Chapter 4
Aortic Valve Surgery

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Introduction

The most common indication for aortic valve replacement in the Western world is degenerative calcified aortic stenosis. In developing countries, rheumatic heart disease remains and continues to be an important indication.

Setup

The approach can be a standard sternotomy or a mini sternotomy incision. The ascending aorta should be cannulated as distally as possible, at or above the pericardial aortic reflection, so as to maximise the space available for subsequent placement of the aortic cross-clamp as well as the aortotomy. A single two-stage venous cannula is placed into the right atrium. Cardiopulmonary bypass is commenced. To optimise visualisation during the operation, a vent may be placed through the right superior pulmonary vein via the left atrium and into the left ventricle. The aortic cross-clamp is applied as close to the aortic cannula as possible. In the absence of significant aortic regurgitation, antegrade cardioplegia may be delivered to arrest the heart prior to aortotomy. Retrograde cardioplegia can also be delivered if desired for continued myocardial protection. This may also be helpful in cases of aortic regurgitation.

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Exposing the Aortic Valve

An oblique or transverse aortotomy about 1–2 cm above the origin of the right coronary artery is made. An oblique incision may be extended into the middle of the non-coronary sinus of Valsalva to increase the exposure or to facilitate subsequent aortic root widening. The incision should stop at least 10 mm from the aortic annulus to facilitate easy placement of sutures and closure of the aortotomy. Pump suction is placed through the aortic valve leaflets to remove blood from the left ventricle. Cardioplegia is given at this stage, directly to the coronary ostia if it has not already been given. Typically, 600–800 ml of cold blood cardioplegia is delivered to the left coronary ostia and 250–400 ml to the right coronary ostia. Stay sutures can be placed on the aorta and an assistant can further retract the aortic wall with a leaflet retractor to maximise exposure.

Decalcification and Excision of Leaflet

The aortic valve leaflets are completely excised and can often be removed intact with the attached calcification. Residual calcification on the aortic annulus is then removed with the help of a Ronguers or similar instrument to crush the calcium, followed by the use of scissors and forceps to cut and remove the calcium. In some cases, the use of a scalpel with a No. 11 blade may be helpful. Removal of all calcium deposits is important to allow proper seating of the valve prosthesis and avoid paraprosthetic leaks.

Care must be taken during leaflet excision and decalcification so that the deeper and surrounding structures of the aortic annulus are not damaged. In general, it is safest to leave a 1-mm rim of leaflet tissue during excision. Any remaining calcium deposits can be subsequently removed. Care must be taken not to perforate the aorta, particularly in the region between the commissure of the non-coronary and left coronary leaflet and the middle of the left coronary

leaflet. Other structures at risk include the right and left coronary ostia, the anterior leaflet of the mitral valve which lies below the non-coronary sinus and the conduction tissues in the region of the membranous septum around the commissure between the right and non-coronary sinus.

High-powered suction is used throughout the decalcification to remove calcium debris and ensure that these do not enter the coronary ostia or the left ventricle chamber. Placement of a small wet gauze into the left ventricle prior to decalcification can be helpful to catch any calcium deposits which may fall into the left ventricle. A washout with cold saline delivered with a 50 ml syringe is used at the end to flush out and remove any calcium deposits which may have fallen into the left ventricle.

Valve Replacement

The annulus is sized using valve obturators of the desired valve prosthesis. The valve should fit snugly onto the aortic annulus. Too loose a fit would suggest that the patient could benefit from a larger sized prosthesis while too tight a fit would make seating the prosthesis difficult and also risk disruption of the aortic annulus and closure of the aortotomy. In small aortic roots or where patient-prosthesis mismatch may occur, for example, in a large patient with a small aortic root, patch enlargement of the aortic root may be necessary, using either an anterior (Nick's/Nunez, Manouguian procedure) or a posterior (Konno/Rastan) approach.

Suture Placement

The valve may be replaced by using semi-continuous Prolene sutures or interrupted Ethibond sutures, with or without pledgets. Simple interrupted non-pledgeted sutures and non-pledgeted horizontal mattress sutures have the advantage of allowing a larger sized valve prosthesis to be placed, but at a

possible risk of increased paraprosthetic leaks. Semi-continuous suturing techniques are also used, which are quicker to perform, but may be less secure than interrupted techniques.

Our preference is to use interrupted pledgeted horizontal mattress non-absorbable 2/0 sutures (e.g. Ethibond) in all patients undergoing aortic valve replacement for degenerative calcification; semi-continuous sutures may be used in non-calcific aortic regurgitation.

The sutures are placed, starting at the commissure between the non-coronary and left coronary leaflets and moving in a clockwise direction along the left coronary leaflet, the right coronary leaflet and ending at the non-coronary leaflet. A double-ended pledgeted suture is used. The needle passes through the annulus with sufficient depth so as to be secure, but care must be taken to avoid injury to deeper structures with a deeper bite of the suture. The suture must pass through annular tissue and not just through leaflet remnants. The mattress sutures are placed appropriately by applying traction to the preceding suture to facilitate visualisation of the aortic annulus for placement of the next suture. Alternating sutures of two colours (e.g. green and white) will help identification of each suture pair. The sutures of each sinus are grouped together to allow easy subsequent placement.

An alternative technique is to place everting horizontal mattress sutures where the pledgets are placed above the annulus rather than below it. This technique has the disadvantage of narrowing the aortic annulus, necessitating the use of a smaller sized valve. However, it may be advantageous if the aortic annulus is large or dilated and it may lower the risk of paraprosthetic leaks. It is also technically easier to perform and avoids the risk of a loose pledget in the left ventricle if the suture breaks, either during placement or knot tying.

