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Pulmonary Valve Reconstruction Using Glutaraldehyde-Treated Pericardium In Adolescent Tof: A Two-Case Experience

Jeconia Agrippina Ruth Sinatra[1,2], Arief Rakhman Hakim[1,2], Heroe Soebroto[1,2], Erdyanto Akbar[1,2]

[1]Dept. of Thoracic, Cardiac, and Vascular Surgery, Faculty of Medicine, Universitas Air-langga, Surabaya, Indonesia
[2]Dept. of Thoracic, Cardiac and Vascular Surgery, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia
Corresponding Author's information:
Arief Rakhman Hakim
Dept. of Thoracic, Cardiac, and Vascular Surgery, Faculty of Medicine, Universitas Airlangga, Dr. Soetomo General Academic Hospital, Surabaya, Indonesia
E-mail: ariefbtkv@gmail.com

ABSTRACT

Background: Tetralogy of Fallot (ToF) is the most common cyanotic congenital heart defect. Advances in early diagnosis and corrective surgery have markedly improved survival; however, late presentation during adolescence remains a challenge in developing countries. Delayed surgical correction carries a higher risk of postoperative complications, including right ventricular dysfunction and pulmonary regurgitation.

Case: We report two adolescent female patients, aged 14 and 23 years, who presented with progressive exertional dyspnea, cyanosis, and digital clubbing. Both had known ToF from early childhood but had not undergone prior corrective surgery. Echocardiography confirmed classic ToF with severe infundibular and valvular pulmonary stenosis. Total corrective sur-gery with transannular patching and reconstruction of a neo-pulmonary valve using glutar-aldehyde-treated autologous pericardium was performed in both cases. The first patient re-quired reoperation due to postoperative bleeding, while the second developed pneumonia, which was successfully treated with antibiotics. Postoperative echocardiography demon-strated competent pulmonary valves without regurgitation. Both patients showed satisfactory early recovery and stable hemodynamics at discharge.

Conclusions: Total corrective surgery with autologous pericardial pulmonary valve recon-struction represents a feasible and effective option in adolescent patients with delayed presentation of ToF. This approach may reduce postoperative pulmonary regurgitation and preserve right ventricular function. Long-term follow-up remains necessary to assess valve durability and functional outcomes**.**

KEYWORDS: Tetralogy of Fallot; pulmonary valve reconstruction; autologous pericardium; adolescent cardiac surgery; case series.

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INTRODUCTION

BACKGROUND:

Tetralogy of Fallot (ToF) is the most common cyanotic congenital heart defect (US Centres for Disease Control and Prevention, 2024). While advances in diagnosis and surgical techniques have improved early outcomes in many settings, late presentation continues to be prevalent in developing countries due to limited access to healthcare, delayed diagnosis, and socioeconomic barriers (Khan et al., 2016; Mocumbi et al., 2011). In such cases, adolescents and even adults may present with uncorrected ToF, posing greater surgical and perioperative risks (Alkashkari et al., 2020; Khan et al., 2016). Corrective surgery at a later age is associated with increased morbidity, including right ventricular hypertrophy, reduced pulmonary artery development, and postoperative complications such as pulmonary regurgitation (PR) and right ventricular dysfunction (Bertranou et al., 1978; Rammohan et al., 1998). Traditional approaches often sacrifice the pulmonary valve, contributing to long-term sequelae. Valve-sparing procedures or valve reconstruction techniques are increasingly favored for their potential to reduce PR and preserve RV function (Bacha, 2012). In this report, we present two adolescent patients with delayed diagnosis of ToF who underwent total correction using a neo-pulmonary valve constructed from glutaraldehyde-pretreated autologous pericardium, demonstrating favorable early postoperative outcomes.

CASE REPORTS:

Case 1

A 14-year-old female presented with progressive exertional dyspnea, central cyanosis, and digital clubbing. Her peripheral oxygen saturation was 78% on room air. Transthoracic echocardiography (TTE) and cardiac catheterization confirmed the

diagnosis of classic Tetralogy of Fallot (ToF), characterized by a large perimembranous ventricular septal defect (VSD), an overriding aorta estimated at 30%, and severe infundibular and valvular pulmonary stenosis with a peak gradient of 69.5 mmHg. The McGoon ratio was calculated at 2.1, indicating suitable pulmonary artery anatomy for surgical repair. The patient underwent total corrective surgery involving resection of the dysplastic pulmonary valve and relief of RVOT obstruction. A glutaraldehyde-pretreated autologous pericardial patch was fashioned into a trileaflet configuration and implanted to reconstruct a competent neo-pulmonary valve. A transannular patch was used to augment the RVOT. Intraoperative transesophageal echocardiography (TEE) demonstrated satisfactory valve function without evidence of pulmonary regurgitation. Postoperatively, the patient experienced a bleeding complication from the residual pericardial bed, necessitating re-exploration and hemostasis within the first six hours. She recovered uneventfully thereafter and was discharged in stable condition on postoperative day 10.

