Aortic Valve Replacement With the Toronto SPV Bioprosthesis

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Aortic valve replacement (AVR) with stentless biological valves is a more complicated operation than AVR with stented valves, because it requires a good knowledge of the functional anatomy of the aortic root. The aortic root has four anatomic components: the aortic annulus, aortic cusps, aortic sinuses, and sinotubular junction. The scallop-shaped aortic annulus is attached to fibrous tissue in approximately 55% of the circumference of the aortic root and to myocardium in the remaining 45%. The shape of the aortic annulus creates three subcommissural triangles, two fibrous and one muscular. The three aortic cusps have a semilunar shape, with the bases approximately 1.5 times longer than the free margins. The cusps are suspended by the commissures, located immediately below the sinotubular junction. Thus the average length of the free margins of the cusps must exceed the diameter of the sinotubular junction. Dilation of the sinotubular pull the free margins of the cusps apart, causing aortic insufficiency (AI). Isolated dilation of the aortic sinuses has no effect on valve competence. In children, the diameter of the aortic annulus is approximately 15% larger than the diameter of the sinotubular junction, but in adults these two diameters tend to be equal. The geometry and function of the aortic root components are interrelated. Thus implantation of a stentless biological valve in the subcoronary position carries a risk of a size mismatch between the valve implanted and the recipient’s root. Careful matching of the valve and aortic annulus and sinotubular junction sizes, and adjustment of one of these diameters when the other is abnormal, prevents valve dysfunction after implantation of a stentless biological valve in the subcoronary position.

The Toronto SPV bioprosthesis (St. Jude Medical, St Paul, MN) is a stentless porcine aortic valve used for AVR. This valve was designed for implantation in the subcoronary position of patients with aortic valve disease and normal or near-normal aortic root geometry. This article reviews the operative technique that my group has used for more than a decade with excellent functional results. We have never seen more than trace AI perioperatively, and indeed most patients experience no AI at all. We have also learned that late dilation of the sinotubular junction is common after AVR, particularly in patients with bicuspid aortic valve. This can be prevented with fixation of the sinotubular junction at the time of surgery.
The ascending aorta is cross-clamped and opened through a generous transverse aortotomy approximately 1 cm above the sinotubular junction or 2 cm above the origin of the right coronary artery. The aorta can also be transected completely to enhance exposure of the aortic root. This is particularly useful when a partial sternotomy (minimal access surgery) is used. Cardioplegia for myocardial protection is delivered directly into the coronary arteries with soft, self-inflating cannulas (my preferred method) or into the coronary sinus in a retrograde fashion. A vent is placed into the left ventricle through the interatrial groove. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)
The diseased aortic cusps are excised. Calcified portions of the aortic annulus and calcific deposits on the anterior leaflet of the mitral valve or interventricular septum must be excised completely. After meticulous debridement, the aortic annulus and the tissues immediately underneath should be free from calcium. Care must be exercised to prevent the entrance of calcium debris into the left coronary artery or left ventricular cavity. Next, the position of the coronary artery orifices is examined. The left coronary artery orifice must be at least 5 mm above the aortic annulus for a safe implantation of the Toronto SPV. The right coronary artery is often nondominant in patients with bicuspid aortic valve and may be very close to the commissure between the right and noncoronary sinuses. Moreover, the orifices of the left and the right coronary arteries tend to be close to 180 degrees from each other in these patients. This anomaly is not a contraindication for implanting the Toronto SPV, however. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)
3. The diameter of the aortic annulus is measured with metric sizers (St. Jude Medical) specifically designed for use with the Toronto SPV. Because the inflow of this valve is trimmed in a horizontal plane, the diameter of the left ventricular outflow tract must be measured at the lowest level of the aortic annulus, as shown. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)
The diameter of the sinotubular junction is also measured. This diameter is often similar to the diameter of the aortic annulus, in which case a valve of that size is selected for implantation. But if the diameter of the sinotubular junction is 2 to 4 mm larger than the diameter of the aortic annulus, a Toronto SPV of diameter equal to the diameter of the aortic annulus is selected, and the diameter of the sinotubular junction must be reduced to the diameter of the valve after it is implanted at the completion of implantation, the diameter of the sinotubular junction of the aortic root must not exceed the diameter of the valve. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)

