answered by multi-institutional, prospective investigations such as the 19-center Aortic Valve Operative Outcomes in Marfan Patients registry sponsored by the National Marfan Foundation,¹⁰ which will continue to 2021 when each patient has been followed up for a minimum of 10 years. This knowledge is essential if we are to learn where valve-sparing aortic root replacement fits in our armamentarium, who should do it, and where it should be performed. Certainly this is one procedure that should not be done in low-volume institutions on an episodic basis. The surgical learning curve is too steep, and too unforgiving.

It is important to remind ourselves that the 15- to 20-year durability of these procedures, the reoperative mortality risk for the obligate failures, and whether the cumulative valve-related morbidity and mortality risk is lower than that of receiving a composite valve graft with a mechanical prosthesis still remain unknown. We should know this information in another 10 years.

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EDITORIAL COMMENTARY

Valve-sparing aortic root replacement: Too many cooks?

John S. Ikonomidis, MD, PhD

See related article on pages 112-4.

According to the Society of Thoracic Surgeons database, approximately 11% of patients who underwent aortic root replacement between January 2000 and June 2011 received a valve-sparing procedure. Valve-sparing aortic root replacement has become a well-established option for patients with aortic root aneurysms who have

morphologically normal tricuspid or noncalcified, pliable bicuspid aortic valves. The procedure carries obvious advantages for young patients in that it avoids the need for a mechanical-valved conduit and the concomitant requirement for long-term anticoagulation.

Since the original descriptions of valve-sparing aortic root replacement by Sir Magdi Yacoub and Dr Tirone David, we have learned much about the characteristics of this procedure. Perhaps the most important thing that we learned relatively early on was that the reimplantation procedure was superior to the remodeling procedure because of its stabilization of the annulus. Since this discovery, numerous iterations of the reimplantation operation have been suggested and performed.

In this issue of the *Journal*, Dr Miller¹ provides an excellent and concise summary of the history and development of the valve-sparing aortic root replacement, with specific attention to the various iterations of the David reimplantation operation. In addition, he describes the outstanding results of his own series of 331 patients at

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Stanford University. Of these patients, 284 underwent a David V “Stanford modification” operation of Dr Miller’s own design, in which an appropriately sized, tailored and proximally plicated graft is used to enclose the aortic valve, followed by use of a second smaller distal graft for accurate remodeling of the sinotubular junction. The results of this operation are indeed admirable, at 10 years showing $92\% \pm 4\%$ freedom from aortic root reoperation and $96\% \pm 2\%$ freedom from structural valve deterioration. Particularly remarkable is that 38% of the patients in this series had Marfan syndrome and 29% had bicuspid aortic valves.

Currently, many modifications of the reimplantation technique of valve-sparing aortic root replacement are being used with success. Some centers have continued to use the original David I (which uses a simple straight graft) with good results.² Others have followed the progression of the David operation with a larger graft, as with the David V modification variably with or without the Stanford modification to neck down the neo-sinotubular junction.³ Whether the proximal portion of the graft enclosing the annulus and valve must be separately plicated before implantation still remains somewhat controversial. Many surgeons do not perform this step but rather rely on the subannular sutures placed across the graft to plicate it when tied.^{3,4} Whether omission of this step will result in late dilatation of the annulus remains uncertain, and it is therefore also uncertain whether omission of this step will contribute to long term aortic insufficiency. Of course, the only way truly to reconcile this point would be to conduct a prospective randomized assessment of plicated versus nonplicated grafts, a study that seems unlikely to ever be undertaken.

Although proximal plication of the graft is certainly reasonable, an important technical point is that care must be taken not to further plicate it through the tying of the subannular sutures. It can be relatively easy to introduce a small plication into the graft with the tying of each suture, the sum total of which can constitute a significant narrowing of the left ventricular outflow tract. Unlike Dr Miller’s technique, I and others prefer to stabilize the annulus with an appropriately sized Hegar dilator to avoid this potential complication. This step seems particularly germane when this procedure is performed in an academic center, where residents are taught this operation but do not yet possess the same amount of skill as a seasoned aortic surgeon. These points make Dr Miller’s results even more remarkable, because in his hands the vast majority of these operations had significant resident input. This indeed is a testament to Dr Miller’s remarkable surgical educational skills and in my opinion in part provides justification for his inheritance of the title of the “world’s best first assistant” from Norman Shumway.

Other versions of the David valve-sparing aortic root replacement procedure include use of a Valsalva-type graft.

Although the use of this graft has been criticized for its lack of capacity to be tailored to varying aortic valve commissural heights, many authors have used it with excellent results and have asserted that this lack has not been an issue.^{5,6} The extent of proximal anchoring of this graft is also variable, with circumferential fixation reported by some authors and only partial fixation by others (for example, only 3 stitches placed, 1 under the nadir of each sinus, by the Hopkins Group).⁶ In addition, other variations of the reimplantation valve-sparing aortic root operation have been used successfully. One such operation is the University of Florida “sleeve” operation, a simplified operation in which a graft is placed over the largely undissected aortic root, is anchored circumferentially proximally, and uses “keyhole” incisions in the graft to enclose the coronary arteries.⁴

Dr Miller outlines the surgical quality standards outlined by the National Marfan Foundation, asserting that valve-sparing aortic root replacement should only be performed in centers where the operative mortality is less than 1% and the 10-year freedom from valve reoperation exceeds 90%. He observes that this operation is complex, requiring a combination of technical skill and art, and as such should be limited to centers where this operation is performed frequently because of the learning curve. The surgical guidelines of the National Marfan Foundation as quoted are quite steep, however, and it is unlikely that even many highly experienced centers will be able to satisfy these stringent requirements.

In summary, the reimplantation valve-sparing aortic root replacement has stood the initial test, with excellent results in the hands of many authors. Dr Miller further questions the long-term durability of these operations, the answer to which will surely be complicated by the myriad of techniques employed by various “cooks” attempting to make the same “broth.” Time will tell.

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