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CASE REPORT

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Diagnostic Value of Computed Tomography Angiography for Infective Endocarditis After Right Ventricle Outflow Tract Repair

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ABSTRACT

Congenital heart disease patients with pulmonary valve replacement or right ventricle-pulmonary artery conduit have increased risk of pulmonary valve endocarditis. We present a 6-patient case series illustrating the diagnostic utility of computed tomography angiography to provide definitive visualization of pulmonary valve vegetation to aid in the diagnosis of endocarditis. (**Level of Difficulty: Intermediate.**) (J Am Coll Cardiol Case Rep 2023;23:102011)

BACKGROUND

Congenital heart disease (CHD) patients with right ventricle (RV)-to-pulmonary artery (PA) conduit placement or pulmonary valve replacement (PVR) have high incidence of infective endocarditis (IE).[1,2]

LEARNING OBJECTIVES

- To recognize and rapidly diagnose pulmonary valve infective endocarditis to decrease associated morbidity and mortality.
- To identify when computed tomographic angiography can be used to definitively image the pulmonary valve or conduit for diagnosis of pulmonary valve infective endocarditis.

Transesophageal echocardiography (TEE) is the primary imaging modality to image cardiac valves for vegetation, which is a major IE diagnostic criterion.[2,3] Clear echocardiographic imaging of the pulmonary conduit and pulmonary valve (PV) is challenging because of imaging artifacts, suboptimal resolution on transthoracic echocardiography (TTE), and potentially suboptimal TEE images secondary to the anterior position of the RV outflow tract (RVOT) within the chest.[4-6] Echocardiographic imaging challenges can lead to delays in PV IE diagnosis and treatment.

We present a case series of 6 CHD patients with transcatheter PV or surgical pulmonary conduit where computed tomographic angiography (CTA) aided in PV IE diagnosis and the identification of pulmonary sequelae.

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ABBREVIATIONS AND ACRONYMS

CHD = congenital heart disease

CTA = computed tomographic angiography

IE = infective endocarditis

PA = pulmonary artery

PV = pulmonary valve

PVR = pulmonary valve replacement

RV = right ventricle

RVOT = right ventricular outflow tract

TEE = transesophageal echocardiography

TTE = transthoracic echocardiography

METHODS

We conducted a retrospective chart review of 4 adult and 2 pediatric CHD patients with PV IE between June 2015 and December 2020 at Children's Minnesota and Abbott Northwestern Hospital, Minneapolis, Minnesota, USA. Clinical history, laboratory reports, and echocardiogram and CTA reports were collected.

Functional CTA examinations were performed using a retrospectively triggered spiral scan with electrocardiogram gating, pulse modulation, and a narrow acquisition window. Dual-phase contrast injection was used for biventricular opacification. The scan range was adjusted cranially to include the cardiac silhouette and the main and branch PAs. An anatomic dataset including the lung fields was obtained using a prospectively electrocardiogram-triggered high-pitch helical scan. Images were obtained on a second- or third-generation Dual Source Scanner (Siemens SOMATOM Definition Force/Flash scanners; gantry rotation time: 250-280 ms; temporal resolution: 66-75 ms; collimation: 2 × 128 mm to 192 × 0.6 mm). Images were reconstructed using iterative reconstruction, and datasets were reviewed on a dedicated workstation (Vitrea). Institutional Review Board approval was received before study initiation.

RESULTS

Six consecutive CHD patients 16 to 40 years old had suspicion for IE (Table 1). Surgical RV-to-PA homografts were present in all patients, and 2 patients also had 18-mm Melody transcatheter PVR (Medtronic) within the surgical conduit. Three adults were initially treated for pneumonia at a non-CHD center (Table 1). One adult and both pediatric patients were directly admitted to a CHD hospital and treated empirically for PV IE. All patients had positive blood

TABLE 1 Clinical Characteristics of Congenital Heart Disease Patients With Pulmonary Valve Endocarditis

