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Original Research Paper

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SINUS- AND COMMISSURE-BASED INNOVATIVE CLASSIFICATION (RPKSAI) OF ALCAPA: SURGICAL IMPLICATIONS

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ABSTRACT Anomalous origin of the left coronary artery from the pulmonary artery (ALCAPA) is a rare congenital cardiac anomaly with potentially fatal outcomes if untreated. Traditional classifications have emphasized infantile versus adult types or collateralization patterns. We propose a novel classification (RPKSAI CLASSIFICATION FOR ALCAPA) based on the precise origin within the pulmonary sinuses or commissures, which directly informs surgical repair. This scheme includes anterior, posterior, and commissural origins, as well as remote non-facing sinus variants, highlighting surgical feasibility for direct reimplantation, intrapulmonary tunneling, or flap-based reconstructions. The classification aims to guide surgical decision-making, reduce technical challenges, and improve outcomes.

KEYWORDS : ALCAPA, Pulmonary sinus origin, Commissural coronary origin, Surgical classification, Takeuchi repair

INTRODUCTION

ALCAPA occurs in approximately 1 in 300,000 live births, representing 0.25–0.5% of congenital cardiac malformations (1). Without surgical correction, mortality approaches 90% in the first year of life (2). Adult survivors often develop collaterals but remain at risk for sudden cardiac death (3).

While infant/adult-type classifications remain standard, these schemes inadequately address surgical complexity tied to anatomical origin within the pulmonary artery. The distance and orientation of the anomalous left coronary artery (LCA) relative to the aorta critically determine whether direct reimplantation, a Takeuchi repair, or a flap-based approach is possible (4; 7). We therefore propose a new sinus- and commissure-based classification.

Current Concepts

- Infant vs. adult types: Defined by collateral development and clinical presentation.
- Collateral-based subtyping: Highlights survival in adult cases but lacks surgical precision.
- Surgical gold standard: Direct reimplantation of the LCA into the aorta when feasible, offering physiological coronary perfusion (8).
- Alternative procedures: Takeuchi repair (intrapulmonary tunnel), coronary bypass with anomalous origin ligation, and extra pulmonary flap tunneling (6,10).

These approaches are anatomically constrained by the exact sinus or commissural origin.

New Classification
Category 1: Sinus-Origin ALCAPA
1a. Anterior Sinus Origin
o Close to the aorta; usually permits direct reimplantation.

1b. Posterior Sinus Origin
o Further from the aortic root; often requires flap-based tunneling or modified Takeuchi repair.

Category 2: Commissural-Origin ALCAPA (rare pattern)
2a. Anterolateral Commissural Origin
o Challenges due to orientation; intrapulmonary baffle or autologous flap recommended.
2b. Posterolateral Commissural Origin
o Distance and tension limit direct implantation; complex tunneling techniques preferable.

Category 3: Remote Non-Facing Sinus Origin
3a. Short-Distance Variant
o Amenable to standard Takeuchi repair.
3b. Long-Distance Variant
o Requires extended flap-based or vein-graft tunneling with higher surgical risk.

DISCUSSION

This classification system links origin anatomy to surgical feasibility:

- Anterior sinus origin: straightforward direct implantation.
- Posterior sinus or commissural origins: higher complexity; intrapulmonary tunneling or autologous flaps often required.
- Remote non-facing sinus variants: demand longer reconstructions, with higher risk of kinking or obstruction.

This framework not only predicts technical difficulty but also helps surgeons select the most durable repair while minimizing complications such as supravalvular pulmonary stenosis or baffle obstruction (9).

Surgical Indications and Contraindications for Each Type
Type 1a (Anterior Sinus):
o Indication: Direct reimplantation.
o Contraindication: None if distance is favorable.

Type 1b (Posterior Sinus):
o Indication: Flap-based tunnel or modified Takeuchi.
o Contraindication: Direct reimplantation under tension.

Type 2a/2b (Commissural Origin):
o Indication: Intrapulmonary tunnel or autologous patch flap.
o Contraindication: Simple reimplantation due to risk of distortion at commissural sites.

Type 3a (Remote Short Distance):
o Indication: Standard Takeuchi repair.
o Contraindication: CABG in infants (poor long-term graft patency).

Type 3b (Remote Long Distance):
o Indication: Flap or vein-graft tunneling with anomalous origin ligation.
o Contraindication: Direct reimplantation.

Despite advances in surgical techniques for ALCAPA, postoperative complications remain an important consideration. **Direct reimplantation** may lead to coronary kinking, stenosis at the anastomotic site, or myocardial ischemia if performed under tension. **Takeuchi repair** carries risks of baffle obstruction, residual shunting, or supravalvular pulmonary stenosis due to distortion of the pulmonary outflow tract. **Flap-based tunnels or vein-graft reconstructions**,

particularly in remote origins, may be complicated by graft occlusion, aneurysmal changes, or late ischemia. Additionally, concomitant **mitral valve insufficiency** may persist or recur postoperatively, requiring re-intervention. Long-term follow-up with echocardiography or CT angiography is therefore critical to monitor graft patency, ventricular function, and baffle integrity.

Summary

A sinus- and commissure-based classification of ALCAPA provides a pragmatic surgical roadmap. By identifying origin within the pulmonary artery—whether anterior, posterior, commissural, or remote—this system anticipates surgical complexity and optimizes repair choice. Incorporating rare commissural variants ensures comprehensive applicability across the full spectrum of anatomical presentations.

Keywords + MeSH Terms

1. ALCAPA (Anomalous Left Coronary Artery from the Pulmonary Artery)

o MeSH: *Coronary Vessel Anomalies*; *Pulmonary Artery/abnormalities*

2. Pulmonary sinus origin

o MeSH: *Pulmonary Artery/anatomy & histology*; *Heart Defects, Congenital*

3. Commissural coronary origin

o MeSH: *Coronary Vessels/anatomy & histology*; *Coronary Circulation/abnormalities*

4. Surgical classification

o MeSH: *Cardiac Surgical Procedures/classification*; *Treatment Outcome*

5. Takeuchi repair

MeSH: *Cardiac Surgical Procedures/methods*; *Thoracic Surgery, Video-Assisted* (as relevant surgical technique category)

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