8

Ross Procedure

8.1 Indications & Scope of the Aortic Valve Procedures

Aortic valve repair or a replacement is required in infants and children for the following conditions:

1. Aortic valve annular hypoplasia.
2. Progressive stenosis of the aortic valve in infants and children.
3. Aortic valve stenosis associated with multilevel left ventricular outflow tract obstruction, not amenable to simple aortic valve repair and requiring enlargement of the outflow tract.
4. Rheumatic aortic valve disease.
5. Aortic valve endocarditis.
6. Aortic insufficiency.

8.1.1 Aortic Valve Repair

Several aortic valve repair techniques have been used in children, including autologous pericardial leaflet extension, leaflet replacement, annuloplasty etc. These valve repair techniques eliminates the need for anticoagulation, but the long term results were less satisfactory, and residual aortic valve lesions (e.g., regurgitation, stenosis) are not uncommon, eventually, requiring reoperation and a possible valve replacement. The aortic valve repair may delay the need for ultimate valve replacement options, which can be offered to the patients after completion of somatic growth, pregnancy, and an increased compliance with anticoagulation regimen.

8.1.2 Mechanical Valve Replacements

Though the incidence of structural valve deterioration is negligible, mechanical valve prostheses are not the ideal valve substitutes in young infants and children due to the lack of appropriate sized prostheses and absence of potential for growth as the child grows. The mechanical valves require a lifetime anticoagulation with a lifetime risk of thromboembolic and bleeding complications, difficulties with future pregnancy, and potential poor compliance with anticoagulation regimen.

8.1.3 Tissue Valves and Homografts

Though homografts and bio prosthetic valves do not require anticoagulation, the lack of appropriate sized prostheses for infants and children at implantation, limited durability due to structural valve degeneration and early calcification, and lack of growth limit their usage.

The Ross procedure, using the pulmonary autograft, provides excellent hemodynamics flow characteristic, and is capable of growth, and does not require anticoagulation. The procedure of replacing the aortic valve with the patient's own pulmonary valve and then using a pulmonary allograft to replace the pulmonary valve is commonly referred to as the Ross procedure.

8.2 Contraindications for Ross Operation

Ross procedure is contraindicated in the presence of pulmonary valve pathology, significant mitral valve pathology that requires mechanical valve replacement, significant dilatation of the aortic root associated with aortic regurgitation, and in several connective tissue disorders (Marfan syndrome) or autoimmune diseases (Reiter disease) associated with aortic valve pathology.

8.3 Principles of Ross Operation

The pulmonary valve and aortic valves are assessed preoperatively by echocardiography for clinically significant regurgitation or any other pathology. It is also useful for assessing the sizes of the aorta and pulmonary annulus. A disparity in a size of more than 2-3 mm is likely to require augmentation or reduction in the diameter of the aortic annulus.

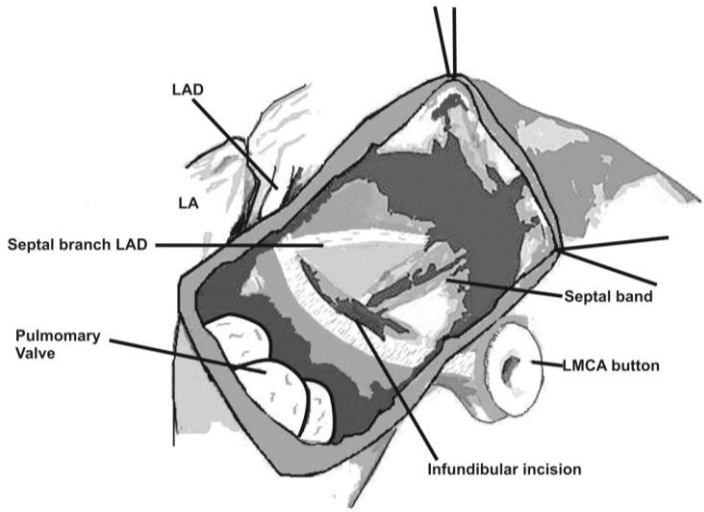

Figure 8.1 *The diagram represents pulmonary valve autograft procurement for the Ross procedure. Note the course of the LMCA and first septal branch of LAD and their close relationship to the subpulmonary conus. LMCA = left main coronary artery, LAD = left anterior descending coronary artery, LA = left atrium.*

Subpulmonary conus is a thin muscular tube beneath the pulmonary valve and the dissection for procuring the autograft should extend to this level. In harvesting the autograft, the knowledge of the course of the left coronary artery, the first septal branch of the left anterior descending artery and their relationship to the right ventricular outflow tract is very important (see Figure 8.1). Knowledge of the configuration of the left ventricular outflow tract and the relationship to the

conduction system is also important when enlargement of the left ventricular outflow tract (Ross-Konno procedure) is required (see Figure 8.2).

