Received: April 24, 2024
Accepted: June 16, 2024

Acad Med J 2024;4(2):159-164
UDC: 616.141-073.756.8:004
DOI: https://www.doi.org/10.53582/AMJ2442159n
Case report

ADVANCEMENTS IN IMAGING TECHNIQUES FOR COMPREHENSIVE ASSESSMENT OF PARTIAL ANOMALOUS PULMONARY VENOUS RETURN

Nikolova Sonja[1], Dimitrijevikj Kristina[2], Dokoska Marija[3]

[1]Institute of Radiology, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia
[2]Clinic for Pulmonology and Allergology, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia
[3]University Clinic for Otorhinolaryngology, Head and Neck Surgery, Faculty of Medicine, Ss. Cyril and Methodius University in Skopje, Republic of North Macedonia
*e-mail:*sonikmk@gmail.com

Abstract

Partial anomalous pulmonary venous return (PAPVR) poses a complex diagnostic challenge due to its varied presentations and intricate vascular anatomy. This article explored the advancements in imaging modalities, particularly computed tomography angiography (CTA) in delineating the diverse manifestations of PAPVR with precision. By a detailed analysis of four clinical cases, this study elucidated the pivotal role of advanced imaging techniques in enhancing diagnostic accuracy and guiding therapeutic interventions for patients with PAPVR.

Keywords: partial anomalous pulmonary venous return (PAPVR), computed tomography angiography (CTA), congenital cardiovascular anomaly, vascular anatomy, diagnostic precision

Introduction

Partial anomalous pulmonary venous return (PAPVR) is a rare congenital cardiovascular anomaly characterized by abnormal drainage of one or more pulmonary veins into systemic veins rather than into the left atrium. The anomaly can manifest in various forms, categorized primarily as supra-cardiac, cardiac, infra-cardiac, and mixed types [1,2].

Supra-cardiac PAPVR involves drainage into the superior vena cava or innominate vein, while cardiac PAPVR drains into the coronary sinus or directly into the right atrium. Infra-cardiac PAPVR typically drains into the portal venous system or into systemic veins below the diaphragm[3].

The complexity of PAPVR poses significant diagnostic challenges due to its varied anatomical presentations and potential for misdiagnosis. Traditional imaging modalities such as echocardiography and conventional angiography may be limited in visualizing the intricate vascular anatomy associated with PAPVR. Advancements in imaging techniques, particularly computed tomography angiography (CTA), have revolutionized the diagnostic approach by offering high-resolution three-dimensional visualization of vascular structures[4].

This study explored the utility of CTA in delineating the diverse manifestations of PAPVR and its implications for patient care by the analysis of clinical cases and discussion of current literature[5].

Conventional imaging modalities such as echocardiography and conventional angiography have limitations in visualizing the intricate vascular anatomy and anomalous venous connections associated with PAPVR. The advent of advanced imaging techniques, particularly CTA, has revolutionized the diagnostic approach to PAPVR by offering high-resolution three-dimensional visualization of vascular structures. Despite these advancements, challenges persist in accurately characterizing PAPVR variants and assessing their hemodynamic significance.

CTA has emerged as a cornerstone in the diagnostic evaluation of PAPVR, offering unparalleled spatial resolution and tissue contrast. Recent advancements in CTA technology, including multi-detector row scanners and dual-energy imaging, have further enhanced its diagnostic capabilities in delineating the complex vascular anatomy and identifying subtle anomalies associated with PAPVR. By providing detailed anatomical information and precise localization of anomalous venous connections, CTA facilitates accurate diagnosis and guides tailored therapeutic interventions for patients with PAPVR.

Methodology

The methodology of the computerized tomography for each case was designed to ensure reproducibility. Each scan was performed using a multi-detector CT scanner with the following parameters:

- **CT acquisition parameters:** Slice thickness of 0.5 mm, reconstruction interval of 0.5 mm, and intravenous contrast protocols using 100 mL of nonionic contrast medium injected at a rate of 4 mL/sec.
- **Image reconstruction techniques:** Utilization of advanced reconstruction algorithms, including 3D volume rendering and multi-planar reformation, to enhance the visualization of vascular structures.
- **Post-processing methods:** Detailed post-processing involved the use of specialized software to manipulate and enhance image quality, ensuring clear delineation of pulmonary veins and anomalous connections.

