

The Ross Operation: Treatment of Choice for Aortic Valve Disease in Children and Young Adults

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The Ross procedure,¹ also called the pulmonary autograft procedure, involves replacement of the diseased aortic valve with the patient's own pulmonary valve (autograft) and implantation of a biological valve (homograft) in the pulmonary position.² It was first described and pioneered by Mr. Donald Ross in 1967 in London. The procedure was popularised in the 1980s when homografts became widely available on both sides of the Atlantic. In its new aortic position the patient's pulmonary valve remains viable, does not calcify, has the potential to grow, does not require anticoagulation and is rarely associated with histological degeneration.³⁻⁶ Perhaps not surprisingly, the Ross procedure was not initially adopted widely. The operation is longer and more complex, commits both the patient and the surgeon to double valve surgery, while the early morbidity and mortality during the learning curve were substantial. However, improved surgical techniques, better myocardial protection during cardiopulmonary bypass and the availability of commercially prepared homografts have stimulated an increase in interest and led to the accumulation of –by now– a much wider experience^{3,4,7,8} with the Ross procedure.

Reoperation for neo-aortic valve regurgitation has been the major complication following the Ross procedure.⁵ Failure of the pulmonary autograft has been attributable to technical errors at

the time of operation, progressive aortic regurgitation due to inadequate coaptation of the leaflets, or pulmonary autograft-to-aortic annulus mismatch.⁸ Transaortic pressure gradients after the Ross procedure are negligible, and clearly better than for bioprostheses or mechanical valves. Ten and 20 years after the procedure 85% and 61% of hospital survivors from the pioneer series⁵ were alive, with 88% and 75% freedom from autograft replacement and 89% and 80% freedom from replacement of the pulmonary homograft, respectively. These results compare favourably to any other bioprosthetic valve replacement.^{7,9} More recently, a reduced incidence of neo-aortic valve regurgitation and reoperation at mid-term follow-up has been reported^{3,4,7} with the implantation of the pulmonary valve and the pulmonary artery as an anatomical unit (root method) compared to the sub-coronary technique. Furthermore, Elkins and colleagues¹⁰ described the insertion of the pulmonary cylinder using the aortic root inclusion technique. Fixation of the autograft root to the relatively dense collagen structure of the aortic annulus and its implantation within the native aorta seems to prevent distortion of the commissures and –by providing external support– minimises dilatation of the pulmonary autograft. Subsequently, Pacifico et al¹¹ utilised bovine pericardial circumferen-

tial wrap to support the distensible root and reduce postoperative bleeding.

The Ross procedure is a double valve operation, and further surgery to replace the bioprosthetic pulmonary valve will be required for paediatric patients or patients operated on during early adulthood. However, homograft valves in the pulmonary position, when implanted beyond childhood, have a long lifespan of 20 to 30 years, with low complication rates. Furthermore, ultimate pulmonary valve replacement is a very low-risk procedure with excellent results, provided that ventricular function is maintained by the time of surgery.¹² Early and late outcomes from the Ross procedure have improved continuously. Current data suggest that perioperative risks of the Ross procedure in large volume units with expertise in this type of aortic valve surgery compare favourably with other valve substitutes. Premature concerns for patients with a bicuspid aortic valve and the theoretical risk of predisposition of the neo-aorta to dilation⁸ have not been substantiated by recent clinical data.¹³ Our personal practice has been to consider patients with a bicuspid aortic valve for the Ross procedure, with the exemption of extreme cases with marked ascending aortopathy and concomitant aortic arch involvement.

Arguably, the choice of the pulmonary autograft for aortic valve replacement obviates the need for permanent anticoagulation and provides a durable and viable valve with the potential to grow.^{1,3-7} The Ross procedure is, therefore, ideally placed for children and adolescents (where somatic growth is a major limiting factor for both biological and mechanical prostheses) and for adults with a rather active lifestyle or specific contraindications for anticoagulant therapy. Furthermore, the Ross procedure is particularly suited for women of reproductive age, because of the major risks and hazards of anticoagulation involved during pregnancy.¹⁴ In addition to negating the need for anticoagulation, the Ross procedure is associated with very low valve degeneration rates during pregnancy.¹⁴ It has to be emphasised, however, that the Ross procedure is an operation that requires high technical skills. It is best performed in an environment familiar with assessing and dealing not only with the aortic valve, but also with the entire intrathoracic aorta and the pulmonary valve and the main pulmonary trunk. In such an environment, the perioperative risk of an elective pulmonary autograft procedure in experi-

