MID-TERM RESULTS OF THE ROSS OPERATION

Seyed-Hamid Mirkhani MD*, Mehrdad Salehi MD

Background – The Ross operation, originally introduced as a scalloped subcoronary implant with an 80% survival and 85% freedom from reoperation, has recently been modified to a root replacement which is now the most commonly utilized implant technique. A review of our experience in assessing the mid-term results with the Ross operation is presented.

Methods – The records of 60 patients who had a Ross operation at the Imam Khomeini Hospital of Tehran University of Medical Sciences (June 2001 to October 2002) were reviewed to assess the operative technique and patient-related factors on survival, autograft valve function, homograft valve function, valve-related complications, and need for reoperation.

Results – Two patients were expired (one case in the operating room and the other one in hospital, 20 days after the operation with neurological disorder). The 2-year actuarial survival rate was 96.6%. At 2 years, 53 (91.3%) surviving patients were in New York Heart Association (NYHA) functional class I and 5 (8.7%) were in NYHA functional class II. No significant aortic valve gradients were noted, and no pulmonary insufficiency, in all cases, was found. At 2 years, freedom from significant aortic regurgitation (grade 2 or more) was 98.3%. Freedom from significant pulmonary homograft stenosis (defined as a pulmonary gradient > 20 mmHg) was 100% at 2 years.

Conclusion – The pulmonary autograft gives excellent mid-term results with low mortality and no morbidity. It completely relieves the abnormal loading conditions of the left ventricle, resulting in a complete recovery of left ventricular function in most patients.

Introduction

The replacement of the diseased aortic valve by Ross procedure,¹ has been shown to provide excellent hemodynamic results, both in children and young adults, and to be associated with low morbidity and mortality rates.²⁻⁴

In 1986, the advent of the root replacement technique for valve replacement⁵ led to increasing use of the Ross operation, which has become the most commonly used procedure. Stelzer and colleagues⁶ reported excellent early and mid-term results in 145 patients who had root replacement with a freedom from reoperation of 88.6% at 7 years. Additional experimental data recently have confirmed growth and dilatation in the autograft root replacement in a growing pig model⁷ and have confirmed similar conclusions based on echocardiographic assessment of dimensional changes in patients, after an autograft root replacement.⁸ In this report, we describe our experience with the replacement of aortic valves by pulmonary autografts in 60 consecutive patients.

Patients and Methods

From June 2001 through October 2002, sixty consecutive patients (mean age, 27.9 years; range, 12 to 60 years) underwent replacement of aortic valve or root by a pulmonary autograft. Indications for operation were aortic stenosis in 34 patients and aortic regurgitation in 33 patients, including 11 patients with aortic valve endocarditis. Congenital lesions including aortic valvular or subvalvular
stenosis, and bicuspid aortic valves, were present in 14 patients. Previous procedures had been performed in 5 patients as follows: surgical valvotomy/valvuloplasty in one patient, subaortic stenosis resection in 3 patients, ventricular septal defect closure in one patient, and aortic valve replacement in 3 patients. Associated procedures were undertaken in 8 patients (Ross-Konno procedure in one patient; ascending aorta replacement in one patient; tricuspid valve commissurotomy in one patient; tricuspid valve annuloplasty with Devega procedure in one patient; repair of pulmonary homograft leaflet in one patient; subaortic membrane resection in 2 patients; and ventricular septal defect closure in one patient).

In all of the cases the only technique used was the root replacement. Their mean homograft diameter was 24.9 mm (range, 21 to 29 mm). There was annual contact for updating database between patient and the physician. All echocardiographic assessment of autograft valve function, homograft valve function, ventricular size and function, and autograft dimensions were maintained in the database. Transesophageal echocardiography (TEE) was performed in all of the patients intraoperatively to assess autograft and homograft valve functions. Contact occurred within 1 year of closure of the study with all of the surviving patients, and echocardiographic assessment was available for all of them within 1 year of operation and within 2 years of closure of the study. Transthoracic M-mode, two-dimensional, color-flow, and Doppler echocardiograms were obtained in all of the patients before hospital discharge at one and 6 months, and annually thereafter. The degrees of autograft and allograft regurgitation were quantitated as none/trivial, mild, moderate, and severe. The peak velocity flow across both semilunar valves was also assessed.

Statistical analysis
Data were expressed as a mean of 6 standard deviations or as the median value and the range. Continuous variables were compared using a two-tailed, paired Student’s t-test. Discrete variables were compared using Fisher’s exact test. Survival analysis and the actuarial estimate of freedom from reoperation were obtained using Kaplan-Meier methods.

Results
Mean aortic cross-clamping time was 129 min (range, 90 to 191 minutes). There was one early death for an operative mortality of 1.6%. Early autograft failure occurred in one patient. Additional morbidity included reexploration for bleeding in 10 (16.6%) patients, pericardial effusion requiring drainage in one patient, complete heart block requiring pacemaker in 2 patients (one temporary and one permanent), and postoperative fever in 17 patients. Seventeen patients with aortic insufficiency (AI) (51.5%), and 6 patients with aortic stenosis (AS) (17.6%) were needed to inotropes support intraoperation and early postoperation. The median hospital stay was 10 days (range, 5 to 31 days).

