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The Ross Procedure in Aortic Valve Replacement: Long-Term Insights and Future Perspectives

O Procedimento de Ross na Substituição da Válvula Aórtica: Perspectivas a longo prazo e perspectivas futuras

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The Ross procedure, introduced by Donald Ross¹ in 1967, offers a unique alternative for aortic valve replacement (AVR) in young patients. By replacing the diseased aortic valve with the patient's pulmonary valve and substituting the pulmonary valve with a homograft, this technique provides two key benefits: the autograft's growth potential - especially advantageous in children and adolescents - and freedom from lifelong anticoagulation. For young adults, particularly those with active lifestyles or women planning pregnancy, the procedure is promising, aligning physiological function with a reduction in thromboembolic risk. Despite its advantages, the complexity of the Ross procedure and the demands on surgical expertise have limited its widespread adoption, making it primarily accessible only in high-volume centres.

In this issue of the journal, Bakhshaliyev et al.² present a study examining the early and medium-term outcomes of the Ross procedure in a paediatric cohort, with a mean follow-up duration of 60.15 months. Among the 20 patients who underwent the procedure, there was one early postoperative mortality, and only one patient required reoperation due to conduit stenosis. Additionally, the majority of patients exhibited minimal or mild aortic regurgitation, obviating the need for further interventions. These findings align with existing literature, underscoring the efficacy of the Ross procedure in paediatric populations, characterised by low mortality and reintervention rates. Notably, the inclusion of neonatal patients and the application of the Ross-Konno procedure in cases of subaortic stenosis highlight the complexity of these cases and the necessity for specialised surgical expertise. The observed mortality in a neonatal patient underscores the challenges inherent in this age group, corroborating other studies that report increased risks among neonates and infants.

The study's limitations include its small sample size and retrospective design, which may affect the generalisability of the results. Furthermore, the absence of extended long-term data precludes a comprehensive assessment of autograft durability and the potential need for future interventions. Nonetheless, this research contributes with valuable insights, reinforcing the viability of the Ross procedure in paediatric patients, particularly when performed in centres with appropriate expertise.

Several studies highlight the Ross procedure's potential and provide valuable insights into long-term outcomes. Notably, Areias et al.³ emphasised the importance of careful patient selection, as factors such as young age, pre-existing aortic regurgitation, and bicuspid valve morphology correlate with autograft failure risks. Recent data from Santa Marta Hospital, in Lisbon, where the procedure has been performed for over two decades, further illustrate its efficacy; Rodrigues et al.⁴ reported a 20-year freedom-from-reoperation rate of 83%, with 80% of patients remaining asymptomatic and in NYHA Class I. In a complementary study conducted by Guerreiro et al.⁵, long-term outcomes of the Ross procedure in an adult cohort were examined, with a median follow-up of 20 years. Their findings, based on 56 patients, reinforce the durability of the Ross procedure, showing an overall survival rate of 77% at 24 years, comparable to the age- and gender-matched general population. Freedom from reoperation was similarly high, with 80% of patients avoiding valve-related reinterventions. Moderate autograft regurgitation was frequent but clinically manageable, underscoring the procedure's stability even in the long term. These findings align with data from large international series, such as those from Toronto General Hospital⁶ and the German Ross Registry^{7,8}, which have reported excellent long-term survival and low rates of reoperation. The procedure's superior haemodynamic profile and physiological advantage over mechanical and bioprosthetic valves make it particularly valuable for younger patients, as it avoids complications related to anticoagulation and promotes native-like flow dynamics.

Despite the favourable outcomes observed, the Ross procedure is not without its limitations. Autograft dilatation remains a significant concern, especially for young males with bicuspid valves, as the autograft in the aortic position can dilate under systemic pressure, leading to progressive aortic insufficiency. This issue often necessitates close follow-up and possible reoperation. Technical refinements, such as reinforcing the sinotubular junction with bioresorbable materials, have been explored in recent years to improve the durability of the autograft and reduce the risk of dilation. Nappi and colleagues^{9,10}, for example, introduced biodegradable scaffolds as a reinforcement method, offering promising results by stabilising the autograft while preserving its growth potential.

Further supporting the Ross procedure's advantages are studies comparing it directly with bioprosthetic and mechanical valve replacements. Mazine et al.⁶, through a propensity-matched study at Toronto General Hospital, demonstrated that Ross patients experienced significantly lower rates of reintervention, valve deterioration, and thromboembolic events compared to those with bioprosthetic aortic valves. At 20 years, survival for Ross patients was markedly better, with fewer complications and superior long-term valve function. These findings reinforce the notion that, when performed by experienced surgeons, the Ross procedure offers unmatched longevity and quality of life for younger patients. However, the procedure's complexity has led to its recommendation only in specialised centres, where surgeons possess the necessary expertise and volume of cases to optimise patient outcomes.

The potential of the Ross procedure to restore survival rates comparable to the general population is one of its most compelling benefits. Unlike mechanical and bioprosthetic valves, which can limit life expectancy and quality of life in younger patients, the Ross

procedure allows for a living, autologous valve replacement. This preserves physiological dynamics in a way prosthetic valves cannot achieve, thus contributing to improved clinical outcomes and better adaptation to physiological demands. However, as highlighted by studies across various centres, including the German Ross Registry and the findings of El-Hamamsy et al.¹¹, the results are highly dependent on surgical expertise and patient selection. This reinforces the value of establishing dedicated centres for the Ross procedure, where patients can benefit from consistent high-quality care and monitoring.

Looking ahead, the Ross procedure could see increased acceptance and application with advances in surgical techniques, materials, and the establishment of specialised centres. The procedure remains a vital option for young, active patients who wish to avoid the limitations of prosthetic valves, offering them superior haemodynamic performance, reduced thromboembolic risks, and a life largely free from the constraints of anticoagulation therapy.

With ongoing innovations aimed at improving autograft durability and mitigating the risks of dilation, the Ross procedure's role in AVR could expand, potentially becoming a mainstay for AVR in younger patients. Establishing centres of excellence and refining patient selection are critical steps in realising the Ross procedure's full potential, ensuring it remains a valuable and sustainable alternative for aortic valve replacement.

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