Aortic valvar replacements

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The search for an ideal valve substitute continues, and we for our part have remained firmly in favour of the use of biological tissue. There are many arguments that can be invoked to support this principle, the most clearly established being that they provide a central unimpeded flow orifice and a total freedom from thromboembolism without the use of anticoagulants. Also, red cell destruction is minimal or absent. While mechanical valves change continuously in design in an attempt to match these advantages, their deficiencies in these three areas remain.

My subsequent remarks will be confined to aortic valvar replacements and I shall consider homografts, pulmonary autografts, and autologous fascia lata. I have no experience with heterografts.

Homograft valves

In 1962 we inserted the first subcoronary aortic valve homograft in Guy's Hospital. In spite of a persistence of some aortic regurgitation from the time of operation, this patient lived 4½ years and died in left ventricular failure. At necropsy the findings were those of a degenerated, distorted, and heavily calcified homograft valve.

This year I removed at operation a homograft valve which had been in place for five years and had only recently become regurgitant. The valve, though prepared in exactly the same way, was only lightly calcified but was dangerously thin and detached at one atrophic commissure.

These two valves, I believe, summarize the homograft dilemma as I see it today as one of excellent initial function for up to five years and an increasing incidence of deterioration thereafter. This deterioration, whether calcific or atrophic, can be related to many factors. Among these one of the most important is that they are non-living structures subject to repeated stresses but without a living cellular component to service and restore their collagen and elastic matrix.

This servicing or continuous replacement of tissue is a unique feature found only in living

cells – the most familiar example being the constant replacement of the surface layers of our skin. Unfortunately, none of the valves I have studied histologically has acquired a complement of living cells within the body of the cusp.

My results with homograft valves are as follows: 394 valves have been inserted in the aortic area, of which 372 were isolated aortic valvar replacements, and these only will be discussed to exclude the problems related to multiple valve replacements. The follow-up extends over the eight-year period to the middle of this year.

The operative and late mortality has been as follows: early 18.5 per cent, late 13.4 per cent.

Although both operative and late mortality has been falling, you will notice that there has also been a reduced utilization of these valves. This has been because of the observed increasing complication rate.

Complications have included early valve failure or regurgitation due to technical mal-seating and late failure from calcific or atrophic degeneration. Infection has not been an important complication (6%).

Of course, only cases coming to operation or necropsy can be graded with accuracy as calcific or atrophic degeneration, but of 61 known cases of late failure 20 showed calcification and 26 atrophic degeneration.

An important observation, and one with clinical implications, is that in our experience late degeneration in a homograft is never sudden but progresses slowly over a number of months. The first feature of failure is the development of a diastolic murmur and less frequently the detection of a systolic thrill, so that the appearance of late diastolic murmurs is our best clinical index of valve failure.

I am of course aware that many factors may be responsible for valve degeneration, including the method of valve preparation, and most of these degenerated valves were freeze-dried. However, there is no clear evidence in this group of cases that any particular method of preparation and storage is preferable, although we concede that one should avoid

techniques which damage the basic cusp structure.

Nor have we supporting evidence from our experimental work in sheep in favour of a particular method of preparation or storage, since freeze-dried, frozen, irradiated, and fresh non-living homologous cusps underwent similar degeneration after implantation. All were acellular at one year and many showed dilatation or aneurysm formation when sewn in the descending aorta. Calcification was, however, rare in the fresh cusp implants.

The use of fresh non-processed valves could be a protection against calcification, but from the available clinical and experimental evidence I have come to the conclusion that the best chance of permanent cusp survival without late degeneration is if the tissue is not only completely fresh but is also living at the time of insertion and continues to live with a normal cellular component after insertion. This implies also that the cells in the cusp are not part of a foreign body or immunological rejection phenomenon.