enced hands today should not be higher than in other types of aortic valve replacement surgery.¹⁵ Excellent early and mid-term results are clearly achievable with the pulmonary autograft root approach in young adults with aortic valve disease. With newer technical modifications, improved long-term results can be anticipated and the indications for the Ross procedure will continue to expand. Protagonists^{3,4,7,16} currently advocate the pulmonary autograft operation for patients with a life expectancy of 20 years or more. Such improved results, however, can only be demonstrated with continued follow-up and the expansion of reported series.

References

1. Ross DN: Homograft replacement of the aortic valve. *Lancet* 1967; 2: 956-958.
2. Colman JM, Oechslin E, Taylor D: Glossary. In: Eds: Gatzoulis MA, Webb GD, Daubeney P. *Diagnosis and Management of Adult Congenital Heart Disease*. Churchill Livingstone, Philadelphia, 2003; 497-508.
3. Elkins RC, Santangelo KL, Randolph JD, et al: Pulmonary autograft replacement in children: the ideal solution? *Ann Surg* 1992; 216: 363-371.
4. Kouchoukos NT, Divila-Romin VG, Spray TL, Murphy SF, Perrillo JB: Replacement of the aortic root with a pulmonary autograft in children and young adults with aortic-valve disease. *N Engl J Med* 1994; 330: 1-6.
5. Chambers JC, Somerville J, Stone S, Ross DN: Pulmonary autograft procedure for aortic valve disease: Long-term results of the pioneer series. *Circulation* 1997; 96: 2206-2214.
6. Matsuki O, Okita Y, Almeida RS, et al: Two decades' experience with aortic valve replacement with pulmonary autograft. *J Thorac Cardiovasc Surg* 1988; 95: 705-711.
7. Santini F, Dyke C, Edwards S, et al: Pulmonary autograft versus homograft replacement of the aortic valve: a prospective randomized trial. *J Thorac Cardiovasc Surg* 1997; 113: 894-899.
8. David TE, Omran A, Webb GD, Rakowski H, Armstrong S, Sun Z: Geometric mismatch of the aortic and pulmonary roots causes aortic insufficiency after the Ross procedure. *J Thorac Cardiovasc Surg* 1996; 112: 1231-1237.
9. Hammermeister KE, Sethi GK, Henderson WG, Oprian C, Kim T, Rahimtoola S: A comparison of outcomes in men 11 years after heart-valve replacement with a mechanical valve replacement or bioprosthesis. *N Engl J Med* 1993; 328: 1289-1296.
10. Elkins RC, Santangelo KL, Stelzer P, Randolph JD, Knott-Craig CJ: Pulmonary autograft replacement of the aortic valve: an evolution of technique. *J Card Surg* 1992; 7: 108-106.
11. Pacifico AD, Kirklin JK, McGiffin DC, Matter CJ, Narda DC, Deithelm AG: The Ross operation-Early echocardi-

- graphic comparison of different operative techniques. *J Heart Valve Dis* 1994; 3: 365-370.
12. Forbess JM, Shah AS, St. Louis JD, Jaggars JI, Ungerleider RM: Cryopreserved homografts in the pulmonary position: Determinants of durability. *Ann Thorac Surg* 2001; 71: 54-60.
 13. Bogers JJC, Kappetein AP, Roos-Hesselink JW, Takkenberg JJM: Is a bicuspid aortic valve a risk factor for adverse outcome after an autograft procedure? *Ann Thorac Surg* 2004; (In press).
 14. Swan L, Lupton M, Anthony J, Yentis SM, Steer PJ, Gatzoulis MA: Pregnancy and Heart Disease. *Lancet* 2004; (In press).
 15. Dore A, Somerville J: Pregnancy in patients with pulmonary autograft valve replacement. *Eur Heart J*. 1997; 18: 1659-1662.
 16. Santini F, Gatti G, Prioli A, Mazzucco A: Pulmonary autograft replacement of the bicuspid aortic valve: A successful surgical option for young adults *Inter J Cardiol* 1999; 71: 115-120.