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Pulmonary Arterial Hypertension After Repair of Classical Tetralogy of Fallot

Klasik Fallot Tetralojisi'nin Onarımı Sonrası Pulmoner Arteriyel Hipertansiyon

ABSTRACT

Tetralogy of Fallot (TOF), the most common cyanotic congenital heart disease, is classically associated with decreased pulmonary blood flow. Classical TOF is characterized by antegrade pulmonary blood flow and right ventricular outflow tract obstruction at varying levels. In the modern era, most children with TOF undergo definitive intracardiac repair during infancy, and pulmonary artery hypertension (PAH) is virtually unheard of in postoperative TOF in the absence of major aortopulmonary collaterals. We report the circumstances in which PAH can occur after definitive repair of classical TOF in the modern era.

Keywords: Congenital heart diseases, cyanosis, pulmonary arterial hypertension, pulmonary hypertension, Tetralogy of Fallot

ÖZET

En sık görülen siyanotik konjenital kalp hastalığı olan Fallot Tetralojisi (TOF), klasik olarak azalmış pulmoner kan akımı ile ilişkilidir. Klasik TOF, değişen düzeylerde antegrad pulmoner kan akımı ve sağ ventrikül çıkış yolu obstrüksiyonu ile ilişkilidir. Modern çağda, TOF'lu çocukların çoğu bebeklik döneminde kesin intrakardiyak onarım geçirir ve pulmoner arter hipertansiyonu (PAH), majör aortopulmoner kollaterallerin yokluğunda postoperatif TOF'ta neredeyse hiç duyulmamıştır. Modern çağda klasik TOF'un kesin onarımından sonra PAH'ın ortaya çıkabileceği durumları bildiriyoruz.

Anahtar Kelimeler: Konjenital kalp hastalıkları, siyanoz, pulmoner arteriyel hipertansiyon, pulmoner hipertansiyon, Fallot Tetralojisi

CASE REPORT
OLGU SUNUMU

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Tetralogy of Fallot (TOF) is classically associated with decreased pulmonary blood flow. Unregulated pulmonary blood flow from major aortopulmonary collaterals (MAPCAs) can cause segmental pulmonary hypertension in TOF with pulmonary atresia, a TOF variant.[1]

Historically, palliation of TOF with large systemic-to-pulmonary artery shunts, particularly the Pott's shunt, was a known cause for pulmonary arterial hypertension (PAH) in postoperative TOF during the past century.[2] However, in the modern era, where definitive intracardiac repair of TOF is performed during infancy, PAH is rarely encountered in postoperative TOF in the absence of major aortopulmonary collaterals. We report an uncommon case of PAH following definitive repair of classical TOF in the modern era.

Case Report

The index patient was diagnosed with TOF with a diffusely small left pulmonary artery (z-score -3.33) and a normal-sized right pulmonary artery (z-score +1.58) in infancy. She underwent transatrial intracardiac repair with a transannular patch and left pulmonary artery plasty at two years of age. Twelve years later, she presented with New York Heart Association (NYHA) class II dyspnea on exertion. A chest X-ray showed an oligemic left lung (Figure 1A). The electrocardiogram revealed sinus rhythm, a normal PR interval, and right bundle branch block with a QRS duration of 154 milliseconds (Figure 1B). Echocardiography demonstrated severe pulmonary regurgitation, no residual ventricular septal defect (VSD), moderate tricuspid regurgitation, and a diffusely small

left pulmonary artery, which was confirmed by cardiac magnetic resonance imaging (MRI) (Figure 2A). The right ventricle was dilated and dysfunctional, with an indexed end-diastolic volume of 141.1 mL/m^2 and an end-systolic volume of 103.9 mL/m^2. High-resolution chest computed tomography showed an oligemic left lung with peripheral left subpleural nodularity, suggestive of intercostal collaterals (Figure 2B). Cardiac catheterization revealed a hypertensive right pulmonary artery (pressure 78/10 mmHg) with a pulmonary vascular resistance of 9.52 WU.