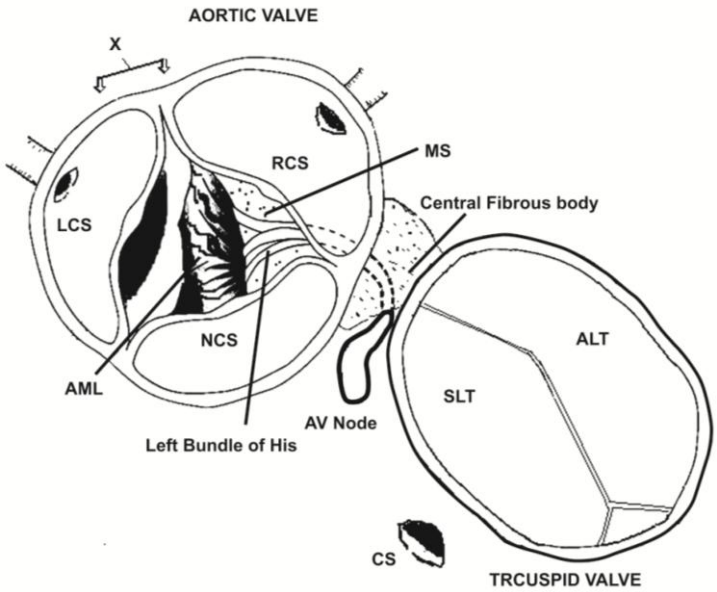

Figure 8.2 *The diagram depicts the anatomical relationships of aortic valve and tricuspid valve to the AV node, bundle of His, central fibrous body, and membranous inter-ventricular septum. The arrow heads with X mark shows the safe area to make incision in the aortic valve annulus to enlarge the aortic root during the Ross-Konno procedure, to avoid damage to the conduction bundle. ALT = anterior leaflet of the tricuspid valve, AML = anterior leaflet of the mitral valve, AV node = atrioventricular node, CS = coronary sinus, LCS = left coronary sinus, MS = membranous inter-ventricular septum, NCS = non coronary sinus, RCS = right coronary sinus, SLT = septal leaflet of the tricuspid valve.*

8.4 Operative Technique

The procedure is performed under CPB (cardiopulmonary bypass), with moderate hypothermia (32-34 ℃) using the standard aortic and bicaval venous cannulation. The heart is arrested by a combination of antegrade and retrograde cardioplegia. The left ventricle is decompressed by venting through the right superior pulmonary vein.

The aorta is transected 1.5 cm above the right coronary artery. If the aortic valve is not repairable, the leaflets are then completely excised and calcium is debrided. The main pulmonary artery is partially opened just proximal to the bifurcation, and the valve is inspected to ensure normal anatomy and function. If the decision is made to proceed with the Ross procedure, the coronary buttons are prepared with a generous rim of aorta around each ostium to allow for suturing to the pulmonary autograft.

The pulmonary artery is dissected free from the aorta up to the bifurcation, and is completely divided at the bifurcation. An incision is made on the RV infundibulum approximately 1 cm below the base of the pulmonary valve cusps. This infundibular incision is facilitated by placing a right-angled clamp through the valve and by bringing the tip through the infundibulum. The right ventricular outflow tract is incised circumferentially using the scissors. Once the dissection proceeds laterally and posteriorly, the left anterior descending artery and its first septal branch are at risk, and care is taken to not injure them. After harvesting of the autograft, retrograde cardioplegia is administered to ensure hemostasis in the bed of the harvested autograft by ligating several venous tributaries.

The autograft and the right ventricular outflow tract are sized with the valve sizers to select an appropriate-sized pulmonary homograft. The aortic root annulus is also sized to determine if there is any discrepancy that needs to be addressed. An annular size difference of 2-3 mm is well tolerated. If the aortic annulus is too large, reduction is best achieved with an imbricating suture passed circumferentially at the level of the annulus and tied over a dilator that sized the pulmonary autograft. Alternatively, a series of mattress sutures can be used with a care to avoid the region of the conduction system. If the aortic root annulus is too small, then an aorto-ventriculoplasty combined with the Ross procedure (commonly known as Ross-Konno procedure) is done.

The autograft should be orientated, so that the commissures of the autograft line up with the commissures of the excised aortic valve, and is sutured to the aortic valve annulus using either a running or an interrupted 4-0 polypropylene suture. The sutures are tied around a circumferential strip of Teflon felt (3 mm wide) if further growth of the aortic annulus is not desired. Small openings are made in both the left and right coronary sinuses of the autograft, and both the left and right coronary arteries are anastomosed using a running 6-0 polypropylene suture. The distal aortic anastomosis is then constructed with a continuous 4-0 polypropylene suture.

The aortic root is deaired and distended with a cold saline solution to test the suture lines. At this point, the right coronary artery if not already is implanted, may be implanted into the autograft once it is distended. The anastomosis is the constructed in a similar fashion as the left coronary button. Antegrade cardioplegia can now be administered, and bleeding in the bed of the harvested auto graft is further controlled.

A cryopreserved pulmonary homograft is then appropriately trimmed, and the distal anastomosis is performed using a continuous 4-0 polypropylene suture. The proximal anastomosis is then constructed with a continuous 5-0 polypropylene.

8.5 Postoperative Management

The postoperative course following the Ross aortic valve replacement is variable. The usual hospital stay averages one week to ten days.

8.5.1 Hemodynamic Management

This is an extensive operation, and inotropic support is frequently required.

Postoperative intracardiac pressures should be normal.

Slightly elevated left atrial pressure may occur secondary to left ventricular hypertrophy and poor left ventricular compliance.

Arterial oxygen saturation should be normal.

8.5.2 Invasive Monitors

Arterial, CVP (central venous pressure), and left atrial catheters. An oximetric catheter is utilized to assess the cardiac output.

8.5.3 Vasoactive Drug Infusions

Dopamine or dobutamine, epinephrine, milrinone, nitroprusside or phenoxybenzamine, and nitroglycerin (see Section I Chapters 4 & 16).

8.5.4 Postoperative Bleeding

As numerous external cardiac suture lines are exposed to systemic pressure, bleeding is a potential complication.

8.5.5 Cardiac Arrhythmias

Occasionally, these occur following the repair. Temporary atrioventricular pacing should be available at the bedside (see Section I Chapter 4).