Clinical Cases

Case 1: A 52-year-old female presenting with symptoms of cardiovascular dysfunction underwent CTA, revealing a mixed-type PAPVR with supra-cardiac and cardiac drainage patterns. High-resolution CTA images provided detailed anatomical information,

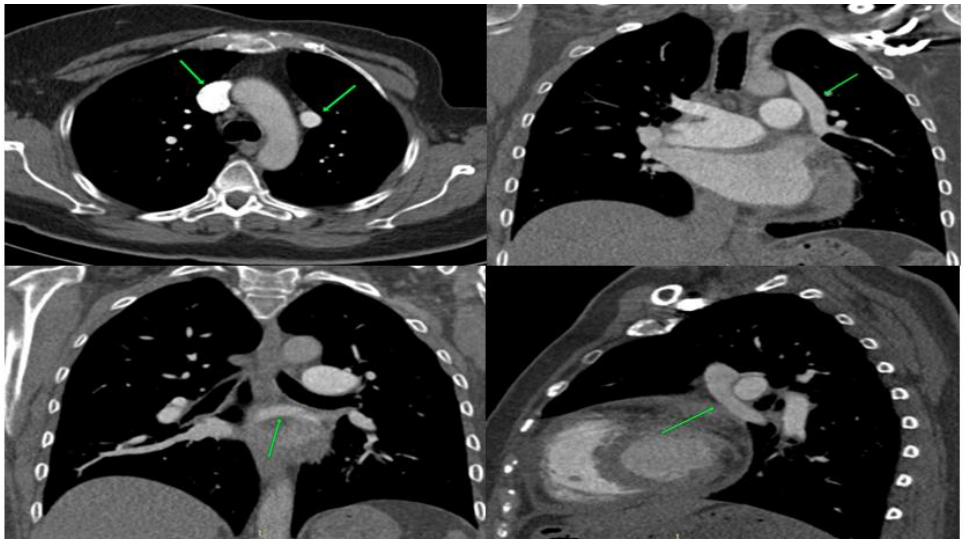

Fig. 1a-d. Mixed PAPVR on the left, type 1 and 2, with proximal pulmonary veins draining into the innominate vein and distal pulmonary veins into the coronary sinus guiding subsequent management strategies. The case highlights the importance of advanced imaging techniques in accurately characterizing complex PAPVR variants (Figure 1a-d).

Case 2: Incidental detection of type 1 supra-cardiac PAPVR in a 38-year-old male undergoing routine imaging highlighted the importance of comprehensive evaluation in identifying asymptomatic cases of PAPVR. The case underscores the role of CTA in detecting subtle anomalies and guiding clinical decision-making (Figure 2a-d).

