



EDITORIAL COMMENT

The hidden legacy of a surgical triumph: Coronary anomalies after arterial switch operation

O legado oculto de um triunfo cirúrgico: anomalias coronárias após cirurgia de *switch* arterial

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The arterial switch operation (ASO) represents one of the most remarkable success stories in congenital cardiac surgery. Since its widespread adoption in the 1980s, this procedure has transformed D-transposition of the great arteries (D-TGA) from a uniformly fatal condition to one with excellent early survival and quality of life.^{1,2} However, as the first generation of ASO patients enters their third and fourth decades of life, we are confronting the long-term sequelae of this complex intervention – particularly involving the coronary arteries.

In this issue, Calvão et al. present a timely study examining coronary anomaly prevalence in adolescents and young adults following ASO.³ Their findings – revealing that 46% of patients harbor some form of coronary anomaly – should prompt the cardiology community to reconsider our approach to long-term surveillance in this population.

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THE ACHILLES HEEL OF A SURGICAL TRIUMPH

Arterial switch operation involves technically demanding reimplantation of coronary arteries from their native aortic sinuses into the neo-aortic root. This maneuver, while restoring ventriculoarterial concordance, creates an inherently vulnerable coronary system. The coronary arteries must be mobilized, translocated, and reimplanted – a process that disrupts their native geometry and may result in acute angulation, kinking, stretching, or aberrant spatial relationships with surrounding structures.⁴

What makes this study particularly valuable is its comprehensive characterization of both congenital and acquired coronary anomalies. The authors document not only expected variants such as single coronary arteries (8%) and anomalous circumflex origin (10%), but also potentially concerning findings including acute proximal angulation (13%), interarterial course (8%), and retroaortic trajectories (21%). These latter findings merit attention, as they represent anatomical configurations that could predispose to myocardial ischemia, particularly during exercise or with progressive neo-aortic root dilation.

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THE CLINICAL CONUNDRUM: ANATOMICAL FINDINGS VERSUS FUNCTIONAL SIGNIFICANCE

One thought-provoking aspect is the apparent disconnect between anatomical complexity and clinical manifestation. Despite high coronary anomaly prevalence, only two patients were symptomatic, presenting with atypical chest pain rather than clear angina. Among 10 asymptomatic patients with anomalies who underwent functional testing, none showed evidence of myocardial ischemia.

This raises fundamental questions about the natural history and clinical significance of post-ASO coronary anomalies. Are we identifying anatomical variants representing stable, benign adaptations? Or are we detecting precursors of future events not yet manifest due to the cohort's young age and limited cardiovascular risk factor exposure?

The answer likely lies between these extremes and varies by specific anatomical pattern. Certain features – acute proximal angulation and interarterial course – are associated with sudden cardiac death in other populations with congenital coronary anomalies,^{5,6} warranting closer monitoring even without symptoms. The authors appropriately note that cardiac denervation following surgical disruption of the cardiac plexus may mask ischemic symptoms,⁷ making anatomical assessment potentially more important than functional testing alone.

THE EVOLVING ROLE OF CARDIAC CT IN POST-ARTERIAL SWITCH OPERATION SURVEILLANCE

Systematic coronary computed tomography angiography (CCTA) use in this cohort – predominantly as routine screening (90% of cases) – represents a proactive surveillance approach differing from current guidelines.^{8,9} The authors demonstrate that CCTA provides detailed coronary anatomy characterization and spatial relationship visualization not reliably assessed by functional testing or invasive angiography.

However, this strategy raises important questions about resource allocation, radiation exposure, and detecting findings of uncertain clinical significance. The challenge lies in distinguishing patients requiring intensified surveillance from those with stable, clinically insignificant variants.

A risk-stratification framework based on anomaly type and severity may help. Patients with high-risk features – acute angulation with stenosis, interarterial course with compression, or progressive obstruction – might warrant closer follow-up and intervention consideration. Those with isolated variant anatomy without obstruction or ischemia might be followed less intensively, with periodic reassessment as cardiovascular risk factors develop.

LIMITATIONS AND FUTURE DIRECTIONS

The authors acknowledge important limitations: single-center retrospective design, modest sample size, and absent longitudinal follow-up. Additionally, lacking preoperative coronary anatomy and surgical data limits the contextualization of the findings. Selection bias – whereby patients

with severe complications may not have undergone CCTA – should be considered.

These limitations point to an urgent need for prospective, multicenter registries with standardized imaging protocols and long-term follow-up.¹⁰ These registries should:

1. Establish natural history of specific coronary anomaly patterns after ASO
2. Determine which anatomical features predict clinical events
3. Define optimal surveillance strategies based on risk stratification
4. Evaluate advanced imaging techniques, including CT-derived fractional flow reserve and stress CMR, and
5. Identify surgical or percutaneous interventions that may prevent future coronary events.

Furthermore, as this population ages, we must remain vigilant for acquired coronary disease superimposed on baseline anatomical complexity. The interaction between congenital/surgical anomalies and atherosclerotic risk factors warrants investigation.

THE PATH FORWARD

This study serves as an important reminder that surgical success does not eliminate the need for lifelong surveillance. The high anomaly prevalence documented suggests routine CCTA may be justified in this population, particularly during transition from pediatric to adult care.

However, imaging alone is insufficient. We urgently need better understanding of which anatomical findings portend clinical risk. This requires collaborative efforts to pool multicentre data, standardize imaging protocols, and follow patients prospectively. Only then can we move from descriptive prevalence studies to predictive models guiding clinical decisions.

Arterial switch operations have saved thousands of lives, but our work continues. As the authors conclude, multicenter longitudinal studies are essential to define prognostic relevance of post-ASO coronary anomalies. Until these data exist, clinicians must balance surveillance benefits against costs and harms, making individualized decisions based on coronary anatomy, clinical presentation, and patient preferences.

This study represents a valuable contribution to this evolving field. The authors should be commended for their systematic approach to characterizing coronary anatomy in their ASO cohort. Their work provides a foundation for future research, ultimately improving outcomes for this unique and growing population.

Conflicts of interest

The authors have no conflicts of interest to declare.

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