

Journal of Molecular Science

www.jmolecularsci.com

ISSN:1000-9035

Comparison of Echocardiography and Computed Tomography Angiography in Detecting Pulmonary Venous Anomalies and TAPVC Types in Pediatric Patients**Jesmin Ara Parven^{1*}, Nusrat Ghafoor², Khalada Parvin Deepa³, Saikat Barua⁴, Abdullah Al Shoyeb⁵, Ibrahim Khalilullah⁶, Shahnoor Aziz⁷**¹Assistant Professor & Associate Consultant, Department of Radiology & Imaging, Ibrahim Cardiac Hospital & Research Institute, Dhaka, Bangladesh.²Professor, Department of Radiology and Imaging, Ibrahim Cardiac Hospital and Research Institute, Dhaka, Bangladesh.³Assistant Professor and Associate Consultant, Department of Radiology and Imaging, Ibrahim Cardiac Hospital and Research Institute, Dhaka, Bangladesh.⁴Associate Professor, Department of Radiology and Imaging, Bangladesh Medical College, Dhaka, Bangladesh.⁵Assistant Professor and Associate consultant, Department of cardiacsurgery, Ibrahim Cardiac Hospital & Research Institute, Dhaka, Bangladesh.⁶Associate Professor, Department of Anaesthesiology, Ibrahim Cardiac Hospital & Research Institute, Dhaka, Bangladesh.⁷Assistant Professor & Associate Consultant, Department of Cardiac Surgery, Ibrahim Cardiac Hospital & Research Institute, Dhaka, Bangladesh.**Article Information****Received: 08-12-2025****Revised: 28-01-2026****Accepted: 12-03-2026****Published: 15-04-2026****Keywords***Echocardiography, Computed Tomography Angiography, Pulmonary Venous Anomalies, TAPVC, Pediatric Patients.***ABSTRACT**

Background: TAPVC is a rare congenital heart defect where pulmonary veins drain into systemic circulation instead of the left atrium, often associated with ASD or PDA. It can cause cyanosis, pulmonary hypertension, and rapid deterioration. So, early and accurate diagnosis is essential. CTA provides a detailed anatomical assessment and is more accurate than echocardiography, especially in complex cases, though data from Bangladesh are limited.

Methods: This cross-sectional study at Ibrahim Cardiac Hospital enrolled 25 pediatric patients (≤ 18 years) to compare echocardiography and CTA in detecting pulmonary venous anomalies and classifying TAPVC subtypes. All patients underwent transthoracic echocardiography and multi-slice CTA, and data were analyzed descriptively for detection rates, TAPVC subtypes, and associated septal defects. Ethical approval and parental consent were obtained.

Results: Echocardiography detected 20 pulmonary venous anomalies, while CTA identified all 25 cases, demonstrating superior sensitivity. CTA also provided more precise characterization of TAPVC subtypes, detecting mixed and infracardiac forms that were underestimated by echocardiography. Associated septal defects were common, with secundum ASD being the most frequent. Echocardiography was reliable for cardiac TAPVC and septal defect detection.

Conclusion: CTA outperforms echocardiography in detecting pulmonary venous anomalies and accurately classifying TAPVC subtypes, particularly mixed and infracardiac forms. Echocardiography remains valuable for PAPVC, cardiac TAPVC, and associated septal defects. Combined use of both modalities enables comprehensive evaluation, facilitating accurate diagnosis and optimal surgical planning in pediatric patients.