Case 2

A 23-year-old female with a known but previously uncorrected congenital heart defect presented with progressive dyspnea and cyanosis that had worsened over the past year. Her clinical history included mild symptoms during childhood, which were not pursued further due to minimal functional impairment. On presentation, her peripheral oxygen saturation was 73% on room air. Transthoracic echocardiography demonstrated classic Tetralogy of Fallot with severe subvalvular and valvular pulmonary stenosis (maximum pressure gradient 74.1 mmHg), a VSD with an overriding aorta measuring 42.9%, and severe tricuspid regurgitation. The McGoon ratio was calculated at 1.93, and cardiac catheterization identified two major aortopulmonary collateral arteries (MAPCAs), measuring 2.12 mm and 2.70 mm, supplying the left and right lungs respectively. The patient underwent total corrective surgery utilizing the same approach as in Case 1. A glutaraldehyde-pretreated autologous pericardial patch was fashioned into a trileaflet neo-pulmonary valve and implanted into the RVOT with a transannular patch reconstruction. Her early postoperative course was complicated by pneumonia and transient hemodynamic instability beginning on postoperative day three. With appropriate supportive management and antibiotic therapy, she stabilized by day 10 and was discharged home on postoperative day 12 in improved clinical condition.

Surgical Technique

The surgical procedure commenced with a median sternotomy and establishment of cardiopulmonary bypass under moderate hypothermia. Following myocardial arrest, the right ventricular outflow tract (RVOT) was exposed via a longitudinal ventriculotomy. Extensive infundibular muscle resection was performed to relieve the RVOT obstruction. A large autologous pericardial patch was tailored to serve as both the transannular patch and the base for valve reconstruction (Figure 1). Two additional smaller pericardial patches, proportioned to match the pulmonary artery diameter, were fashioned into semilunar leaflet-like structures. These were then sutured into the central base patch to create a monocusp neo-pulmonary valve (Figure 2).The composite pericardial valve structure was anchored to the native pulmonary valve annulus using continuous 5-0 polypropylene sutures (Figure 3). The remaining length of the transannular patch was then extended and sewn to the ventriculotomy margins on the right ventricle, thereby reconstructing the RVOT while ensuring adequate outflow diameter. Intraoperative transesophageal echocardiography (TEE) confirmed satisfactory motion of the newly created valve leaflets with no evidence of pulmonary regurgitation or stenosis (Figure 4A, 4B). Hemostasis was secured, and the patient was weaned off bypass uneventfully.

DISCUSSION:

Late presentation of Tetralogy of Fallot (ToF) is still a significant clinical challenge in developing countries due to limited access to early diagnostic facilities and surgical interventions (Mocumbi et al., 2011). Prolonged cyanosis in uncorrected ToF leads to chronic hypoxemia, resulting in compensatory right ventricular (RV) hypertrophy, decreased pulmonary artery growth, and systemic complications including polycythemia and coagulopathy. The adult or adolescent repair of ToF has been associated with increased perioperative risks such as arrhythmias, bleeding, and right ventricular failure (Alkashkari et al., 2020; Khan et al., 2016; Mocumbi et al., 2011). A major concern in ToF correction, especially in older patients, is postoperative pulmonary regurgitation (PR), which has long-term consequences such as right heart dilation and reduced functional capacity (Rammohan et al., 1998). Valve-sparing techniques are preferred but are not always feasible when severe annular hypoplasia or valve dysplasia is present (Bacha, 2012). In our cases, we employed a novel method of pulmonary valve reconstruction using autologous pericardium, tailored to the patient's anatomy. The use of autologous pericardial tissue allows for biocompatibility and growth potential, although long-term durability remains a subject of study. Previous reports have shown that pericardial valve reconstruction can provide immediate competence and reduce PR rates postoperatively, though some studies suggest progressive degeneration or retraction over time (Bacha, 2012). Nevertheless, early outcomes in both our patients were favorable. One case required reoperation for bleeding but ultimately stabilized, while the other had transient pulmonary complications. Both showed no signs of PR on postoperative TEE, and were discharged in stable condition These outcomes highlight that even in delayed ToF presentations, innovative valve reconstruction strategies can improve surgical results and quality of life. Continued follow-up and imaging will be essential to evaluate valve function and determine the long-term efficacy of this technique.

CONCLUSION:

Total corrective surgery with reconstruction of the pulmonary valve using glutaraldehyde-pretreated autologous pericardium is a viable and technically feasible option in adolescent patients with delayed presentation of Tetralogy of Fallot. This valve-sparing approach may help mitigate the incidence of postoperative pulmonary regurgitation, a major contributor to long-term right ventricular dysfunction. Our initial experience demonstrates favorable short-term outcomes, supporting the consideration of this technique in appropriately selected patients. Long-term follow-up is necessary to evaluate the durability and functional performance of the reconstructed neo-pulmonary valve.

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Figure Legends
Figure 1. Schematic design of pulmonary valve creation. A pericardial patch is tailored to form a neo-pulmonary valve using three equal widths (a = b = c) and attached to the transannular patch extending from the right ventricular outflow tract (RVOT) to the pulmonary artery (PA).
Figure 2. Intraoperative image showing pulmonary valve creation using autologous pericardium. The base patch is prepared and sutured to serve as both the neo-pulmonary valve and transannular extension.
Figure 3. Neo-pulmonary valve attachment to the pulmonary valve annulus. The constructed valve using autologous pericardial patch is being sutured into place.
Figure 4A. Postoperative TEE with color Doppler shows competent valve function and no pulmonary regurgitation.
Figure 4B. Additional TEE view confirming unobstructed pulmonary flow through the reconstructed valve.