Patient	CHD Diagnosis	RVOT Intervention	Age, y	Clinical Presentation	Organism	Follow-Up
1	Tetralogy of Fallot with pulmonary atresia	RV-PA conduit (unknown size)	24	Sepsis (intravenous drug user)	*Pseudomonas aeruginosa*	Died 10 months after initial presentation of recurrent pulmonary valve IE in the setting of intravenous drug use.
2	Congenital aortic stenosis, Ross procedure, and RV-PA conduit, followed by mechanical aortic valve	27-mm Cryolife pulmonary homograft	28	Pneumonia with multiple ED visits. Admitted to hospital after ED blood culture findings were positive.	*Streptococcus*	Percutaneous PVR 9 months after IE for severe pulmonary insufficiency. No further IE at 1.5-y follow-up.
3	Tetralogy of Fallot	23-mm pulmonary homograft	40	2 inpatient admissions for pneumonia with empyema before third admission	Negative—drawn after several weeks of antibiotics	At 5 months after IE, had surgical PVR for severe pulmonary insufficiency. No further endocarditis at 3.5-y follow-up.
4	Tetralogy of Fallot	RV-PA conduit with an 18-mm Melody valve with prevalve stenting	34	Admitted twice for fever and rigors before third admission for positive blood culture findings	*Lactobacillus bacteremia*	At 1.5 months postdiagnosis, surgical 23-mm pulmonary homograft. No further IE at 6-y follow-up.
5	Tetralogy of Fallot	18-mm Melody valve with prevalve stenting in an 18-mm Contegra graft	16	Fever and difficulty breathing	*Streptococcus*	At 3 months postdiagnosis, RV-PA conduit replacement with 25-mm Cryolife pulmonary homograft. No further IE at 1.5-y follow-up.
6	L-TGA, VSD, pulmonary atresia, Senning-Rastelli procedure, and RV-PA conduit	20-mm Contegra homograft	16	Shock, upper respiratory symptoms, vomiting, and diarrhea	Methicillin-sensitive *Staphylococcus aureus*	At 15.5 months postdiagnosis, ventricular fibrillation cardiac arrest with cooling; subcutaneous implantable cardioverter-defibrillator placed.

CHD = congenital heart disease; ED = emergency department; IE = infective endocarditis; L-TGA = levo-transposition of the great arteries; PVR = pulmonary valve replacement; RV-PA = right ventricular to pulmonary artery; RVOT = right ventricular outflow tract; VSD = ventricular septal defect.

TABLE 2 Echocardiographic and CTA Findings in Congenital Heart Disease Patients With Pulmonary Valve Endocarditis

Patient	Echocardiography Findings[a]	Cardiac CTA Findings
1	TTE: 2.1 × 0.8-cm mobile vegetation moving between the RVOT and pulmonary artery, moderate pulmonary insufficiency, and ↑RV-PA peak gradient (23 mm Hg)	• Large vegetation with multiple small vegetations attached to the pulmonary valve leaflet • Pulmonary septic emboli
2	TTE: ↑RV-PA peak gradient (36 mm Hg, from 23 mm Hg 6 months prior)	• Vegetation attached to the pulmonary valve leaflet • No pulmonary septic emboli to the lungs
3	TTE: worsening of pulmonary insufficiency (severe from moderate), ↑RV-PA peak gradient (45 mm Hg, from 25 mm Hg 8 months prior), pulmonary valve leaflets prolapsed into RVOT	• Pulmonary valve leaflets thickened, dysplastic, and prolapsed into the RVOT • Multiple bilateral pulmonary emboli
4	TTE: ↑RV-PA peak gradient (62 mm Hg)	• Low attenuation material (1.4 × 0.5 cm) within the Melody valve • Small pulmonary emboli of left lung
5	TTE: ↑RV-PA peak gradient (82 mm Hg, from 10 mm Hg 3 y prior)	• Low attenuation material within the Melody valve • Small pulmonary emboli
6	TTE: RVOT not well visualized TEE: no vegetations, ↑RV-PA peak gradient	• Bilateral multifocal pulmonary infarctions • Moderate-sized bilateral pleural effusions • Valvular thickening and mobile vegetations on the Contegra valve leaflets and thickening of the wall of the graft

[a]The ↑ symbol indicates "increased."