Long-term follow-up mean was 25 months (range, 8 to 33 months). No patient was lost during follow-up. Two patients were expired (one case in the operating room and the other in hospital, 20 days after operation with neurological disorder). The 2-year actuarial survival rate was 96.6%. At 2 years, 53 (91.3%) surviving patients were in New York Heart Association (NYHA) functional class I and 5 (8.7%) were in NYHA functional class II. No single episode of endocarditis or thromboembolism was noted during follow-up. On echocardiography, no significant aortic valve gradients were noted, and no pulmonary insufficiency in all the cases was found. The majority of patients had no or trivial aortic regurgitation. Among the remaining patients, 3 had a mild degree of regurgitation and one patient with moderate aortic regurgitation. At 2 years, freedom from significant aortic regurgitation (grade 2 or more) was 98.3%. Four patients exhibited pulmonary gradients of 20 to 40 mmHg, and in other 54 patients, gradients of 10 to 20 mmHg were observed. Freedom from significant pulmonary homograft stenosis (defined as a pulmonary gradient > 20 mmHg) was 100% at 2 years.

Discussion
Clinicians taking care of children or young adults with significant aortic valve disease often face the difficult dilemma of when to operate and what graft material to implant. Practically, the choice is usually between mechanical prostheses, which are long lasting but require anticoagulation, exposing higher risky infection, and may display suboptimal hemodynamic performance particularly on exertion. Xenografts, do not require
anticoagulation but often exhibit worse hemodynamic performances than the former and frequently degenerate particularly in the young, while, homografts, having limited durability, do not grow and hence often require reoperation (as in one of our patients). Because of these challenges, the decision to resort to operation is often delayed, particularly in pediatric patients, which exposes the patient to a potential risk of permanent left ventricular damage.

Results of large-scale clinical studies have indicated that this procedure was safe, with favorable short- and long-term outcomes. The present data are thus in agreement with these earlier reports. In our series, the hospital mortality was quite low (1.6%) and there was one late death. In addition, there have been no thromboembolic events or endocarditis. Because of its potential for growth and annular enlargement, we always choose to perform the root procedure in children. Previous reports using echocardiography had suggested that continuing enlargement of the pulmonary autograft, which is probably the result of growth, may also occur. Although attractive, the concept that progressive dilatation of the annulus after root replacement, represents growth and not a pathologic process that could lead to the development of subsequent valvular regurgitation, remains speculative. In our series, annulus enlargement was observed in a minority of patients, all belonging to the pediatric group.

Our data also demonstrate that some degrees of aortic regurgitation eventually develop during follow-up. Although a minority of these aortic regurgitations was probably related to the surgical technique itself, the vast majority developed despite of nonapparent technical problems. It is probable that the late occurrence of aortic regurgitation after the Ross operation somehow reflects the relative inability of the autologous pulmonary valve to adapt to systemic pressure. Even if this risk is real, the hemodynamic profile of the pulmonary autograft is far better than that of any of the currently available alternatives. In our series, aortic gradients were always lower than 5 mmHg, thus much lower than those reported for mechanical valves and bioprostheses, at rest and during exercise.

The fate of the pulmonary homograft represents the second unresolved issue, because, the results of follow-up studies on the long-term outcome of patients with cryopreserved pulmonary homografts was used. Cryopreservation and the more liberal use of pulmonary homografts might thus be beneficial. In our series, among the 58 survivors with a pulmonary homograft, in one year, only one patient had a significant pulmonary gradient. That was not more than 40 mmHg, the limit beyond which reoperation should be contemplated. Finally, in a previous study showed that the Ross procedure permitted recovery of left and right ventricular functions, and improvement of patients of New York Heart Association (NYHA) class, particularly when it had been altered by a long-standing aortic regurgitation.

The present study demonstrates that this benefit persists over time. Our results are thus in agreement with those of Moidl and colleagues, who demonstrated that the Ross procedure results in more complete and more rapid return of left ventricular function and volumes than with other substitutes. In our study, indication for operation in 11 patients was aortic valve endocarditis, and we had a very good results utilizing Ross procedure in these patients. Therefore, the Ross operation is a choice procedure for aortic valve endocarditis. The need to inotropes support intraoperation and early postoperation was more in aortic valve insufficiency compared to aortic valve stenosis (17 patients with AI and 6 patients with AS), thus aortic valve stenosis pathology is better for Ross procedure than aortic valve regurgitation.

In conclusion, our current experience with the Ross procedure suggests that replacement of the aortic root by a pulmonary autograft can be safely performed in children and young adults, and is associated with low mortality and morbidity rates. Although in children some degree of annular enlargement could be observed, it was not associated with an increasing incidence of aortic regurgitation. Therefore, we believe that it reflects more annular growth than pathologic annular dilatation. The Ross procedure does not require permanent anticoagulation and is associated with low rates of endocarditis, thromboembolism, and degeneration. It constitutes an elegant alternative to the use of prosthetic valves in the treatment of aortic valve diseases.

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References