©2026 The authors

This is an Open Access article distributed under the terms of the Creative Commons Attribution (CC BY NC), which permits unrestricted use, distribution, and reproduction in any medium, as long as the original authors and source are cited. No permission is required from the authors or the publishers. (<https://creativecommons.org/licenses/by-nc/4.0/>)

INTRODUCTION:

Total anomalous pulmonary venous connection (TAPVC) is a congenital heart defect in infants and neonates that can resemble various cardiac and non-cardiac conditions and requires urgent surgical correction [1]. In TAPVC, oxygenated blood from the lungs drains into the systemic veins instead of the left atrium. It can be cardiac, supracardiac, infracardiac, or mixed, depending on the site of abnormal connection [2]. It can cause neonatal cyanosis and rapid death if blood cannot pass from the right to left heart. Isolated TAPVC occurs with atrial septal defect (ASD), patent ductus arteriosus (PDA), or both, while complex TAPVC involves additional heart defects. Precise assessment of TAPVC and associated anomalies is essential for surgical planning [3].

Congenital pulmonary venous anomalies can occur alone or with other heart defects, ranging from mild partial anomalies to life-threatening obstructed TAPVC. Precise identification of these anomalies and associated defects is essential for proper management [4]. TAPVC accounts for 1–3% of major congenital heart diseases, while partial anomalous pulmonary venous connection (PAPVC) occurs in about 0.5% of cases [5].

According to global studies, in a cohort of 18 children with obstructed TAPVC, CT angiography (CTA) accurately identified all pulmonary venous drainage sites, perfectly matching surgical findings, while echocardiography (Echo) correctly identified drainage sites in only 61% of cases. CTA was significantly superior to Echo in detailing venous anatomy and detecting obstructions [6]. In a study of 40 surgically confirmed TAPVC patients, CT angiography (CTA) was more accurate than transthoracic echocardiography (TTE) in identifying TAPVC subtypes (95% vs. 70%), while both methods were similarly effective in detecting associated malformations [7]. In another study of 84 patients with anomalous pulmonary venous connections, echocardiography showed high

accuracy, correctly diagnosing most cases and achieving 94% accuracy specifically for TAPVC classification [5]. A study from Pakistan found that echocardiography was highly sensitive for isolated TAPVC (81%) but much less reliable for mixed or heterotaxy cases (20–27%), highlighting the need for additional imaging like CTA in complex anomalies [8].

A study at Dhaka Shishu Hospital on 34 children with TAPVR found most presented in early infancy with tachypnea, cyanosis, and pulmonary hypertension. Supracardiac TAPVR was most common, and ASD/PFO were frequent associated defects. Early diagnosis and surgical referral were crucial, with 8.8% mortality before surgery [9]. In the Bangladeshi case report of a 1-year-3-month-old boy with total anomalous pulmonary venous connection (TAPVC) presented with repeated cough, tachypnea, fever, failure to thrive, and sweating during feeding with mild cyanosis, but no signs of heart failure. He underwent successful surgical repair, which involved connecting the pulmonary venous confluence to the left atrium, ligating the vertical vein, and closing an atrial septal defect (ASD). On follow-up, the child was doing well without symptoms [10].

Research on TAPVC in Bangladesh is limited, with scarce data on diagnosis, outcomes, associated defects, and imaging comparisons, underscoring the need for larger prospective studies. The aim of this study was to compare the diagnostic accuracy of echocardiography and computed tomography angiography (CTA) in detecting pulmonary venous anomalies and classifying types of total anomalous pulmonary venous connection (TAPVC) in pediatric patients.

METHODOLOGY:**Study Design and Settings:**

This was a hospital-based, observational cross-sectional study conducted to compare the diagnostic accuracy of echocardiography (Echo) and computed tomography angiography (CTA) in detecting pulmonary venous anomalies and characterizing types of total anomalous pulmonary venous connection (TAPVC) in pediatric patients. The study was conducted at Ibrahim Cardiac Hospital, a tertiary-level cardiac care center providing specialized pediatric cardiology services over a period of 12 months, from July 2024 to June 2025.

Study Population:

The study included pediatric patients (age ≤ 18 years) who were suspected to have pulmonary venous anomalies based on clinical evaluation, presenting symptoms, or prior imaging studies. Patients with contraindications to CTA, including

severe contrast allergy or impaired renal function, were excluded. A total of 25 pediatric patients were enrolled consecutively during the study period, based on availability and eligibility criteria.