CTA = computed tomographic angiography; TEE = transesophageal echocardiogram; TTE = transthoracic echocardiogram; other abbreviations as in Table 1.

culture results except for 1 patient, who had a month of antibiotics before IE diagnosis. All patients received 6 weeks of intravenous antibiotics.

All patients underwent TTE (Table 2). Valvar vegetation was noted on TTE in 1 patient. Five patients had significant changes in PV function with increasing stenosis or regurgitation. One patient underwent TEE that did not aid in diagnosis because of significant imaging artifacts.

Cardiac CTA was ordered in all patients to evaluate the RV-to-PA conduit, PV, PA, and lung parenchyma (Table 2). The 2 Melody valve patients had severe thickening of the valve leaflets and nodular, mobile, low attenuated material within the Melody valve stent complex (Figures 1D and 1E). Two patients with RV-to-PA conduits had thickened PV leaflets with vegetations noted (Figures 1A and 1B, Videos 1 and 2). The other 2 RV-to-PA conduits had thickened leaflets, with 1 patient having the PV leaflets prolapse into the RVOT (Figure 1C). One patient had thickening of the RV-to-PA graft concerning for abscess along the graft wall anteriorly (Figure 1F). Three patients had evidence of septic pulmonary emboli (Figures 2B and 2C), one with pulmonary infarct in the region of the emboli. Three patients had evidence of septic pulmonary nodules in their lung parenchyma (Figures 2A, 2B, and 2D).

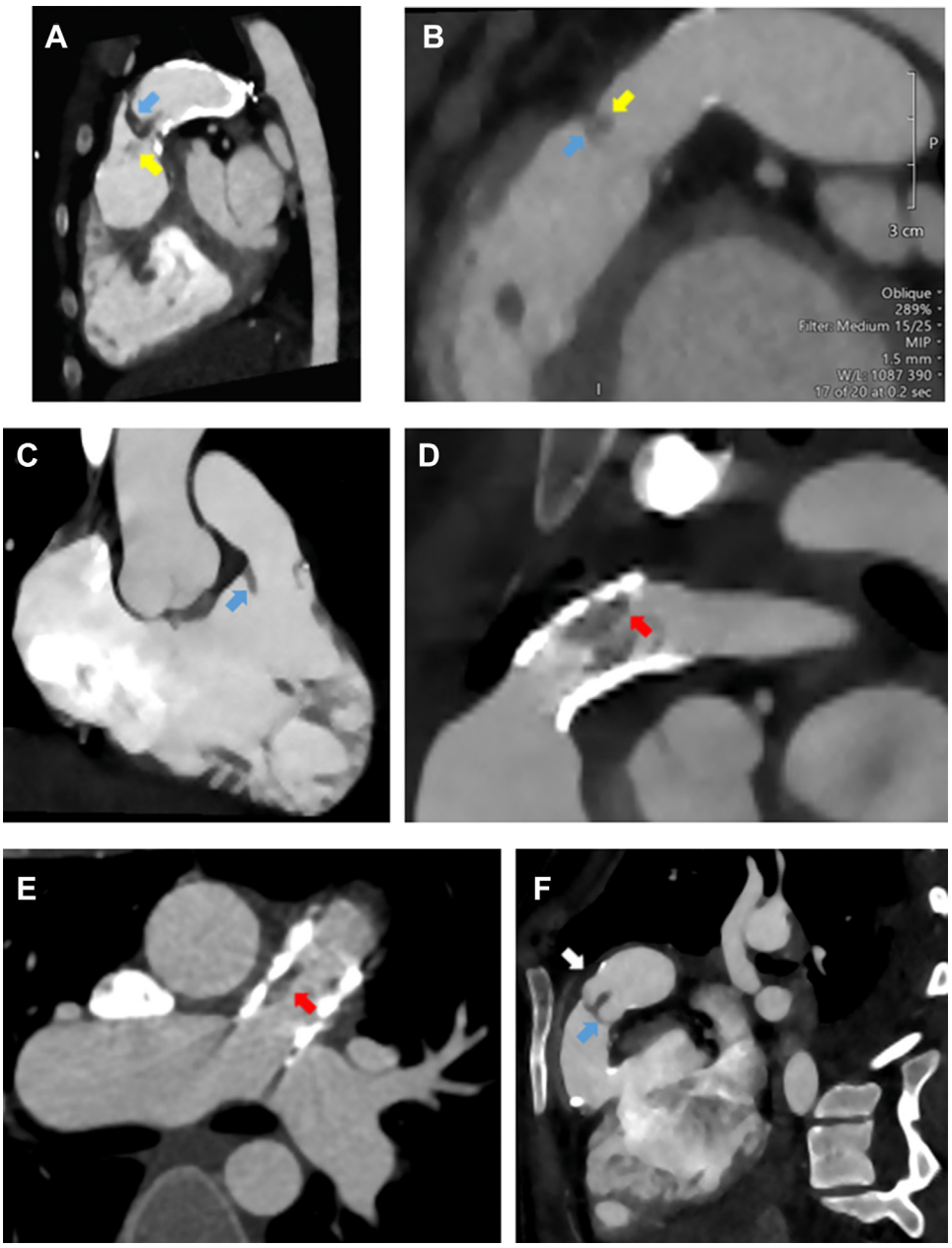
Three patients underwent surgical PV replacement. Surgical findings correlated with imaging for these patients. Three patients were treated medically. Patient 2 had a percutaneous pulmonary valve-in-valve procedure 9 months after IE diagnosis; the patient remained endocarditis free at the 1.5-year follow-up.