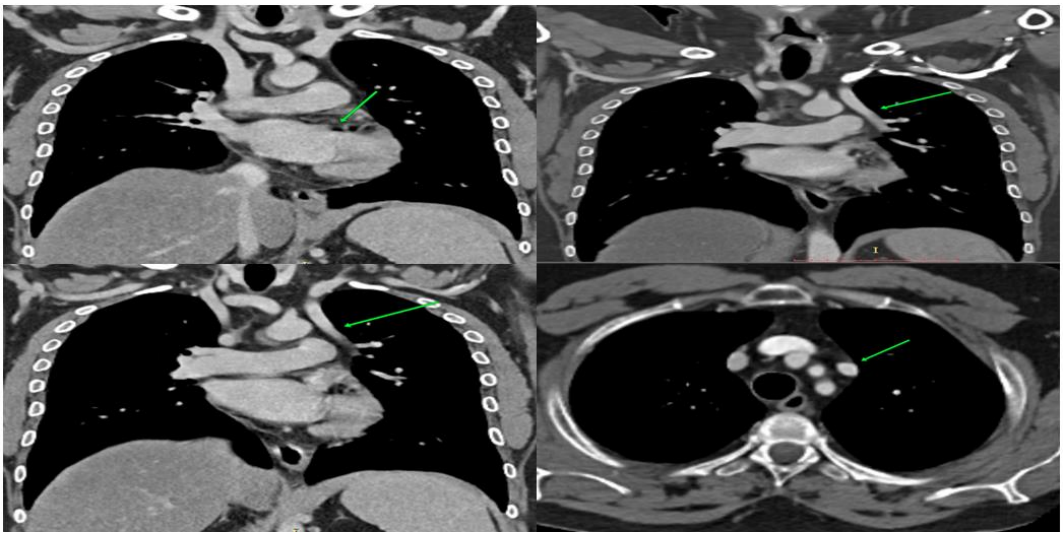

Fig. 2a-d. Proximal pulmonary veins not draining into the left atrium, but PAPVR, type 1 - supra-cardiac, where the proximal pulmonary veins drain into the systemic circulation through the innominate vein

Case 3: Diagnosis of type 1 supra-cardiac PAPVR in a 77-year-old female undergoing evaluation for severe aortic stenosis demonstrated the utility of CTA in detecting concurrent cardiovascular pathologies. The case emphasizes the role of advanced imaging techniques in comprehensive assessment of PAPVR and associated comorbidities. (Figure 3a-d).

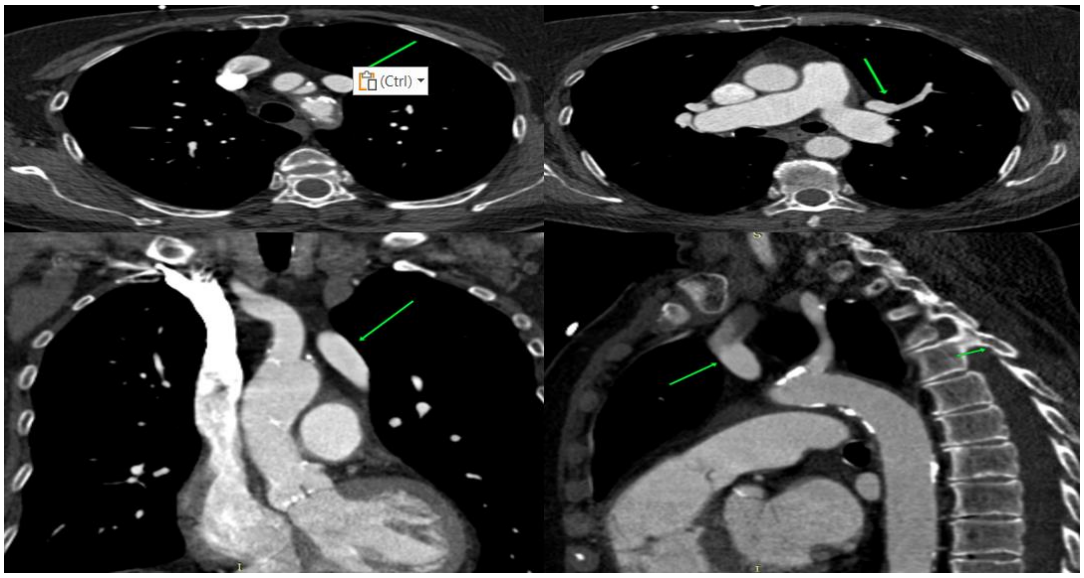

Fig. 3a-d. Proximal pulmonary veins not draining into the left atrium, but PAPVR, type 1 - supra-cardiac, where the proximal pulmonary veins drain into the systemic circulation through the innominate vein

Case 4: A 54-year-old male with a history of laryngeal cancer was incidentally diagnosed with type 1 supra-cardiac PAPVR during follow-up imaging, emphasizing the role of CTA in surveillance of high-risk populations. The case illustrates the importance of vigilance and thorough evaluation in detecting PAPVR in diverse clinical settings. (Figure 4a-d).

