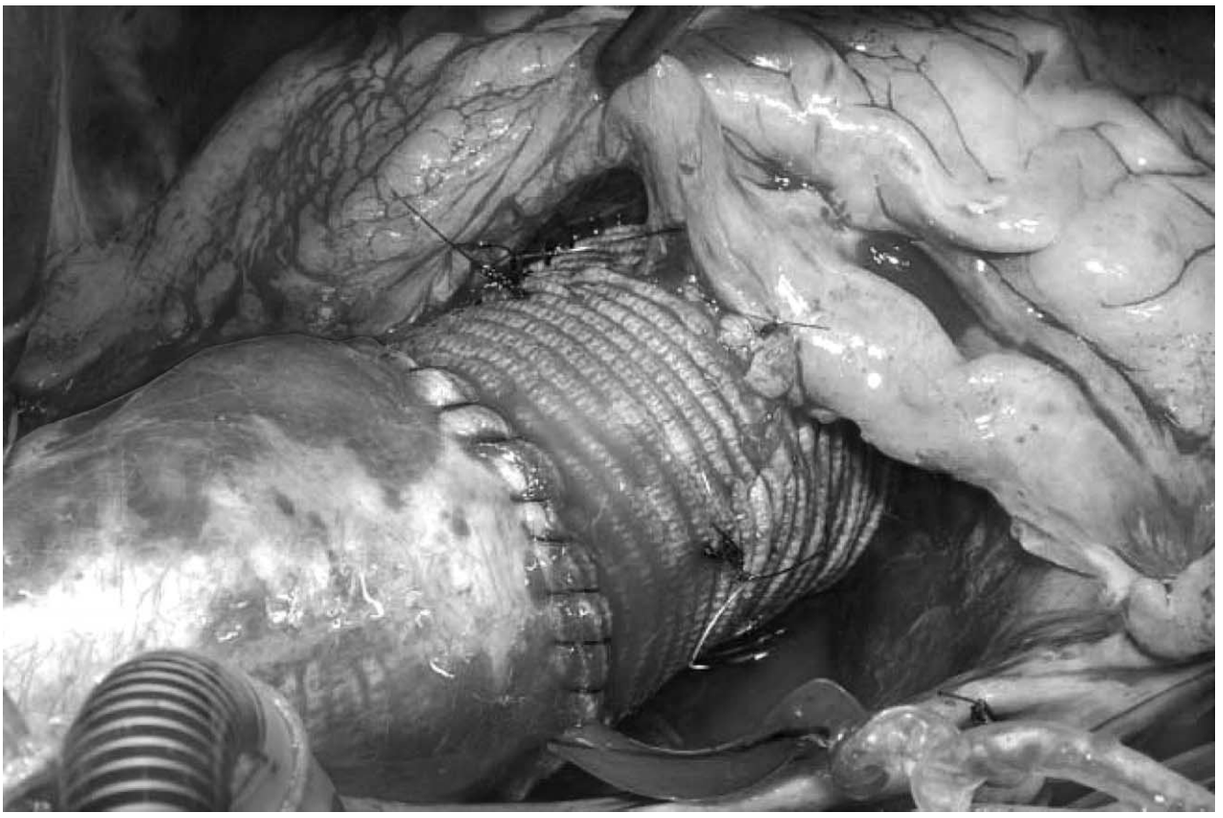

Figure 12 shows the completed repair resulting in a proximal ascending aortic replacement.

Conclusions

Aortic valve reimplantation is a safe and straightforward procedure with a well predictable outcome once a few key issues are addressed. The decision on whether to retain the valve should be founded on careful examination of the valvular leaflets for structural changes, such as dense calcifications, large fenestrations, or severe valve prolapse. Once the decision to retain the valve has been made, the aortic root has to be mobilized around its entire circumference except for a small segment of the perimeter near the membranous septum. Excision of the sinuses should be done with utmost care so as not to damage the valvular leaflets. The buttons of the excised coronary ostia must be mobilized enough to allow for tension-free reimplantation into the graft. Sizing of the graft is a key issue too. The commissures need to be trimmed high enough into the vascular graft to prevent later prolapse. The suture lines for reimplantation of the neocoronary sinuses and the coronary ostia must be blood tight in the first place, because secondary hemostatic sutures may be difficult to position.

Even though evolution of this procedure toward a more physiological operative result is attractive for theoretical reasons, we still trust the original David type I operation and we believe that our confidence is well supported by the favorable follow-up data we have obtained so far.