DISCUSSION

TTE and TEE are recommended as the initial imaging modalities for IE diagnosis.[2,3] For patients with CHD, TTE acoustic windows are often compromised by scar from prior sternotomy, artifact from prosthetic material, and body habitus. TEE may not provide definitive imaging of the PV because of artifacts from prosthetic material and the anterior position within the chest. Intracardiac ultrasound has been proposed to overcome these limitations; however, CTA can provide similar information noninvasively and evaluate for pulmonary complications.[6] The updated 2023 Duke Criteria for diagnosing endocarditis now recognizes similar echocardiographic findings visualized on CTA as a major criterion for IE.[3]

CTA has aided in IE diagnosis for other valves and can help determine the etiology of PV dysfunction in this clinical scenario.[2-5] We believe functional CTA is preferable to routine computed tomography for this indication. Abnormal valve motion or mobile vegetations can be visualized, given the ability to manipulate the viewing angle on 3-dimensional CTA reconstruction. CTA also has improved image resolution compared to 3-dimensional echocardiography. CTA can have better sensitivity for diagnosing

FIGURE 1 Cardiac CTA Findings for Pulmonary Valve Infective Endocarditis

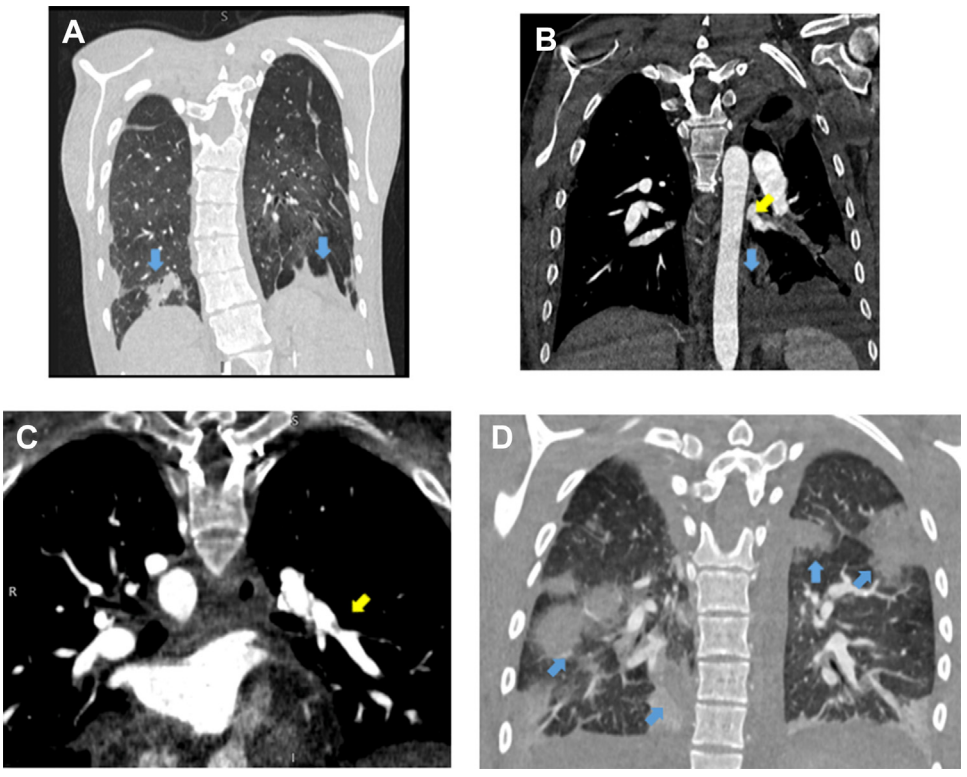


(A to F) Patients 1 through 6, respectively. **(A, B, C, F)** Pulmonary valve leaflets were thickened **(blue arrows)**, and **(A, B)** vegetation was noted in 2 patients **(yellow arrows)**. **(C)** Patient 3: during diastole, the pulmonary valve leaflets prolapse into the RVOT. **(D, E)** Patients 4 and 5 had significant amounts of low attenuation material **(red arrow)** within the Melody valve. **(F)** Patient 6 had thickening of the wall of the Contegra (Medtronic) graft consistent with abscess formation **(white arrow)**.