One solution suggested by Shumway's group has been to use freshly removed *living* homograft valves. This, though an attractive concept, poses tremendous collection problems. Also, with living homologous tissue we cannot completely ignore immunology, and if we are to insert living valves, I believe they should if possible be autologous (that is, taken from the patient's own tissues).

Pulmonary autograft valves

Adhering to these criteria, which include the need for both living and autologous tissue, and in order to preserve the advantages already enumerated and inherent in the homograft, I began in 1967 to use the patient's own pulmonary valve as a living autologous aortic valve replacement in place of a dead homograft. The results with this valve have been encouraging.

One hundred and four patients with isolated aortic valve disease have been operated upon by this method. They have been selected from a younger age group because of the desirability

The results are given in the Table. The principal difference becoming apparent so far between these living autograft valves and the non-living homografts is in the virtual absence of late failures in this series, suggesting a persistence of normal valve function during the period of follow-up and also when compared with homografts inserted during the same period.

Only three patients represent late technical failures, all of whom had aortic regurgitation from the time of operation because of a misplaced valve. The interesting and important feature is that the two valves removed at four months and one year both showed structurally normal valves with a full cellular component.

Autologous fascia lata valves

I am aware of the increased technical difficulties of this operation and of the need to replace the excised pulmonary valve and right ventricular outflow tract. This has been achieved with an aortic homograft in 89 cases, but in the last 11 cases a fascia lata tube and valve made from the patient's own living tissue has been used. This means that the operation is now completed entirely with autologous living tissue. To date no long-term complications can be attributed to the right ventricular reconstruction.

For the young patient under 40 years of age with isolated aortic valve disease, and particularly in those rare instances where aortic valve replacement is needed in children, this is my operation of election at present. It seems to meet the criteria we have defined – namely, a central unimpeded flow, an absence of emboli, and the use of autologous living tissue.

At the same time, I like others am conscious of the need for a more easily inserted valve, one that is predictably competent and readily available in varying sizes but embodying all the features mentioned so far.

Here we have hopes that fascia lata valves constructed at operation will supply an answer, and in this we are encouraged by our own results and the long-term results of Senning.

These frame-mounted fascia lata valves represent a compromise between the rigid mechanical prosthesis and the homograft or autograft, and, as inevitably happens with compromises, we inherit some of the advantages and disadvantages of both. These have included gradients, haemolysis, and an increased incidence of infection.

Gradients and haemolysis we believe we have eliminated with improved structural design, and the incidence of infection is a

TABLE Results with 104 pulmonary autografts (3 years' experience)

Operative mortality	16%
Late failure due to technical problems at time of insertion	3%
Late degeneration	—

of having a permanent or really long term replacement in patients under 40 years of age.

feature we hope to be able to control. It is, however, at present significantly above that for both homografts and autografts.

We do know, however, from a study of these valves over a period of over a year that they can remain as fully functional living structures. Also, judging by Senning's reported results, they do not appear to become rigid or calcify for periods up to seven years. However, we are still somewhat concerned about the need for a rigid frame in order to achieve competence and believe it runs counter to the original biological valve concept.

More recently, in collaboration with my colleague Mr. Alan Yates, of Guy's Hospital, we have been inserting fascial aortic valves without a supporting frame in a manner somewhat similar to Senning's method but based on a different design criterion and resembling more closely the natural valve. This, we believe, may enable us to maintain the original

flow characteristics and other advantages of the homograft valve.

In summary, 548 biological aortic valves of varying types have been inserted over the past eight years. Autografts have been followed for three years and fascia lata for 15 months.

All of these valves have to my satisfaction demonstrated the unquestioned advantages of biological tissue and they have proved their worth as realistic alternatives to their prosthetic counterparts.

If we are to continue to use homografts we must develop methods of storage which will preserve the structural integrity and if possible the viability of the cusps. Therefore, for the present, I prefer to use living autologous tissue, and in this respect the pulmonary valve autograft has, I believe, an important and selective role to play in the younger age group, while fascia lata offers a good prospect for the future.