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Mini Review

Bicuspid Aortic Valve Repair and Associated Aortopathy: Current Concepts and Imaging Advances

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Abstract

Repair of the Bicuspid Aortic Valve (BAV), when durable, remains the preferred intervention as it preserves native tissue, avoids prosthesis-related complications, and maintains physiologic hemodynamics. Contemporary repair strategies demonstrate excellent operative safety and strong mid-term outcomes, particularly when combined with annular and root stabilization. However, long-term durability data remain limited compared with replacement strategies. The Ross procedure has re-emerged as a compelling option in young adults, with long-term series confirming excellent autograft performance. Advanced imaging, particularly four-dimensional (4D) flow Cardiovascular Magnetic Resonance (CMR), provides transformative insights into valvulo- aortopathy, offering dynamic biomarkers that may refine operative thresholds beyond traditional diameter-based criteria. This commentary reviews current concepts in BAV repair, replacement strategies, and imaging advances, while highlighting limitations and areas for future investigation.

Keywords: Bicuspid aortic valve, Valve repair, Ross procedure, Aortopathy, Annuloplasty, 4D flow CMR

Introduction

Bicuspid aortic valve disease represents the most common congenital cardiac anomaly, frequently associated with progressive valvular dysfunction and ascending aortic dilatation. The choice between repair and replacement remains central to management, with repair favored when durable correction is achievable. This commentary evaluates current repair techniques, replacement strategies, and imaging advances, while addressing limitations in long-term outcomes and patient selection.

Valve Repair: Principles and Techniques

Durable repair requires correction of all contributors to regurgitation, including cusp prolapse, annular dilation, and root asymmetry. Techniques such as external annuloplasty, subcommissural repair, and selective root remodeling have improved outcomes, particularly in valves with pliable cusps and minimal calcification. Anatomy-focused strategies—cusp plication, commissural resuspension, and raphe modification—are grounded in geometric analyses of BAV morphology [1-3]. Limitation: Long-term durability data for BAV repair remain less robust than for replacement, necessitating ongoing surveillance and further study.

Valve Replacement: The Ross Procedure and Alternatives

When repair durability is doubtful—particularly in heavily calcified or stenotic valves—replacement becomes the preferred option. The Ross procedure offers excellent long-term outcomes in young adults, with >80% freedom from autograft reoperation at 20 years [4-6]. Its ability to restore physiologic hemodynamics and near-normal life expectancy makes it unique among replacement strategies. Limitation: Patient selection must be individualized; older patients or those with comorbidities may be better served by prosthetic replacement, despite its inherent limitations.

Imaging Advances in Valvulo-Aortopathy

BAV should be considered in the context of its structural and flow-dynamic interactions with the aorta. Advanced imaging is essential, as 50–70% of patients develop ascending aortic dilatation. 4D flow CMR characterizes flow eccentricity, jet angle, vortex formation, and wall shear stress—parameters strongly associated with BAV phenotype and aortic growth [7-9]. Limitation: Despite its promise, 4D flow CMR faces practical barriers including cost, availability, and reproducibility. Integration with guideline-

based thresholds (e.g., 5.0–5.5 cm diameter criteria) is necessary for clinical adoption.

Discussion

The overarching objective remains to provide a durable, physiologic, and individualized solution. Repair is preferred when anatomy allows durable correction; the Ross procedure is an excellent option in young adults when repair is not feasible; prosthetic replacement remains appropriate in older or higher-risk patients. Emerging imaging modalities will refine patient selection and deepen understanding of BAV-associated aortopathy, though their role must be balanced against practical considerations.

Conclusion

Repair of the bicuspid aortic valve offers physiologic advantages when durable correction is achievable. Replacement, particularly the Ross procedure, provides excellent long-term outcomes in young adults. Advanced imaging such as 4D flow CMR represents a promising frontier, though integration with established guidelines and real-world feasibility must be addressed. Future research should focus on long-term durability of repair, broader patient selection strategies, and clinical translation of imaging biomarkers.

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None.

Conflict of Interest

None.

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