of the prostheses are also major setbacks in their use (Kaltman, 1971; Hylen, 1972; Shaw *et al.*, 1974). These problems were found to be more pronounced in some disc-type valves (Lee *et al.*, 1974), when compared to the ball type. This led Roberts (Roberts, 1976) to conclude that the caged-disc type prostheses are the least desirable to use. In addition other incidences of postoperative complications have also been documented. Hemolysis, usually caused by paravalvular insufficiency is still a problem especially in the aortic position (Kaltman, 1971). Hemolysis though controllable in many cases can sometimes be serious as has been observed in some disc-type substitutes (Roberts *et al.*, 1975; Nitter-Hauge *et al.*, 1974). All mechanical prostheses are mildly stenotic and show appreciable transvalvular pressure gradients especially during exercise (Bristow and Kremkau, 1975). However this problem is least in the tilting-disc type though its hemodynamic superiority has not yet been fully established. Problems of sepsis, leak, dislodgement, infections and annular injuries have also been associated with mechanical prosthetic use (Kaltman, 1971; Bowes *et al.*, 1974).

More recent improvements in material and structural design have resulted in so called cloth-covered prostheses. These were first used in 1967 and allow endothelialisation. This markedly reduces the occurrence of thromboembolism (Bonchek and Starr, 1975). However other complications still exist. They include hemolysis (Lefemine *et al.*, 1974), obstruction across the prosthesis due to the added fabric material, higher infection rate and strut cloth wear (Wukasch *et al.*, 1975). The last of the above problems is now prevented in new models which contain a narrow metal track on the inner surface of each strut.

Hence though significant advances have been made in the development of mechanical prostheses, the major problems of thromboembolism and mechanical malfunction have yet to be eliminated. Thromboembolism is the most frequent and serious complication and it occurs in 5% to 30% of patients, depending on the type of prosthesis used and whether or not anticoagulant was adequately utilised.

Tissue Valves

Whereas mechanical prostheses have been used with a certain degree of success, the desire to develop an artificial valve that will simulate much of the in vivo functioning and flow conditions led to experiments with leaflet type tissue valve substitutes. Valves fashioned from biological tissues such as fascia lata, dura mater and parietal pericardium were tried. Aortic homografts, aortic heterografts and autologous pulmonary valve grafts were also used. All of these tissue valve substitutes provide a central blood flow.

The use of fascia lata in the construction of a valve substitute was prompted by the initial work of McArthur (1901) and Gallie (1948) who demonstrated histologically that autologous fascia transplants resembled normal fascia even several years after transplantation.

Senning (1967) began the use of unsupported autologous fascia lata in aortic valve replacements in 1967 and subsequently others have experimented with either mounted or unsupported valves fashioned from fascia lata in the mitral, aortic and tricuspid areas (Ionescu and Ross, 1967; Joseph *et al.*, 1974; Petch *et al.*, 1974). The immediate results of the fascia valve substitutes were good and incidences of thromboembolism were low even in the absence of anticoagulant therapy. However long term follow up studies have demonstrated a high rate of valve failure resulting from the thickening and stiffening of the valve cusps. This is especially common in the posterior cusp of the mitral position (Petch *et al.*, 1974; Ross and Johnson, 1974). Hence fascia lata valves were found to be unsatisfactory after 1 to 2 years of use (Joseph *et al.*, 1974; Petch *et al.*, 1974). In fact a great number of surgeons have abandoned the use of fascia lata valves. Reports on the viability of autologous fascia lata valves after use have indicated that tissue changes do occur and this could result in the observed valve failure (Lincoln *et al.*, 1971; Silver and Trimble, 1972).

Recently preserved bovine pericardium has been tried as a material for the construction of an artificial tissue valve. Ionescu *et al.* (1974) reported reasonable results after a 3 year follow up study, and suggested that preserved pericardium has the potential qualities for use in a heart valve substitute. The apparent success of the latter and the almost complete failure of fascia lata led some clinicians and scientists to suspect that the tissue mechanical properties might be an important factor in determining the success or failure of the material used for constructing a tissue valve substitute. On this, a series of papers have been published by Lim and Boughner (1975, 1976, 1977) on the elasticity of normal natural valvular tissues. Their findings might be of use to those interested in the fabrication of tissue or leaflet type valve substitutes from different materials, be they of biological or synthetic origin.

The clinical application of aortic valve homografts was initiated by Ross (1962) and Barratt-Boyes (1964) in the subcoronary position after Murray (1956) demonstrated the long term function of the aortic homograft in the descending thoracic aorta of

dogs. Since these early attempts, surgeons in different medical centres have tried using the same grafting technique with fresh as well as preserved and sterilised aortic valve homografts and heterografts obtained from pigs, calves and sheep. (Ross and Johnson, 1974; Wallace, 1975). Hospital mortality and incidences of thromboembolism were low and good performance was observed in the early postoperative period. However with a longer follow-up, the incidence of valve failure resulting from rupture and tearing of cusps increased. In some, the cusps became stiff and relatively immobile. Calcification of the aortic wall was also common (Wallace, 1975). Use of mounted aortic homografts for replacement in the mitral position has also been disappointing (Ross and Johnson, 1974). One group reported that only 50% of patients were alive with a well functioning valve at the end of 5 years. (Graham *et al.*, 1971). Hence at present little enthusiasm exist for using aortic homografts in the atrioventricular positions.

Though Kosek *et al.* (1969) have reported the presence of viable cells 5 years after implantation of fresh valve grafts, the difficulty in procuring fresh and sterile tissue, limits the wide application of fresh valve grafts; therefore valves sterilised and stored in various types of antibiotics are used. A recent study of these treated valves (McGregor *et al.*, 1976) indicated that of the 23 human aortic valves studied, only 3 showed any evidence of viability. These valves were antibiotic sterilised and stored for varying periods of time before examination. This report therefore casts doubts regarding the viability of the homograft valves used. Hence it appears that tissue deterioration will occur and this will lead to eventual valve dysfunction, the major problem in the use of tissue valves. In spite of this, tissue valves are still in use because of the advantage of the very low incidences of thromboembolism. Of all the valve grafts tried, porcine xenografts appear at present to have the least problem and hence its use is now increasing (Roberts, 1976). The porcine xenograft is attached to a semiflexible stent and preserved by a glutaraldehyde process.

The presence of degenerative changes in aortic homografts prompted Ross (1967) to use the patient's own pulmonary valve for replacing the diseased aortic valve. The removed pulmonary valve was replaced by an aortic homograft. The use of autologous pulmonary graft has also been tried in the mitral position (Ross, 1967). This procedure however has been associated with a higher operative mortality rate and hence is not popular. Mounted pulmonary homograft has also been tried in the mitral position without success (Ross and Johnson, 1974).

Hence, though all tissue valve substitutes are associated with low incidences of thromboembolism, are atraumatic to blood cells and have good hemodynamic performance, the greatest problem of eventual tissue failure is still unresolved and hence their long term fate is uncertain.

Conclusion

At present it is apparent that an ideal valve substitute is still not available, and there is still no general consensus as to which of the currently available cardiac valve prostheses is the best. They all give comparable survival rates and while one prosthesis might be superior in certain characteristics, it is also inferior in others. The different types of prostheses all have problems associated with their use and solutions to these problems are not in sight, though progress is good.

Before a defective heart valve is replaced with an artificial device, it is pertinent for the clinician to evaluate the chances and duration of survival if the diseased valve be allowed to take its natural course against the risk and complications associated with a prosthetic valve replacement. Present evidences certainly do not warrant valve replacement for all detected defective valves.

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