Chapter 13
Aortic Valve Repair and Replacement

Nicholas Oh and Douglas Johnston

Overview

- Various valve pathologies contribute to hemodynamically significant aortic stenosis or aortic regurgitation.
- When surgical indications are met, the aortic valve disease can be addressed with aortic valve replacement or repair. However, the choice of valve replacement or type of repair can vary depending on valve anatomy and clinical situation.
- Small aortic roots, prosthetic valve-patient mismatch, and paravalvular regurgitation are additional considerations when addressing aortic valve pathology.

Basic Introduction to Valve Pathologies

Aortic Stenosis

- Aortic Stenosis (AS) is the most prevalent valvular heart disease in adults in developed countries. AS is present in 5% of the population by the age 65 with increasing prevalence with age [1, 2].
- Acquired AS is usually caused by degenerative calcification of the aortic valve. Calcium deposits involve the aortic valve leaflets and may extend into the aortic annulus.
- Bicuspid aortic valves represent the most common form of congenital AS, presenting in 1–2% of the general population. Gradual calcification of the bicuspid AV results in significant stenosis [3].

N. Oh (✉) · D. Johnston
Department of Thoracic and Cardiovascular Surgery, Cleveland Clinic, Cleveland, OH, USA
e-mail: OHN2@ccf.org; JOHNSTD3@ccf.org

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- Rheumatic aortic stenosis is the least common form of AS in adults in the developed world, though prevalence is higher in developing countries. Rheumatic aortic valves are typically thickened and fibrotic with rolled edges and associated cusp fusion.

Aortic Regurgitation

- The pathophysiology of aortic regurgitation (AR) can be differentiated by onset and duration of disease.
- Acute AR can occur in the setting of endocarditis, dissection, or trauma. Hemodynamically significant acute AR usually requires surgery.
- Chronic AR occurs due to distortion of valve leaflets or dilation of the aortic root.
- Distortion of the valve leaflets and improper coaptation can be caused by aortic leaflet calcific degeneration, myxomatous degeneration, infective endocarditis, rheumatic disease, or bicuspid aortic valve.
- Dilation of the aortic root can also disrupt the integrity of the aortic valve. Aortic dissection, trauma, connective tissue disease can dilate the aortic root and annulus, leading to improper coaptation.
- A mixed aortic regurgitation and aortic stenosis are often seen in combination due to calcification or rheumatic disease.

Indications for Repair vs Replacement

- In AS, surgical intervention is considered when severe AS is diagnosed (mean AV gradient >40 mmHg, peak velocity >4 m/s, AVA <1.0 cm^2 dimensionless index <0.25) (Fig. 13.1a).

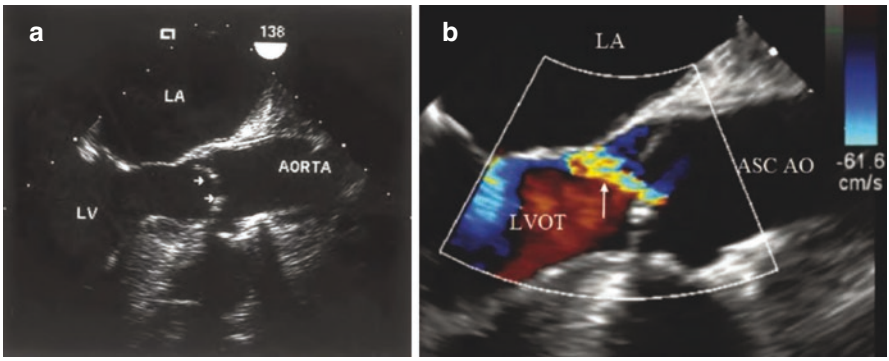

Fig. 13.1 Echocardiogram demonstrates leaflet doming (arrows) indicating severe aortic stenosis (**a**). Color flow doppler shows an eccentric aortic regurgitant jet directed anteriorly (**b**)

- In AR, surgical intervention is considered when severe AR is diagnosed (jet width >65% of LVOT, vena contract >0.6 cm, holodiastolic flow reversal in proximal abdominal aorta, regurgitant volume >60 mL/beat, regurgitant fraction >50%, effective regurgitant orifice >0.3 cm^2, angiographic grade 3+ or 4+) (Fig. 13.1b).
- The ACC/AHA Guidelines for the Management of Valvular Heart Disease provides recommendations for surgical timing based on the severity of disease, presence of symptoms, left ventricular morphology and function, and surgical candidacy. Aortic valve surgery is recommended in the presence for severe disease in symptomatic patients, and in asymptomatic patients with reduced ejection fraction, positive stress test, or other changes in cardiac morphology [4].
- When surgical indications are met, most patients undergo an aortic valve replacement. However, aortic valve repair is an option in selected patients with AR at experienced centers. Successful repair requires careful consideration of the size and quality of the aortic cusps, size of the aortic root, and possible reimplantation.