paravalvular lesions and abscess and, when used in conjunction with TEE, may have superior sensitivity for diagnosing IE than TEE alone.[3]

Our case series highlights 6 patients with PV IE where diagnosis was aided by cardiac CTA. Three patients had significant metallic artifacts from a mechanical aortic valve, RVOT stenting, and a Melody valve, presenting an echocardiographic challenge. With proper CTA protocoling and postprocessing, a diagnostic study for PV endocarditis was obtained.

FIGURE 2 **Pulmonary Complications Secondary to Pulmonary Valve Infective Endocarditis**



(A to D) Patients 1, 3, 4, and 6, respectively. Septic pulmonary nodules **(blue arrows)** in the lung parenchyma were visualized in **(A)** patient 1, **(B)** patient 3, and **(D)** patient 6. Septic pulmonary emboli **(yellow arrows)** were seen in **(B)** patient 3 and **(C)** patient 4. Patient 5 had subtle pulmonary emboli not well visualized on still frames. Patient 2 did not have significant pulmonary findings.

Our series has a high percentage of patients with pulmonary complications (5 of 6 patients), which may be from diagnosis delays and increased pulmonary imaging.

Our study has several limitations. TEE was obtained in only 1 patient because our local practice is to use CTA in this setting. The case series is small, and in patients with high levels of metallic artifacts, subtle valvar abnormalities or small vegetations could be missed.

CONCLUSIONS

In patients with high clinical suspicion for PV or pulmonary conduit IE, functional cardiac CTA can allow for definitive visualization of the PV and can aid in the diagnosis. CTA has the additional advantage of providing information on perivalvular and pulmonary complications.

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KEY WORDS computed tomography angiography, congenital heart disease, infective endocarditis, pulmonary valve

APPENDIX For supplemental videos, please see the online version of this paper.