

# UPDATE ON CHOICES IN HEART VALVE REPLACEMENT

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## Introduction

Cardiac surgery in general and heart valve replacement in particular have become very safe with mortality rates quoted at between 1 and 3%. The valves themselves have been modified and developed over the years but there is still no ideal heart valve replacement. An ideal valve would be durable and would not require continuing medication such as warfarin therapy. The two most common types available for insertion in the aortic or mitral position are the metallic bileaflet valve, which requires anticoagulation but are durable, and the bioprosthetic porcine or pericardial valve, which do not require warfarin but may need to be replaced in time. Alternatives for the aortic position are stentless porcine valves, homografts or autografts (Ross procedure).

## Mechanical prostheses

The first successful mechanical prosthesis was the Starr-Edwards caged-ball valve, which was the gold standard for over 20 years until the early 1980s. These worked well but were large and obstructive in the outflow tract. Subsequent mechanical prostheses were monoleaflet and later bileaflet, with much improved haemodynamic performance. The most frequently implanted valves now are the bileaflet St Jude or Carbomedics valves. They are constructed with pyrolytic carbon leaflets and titanium or pyrolytic carbon housing. A distinctive hinge mechanism allows the leaflets to move freely in the pivot which allows retrograde washing. This reduces blood stasis and thrombus formation. Bileaflet design allows three effective orifice areas, minimal turbulence and decreased transvalvular diastolic pressure gradients. The central opening angle is 85° with a closing angle of 30–35°. Of course, the ideal valve should open to 90° but for the leaflet to remain free and mobile in the hinge mechanism there must be several degrees of tilt. They have as low a profile as possible and there are no pivot guards, struts or orifice projections to decrease blood flow impedance and turbulence through the valve.

Mechanical valves provide extended durability but mechanical prostheses are subject to thromboembolic phenomena and anticoagulant haemorrhage. Both risks can be minimised with strict anticoagulant management within an INR range of 2.5-3.5 for the aortic position and 3.0-4.0 for the mitral position.

## Bioprostheses

The possible sources of tissue for bioprostheses are three-fold: (a) homograft valves or valved conduits are from a cadaver; (b) autograft tissue is from the same person/patient and in this context is more specifically used to refer to the operation devised by Ross whereby the aortic valve is replaced by the patient's own pulmonary valve and the pulmonary valve is replaced with a homograft; and (c) heterograft/xenograft tissue is from another species, porcine or bovine. The heterograft tissue may be used to construct bioprosthetic valves in three forms:

- Stented pericardial: bovine pericardium mounted on a polymer stent.
- Porcine stented: porcine leaflets attached to a polymer stent.
- Porcine stentless: porcine leaflets constructed to form a valve with or without a full aortic root.



Figure 1. Stented pericardial valve

The bovine pericardial and porcine bioprostheses are preserved with glutaraldehyde at high, low or zero pressure. Glutaraldehyde cross-links collagen and as fixation pressure approaches zero the collagen crimp framework is maintained to increasing degrees in the valve cusps and cords. Bovine pericardial prostheses use pressure-free fixation with glutaraldehyde and advanced engineering techniques are used to determine the tissue-stent relationship. Tissue preservation methods and stent design determine the anatomical characteristics and biomechanical properties of the leaflets. The predominant problem is mineralisation of



**Figure 2.** Stented porcine valve



**Figure 3.** Stentless porcine valve

the heterographic tissue with or without stress-related fatigue injuries. Valve failure (structural valve deterioration [SVD]) is primarily due to calcification. This process is accelerated in the young and in pregnancy. As tissue preservation processes improve, so too the calcification process is delayed and the longevity of the bioprosthetic valves is increasing. Present data on 18 years of follow up report freedom from SVD for the pericardial valves of 80-90% in the aortic position. For the elderly population this approaches 100%. In the mitral position, bioprostheses have been more or less contraindicated due to their high rate of early SVD. However, in an elderly population who have retained sinus rhythm, the newer pericardial valves may be used. The freedom from SVD at 15 years is greater than 75%.



**Figure 4.** Bileaflet mechanical valve

Stentless porcine valves are infrequently used but may become more popular. The advantage they possess is a greater valve orifice area than a stented valve for an equivalent diameter. This allows for a greater reduction in gradient across the outflow tract and faster reduction in left ventricular hypertrophy in the post-operative period. For smaller valve sizes this may be of very significant benefit.

The Ross operation involves the transfer of the patient's own pulmonary valve to the aortic position (autograft) together with reconstruction of the right ventricular outflow tract using a homograft. This is possible because the pulmonary valve is structurally and anatomically virtually identical to the aortic valve. It is a complex operation but may be ideal for younger patients who have not finished growing or for those who do not wish to be subjected to anticoagulation for life. Invariably, a second operation will be necessary as the homograft will deteriorate with time.

### General recommendations

Bioprostheses, stented porcine or pericardial valves, are generally preferred for aortic valve replacement in the elderly (>65 years). In the age group 40-65 years, mechanical prostheses are recommended. Allografts, mechanical prostheses and autografts (Ross procedure) are alternatives for the age group 16-40 years. The complex autograft (Ross) procedure will be used sparingly in the adult population. The paediatric group are beyond the scope of this article.

Biological prostheses are also indicated in certain special circumstances, such as contraindications for anticoagulation, women of child-bearing age and patients with reduced life expectancy from compromised ventricular function, coronary artery disease or other systemic disease. Mechanical prostheses, on the other hand, are indicated in hypercalcaemic syndromes and chronic renal failure.

### The future

If the complex issue of calcification can be resolved, polyurethane prostheses may be possible. These would deliver the elusive coupling of durability with freedom from the requirement for anticoagulation. Future mechanical prostheses will probably be designed using advanced evaluative testing to avoid stasis areas for prevention of thrombus. Improvements will hopefully come from advancing engineering design concepts. The possibility of seeding viable endothelial cells onto a valve framework is being investigated with promising results but we are still some way from clinical trials.

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