Data Collection:

Each patient underwent:

Echocardiography (Echo): Performed by a pediatric cardiologist using standard transthoracic techniques. The examination assessed pulmonary venous connections, types of TAPVC, and associated cardiac anomalies, including septal defects.

Computed Tomography Angiography (CTA):

Conducted using a multi-slice CT scanner with intravenous contrast. CTA was performed to provide detailed anatomical visualization of pulmonary veins, confirm the presence and type of TAPVC, and detect associated anomalies.

Variables:

The primary outcomes measured were:

- Presence and type of pulmonary venous anomaly (PAPVC, TAPVC, pulmonary vein stenosis)
- Subtypes of TAPVC (supracardiac, infracardiac, cardiac, mixed)
- Associated septal defects (sinus venosus ASD, secundum ASD, VSD)

Data Analysis:

Data were entered into Microsoft Excel and analyzed using SPSS version 25. Descriptive statistics, including frequencies and percentages, were used to summarize categorical variables. Comparative analysis between echocardiography and CTA findings was performed to assess the detection rates and concordance of both imaging modalities.

Ethical Considerations:

The study protocol was approved by the Institutional Review Board of Ibrahim Cardiac Hospital. Informed consent was obtained from the parents or legal guardians of all pediatric participants before enrollment. All patient information was kept confidential, and imaging procedures were performed following standard clinical safety protocols.

RESULTS:

A total of 25 pediatric patients with suspected pulmonary venous anomalies were evaluated using both echocardiography (Echo) and computed tomography angiography (CTA). The distribution of pulmonary venous anomalies detected by each modality is summarized in **Table 1**.

Echocardiography identified 20 cases of pulmonary venous anomalies, including 10 cases of partial anomalous pulmonary venous connection (PAPVC), 9 cases of total anomalous pulmonary venous connection (TAPVC), and 1 case of pulmonary vein stenosis. In comparison, CTA detected a total of 25 anomalies, including 8 cases of PAPVC and 17 cases of TAPVC, while no cases of pulmonary vein stenosis were observed. Echocardiography misdiagnosed 2 cases of TAPVC as PAPVC. Overall, CTA identified more cases of TAPVC than echocardiography, suggesting higher sensitivity for detecting total anomalous pulmonary venous connections.

Table 1. Number of cases with pulmonary venous anomalies according to Echocardiography and CTA

Pulmonary Venous Anomaly	Echocardiography (n)	CTA (n)
PAPVC	10(50%)	8(32%)
TAPVC	9(45%)	17(68%)
Pulmonary vein stenosis	1(5%)	0(0%)
Total	20	25

The types of TAPVC detected by each modality are presented in **Table 2**. Echocardiography identified 5 cases of supracardiac TAPVC, 3 cases of mixed type, 1 case of cardiac type, and no cases of infracardiac TAPVC. CTA, however, detected 8 cases of supracardiac TAPVC, 6 mixed, 1 cardiac, and 2 infracardiac TAPVC cases. This indicates that CTA provided more detailed delineation of TAPVC subtypes, particularly for mixed and infracardiac forms, which were underestimated by echocardiography.

Table 2. Types of TAPVC detected by Echocardiography and CTA

TAPVC Type	Echocardiography (n)	CTA (n)
Supracardiac	5(55.6%)	8(47.1%)
Mixed	3(33.3%)	6(35.3%)
Cardiac	1(11.1%)	1(5.9%)
Infracardiac	0	2(11.8%)

Associated septal defects detected by both echocardiography and CTA are shown in **Table 3**. Among the study population, sinus venosus atrial septal defects (ASD) were identified in 8 patients, secundum ASDs in 12 patients, and ventricular septal defects (VSD) in 2 patients. This suggests a high prevalence of associated atrial septal defects in patients with pulmonary venous anomalies.

