Heart valve surgery

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Abstract

With an ageing population, the incidence of degenerative valve disease is increasing and subsequently more patients are being diagnosed and being referred for intervention. Improvements in diagnostic imaging techniques have facilitated earlier diagnosis and strategic planning of intervention. Decision making can be complex and challenging, hence valvular heart disease is now managed through a multidisciplinary 'heart team' approach and guidelines have been developed that have a strong evidence base. Advances in perioperative management and operative techniques have resulted in reductions in morbidity and mortality associated with surgery. Surgical therapy for valvular heart disease is associated with excellent symptomatic improvements and long-term outcomes. The advent of transcatheter valves has revolutionized the management of aortic valve disease, especially in high risk patients that were previously deemed inoperable.

Keywords Aortic; heart valve; mitral; pulmonary; tricuspid

Introduction

Valvular heart disease is now presenting in older patients, frequently in association with multiple co-morbidities, and frailty and the risks of intervention are increasing. Therefore, the decision making process should now be undertaken by a multidisciplinary 'heart team' with specific expertise in valvular heart disease (ideally interventional cardiologists, non-interventional cardiologists with specialist imaging skills, anaesthetists, intensive care physicians and geriatricians). This approach is particularly useful in the management of high-risk patients. Guidelines for the management of valvular heart disease have been developed by the American College of Cardiology and European Society of Cardiology/European Association of Cardiothoracic Surgery.

In order to understand the surgical management of heart valve disease it is crucial to appreciate the structure and function of normal valves. The success of cardiac surgery in treating heart valve disease is dependent on excellent operative technique which is underpinned by a firm knowledge of anatomy. The timing of intervention is critical in order to avoid the irreversible consequences of ventricular dysfunction or pulmonary hypertension.

Clinical assessment

The first steps in managing valvular heart disease are to take a comprehensive history and perform a cardiovascular examination.

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It is essential to appreciate the natural history of valvular conditions, with the knowledge that development of symptoms is often a late sign. Thus, the onset of symptoms is in itself an indication for intervention. The key aims in taking a history are to elucidate the symptoms in terms of their effects on daily activities and quality of life, especially in the elderly population. In addition, it is crucial to assess co-morbidities that may contribute to increased surgical risk. Clinical examination is critical in diagnosing the underlying valvular defect through detection of murmurs but the finding of other clinical features such as heart failure are also important in the overall evaluation and decision making process.

Investigations

Transthoracic echocardiography is the 'gold standard' diagnostic technique and is used to assess severity and prognosis. Echocardiography enables the assessment of valve area, flow dependent indices such as mean gradient and/or maximal flow velocity in stenotic valvular heart disease. In the assessment of regurgitant valves, severity is quantified by measuring regurgitant volumes and effective regurgitant orifice area (EROA). Indices of left ventricular (LV) enlargement and function are also strong prognostic factors.

Transoesophageal echocardiography (TOE) should be considered when transthoracic examination is of suboptimal quality, or when thrombus, prosthetic dysfunction or endocarditis is suspected. It should be performed during surgery to assess the success of valve repair, complex procedures and transcatheter valve interventions. Three-dimensional echocardiography is a promising technique, particularly for the functional evaluation of the valve.

Exercise echocardiography may be useful in patients who are said to be asymptomatic or with non specific symptoms by demonstrating an increase in the degree of mitral regurgitation or aortic gradient on exercise.

Low-dose dobutamine stress echocardiography is useful in assessing contractile reserve in patients with aortic stenosis and impaired LV function.

Cardiac MRI is being used increasingly in the assessment and monitoring of valvular heart disease. It provides high-resolution dynamic images, and allows the accurate quantification of cardiac function, dimensions and regurgitant volumes.

Multi-slice computed tomography (MSCT) has been increasingly used in the workup of patients considered for Transcatheter Aortic Valve Implantation (TAVI), especially when investigating peripheral vasculature for potential access sites and aortic valve dimensions.

Coronary angiography: many patients with valvular heart disease, especially aortic stenosis, have coronary artery disease. Characterization of the coronary anatomy determines whether concomitant coronary revascularization is indicated and assists risk stratification. Coronary angiography is recommended where there is a history of coronary artery disease, known risk factors for ischaemic heart disease, left ventricular dysfunction and in men aged over 40 and postmenopausal women with $\geq$1 cardiovascular risk factor. Right heart catheterization studies, especially in patients with pulmonary hypertension, may be beneficial in

assessing pulmonary artery pressures and haemodynamics prior to operation.