Once the sutures have been placed around the aortic annulus, they are then passed through the sewing ring of the valve prosthesis, starting with the sutures from the commissure of the right and left coronary sinus and moving towards the commissure of the left and non-coronary sinus, then with

the sutures from commissure of the left and right sinus and moving towards the commissure of the right and non-coronary sinus and ending with the sutures from the non-coronary sinus. Care is taken to ensure equal spacing of the sutures.

Securing the Valve

The sutures are held taut and the valve is lowered into the annulus. The sutures may be relaxed as the valve passes into the aorta and the valve is angled through the aortotomy. The sutures are then pulled taut again while supporting the valve prosthesis to ensure a correct placement on the aortic annulus.

The valve holder is then removed. Sutures are tied, starting at the commissure of the non-coronary and left coronary sinus and moving in a clockwise direction along the left coronary sinus and the right coronary sinus and ending at the non-coronary sinus, following the pattern of placement. Sutures should be tied in a direction parallel to the sewing ring to avoid injury to the leaflet tissue. A minimum of four knots are used. The coronary orifices are inspected to ensure that they are not obstructed by the valve or its struts and the valve leaflets are inspected for optimum opening and closure without obstruction.

Aortic Root Enlargement

If enlarging a small aortic root is felt necessary, a pericardial patch is used. The Nick's/Nunez procedure is generally preferred. The aortotomy is extended downwards through the middle of the non-coronary sinus onto the subaortic fibrous curtain. It is preferable not to include the mitral annulus so as not to affect mitral valve function. A pericardial patch is then used to close this defect, using continuous 3/0 Prolene. The valve prosthesis is stiched onto the pericardial patch using a

pledgeted horizontal mattress suture with the knot tied onto the pledget outside the pericardial patch.

Alternatively, the Manouguian procedure can be used. The aortotomy incision is extended downwards through the commissure between the left and non-coronary sinuses into the inter-leaflet triangle and ending just above the anterior mitral leaflet annulus. There is little fibrous support in this region and the edges of the aortotomy can separate widely. The left atrium is dissected away and may or may not be opened. Depending on the degree of aortic root enlargement needed, some or all of the non-coronary sinus can be excised. An appropriate sized pericardial patch, usually about 4 cm in diameter, is used to fill the defect created. A pericardial strip is placed along the incision, outside the aortic wall. Continuous 3/0 Prolene sutures or multiple interrupted horizontal mattress 3/0 Ethibond sutures are then placed through the pericardial strip, the aorta and the patch. If the left atrium is opened, this will need to be closed by suturing to the pericardial patch.

The prosthetic valve is then sutured to the patch using interrupted horizontal matress 2/0 Ethibond sutures with the sutures passing through the patch and tied on the outside, supported by pledgets. The sutures can also pass through the anterior mitral annulus in this region for additional support.

The anterior approach described by Konno/Rastan is generally used in the paediatric population. A longitudinal aortotomy is made and is extended into the right coronary sinus of Valsalva, as far to the right of the right coronary ostia as possible, but not reaching the commissure between the right and non-coronary sinuses and onto the anterior wall of the right ventricle. The ventricular septum is incised. An appropriately sized oval pericardial patch is then sutured on the right ventricular side of the incised septum, continuing up to the level of the aortic annulus using interrupted pledgeted horizontal matress 3/0 Ethibond sutures. The valve sutures are then placed through the patch as a horizontal mattress suture supported by pledgets, with the knot tied on the outside of the patch. A separate continuous 3/0 Prolene suture is

used to stich the patch to the aorta, closing the aortotomy. Another patch is then used to close the right ventricular outflow tract. This is sewn onto the edges of the right ventricular outflow tract and across the first patch at the level of the prosthetic valve, using continuous 3/0 Prolene.

Aortotomy Closure

A two-layered closure is used. A double-ended pledgeted 4/0 Prolene suture is used, starting at one end of the aortotomy. An everting horizontal mattress stich is first placed. Both needles are passed through both edges of the aortic wall about 5 mm apart and 5 mm in depth and another pledget is placed through these and the two ends of the sutures are tied down. A rubbershot clip is applied to one end of the sutures while the other end is used to close the aorta. A continuous horizontal mattress suture is used, approximating the two edges of the aortic wall and everting them. The sutures are placed about 5 mm in depth and moved about 5 mm at a time along the aortic wall. This is continued until about halfway along the aortotomy. The procedure is then repeated, using another double-ended suture, starting at the other end of the aortotomy and moving towards the first suture.

If the aortotomy has extended too close to the annulus, it may be necessary to close the aortotomy using a pericardial patch. In such cases, it is better to suture the pericardial patch to the aortic wall before lowering the valve prosthesis onto the annulus. If a pericardial patch is not used, it is advisable to place the first stitch for aortotomy closure first before lowering the valve.

Once the second suture has reached the first suture, the aorta is de-aired. The patient is placed in a head-down position, the anaesthetist is asked to inflate the lungs and hold them in inflation, the perfusionist is asked to fill the heart and the aortic cross-clamp is removed. Forceps can be placed in the space between the two sutures to allow the escape of

trapped air. The two sutures are then tied together once de-airing is complete.

One end of the suture is then used as a continuous suture towards one end of the aortotomy. The depth of the suture should be above the previous horizontal matress suture. The suture is tied to the suture remaining at one end of the aortotomy and the procedure is repeated for the other side of the aortotomy.