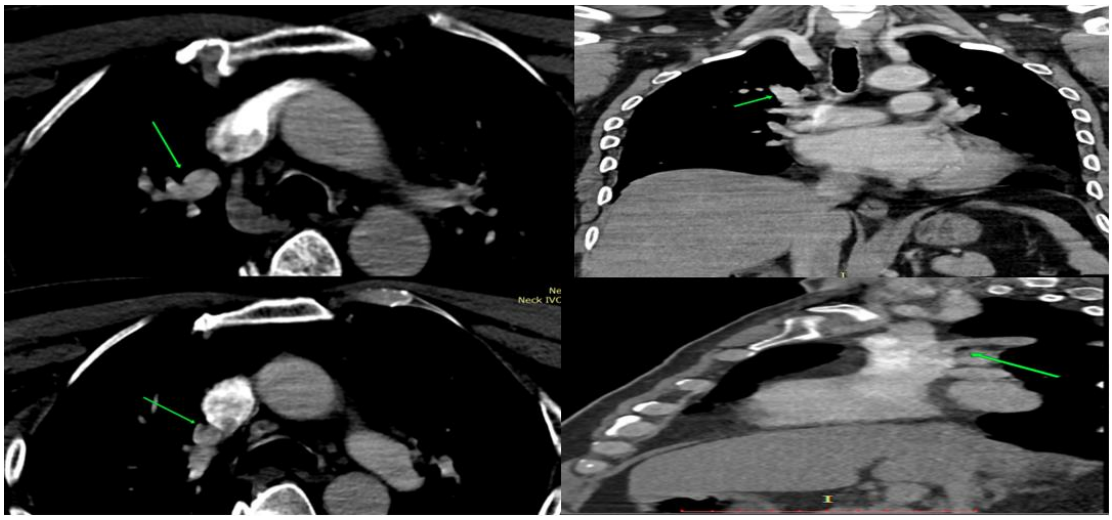

Fig. 4a-d. Proximal pulmonary veins on the right not draining into the left atrium, but PAPVR, type 1 - supra-cardiac, where the proximal pulmonary veins drain into the systemic circulation through the SVC

Discussion

The clinical cases presented in this study have shown the diverse presentations and diagnostic challenges associated with partial anomalous pulmonary venous return (PAPVR). Advanced imaging techniques, particularly computed tomography angiography (CTA), play a pivotal role in the accurate diagnosis and management of PAPVR[6]. These cases underscore the variability in anatomical presentations and emphasize the critical role of CTA in providing detailed anatomical information and guiding therapeutic decisions.

Several similar cases from the literature further illustrate the complexity and variability of PAPVR. Sarkar and Khasnis[8] reported on a case of a 56-year-old male with type 2 PAPVR, where CTA identified anomalous drainage into the superior vena cava. This case demonstrates the utility of CTA in detecting intricate vascular anomalies that may be missed by echocardiography alone. Additionally, Takata *et al.*[9] presented three cases of PAPVR with varied presentations, highlighting the diagnostic challenges and successful management strategies facilitated by advanced imaging modalities.

CTA offers superior spatial resolution and the ability to visualize extra-cardiac structures, providing comprehensive assessment of the thoracic vasculature. This is crucial for surgical planning and accurate localization of anomalous venous connections. The high-resolution three-dimensional images obtained with CTA allow precise anatomical mapping, which is essential for guiding therapeutic interventions[5]. However, CTA involves exposure to ionizing radiation and the use of contrast agents, which pose risks, particularly in vulnerable populations. Moreover, its higher cost and limited availability in certain settings may restrict its widespread use for routine screening.

Echocardiography remains a valuable tool in the initial evaluation of patients suspected of having PAPVR due to its real-time imaging capabilities, non-invasiveness, and absence of radiation exposure. It is particularly useful for assessing cardiac function and detecting hemodynamic changes associated with PAPVR. Nevertheless, echocardiography has limitations in visualizing extra-cardiac structures and may not reliably detect all types of PAPVR, especially when anomalous connections are complex or located outside the heart chambers. Operator dependency and variable acoustic windows further contribute to its diagnostic limitations[6].

Accurately characterizing PAPVR variants and assessing their hemodynamic significance remain significant challenges. The variability in anatomical presentations necessitates meticulous imaging protocols and advanced post-processing techniques. High-resolution CTA enables detailed visualization of small anomalous veins and precise delineation of complex vascular connections. However, the interpretation of CTA findings requires expertise in distinguishing PAPVR from other congenital anomalies and acquired conditions affecting pulmonary venous drainage[7].