Aortic valve disease

Aortic stenosis

Aortic stenosis is the most common type of valvular heart disease and typically presents as calcific degeneration in the elderly and affects 2–7% of the population >65 years. Congenital bicuspid aortic stenosis is the second most common aetiology, being prevalent in approximately 2% of general population. Rheumatic aortic stenosis is now rare in Western countries.

Pathophysiology: as aortic stenosis progresses the effective valve area is reduced from the normal 3–4 cm^3, resulting in an increase in resistance to blood flow across the left ventricular outflow tract.

A pressure gradient during systole develops between the left ventricular cavity and the aorta in order to maintain stroke volume. This results in raised left ventricular systolic pressure, which in turn leads to compensatory concentric left ventricular hypertrophy aimed at reducing wall stress. As the left ventricle hypertrophies the ventricle becomes less compliant and impairs the ability of the ventricle to fill, manifested as diastolic dysfunction. In the late stages of aortic stenosis the left ventricular systolic function decompensates culminating in dilated cardiomyopathy and heart failure.

Presentation: the natural history of calcific degenerative aortic stenosis includes a lengthy latent asymptomatic phase which is very variable. The classic triad of symptoms of aortic stenosis are angina, syncope and dyspnoea (or other symptoms of heart failure such as orthopnoea, paroxysmal nocturnal dyspnoea). A small number may present with sudden death most likely due to life-threatening arrhythmias. Once symptoms develop the life expectancy is usually only 2–3 years, hence the need for expedient intervention.

Diagnosis

Examination

- Reduced volume and slow rising pulse.
- Systolic thrill is often palpable over the aortic area and the carotid arteries.
- Auscultation reveals a systolic murmur that is crescendo-decrescendo in nature caused by turbulent flow across the aortic valve. The murmur is best heart in the right second intercostal space and often radiates to the carotids.

Investigations – the echocardiogram shows a valve that is thickened, rigid and calcified associated with left ventricular hypertrophy. Doppler studies provide quantitative assessment of the pressure gradient across the valve and may also show aortic regurgitation. The classification of aortic stenosis severity is listed in Table 1. The definition of severe AS is based on natural history studies of patients with unoperated AS, which show that the prognosis is poor once there is a peak aortic valve velocity of >4 m per second, corresponding to a mean aortic valve gradient >40 mmHg.

Treatment: There is no medical therapy for symptomatic severe aortic stenosis.

Severity of aortic stenosis

Stenosis type	Valve area (cm^2)	Mean gradient	Peak velocity (m/s)
Mild	>1.5	15–25	<3.0
Moderate	1.0–1.5	25–40	3.0–4.0
Severe	<1.0	>40	>4.0

Table 1

Replacement of the aortic valve is the only effective treatment for severe aortic stenosis in adults and the indications for surgical intervention are listed in Box 1.

Transcatheter aortic valve implantation (TAVI) is recommended for patient for severe symptomatic AS, whom the heart team consider too high risk for conventional aortic valve replacement (AVR). In patients not suitable for conventional AVR, TAVI has been shown to be superior than conservative treatment and in a randomized trial compared to surgical AVR showed similar outcomes in terms of death at 2 years.

Percutaneous aortic valvotomy has a role in the treatment of children with aortic stenosis and in achieving temporary symptomatic relief in adults who are poor candidates for surgery or as a bridge to surgical AVR or TAVI.

Aortic regurgitation

Aetiology: aortic regurgitation is the diastolic backflow of blood from the aorta into the left ventricle due to failure of the leaflets of the aortic valve to co-apt properly.

Aortic regurgitation may be caused by a primary disease of the aortic valve leaflets and/or abnormalities of aortic root geometry. Diseases affecting the valve leaflets are congenital bicuspid valve disease, infective endocarditis, rheumatic heart disease or leaflet calcification. Causes for aortic root disease are shown in Box 2. Aortic root disease causes aortic regurgitation by dilation of the valve annulus, but many cases are idiopathic.

Pathophysiology: aortic regurgitation volume-loads the left ventricle; if this occurs acutely, the Starling reserve of the ventricle is often exceeded, resulting in pulmonary oedema and low output failure. Left ventricular dilation and hypertrophy

Indications for aortic valve replacement in aortic stenosis

- Symptomatic severe aortic stenosis
- Moderate/severe AS undergoing CABG or surgery of ascending aorta
- Asymptomatic patients with severe AS
  - Left ventricular systolic dysfunction (EF < 50%)
  - Abnormal response to exercise test
- Very severe AS (peak velocity gradient ≥5.0 m/s mean gradient >60 mmHg aortic valve area <0.6 cm^2)

Box 1