Pulmonary Autograft Versus Aortic Homograft for Rereplacement of the Aortic Valve
Results From a Subset of a Prospective Randomized Trial

Gerald S. Carr-White, MRCP; Sally Glennan, REN; Sue Edwards, BSc; Francis D. Ferdinand, MD; Anthony C. Desouza, FRCS; John R. Pepper, FRCS; Magdi H. Yacoub, FRS

Background—The use of a pulmonary autograft for rereplacement of the aortic valve has both potential advantages and disadvantages. This study details the early results of a subset of patients enrolled in a prospective randomized trial comparing pulmonary autografts and aortic homografts who have had previous aortic valve replacements.

Methods and Results—A total of 47 patients who had undergone ≥1 previous aortic valve replacement were randomized to receive either a pulmonary autograft (24 patients aged 40–11 years) or an aortic homograft (23 patients aged 37–11 years) for rereplacement of the aortic valve. One early death occurred in the homograft group, and 1 late (7 months) death occurred in the autograft group. One patient who received a pulmonary autograft was reoperated on for inflammatory pulmonary stenosis. One patient in each group was reopened for bleeding (both within 24 hours). Two patients in the autograft group had postoperative neurological weakness; they fully recovered over 2 months. Hospital stay, blood loss, incidence of perioperative arrhythmia, and markers of coronary ischemia were similar between the 2 groups. At 6-month follow-up (range, 1 to 12 months), left ventricular end-diastolic diameter was similar in both groups (homografts, 5.0±0.9 cm; autografts, 5.2±0.6 cm; P=NS), and no patient in either group had significant aortic valve dysfunction.

Conclusions—Rereplacement of the aortic valve with a pulmonary autograft is feasible and safe in patients aged 14 to 60, regardless of their preoperative diagnosis or clinical condition. (Circulation. 1999;100[suppl II]:II-103–II-106.)

Key Words: aorta • valves • autograft • surgery

The mortality and morbidity associated with rereplacement of the aortic valve is declining as both surgical technique and myocardial protection improve.1–4 It is also becoming increasingly clear that early reintervention to prevent associated ventricular damage produces more favorable results.5,6 The ideal valve substitute, however, remains unclear. The use of biological valves offers several theoretical advantages, including preservation of the normal aortic valve mechanism and increased adaptability in aortic root destruction or distortion. Although free-standing homograft root replacements for rereplacement of the aortic valve are safe and effective in the short and long term,7 concerns still remain regarding late degeneration and calcification. The use of a pulmonary autograft has several additional theoretical advantages over homografts,8–11 in particular, the ability to grow and improved hemodynamics and durability. However, potential disadvantages also exist, particularly in patients who have undergone previous aortic valve replacement. These disadvantages include the increased complexity and longer duration of the operation. As yet, no series has examined the feasibility of using a pulmonary autograft for rereplacement of the aortic valve. The objective of this study was, therefore, to prospectively compare the effect of rereplacement of the aortic valve with an aortic homograft or pulmonary autograft on perioperative variables and short- and medium-term clinical performance.

Methods

Patient Selection
From May 1994 to July 1998, 47 patients were prospectively randomized to undergo aortic valve replacement with an aortic homograft or a pulmonary autograft as part of a larger ongoing randomized trial.12 Local ethical committee approval was obtained before starting the study, and full informed consent was obtained from each patient. The study included all grades of ventricular function, bacterial endocarditis, and emergency operations. Exclusion criteria included the need for double-valve replacement or coronary artery bypass grafting, connective tissue disorders, and autoimmune diseases known to affect the aortic valve and root. Fourteen of the 47 patients had previously undergone >1 aortic valve replacement, 8 had undergone 2 previous replacements, 6 had 3 previous replacements, and 1 patient had 6 previous replacements. The patient demographics, reasons for reoperation, duration of previous valve substitutes, and preoperative ventricular function were similar between the 2 groups and are illustrated in Table 1. None of the patients with endocarditis had Staphylococcus aureus as
sutures, without the inclusion of strips of prosthetic or autologous homovital or antibiotic sterilized pulmonary homograft (mean size, were used for the distal aortic suture line. In the autograft group, the line was used. For coronary reimplantation, continuous 4-0 sutures pulmonary autograft. In all cases, an interrupted 4-0 proximal suture presentation. The left ventricular outflow tract was reconstructed with patients underwent aortic root replacement with coronary reimplantation commencing anteriorly and extending into the middle of the noncoronary ostia. The myocardial temperature (measured by a myocardial temperature probe placed in the ventricular septum) was reduced to 10°C. Cardioplegia infusions were repeated every 20 minutes. The temperature achieved using crystalloid cardioplegia at 4°C (St. Thomas hospital center.