Repair Techniques

- There are many well-described techniques for aortic valve repair. Each technique must address the underlying pathology and ensure function of the anatomic components of the aortic valve: commissures, leaflets, annulus, sinotubular junction, and sinuses.
- Aortic valve cusp perforation typically occurs in the setting of infective endocarditis or iatrogenic injury. Small perforations can be repaired using a patch of fresh or glutaraldehyde-fixed autologous pericardium.
- Aortic cusp prolapse occurs when free margin of the leaflet is elongated. This can be repaired by plication or suspension of the free margin, or with a commissuroplasty (Fig. 13.2a).
- Dilation of the sinotubular junction from aortic root or ascending aortic aneurysms can lead to increased stress along the free margin of the cusp, causing thinning and stress fenestrations. Small fenestrations can be addressed using a simple stitch.
- The normal valve movement may be restricted by calcification, infective endocarditis, or fibrotic tissue. Aortic cusp restriction can be addressed by removal of calcium, valve extension or extended resection and reconstruction.
- Bicuspid aortic valves can also be repaired when anatomy is favorable. General principles include ensuring good coaptation by creating similar free margin lengths of the bicuspid leaflets and suspension of valve commissures.

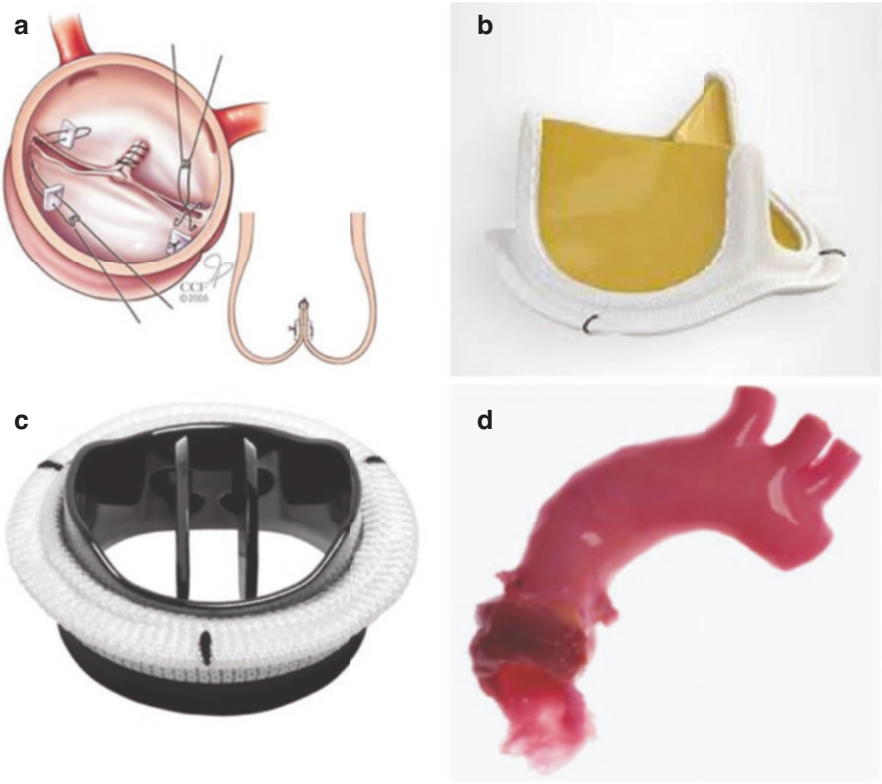

Fig. 13.2 Aortic valve repair of a bicuspid aortic valve with R-L fusion (**a**), bioprosthetic aortic valve (**b**), mechanical aortic valve (**c**), aortic homograft (**d**)

Replacement Techniques

Stented Bioprosthetic Valves

- Stented bioprosthetic valves are constructed using porcine valves or bovine pericardium, mounted on a plastic or metal frame (Fig. 13.2b). These valves are pretreated to prevent extracellular matrix buildup and/or calcium deposition.
- Because of the relative ease of implantation relative to other biological valves, stented valves represent the majority of biological aortic valve replacements.
- Bioprosthetic valves do not require anticoagulation. However, leaflets degrade slowly over time, resulting structural valve deterioration (SVD) and eventual reoperation.
- The advantages and disadvantages of valve type require careful consideration based on patient age, anatomy, risk profile, and patient preference.

