

# The Ross procedure: time for a hard look at current practices and a reexamination of the guidelines

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*Comment on:* Mazine A, David TE, Rao V, *et al.* Long-Term Outcomes of the Ross Procedure Versus Mechanical Aortic Valve Replacement: Propensity-Matched Cohort Study. *Circulation* 2016;134:576-85.

**Abstract:** The ideal aortic valve substitute for young adults requiring aortic valve replacement (AVR) remains elusive. Young and middle-aged patients have a longer anticipated life expectancy and a higher level of physical activity than their elderly counterparts. In recent years, there has been a growing focus on long-term outcomes following AVR in this specific patient population. These studies highlight the direct impact of the choice of prosthesis on long-term survival, quality of life and rates of valve-related complications in younger adults. Although conventional AVR using a biological or mechanical prosthesis significantly improve the natural history of the disease, there are many inherent limitations, which need to be addressed. Despite declining use of the Ross procedure in recent years, several long-term registry, cohort and comparative studies in the last decade, indicate a clear role for this operation in young and middle-aged adults requiring AVR. These advantages are manifest in terms of long-term survival, freedom from valve-related complications and quality of life. In this Perspective article, we discuss findings from a recently published propensity-matched analysis of long-term outcomes following mechanical AVR versus the Ross procedure, showing better cardiac- and valve-related survival in the Ross cohort, lower rates of stroke and major bleeding and equal rates of reoperation at 20 years. These data are placed in the broader context of currently available evidence regarding the Ross procedure and a broader discussion pertaining to its role in today's practice and the need to reexamine current valvular guidelines so they are more reflective of the actual evidence.

**Keywords:** Ross procedure; aortic valve replacement (AVR); young adults

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## Introduction

The ideal aortic valve substitute for young adults requiring aortic valve replacement (AVR) remains elusive. In contrast to their elderly counterparts, young adults have a longer anticipated life expectancy and a higher level of physical activity. Therefore, the impact of the selected prosthesis on lifelong valve-related complications is significant. In recent years, there has been a mounting number of

publications examining long-term survival and quality of life in this specific patient population. From these studies, it is becoming apparent that, in contrast to elderly patients undergoing AVR, young and middle-aged adults have significantly lower survival compared to the age- and gender-matched general population, following mechanical or biological AVR (1-4). Combined with the fact that younger adults have higher lifetime risks of valve-related complications (5), it becomes obvious that although great

progress has been made in the management of aortic valve disease in the elderly, major challenges remain in young adults.

### Currently available surgical options

Currently available options for young and middle-aged adults requiring AVR include stented mechanical or biological prostheses, stentless biological prostheses, aortic homografts or pulmonary autografts (Ross procedure). None of these options is perfect, but when used in a tailored fashion, each presents specific benefits. Although mechanical prostheses offer excellent durability, the need for lifelong anticoagulation is associated with a significant risk of lifetime bleeding, lower quality of life compared to alternatives that do not require anticoagulation, concerns for female patients contemplating pregnancy and impaired survival compared to the general population (3,6-8). In contrast, biological options (stented or stentless) have limited durability in young patients and also appear to be associated with reduced long-term survival compared to the general population, especially in the presence of patient-prosthesis mismatch, which is observed in ~25% of patients with stented prostheses (2,4). Although the advent of transcatheter heart valves has led to a steady decrease in the age of implantation of stented biological valves with the promise of valve-in-valve approaches, current data using this strategy require some pause (9), especially considering that the majority of implanted bioprosthesis are 21 and 23 mm, both of which present suboptimal hemodynamics with current valve-in-valve technology.

The Ross procedure, which was originally described in 1967 (10), consists of replacing the aortic valve with the patient's own pulmonary root (autograft), and replacing the pulmonary root with a pulmonary homograft. It is a technically more complex operation requiring specific surgical expertise and understanding of the aortic root dynamic and functional anatomy. However, it is the only operation guaranteeing long-term viability of the aortic valve substitute, which appears to translate into improved clinically-relevant outcomes. After a wave of enthusiasm in the 1990s, its use in North America has declined to <1% of all AVRs (11). In addition to the fact that the Ross procedure requires intervention on two valves to address a single-valve disease, the main concerns relate to its technical complexity and associated operative risk, as well as the risk of late autograft root dilatation requiring reintervention. Nevertheless, a number of long-term

studies have emerged in the last decade, warranting a reevaluation of the role of the Ross procedure in today's armamentarium (12-19).