### Operative Technique

All operations were performed by the same surgeon (M.Y.). Cardiopulmonary bypass with moderate hypothermia (30°C) was used. In both groups, myocardial protection was achieved by either antegrade crystalloid or cold blood cardioplegia. Patients were cooled to 28°C under total cardiopulmonary bypass. Myocardial preservation was achieved using crystalloid cardioplegia at 4°C (St. Thomas hospital No. 1) infused through the aortic root or directly into the coronary ostia. The myocardial temperature (measured by a myocardial temperature probe placed in the ventricular septum) was reduced to <10°C. Cardioplegia infusions were repeated every 20 minutes. The left ventricle was vented through the apex in all cases.

The aortic valve was exposed through a curved aortotomy, commencing anteriorly and extending into the middle of the noncoronary cusp. This allowed excellent exposure of the valve. All patients underwent aortic root replacement with coronary reimplantation. The left ventricular outflow tract was reconstructed with either a homovital or antibiotic sterilized aortic homograft or the pulmonary autograft. In all cases, an interrupted 4-0 proximal suture line was used. For coronary reimplantation, continuous 4-0 sutures were used for the distal aortic suture line. In the autograft group, the right ventricular outflow tract was reconstructed with a large homovital or antibiotic sterilized pulmonary homograft (mean size, 25 mm; range, 23 to 28 mm) conduit inserted by continuous 4-0 sutures, without the inclusion of strips of prosthetic or autologous tissue for support. These suture lines were placed before release of the aortic clamp.

In the presence of endocarditis, aggressive and complete debride-ment of the infected and necrotic tissue was performed, and no foreign material was used for reconstruction. This subgroup of patients received intravenous antibiotics for 6 weeks after the operation. Even in those patients with endocarditis in whom extensive debridement of the aortic root was necessary, no additional problems with filling tissue defects were encountered with root replacements. In all patients, additional care was necessary in enucleating the pulmonary autograft due to the frequent dense adhesions to the scarred aortic root. When necessary, parts of the adherent aortic root were taken out with the autograft. In all patients, the facing sinus of the autograft (which is thin and not supported by pericardium) was placed in the left coronary sinus position of the new aortic root.

Intraoperative transesophageal echocardiography was used to monitor valve and ventricular function before and after insertion of the graft. Valve function was judged to be good echocardiographically in all patients immediately after release of the aortic clamp. X-clamp and bypass times were significantly longer in the autograft group (132±15 and 194±34 minutes) than the homograft group (98±16 and 136±25 minutes; P<0.001). Trasylol was used routinely in all patients.

### Statistical Analysis

Statistical analysis was performed with a commercially available software package (SPSS Inc). Comparison of demographic and preoperative data between groups was performed with the use of an unpaired t test. Comparison of data over time was done with the use of a 1-way ANOVA. P<0.05 was significant.

### Results

#### Mortality

One early death occurred in the homograft group. A 44-year-old man with 2 previous Starr-Edwards valve replacements, the last one in 1987, developed acute *Streptococcus bovis* endocarditis with resistant severe heart failure. Twenty minutes after coming off bypass, rapidly progressive deterioration in biventricular function occurred due to widespread intravascular coagulation with associated aortic and intracoronyal clot. The cause of the intravascular coagulation was not apparent, although Trasylol and active infection were assumed to have played a part. One late death occurred in the autograft group. A 38-year-old man died suddenly 7 months after the operation, while participating in a martial arts class, due to a cardiac arrhythmia presumed to be ventricular fibrillation or tachycardia. At post mortem examination, both the aortic and pulmonary valves were functioning normally.
**Reoperation**

One patient in the autograft group needed reoperation 18 months postoperatively for pulmonary stenosis. During the operation, the pulmonary homograft was compressed by granulation tissue, and subsequent histological and microbiological examination showed only an inflammatory response, with no evidence of endocarditis or an underlying cause.

**Morbidity**

Postoperative complications included re-exploration for bleeding in 2 patients (1 in each group) and hemiparesis, which completely resolved over 2 to 3 months, in 2 patients in the autograft group. No statistically significant differences were identified between the 2 groups with regard to total blood loss or hospital stay. No patient in either group had electrocardiographic or biochemical (creatine kinase MB) evidence of significant postoperative myocardial ischemia or infarction. Transient atrial arrhythmia, which had resolved by discharge, was present in 5 patients in each group. One patient in each group developed complete heart block, necessitating implantation of a permanent pacemaker. Postoperatively, all patients were either in New York Heart Association class I or II, with no significant difference between the 2 valve groups ($P=0.63$, unpaired $t$ test). No evidence of postoperative endocarditis was seen in either group.

