The aortic valve–sparing operation

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In 1989, I was referred a young woman with Marfan syndrome and an aortic root of 54 mm with a normally functioning aortic valve. I explained the nature of her medical problem and indicated that replacement of the aortic root with a conduit containing a valve was the standard treatment. I went on to explain the pros and cons of mechanical and biologic valves. She chose to have an aortic valve homograft, because she wanted to get married and have children some day. I operated on her on August 3, 1989. Carolyn Dresler, a general thoracic surgical resident and Joanne Bos, my personal physician assistant, assisted me. After examining the anatomically normal aortic cusps I held still long enough for Carolyn to ask me if I was all right. I told her I was thinking and the thinking went on for at least another minute. I conceptualized the native aortic valve inside a tubular Dacron polyester fabric graft. I started by detaching the coronary arteries, as was routinely done when the aortic root was replaced. Next, I dissected the aortic root circumferentially and excised most of the aortic sinuses. Carolyn and I pulled the 3 commissures upward, and we observed what happened to the cusps, the dilated aortic annulus, and the subcommissural triangles. The patient was relatively small, and so were the aortic cusps. I took a tubular Dacron polyester fabric graft of 26 mm and placed it around the dissected aortic root. Carolyn held the graft immediately below the level of the aortic annulus, and I temporarily secured the 3 commissures in the graft. We again observed what happened to the cusps, annulus, and subcommissural triangles. Everything seemed to fit. At that moment, I knew that I could repair the aortic root without replacing the valve, and the first aortic valve reimplantation was performed.¹

I removed the temporary sutures from the commissures and secured the graft to the left ventricular outflow tract with multiple mattress sutures. The fixation of the graft on the outside of the left ventricular outflow tract reduced the dilated aortic annulus, mostly along the subcommissural triangles of the non-coronary cusp. I suspended the 3 commissures and sutured the remnants of the aortic sinuses to the Dacron polyester fabric graft, just as I had numerous times

before when implanting an aortic valve homograft in the subcoronary position. Finally, I reimplanted the coronary arteries and anastomosed the graft to the distal ascending aorta. At the completion of the operation there was good cusp coaptation but mild aortic insufficiency, which worried me immensely because there had been none before surgery. I followed up that patient obsessively with frequent echocardiograms during the 1st postoperative year and annually thereafter, and her aortic valve function did not change through the years. She underwent magnetic resonance imaging (Figures 1 and 2) and echocardiography 21 years after surgery and was found to have an intact aortic root with mild aortic insufficiency.

Was the development of this operation a stroke of surgical genius? No. It resulted from the accumulation of knowledge of anatomy, physiology, pathology, and surgical experience. By the time I developed aortic valve–sparing operations, I had already amassed a large experience with aortic root replacement with mechanical and biologic

FIGURE 1. Magnetic resonance image of aortic root and thoracic aorta 21 years after reimplantation of aortic valve. Note lack of aortic sinuses.

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FIGURE 2. Magnetic resonance images of closed and open aortic cusps 21 years after reimplantation of aortic valve. Valve continues to function satisfactorily with mild aortic insufficiency.

valves, including the Ross procedure. I had already developed a stentless porcine aortic valve² and several other operations to treat complex problems of the mitral and aortic valves.³ I had replaced 1 or more aortic sinuses during surgery for acute type A aortic dissection. I knew the anatomy of the aortic root and surrounding structures in great detail. The development of this operation was a natural evolution of innovative operative techniques on the aortic root.

I was thrilled and at the same time humbled when John W. Kirklin and Brian G. Barrat-Boyes, both of them pioneers and giants of cardiac surgery, named this type of aortic root replacement with preservation of the aortic valve “the David operation,”⁴ a term that has been used since then.

During the first 5 years of experience, we performed aortic valve-sparing operations only on patients with normal aortic cusps. As our confidence in these operations increased, however, we expanded the indications to patients with abnormal cusps. Intact but prolapsing cusps could be safely shortened by plication along the nodule of Arantius. Cusps with fenestration in the commissural area or elongated and flimsy cusps were shortened and reinforced with a double layer of fine expanded polytetrafluoroethylene sutures (Gore-Tex; W. L. Gore & Associates, Inc, Flagstaff, Ariz).⁵ Both techniques have withstood the test of time.⁵⁻⁷ Patients with bicuspid or tricuspid aortic valves with a coronary artery orifice too close to a commissure to be safely detached and reimplanted with the button technique can be treated with a modified operative technique,⁸ and so on. We have carefully monitored the outcomes of these operations and have reported our results at regular intervals.^{6,7}

We learned that reimplantation of the aortic valve was a more durable procedure than remodeling of the aortic root because of delayed dilation of the aortic annulus.⁹ Because remodeling is physiologically sounder than reimplantation, we added an aortic annuloplasty during remodeling of the aortic root¹⁰; however, time showed that the tissue

in between suture lines dilated and caused aortic insufficiency in young patients, particularly those with Marfan syndrome.⁹ Later on, we found that remodeling of the aortic root was as durable as reimplantation of the aortic valve in older patients with aortic root or ascending aortic aneurysm without annuloaortic ectasia.⁷

Another important issue is the that of aortic sinuses. Although our longest follow-up available is for patients who had the aortic valve implanted into a cylinder, and these results have been excellent,⁷ intuition tells me that the aortic sinuses are important for valve function not only because it has been shown that they play a role in the movements of the aortic cusps during the cardiac cycle but simply because our creator put them there for a reason. I therefore believe that we should create neo-aortic sinuses during reimplantation of the aortic valve into a tubular Dacron polyester fabric graft and have done so by using larger graft than needed and plicating the spaces in between commissures. I remain skeptical regarding Vascutek Gel-weave Valsalva Grafts (Terumo Cardiovascular Systems Corporation, Ann Arbor, Mich), because this type of graft deforms the aortic annulus from its cylindric shape to a spherical shape. Several surgeons are using them, however, and time will show whether my concerns are unfounded.

Finally, reimplantation of the aortic valve places the aortic cusps inside a rigid structure and probably will shorten the durability of the cusps. We have found age to be an independent predictor of development of late aortic insufficiency.⁷ It is possible that the aortic cusps of young patients have greater ability than older, less elastic cusps to adapt themselves to a rigid structure. If this is so, remodeling of the aortic root may be a better operative technique than reimplantation of the aortic valve in older patients without annuloaortic ectasia. Much remains to be learned about aortic valve-sparing operations. That is why clinical research is so exciting.

Aortic valve–sparing operations are no longer experimental procedures, as I was told repeatedly when I first introduced them. These operations are now part of the surgical armamentarium to treat patients with aortic root or ascending aortic aneurysm, and the results during the first 2 decades have been nothing short of excellent.

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