She was initiated on sildenafil and bosentan therapy. The case was discussed at the institute's joint cardiac conference. She was advised to undergo pulmonary valve replacement with left pulmonary artery augmentation. As the left pulmonary artery remained diffusely small despite left pulmonary artery plasty in infancy, she was considered for left pulmonary artery stenting followed by pulmonary valve replacement. Left pulmonary artery stenting was performed using a 10 mm x 30 mm Cook Formula™ 535 stent (Cook Medical, Bloomington, IN, USA) at 10 atm. The patient was unable to afford percutaneous pulmonary

ABBREVIATIONS

MAPCA	Major aortopulmonary collateral artery
NYHA	New York Heart Association
PAH	Pulmonary arterial hypertension
PAH-CHD	Pulmonary arterial hypertension associated with congenital heart disease
TOF	Tetralogy of Fallot
VSD	Ventricular septal defect
WU	Wood units

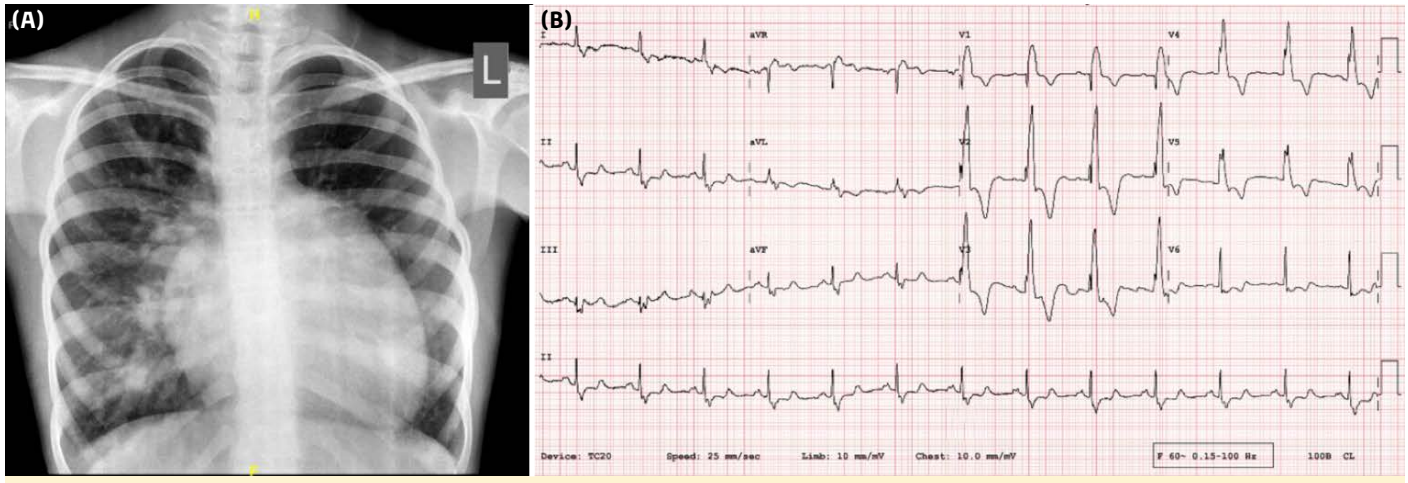

Figure 1. (A) Chest X-ray in the posteroanterior projection showing oligemic left lung fields. (B) Electrocardiogram demonstrating right bundle branch block (RBBB) with a QRS duration of 154 milliseconds.