Sizers for the Toronto SPV bioprosthesis have three marks 120° apart. The Toronto SPV bioprosthesis also has three equidistant marks on its inflow. The sizer corresponding to the diameter of the aortic annulus can be used to assist the surgeon in placing three equidistant sutures in the left ventricular outflow. These sutures are placed in the triangles underneath the commissures, level with the lowest portion of the aortic annulus. These three sutures are passed through the marked areas in the inflow of the Toronto SPV. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)
Multiple interrupted 3-0 or 4-0 polyester sutures or continuous 3-0 or 4-0 polypropylene sutures are used to secure the Toronto SPV bioprosthesis to the left ventricular outflow tract and aortic annulus. We prefer to use interrupted 4-0 polyester sutures. These are simple, interrupted vertical sutures placed in the left ventricular outflow tract along the subcommissural triangles and in the aortic annulus on a single horizontal plane. Along the membranous septum, care must be taken to not include myocardium immediately underneath, to avoid the conduction system. As long as the sutures are passed through fibrous tissue, no damage can occur to the conduction pathways. Occasionally, a patient may have a membranous septum that is higher than the lowest portion of the aortic annulus. In such a patient, the sutures should be placed slightly higher and the same thing should be done when they are passed through the Toronto SPV. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)
The remnants of the porcine wall in the Toronto SPV bioprosthesis are of uneven height. The area that contains the septal muscle is the tallest, and the one that corresponds to the porcine noncoronary aortic sinus is the shortest. This difference must be taken into account when orienting the valve inside of the aortic root. In a patient with a normal aortic root, the left coronary artery orifice is 6 or 7 mm from the aortic annulus, and the valve must fit in this space. At least 2 to 3 mm of clearance from the coronary artery orifice is needed, to decrease the risk of pannus obstruction of the coronary artery orifice once the valve heals in the aortic root. For this reason, it is safer to orient the valve’s noncoronary aortic sinus toward the patient’s left aortic sinus and the valve’s right aortic sinus toward the patient’s noncoronary aortic sinus. This orientation provides maximum clearance between the valve and the coronary artery orifices. The first three sutures that were placed beneath the commissures of the aortic root 120° apart are passed through the areas marked in the valve inflow that are also 120° apart. The remaining sutures are evenly spaced in between the first three sutures. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)
The valve is gently placed into the left ventricular outflow tract, and all sutures are tied. The first sutures tied are those immediately below the left main coronary artery; this forces the valve to lie at the lowest possible level of the aortic annulus. The three commissures are aligned within the aortic root, and a 4-0 polypropylene horizontal mattress suture is passed through the arterial walls of the valve and aortic root but left untied. The valve’s commissures should lie immediately below the sino-tubular junction of the aortic root, and should be spaced accordingly to the sizes of the valve’s aortic cusps. The three cusps should touch one another without bends or folds, and the free margins must all be at the same level. Once the three commissures are spatially aligned by moving them up or down and left or right, the suture that suspends the commissure between the left and right cusps is tied, and one of its arms is used to secure the remnants of the porcine arterial wall to the patient’s aortic sinus wall. We prefer to use full-thickness bites, as shown. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)

To suture most of the valve with full-thickness bites, the surgeon must dissect the aortic root circumferentially. This can be done even below the coronary arteries, but the best approach may be to sew the porcine valve from the inside of the aortic root along the spaces immediately below the coronary artery orifices, as shown. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)
Alternatively, the remnants of the porcine wall can be secured to the aortic sinus wall with a continuous suture from the inside of the aorta. Extreme care must be taken to prevent damage to the aortic cusps. If the needle goes through a cusp, then the valve should be explanted and a new valve implanted. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)

If the sinotubular junction is larger than the diameter of the valve used, then it should be plicated with an U-shaped stitch on a Teflon felt pledget at the level of or immediately above the sinotubular junction, as shown. This maneuver approximates the commissures of the corresponding cusp. It can be done in any area of the sinotubular junction that appears larger than what the cusp can seal. Whenever this is needed, it is advisable to use a band of Dacron fabric on the outside of the aorta and secure it at the level of the sinotubular junction. This band should be 4 to 5 mm wide and of a diameter equal to the valve diameter. The band's length can be calculated by multiplying its diameter by $\pi$ ($\pi = 3.14$). The band is secured to the aortic wall with a few interrupted sutures to prevent migration. Patients with a normal sinotubular junction do not need plication or a Dacron band on the outside of the aorta. Most if not all patients with bicuspid aortic valve should have a Dacron band even if the sinotubular junction is not dilated at the time of surgery. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)
The aortotomy is closed, and the procedure is completed. If the ascending aorta is dilated and needs to be replaced, then a graft of diameter equal to the valve’s diameter should be anastomosed to the aortic root at the level of the sinotubular junction. If the implanted valve is smaller than 25 mm, then a graft of 26 to 28 mm should be used, and the end of the graft anastomosed to the sinotubular junction should be reduced to the valve’s diameter. This guarantees that the sinotubular junction will not dilate over time. (Reprinted with permission from St. Jude Medical, St. Paul, MN.)

Comments
AVR with stentless valves should be performed with intraoperative Doppler echocardiography. Preoperatively, the sonographer can measure the diameters of the aortic annulus and sinotubular junction and obtain information about the aortic root anatomy. Patients with normal or near-normal aortic root geometry are candidates for Toronto SPV implantation.

It takes longer to implant a stentless valve than a stented valve, but the attendant increase in aortic cross-clamping time has not been associated with increased mortality and morbidity. The most gratifying benefit of AVR with the Toronto SPV has been the hemodynamic and clinical outcomes at midterm. The hemodynamic performance of this valve is similar to that of aortic valve homografts and is clearly superior to stented porcine bioprostheses. This hemodynamic advantage may confer benefits in terms of functional improvement and survival. A case-match study of patients who underwent AVR with the Toronto SPV and the Hancock II bioprosthesis showed a survival benefit associated with stentless valves, mostly from a reduced number of cardiac deaths. Because of the heterogeneity of patients with aortic valve disease, large randomized clinical trials are needed to establish whether functional improvement and late survival in AVR is better with stentless valves than with stented bioprostheses.

REFERENCES