### The study

The study by Mazine *et al.* in *Circulation* (20) is a significant contribution to the field of AVR in young and middle-aged adults. Using a propensity-matched analysis, the authors compared 20-year outcomes in patients undergoing a Ross procedure (n=208) or mechanical AVR (n=208) with a mean follow-up of 14.2±6.5 years. Mean age of the patients at the time of surgery was 37 years and follow-up was 98% complete (a true tour de force in such a young patient population). All Ross procedures were performed by a single surgeon, while mechanical AVRs were performed by a number of surgeons over the study period. Their results show that although overall survival was not different between the two groups, cardiac- and valve-related mortality was significantly better in the Ross cohort at 20 years (P=0.03). In addition, there was significantly better freedom from stroke and major bleeding in the Ross cohort compared to the mechanical AVR group at 20 years (99% in the Ross cohort versus 80% in the mechanical AVR group; HR 0.09; P<0.001). Finally, and perhaps strikingly, freedom from any operated valve reintervention at 20 years was statistically similar between both groups, despite the fact that one quarter of the patients in the Ross cohort were operated for aortic regurgitation (87% in the Ross cohort versus 94% in the mechanical AVR group, P=0.19). This study represents one of the few long-term comparative valve studies examining the Ross procedure. The length and completeness of follow-up make it uniquely valuable and the authors should be commended for systematically pursuing prospective long-term clinical follow-up of their patients. This should serve as a model for all high-volume centers. Short of randomized controlled trials, these types of prospectively followed cohort studies provide very useful information.

### The Ross procedure

Findings from Mazine *et al.*'s study reaffirm the main rationale behind the Ross procedure: a living valve in the aortic position translates into improved clinically relevant long-term outcomes, owing to its capacity to adapt and remodel in response to changing conditions, as well as provide optimal biological and hemodynamic features.

Although the authors did not report echocardiographic parameters of valvular and ventricular function, other studies have demonstrated excellent hemodynamics across the autograft valve at rest and importantly, with exercise, mimicking a normal aortic valve (12,21). Combined with the low rate of valve-related complications following a Ross procedure, survival and quality of life after this operation have repeatedly been shown to be superior to other AVR options, in several long-term studies (7,12,22,23). Indeed, the Ross procedure has consistently demonstrated restored long-term survival compared to the age- and gender-matched general population (13,16,17,19,24,25). Although this is in part attributable to careful patient selection, the living properties of the aortic valve and the degree of associated ventricular remodeling are undoubtedly key factors. In contrast, a number of studies evaluating long-term outcomes in young and middle-aged adults undergoing conventional AVR (mechanical or biological) have repeatedly demonstrated survival lower than the matched general population, including in patients undergoing elective isolated AVR (1,3,4,26,27).

### Where do we go from here?

Despite the abundance of evidence, including a randomized trial (12), a systematic review and meta-analysis (28) and several cohort studies, use of the Ross procedure continues to decline, representing <1% of all AVRs in the STS database (11). This is partly led by a higher reported rate of perioperative complications with the Ross procedure compared to conventional AVR in low volume centers across the STS database (11). Nevertheless, it has been shown that in dedicated aortic centers, despite the learning curve effect, operative outcomes are similar between the two approaches (29). Indeed, we believe that the Ross procedure is no more technically demanding than other complex procedures such as aortic valve-sparing operations. The technical principles and success factors are now clearly understood (30), making it a reproducible and standardized operation in high-volume centers with expertise in aortic root surgery. Declining use of the Ross procedure is further driven by current guidelines on the management of patients with valvular heart disease, which place the Ross procedure as a class IIb (2014 ACC/AHA guidelines) or even III indication (STS guidelines). This reflects a major disconnect between currently available best evidence and practice guidelines, which

poses important questions. Indeed, in those published guidelines, none of the herein reported studies are cited, which represents a significant omission, since this would not only improve the reported level of evidence from C to B, but also potentially modify the recommendations. In contrast, the 2016 Canadian Cardiovascular Society Position Statement on Thoracic Aortic Disease recommend that the Ross Procedure should be considered as an alternative to prosthetic valve replacement for young adults with bicuspid or tricuspid aortic valve disease (strong recommendation, medium quality evidence) (31).

In conclusion, the study by Mazine *et al.* represents an important addition to the conundrum of choice of AVR in young and middle-aged adults with aortic valve disease. Until a prospective randomized trial can definitively answer this question, their findings clearly support the notion that the Ross procedure constitutes the best available option in young and middle-aged adults requiring AVR, especially those with aortic stenosis. This study, and others, showing excellent long-term outcomes following the Ross procedure in this patient population mandate a hard look at current practices and reexamination of the guidelines.

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### Footnote

*Conflicts of Interest:* The authors have no conflicts of interest to declare.

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