**Hemodynamic Follow-Up**

Postoperative echocardiographic evaluation of left ventricular diameters and aortic and pulmonary valve function were carried out at regular intervals (Table 2). Left ventricular diastolic diameter was reduced in both groups over the first postoperative year when compared with the preoperative value (homografts by 22%, autografts by 11%; $P=\text{NS by 1-way ANOVA}$).

**Discussion**

Previous studies have demonstrated that reoperative aortic valve replacement with a homograft root can be performed, with acceptable early and late risks. In certain groups of patients, using a pulmonary autograft may offer further theoretical advantages. This study describes the early results of rereplacement of the aortic valve with a pulmonary autograft; this can be accomplished with acceptable early- to medium-term mortality and morbidity. We used biological valves for second or subsequent aortic valve replacements in this study, rather than mechanical valves, because of the

<table>
<thead>
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<th>Variable</th>
<th>Homograft</th>
<th>Autograft</th>
<th>$P$</th>
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<tr>
<td>Cardiopulmonary bypass time, min</td>
<td>135.7±25</td>
<td>194.3±34</td>
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<td>(mean±SD)</td>
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<td>Cross-clamp time, min (mean±SD)</td>
<td>98.9±16</td>
<td>131.6±15</td>
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<td>Blood loss, mL/first 24 hours</td>
<td>654.5±812</td>
<td>681.6±566</td>
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<td>In-hospital stay, days</td>
<td>10.55±4.350</td>
<td>11±5.3</td>
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<td>Postoperative echocardiographic variables</td>
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<tr>
<td>End diastolic diameter, cm (mean±SD)</td>
<td>5.0±0.9</td>
<td>5.2±0.6</td>
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<tr>
<td>End systolic diameter, cm (mean±SD)</td>
<td>3.3±0.8</td>
<td>3.6±0.6</td>
<td>NS</td>
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<tr>
<td>Fractional shortening, % (mean±SD)</td>
<td>35.0±8</td>
<td>30.7±9</td>
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<td>&gt;40</td>
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<td>0–1</td>
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<td>21</td>
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Echocardiographic measurements were taken an average of 6 months postoperatively (range, 3–12 months). Statistical analysis was done with the unpaired $t$ test. AV indicates aortic valve; AR, aortic regurgitation; PV, pulmonary valve; and PR, pulmonary regurgitation.
excellent long-term survival reported in patients with a similar age distribution who underwent reoperative aortic homograft implantation, with no evidence of accelerated degeneration after the second operation. In addition, we hoped that using a pulmonary autograft would improve the acknowledged life span of aortic homografts. A direct comparison of biological and mechanical valves in a prospective, randomized trial has not, as yet, been performed. Such a trial would provide the definitive answer to the clinical question of which type of valve substitute is optimal.

Our study population was a subset of an ongoing randomized, controlled trial, and it was not part of a separate randomization process; however, we think that the patient groups are similar enough to allow simple comparisons regarding the short-term safety of using a pulmonary autograft. Two potential early disadvantages of using a pulmonary autograft, particularly in patients who have undergone previous cardiac surgery, are the increased complexity of the surgery and the increased risk of coronary artery injury. It is, therefore, reassuring to note that in our group of patients, no differences existed between the groups with regard to blood loss, hospital stay, inotropic use, or postoperative myocardial ischemia. Given the patient numbers involved and the diversity of ventricular function in patients who have undergone previous aortic valve replacement, precise comparisons of ventricular function are impossible. However, in both groups, left ventricular function seems to be preserved, with improvement in end-diastolic diameters over the first postoperative year. In addition, all patients postoperatively are either in New York Heart Association class I or II.

One patient developed inflammatory pulmonary stenosis, but the cause of this was unclear. The lack of cusp involvement or valve destruction suggests that an immunologically mediated mechanism or occult infection was not the cause; the histologic examination demonstrated an extrinsic perivalvular inflammatory infiltrate and suggests a chronic perivalvular inflammatory process, the cause of which is not known.

This study shows that although pulmonary autograft implantation is a technically more complex operation in patients having a second or subsequent aortic valve replacement, it carries a low risk of death and complications. The mortality and complication rates were comparable to those for the implantation of either homografts or other substitutes, both in this study and others. Further follow-up is needed to determine if the potential long-term advantages of pulmonary autografts are realized. Long-term monitoring of pulmonary valve and right ventricular function and neurological events will continue to be important in those who have undergone pulmonary autograft operations.

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References

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