Table 3. Associated septal defects detected by both Echocardiography and CTA

Septal Defect	Number of cases (n)
Sinus venosus ASD	8(36.4%)
Secundum ASD	12(54.5%)
VSD	2(9.1%)

Table 4 summarizes the distribution of pulmonary venous anomalies based on CTA findings. Of the 25

cases, 8 had PAPVC, 8 had supracardiac TAPVC, 6 had mixed TAPVC, 2 had infracardiac TAPVC, and 1 had cardiac TAPVC. No cases of pulmonary vein stenosis were detected by CTA. These findings highlight the predominance of TAPVC, particularly the supracardiac and mixed types, in this pediatric cohort.

Table 4. Number of patients according to type of pulmonary venous anomaly on CTA

Type of Venous Anomaly	Number of cases (n)
PAPVC	8(32%)
TAPVC (Supracardiac)	8(32%)
TAPVC (Mixed)	6(24%)
TAPVC (Infracardiac)	2(8%)
TAPVC (Cardiac)	1(4%)
Pulmonary vein stenosis	0(0%)

In summary, CTA demonstrated superior detection of TAPVC cases and provided more precise characterization of TAPVC subtypes compared to echocardiography. Echocardiography remained effective in identifying cardiac TAPVC but underestimated infracardiac and mixed forms. Both modalities were useful in detecting associated septal defects, with secundum ASD being the most common.

DISCUSSION:

The present study compared echocardiography and computed tomography angiography (CTA) in detecting pulmonary venous anomalies and in characterizing the types of total anomalous pulmonary venous connection (TAPVC) in pediatric patients. Our findings demonstrate that CTA detected a higher number of pulmonary venous anomalies overall and was superior in identifying TAPVC, particularly mixed and infracardiac types, whereas echocardiography remained useful for initial screening and cardiac type TAPVC and associated septal defects.

In this study, echocardiography identified pulmonary venous anomalies in 20 out of 25 patients, while CTA detected anomalies in all 25 cases. Notably, CTA detected almost double the number of TAPVC cases compared to echocardiography (17 vs. 9). This observation is consistent with the findings of Ali et al., who reported that although echocardiography has good diagnostic accuracy for TAPVC, certain subtypes—especially infracardiac and mixed forms—can be missed due to limited acoustic windows and complex venous pathways [8]. Similar underdiagnosis by echocardiography has also been highlighted by Zhang et al., who noted that supracardiac TAPVC is more readily identified on echocardiography than infracardiac or mixed variants [11].

The predominance of TAPVC over PAPVC in our

cohort aligns with regional clinical experiences reported by Munsif et al. in Bangladesh, where TAPVC constituted a significant proportion of complex congenital heart diseases presenting to tertiary pediatric cardiac centers [9]. The higher detection rate of TAPVC on CTA in our study further supports the role of advanced cross-sectional imaging in comprehensive anatomical evaluation, as also emphasized by Osama, who demonstrated the superiority of multislice CT angiography in delineating pulmonary venous anatomy and drainage patterns [12].

Regarding TAPVC subtypes, CTA detected supracardiac TAPVC as the most common type (32%), followed by mixed (24%), infracardiac (8%), and cardiac (4%) forms. Echocardiography failed to identify infracardiac TAPVC altogether and underestimated mixed TAPVC. These findings are in close agreement with the comparative study by Sangi et al., which showed that CTA was significantly more accurate than echocardiography in defining mixed and infracardiac TAPVC due to its ability to provide three-dimensional visualization of venous pathways and extracardiac anatomy [13]. Rahman et al. and other case-based reports from the region have also stressed that infracardiac TAPVC is particularly challenging to diagnose on echocardiography alone [10].