From personal experience and comparative literature data, challenges in accurately characterizing PAPVR include the variability in anatomical presentations and the need for comprehensive evaluation to avoid diagnostic pitfalls. For instance, the assessment of hemodynamic impact using CTA and MRI has proven essential in planning surgical interventions in patients with significant left-to-right shunts[10].

Future research should focus on refining imaging protocols, including the development of low-dose CT protocols to minimize radiation exposure, and exploring novel imaging modalities such as perfusion MRI to assess the hemodynamic impact of PAPVR. Additionally, advancements in artificial intelligence and machine learning could potentially automate the detection and characterization of PAPVR, thereby enhancing diagnostic accuracy and reducing inter-operator variability[11].

Conclusion

Advancements in imaging modalities, particularly computed tomography angiography, have revolutionized the diagnostic approach to partial anomalous pulmonary venous return. Through high-resolution visualization of vascular anatomy, CTA enables accurate diagnosis and facilitates optimal therapeutic interventions in patients with PAPVR. As we continue to harness the power of advanced imaging techniques, the diagnostic landscape of PAPVR is poised for further enhancement, promising improved outcomes and enhanced patient care. Collaborative efforts among clinicians, radiologists, and researchers are essential in advancing the field of cardiovascular imaging and optimizing patient outcomes in PAPVR and other congenital heart diseases.

Conflict of interest statement. None declared.

References

1. Chaaban N, Shah H, Joshi A, Kshatriya S. Partial Anomalous Pulmonary Venous Return in Adults. *Cureus* 2022; 14(7): e26777. doi: 10.7759/cureus.26777.
2. El-Kersh K, Homsy E, Daniels CJ, Smith JS. Partial anomalous pulmonary venous return: a case series with management approach. *Respir Med Case Rep* 2019; 3(27): 100833. doi: 10.1016/j.rmcr.2019.100833.
3. Tan RB, Cuaso CC, Hiyao C, Reyes KG. A rare anatomic variant: partial anomalous pulmonary venous connection of the right pulmonary veins to an aneurysmal left vertical vein. *Ann Thorac Surg* 2014; 97(30): 1083. doi: 10.1016/j.athoracsur.2013.08.068.

4. Kivistö S, Hänninen H, Holmström M. Partial anomalous pulmonary venous return and atrial septal defect in adult patients detected with 128-slice multidetector computed tomography. *J Cardiothorac Surg* 2011; 30(6): 126. doi: 10.1186/1749-8090-6-126.
5. Kim C, Cho YH, Lee M, Yang JH, Jun TG, Song JY, *et al*. Surgery for partial anomalous pulmonary venous connections: modification of the warden procedure with a right atrial appendage flap. *Korean J Thorac Cardiovasc Surg* 2014; 47(2): 94-99. doi: 10.5090/kjtcs.2014.47.2.94.
6. Stout KK, Daniels CJ, Aboulhosn JA, Bozkurt B, Broberg CS, Colman JM, *et al*. 2018 AHA/ACC Guideline for the Management of Adults With Congenital Heart Disease: Executive Summary: A Report of the American College of Cardiology/ American Heart Association Task Force on Clinical Practice Guidelines. *J Am Coll Cardiol* 2019; 73(12): 1494-1563. doi: 10.1016/j.jacc.2018.08.1028.
7. Sears EH, Aliotta JM, Klinger JR. Partial anomalous pulmonary venous return presenting with adult-onset pulmonary hypertension. *Pulm Circ* 2012; 2(2): 250-255. doi: 10.4103/2045-8932.97637.
8. Sarkar S, Khasnis A. Case report of partial anomalous pulmonary venous return: role of computed tomography angiography in diagnosis. *J Radiol Case Rep* 2019; 13(1): 1-5.
9. Takata S, Shimamoto K, Noda R, *et al*. Three cases of partial anomalous pulmonary venous return: diagnostic challenges and management strategies. *Cardiovasc Diagn Ther* 2020; 10(6): 1872-1880.
10. Hoffman JI, Kaplan S. The incidence of congenital heart disease. *J Am Coll Cardiol* 2002; 39(12): 1890-1900. doi: 10.1016/s0735-1097(02)01886-7.
11. Brown DW, Dipchand AI, Rossano JW, *et al*. Cause of death in children with congenital heart disease. *Pediatr Cardiol* 2018; 39(6): 1134-1140.