Mechanical Valves

- Mechanical valves are constructed from pyrolytic carbon, using two hinged leaflets and have demonstrated very low failure rates related to the valve mechanism (Fig. 13.2c).
- All current mechanical valves require anticoagulation with warfarin. Reoperation for mechanical valves can occur due to infection, formation of thrombus on the valve, or pannus (scar tissue) ingrowth which interferes with leaflet function.
- Reoperation rates for mechanical valves are lower than that for bioprosthetic valves, however rates of hemorrhage and stroke are higher.

Stentless Valves

- Intact preserved porcine aortic roots or cryopreserved aortic homografts constitute stentless valve options (Fig. 13.2d).
- These provide several advantages including excellent hemodynamic profiles, no anticoagulation requirement, and lower risk for prosthetic valve infection.
- The use of stentless valves may help in avoiding patient prosthesis mismatch in the setting of small aortic root.
- Implantation of stentless valves is more complex than stented valves, often requiring reattachment of the coronary arteries as a "full root" replacement.
- The use of homografts is indicated in cases of active aortic valve endocarditis particularly with a root abscess, prosthetic valve infection, or fistula formation.

Ross Procedure

- The Ross procedure uses the autologous pulmonary valve to replace the native aortic valve, and a homograft to replace the pulmonary valve.
- The pulmonary autograft shares the hemodynamic advantages and antithrombotic features of a homograft but has the additional benefit of a fully viable autologous tissue.
- However, the Ross procedure is a technically complex surgery that should be performed in experienced centers. Long-term risks include aortic root dilation, leading to aortic regurgitation and pulmonary homograft dysfunction.
- The Ross procedure is of particular benefit in younger patients with aortic valve pathology, especially in the setting of small aortic root.

Ozaki Procedure

- The Ozaki procedure is a novel technique that uses fixed autologous pericardium to achieve aortic valve neocuspidization.

- This technique requires excision of diseased cusps from the native valve, and shaping new cusps from autologous pericardium, and suturing them into neo-cusps. Studies have demonstrated favorable mid-term outcomes; however, further studies are required to evaluate long-term durability [5].

Prosthesis Selection

- The ACC/AHA Guidelines suggest the use of mechanical valves in those <50 years old, and bioprosthetic valves in >65 years old. For patients between the ages of 50 and 65 years old, it is reasonable to use either valve. Homografts are often considered in infective endocarditis or small aortic roots. Autografts such as the Ross or the Ozaki procedure should be considered on an individual basis with a multi-disciplinary discussion [4].

Special Circumstances

Small Aortic Root

- Small aortic roots pose hemodynamic concerns because of the risk for prosthetic valve-patient mismatch (PPM).
- PPM is used to describe a small aortic valve with a large body surface area, an absolute small valve size, excessive transvalvular gradient post-implantation, increased transvalvular gradient with exercise, or a small indexed effective orifice area.
- The residual stenosis from PPM is thought to hinder reverse remodeling of the left ventricle, may result in limited symptom improvement, and in some cases worse long-term survival.
- Aortic root enlargement techniques can reduce the incidence of PPM by enlarging the aortic annulus to accommodate a larger valve.
- Though the data on PPM are conflicting, it is thought to be associated with adverse early and long-term outcomes, particularly in younger patients.

Paravalvular Regurgitation

- Paravalvular regurgitation occurs when gaps are present between implanted aortic valve and the annulus, leaving portions of the prosthesis unopposed.
- Etiologies include technical error, incomplete decalcification of the anulus, connective tissue disorder, and infective endocarditis.

- Sufficiently large paravalvular regurgitation can cause significant hemolysis or heart failure from aortic regurgitation.
- Clinically significant or symptomatic paravalvular regurgitation typically require surgical intervention, although some cases may be amenable to transcatheter occlusion techniques.

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