This may be attributed to the ease of visualizing anomalous pulmonary venous drainage into the right atrium or superior vena cava in cases of PAPVC, especially when associated with sinus venosus atrial septal defect (ASD). Wojtal et al. [14] and Surkova et al. [15] have similarly reported that echocardiography, when combined with careful assessment of interatrial septal morphology, is effective for detecting PAPVC associated with sinus venosus ASD, although CT or MRI is often required for confirmation [14,15].

Associated septal defects were common in our study population, with secundum ASD being the most frequent, followed by sinus venosus ASD. This high prevalence of ASDs is consistent with established literature, as highlighted by Surkova et al., who described the close embryological and anatomical association between pulmonary venous anomalies and atrial septal defects [15]. Both echocardiography and CTA were effective in identifying septal defects in our study, supporting their complementary roles in comprehensive congenital heart disease evaluation.

The absence of pulmonary vein stenosis on CTA in our cohort contrasts with the findings of Salman et al., who reported that cardiac CT angiography is

particularly valuable in evaluating pediatric pulmonary vein stenosis [16]. This discrepancy may be due to differences in study populations, as our cohort primarily consisted of patients with suspected anomalous pulmonary venous connections rather than post-surgical or acquired pulmonary vein pathology.

Overall, our findings are in line with previous comparative studies, including those by Öztürk et al. and Kumar et al., which emphasized that while echocardiography remains the first-line, non-invasive, and widely available diagnostic tool in pediatric congenital heart disease, CTA provides superior anatomical detail and higher diagnostic confidence for complex vascular anomalies [17,18]. The combined use of echocardiography and CTA therefore offers a more accurate and comprehensive diagnostic approach, facilitating optimal surgical planning and improving clinical outcomes in pediatric patients with pulmonary venous anomalies.

CONCLUSION:

This study demonstrates that computed tomography angiography (CTA) is more accurate than echocardiography in detecting pulmonary venous anomalies and in precisely classifying TAPVC subtypes, particularly mixed and infracardiac forms that are often underestimated by echocardiography. CTA provides detailed anatomical visualization crucial for surgical planning. Utilizing both imaging modalities together ensures comprehensive evaluation, facilitating accurate diagnosis, better preoperative assessment, operative planning and improved management of pediatric patients with pulmonary venous anomalies.

REFERENCES:

- Lee ML, Wu MH, Wang JK, Lue HC. Echocardiographic assessment of total anomalous pulmonary venous connections in pediatric patients. *Journal of the Formosan Medical Association*. 2001 Nov 1;100(11):729-35.
- Sangi R, Ahsan AK, Akhtar P, Shaikh AS, Mumtaz S, Alisher N, Kamran A, Sandano MN. Evaluating Types of TAPVR on Echocardiography and CT Angiography in Paediatric Patients Admitted in Tertiary Care Hospital: A Comparative Study. *Pakistan Journal of Medical & Health Sciences*. 2023 Jun 1;17(04):387.
- Türkvan A, Tola HT, Ayyıldız P, Öztürk E, Ergül Y, Güzeltaş A. Total anomalous pulmonary venous connection in children: preoperative evaluation with low-dose multidetector computed tomographic angiography. *Texas Heart Institute Journal*. 2017 Apr 1;44(2):120-6.
- Türkvan A, Güzeltaş A, Tola HT, Ergül Y. Multidetector computed tomographic angiography imaging of congenital pulmonary venous anomalies: a pictorial review. *Canadian Association of Radiologists Journal*. 2017 Feb;68(1):66-76.
- Zhang Z, Zhang L, Xie F, Wang B, Sun Z, Kong S, Wang X, Dong N, Wang G, Lv Q, Li Y. Echocardiographic diagnosis of anomalous pulmonary venous connections: Experience of 84 cases from 1 medical center. *Medicine*. 2016 Nov 1;95(44):e5389.
- Shen Q, Pa M, Hu X, Wang J. Role of plain radiography and CT angiography in the evaluation of obstructed total anomalous pulmonary venous connection. *Pediatric radiology*. 2013 Jul;43(7):827-35.
- Juan XI, Mei WU, Jingjing WA, Shurui XI, Jie WA, Yanling XU, Xiaojing MA. Comparison of the diagnostic value of transthoracic echocardiography and CTA in total anomalous pulmonary venous connection. *J Clin Cardiol*. 2023 Dec 13;39(12):930-4.
- Ali F, Qureshi S, Amanullah M, Atiq M. Accuracy of echocardiography in diagnosing total anomalous pulmonary venous return. *Pakistan Journal of Medical Sciences*. 2018 Sep;34(5):1094.
- Munsi AS, Hussain M, Rima R, Biswas R, Sayeed A. Clinical profile of patients with total anomalous pulmonary venous return and their short term outcome in pediatric cardiac centre at Dhaka Shishu Hospital. *Bangladesh Journal of Medical Science*. 2015 Jun 20;14(3):270-3.
- Rahman MM, Islam SM, Islam MS, Siraj N, Khanum S, Saklayen G, Uddin J. Total anomalous pulmonary venous connection (TAPVC)-a case report. *Ibrahim Cardiac Medical Journal*. 2011;1(1):59-61.
- Zhang Z, Zhang L, Xie F, Wang B, Sun Z, Kong S, Wang X, Dong N, Wang G, Lv Q, Li Y. Echocardiographic diagnosis of anomalous pulmonary venous connections: Experience of 84 cases from 1 medical center. *Medicine*. 2016 Nov 1;95(44):e5389.
- Osama A. Role of multi-slice CT angiography in the evaluation of pulmonary venous anomalies. *The Egyptian Journal of Radiology and Nuclear Medicine*. 2013 Jun 1;44(2):193-201.
- Sangi R, Ahsan AK, Akhtar P, Shaikh AS, Mumtaz S, Alisher N, Kamran A, Sandano MN. Evaluating Types of TAPVR on Echocardiography and CT Angiography in Paediatric Patients Admitted in Tertiary Care Hospital: A Comparative Study. *Pakistan Journal of Medical & Health Sciences*. 2023 Jun 1;17(04):387.
- Wojtal R, Spirig A, Ohletz T, Haegeli L, Fuchs T. Sinus venosus atrial septal defect with partial anomalous pulmonary vein return, diagnostic approach of this rare entity. *Cardiovascular Medicine*. 2022 Jul 1;25(04).
- Surkova E, Babu-Narayan SV, Semple T, Ho SY, Li W. International Journal of Cardiology Congenital Heart Disease the ACHD multi-modality imaging series: imaging of atrial septal defects in adulthood. *International Journal of Cardiology Congenital Heart Disease*. 2021 Aug 1; 4:100188.
- Salman R, More SR, Botelho MF, Ketwaroo PM, Masand PM, Jadhav SP. Evaluation of paediatric pulmonary vein stenosis by cardiac CT angiography: a comparative study with transthoracic echocardiography and catheter angiogram. *Clinical Radiology*. 2023 Oct 1;78(10):e718-23.
- Öztürk E, Tamdır İC, Kamalı H, Ayyıldız P, Topel C, Onan İS, Türkvan A, Haydin S, Güzeltaş A. Comparison of echocardiography and 320-row multidetector computed tomography for the diagnosis of congenital heart disease in children. *Revista Portuguesa de Cardiologia (English Edition)*. 2021 Aug 1;40(8):583-90.
- Kumar, A., Sahu, A.K., Goel, P.K., Jain, N., Garg, N., Khanna, R., Kumar, S., Tewari, S. and Kapoor, A., 2023. Comparison of non-invasive assessment for pulmonary vascular indices by two-dimensional echocardiography and cardiac computed tomography angiography with conventional catheter angiography in unrepaired Tetralogy of Fallot physiology patients weighing more than 10 kg: a retrospective analysis. *European Heart Journal-Cardiovascular Imaging*, 24(3), pp.383-391.