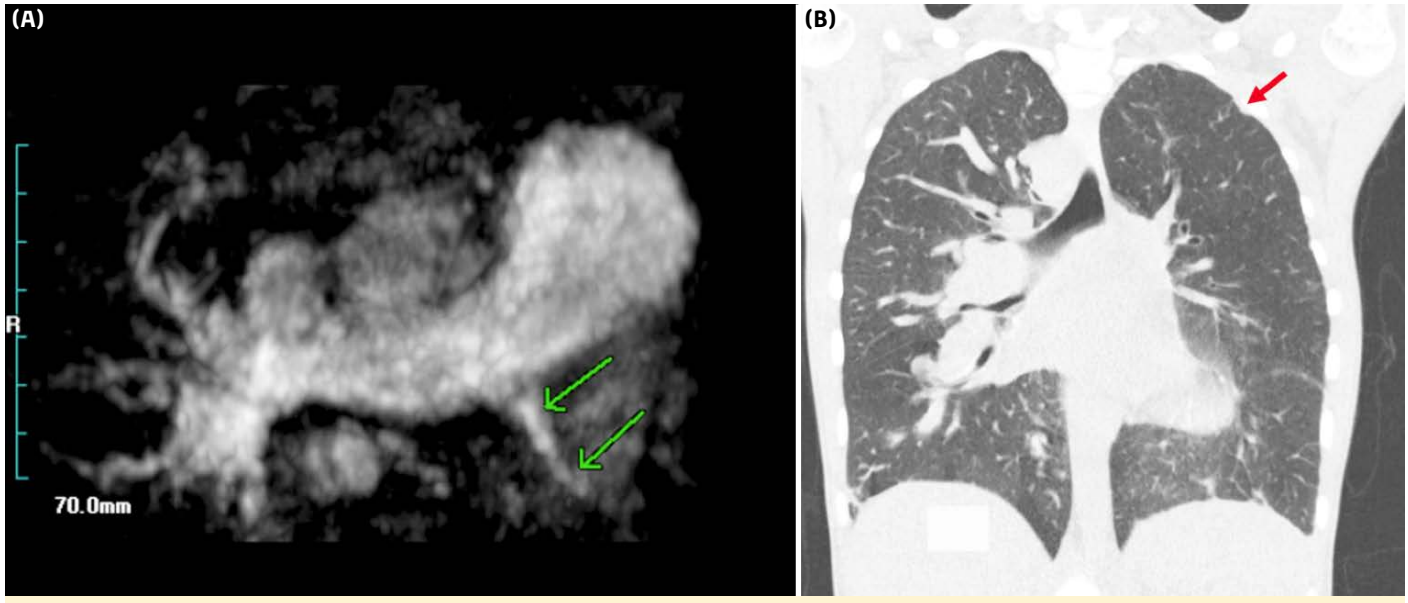

Figure 2. (A) Cardiac magnetic resonance angiogram showing a diffusely small left pulmonary artery (green arrows). (B) Coronal section of computed tomography showing markedly dilated right pulmonary artery branches with abrupt peripheral pruning and an oligemic left lung with a subpleural nodule (red arrow).

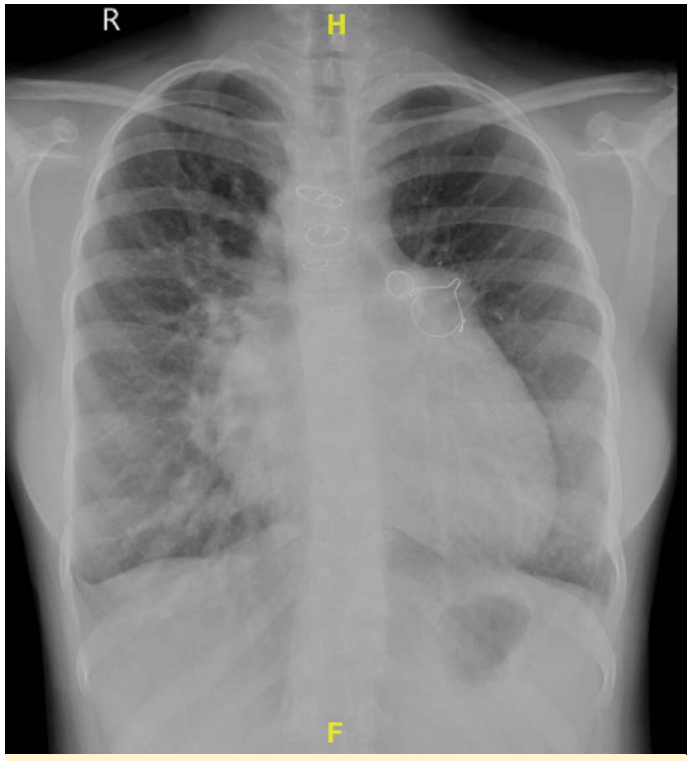

Figure 3. Chest X-ray in the posteroanterior projection after pulmonary valve replacement and left pulmonary artery augmentation.

valve replacement. Two months later, she underwent surgical pulmonary valve replacement with a 25 mm Flomero bovine pericardial bioprosthesis (Meril Life Sciences, Vapi, Gujarat, India) (Figure 3). The patient improved to NYHA class I and remained well at the one-year follow up. The peak gradient on the trivial pulmonary regurgitation measured 21 mmHg.

Discussion

Pulmonary artery hypertension is exceedingly rare after the repair of classical TOF. The index case highlights the role of pulmonary artery anatomy in the development of PAH in repaired TOF. Inadequate closure of VSDs, excessively large systemic-to-pulmonary shunts, delayed intracardiac repair, undetected branch pulmonary artery stenosis, and absent branch pulmonary arteries are among the reported causes of PAH after TOF repair, occurring in 1% of patients undergoing TOF repair.[3] PAH in the absence of demonstrable intracardiac lesions, aortopulmonary collaterals, or pulmonary artery pathology, which would fit into subclass 4 of the Nice Classification, is distinctly unusual in repaired classical TOF.[4] The World Health Organization classification system categorizes PAH in repaired TOF as pulmonary arterial hypertension associated with congenital heart disease (PAH-CHD) and includes it in Group 1 of the classification.[5]

Even in the absence of MAPCAs, TOF can be associated with hypoplasia of lung segments and pulmonary vasculature. Abnormalities in pulmonary artery arborization, residual peripheral pulmonary stenosis, ventilation-perfusion mismatch, and vascular abnormalities in areas of alveolar hypoventilation can elevate pulmonary artery pressures in TOF patients and may persist after repair.[6,7] Chronic upper airway obstruction, pulmonary thrombosis, and Down syndrome are additional factors that may contribute to PAH after TOF repair.[3]

The treatment of these patients involves addressing the mechanical factors that contribute to PAH. Stenting of diminutive branch pulmonary arteries has been shown to reduce total vascular resistance, low-frequency impedance, and wave reflection, while also improving ventricular-vascular interaction, as demonstrated by a leftward shift of the right ventricular pressure-area loop.[8]

Targeted pulmonary vasodilator therapy improves symptoms and exercise capacity in PAH associated with congenital heart disease, including repaired TOF. Treatment with bosentan has demonstrated hemodynamic improvement in children, as well as improvements in the 6-minute walking distance, Borg dyspnea scale, and World Health Organization (WHO) functional class in adults with TOF and segmental pulmonary hypertension.[9,10] The use of tadalafil has been associated with improved exercise time and endothelial function, as assessed by flow-mediated dilation of the brachial artery, in repaired TOF;[11] however, it has not been specifically evaluated in patients with associated PAH. However, not all patients with PAH after TOF repair respond to such therapies.[12] PAH secondary to a residual VSD is associated with early pulmonary microcirculatory changes and worse outcomes in repaired TOF compared to PAH resulting from significant peripheral pulmonary artery obstruction.[13]

Conclusion

Peripheral pulmonary artery stenosis is a rare cause of pulmonary arterial hypertension after the repair of tetralogy of Fallot. These patients require prompt correction of anatomical abnormalities in addition to pulmonary vasodilator therapy and close follow-up after TOF repair.

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

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