

The pivotal role of cardiac computed tomography angiogram and ¹⁸F-fluorodeoxyglucose positron emission tomography-computed tomography in the diagnosis of right sided endocarditis: a case report

Abdelilah El Barzouhi^{1*}, Wilco Tanis¹, Rogier E. van Gelder², and Joris W.J. Vriend¹

¹Department of Cardiology, Haga Teaching Hospital, Postbus 40551, 2504 LN The Hague, The Netherlands; ²Department of Radiology, Haga Teaching Hospital, Postbus 40551, 2504 LN The Hague, The Netherlands

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Background

Infective endocarditis (IE) poses many clinical and diagnostic challenges. Echocardiography is regarded as the imaging modality of choice for the diagnosis of IE, and plays a key role in both the diagnosis and management of endocarditis. We report on a case in which one could have overlooked an endocarditis of a pulmonary homograft if one had relied on echocardiography alone.

Case summary

A 38-year-old man presented with intermittent fever and fatigue for 1 month. He had undergone a Ross procedure for a bicuspid aortic valve stenosis at the age of 17 years. At the age of 36 years a valve-sparing aortic root replacement was performed because of aortic root dilatation. Besides a systolic murmur 3/6 noted at the left sternal border, physical examination was normal. Multiple blood cultures grew *Streptococcus mitis*. Both transthoracic and transoesophageal echocardiogram could not detect any signs of endocarditis. As endocarditis can be overlooked due to reverberations and acoustic shadowing, we performed ¹⁸F-fluorodeoxyglucose positron emission tomography-computed tomography (FDG-PET/CT) and cardiac computed tomography angiogram (cardiac CTA). Both imaging modalities showed large vegetations attached to the pulmonary homograft.

Discussion

Endocarditis poses diagnostic challenges. While echocardiography is the cornerstone of imaging, one may overlook a pulmonary homograft endocarditis due to reverberations and acoustic shadowing. Therefore, if clinical suspicion of endocarditis is strong, one should consider additional imaging by means of cardiac CTA and/or ¹⁸F-fluorodeoxyglucose positron emission tomography-computed tomography imaging to assess valves in pulmonary position, especially in those whom have had prior surgical intervention at this location.

Keywords

Endocarditis • Ross procedure • Pulmonary valve • Pulmonary homograft • Echocardiography • PET/CT • Cardiac CTA • Case report

* Corresponding author. Tel: +31 646570264, Fax: +31 70 2104014, Email: A.elbarzouhi@hagaziekenhuis.nl

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Learning point

- One may overlook a pulmonary homograft endocarditis with echocardiography alone. Therefore, if clinical suspicion of endocarditis is strong, one should consider additional imaging by means of cardiac computed tomography angiogram and/or ^{18}F -fluorodeoxyglucose positron emission tomography-computed tomography imaging to assess valves in pulmonary position, especially in those whom have had prior surgical intervention at this location.

Introduction

Infective endocarditis (IE) is a severe disease associated with significant morbidity and mortality.¹ It is surprising that 1-year mortality has not improved and remains at 30%, despite the emergence of novel diagnostic and therapeutic strategies.^{2,3} Infective endocarditis affects 3–10 patients per 100 000 years and the incidence will probably rise in the future.^{2,4,5} Infective endocarditis most commonly involves the aortic and mitral valves with the tricuspid and pulmonary valve less commonly affected.⁶

Although right-sided IE accounts for 5–10% of all IE,⁷ the prevalence is significantly higher in patients with congenital heart defects. In patients with congenital heart defects, right-sided IE accounts for 32.7% of all IE.⁸ Complications of right-sided endocarditis may be either cardiac (e.g. right-sided volume overload, chamber dilatation, and right heart failure) or pulmonary (e.g. a variety of complications attributed to septic pulmonary emboli have been described including pulmonary infarction and pulmonary abscesses).^{7–9}

Infective endocarditis poses many clinical and diagnostic challenges. Echocardiography is regarded as the cornerstone of imaging in the diagnosis of IE.^{2,10,11} In recent years new imaging modalities have been added to the arsenal of diagnostic (imaging) methods in IE. We report on a patient with a congenital heart defect in which one could have overlooked an endocarditis if one had relied on echocardiography alone.

Timeline

Case presentation

A 38-year-old man presented with intermittent fever, weight loss, and fatigue for 1 month. In 1997, he had undergone a Ross procedure for a bicuspid aortic valve stenosis at the age of 17 years. During this procedure, the diseased aortic valve was replaced by his own pulmonary valve followed by reconstruction of the pulmonary outflow tract with a homograft. In 2016, at the age of 36 years, a valve-sparing aortic root replacement procedure was performed because of aortic root dilatation. The patient reported to have undergone dental treatment, i.e. treatment of superficial caries, 3 months ago. In agreement with current guidelines, he was not advised antibiotic prophylaxis.¹¹ He did not report any use of intravenous drugs. Besides a systolic murmur 3/6 noted at the left sternal border, physical examination was normal. Blood tests were unremarkable except for a C-reactive protein level of 110 mg/L (normal <8), leucocytosis of $12.0 \times 10^9/\text{L}$ (normal $<10.0 \times 10^9$), and a haemoglobin level of 6.8 mmol/L (normal >8.0). The electrocardiogram showed sinus rhythm with a rate of 76 b.p.m. and normal conduction times. Multiple blood cultures grew *Streptococcus mitis*, sensitive to penicillin. The patient did not have any symptoms or signs suspicious of a possible source of infection. He was treated with benzyl penicillin 12 million units/day. We observed a mildly elevated gradient across the pulmonary homograft, which was already known from previous echocardiography. We measured a peak gradient of 31 mmHg with continuous Doppler across the pulmonary homograft (Figure 1). Furthermore there was also a moderate regurgitation of the pulmonary homograft (Supplementary material online, Video S1), which was also already

| Day | Events |
|-----|--|
| 0 | The patient presented with intermittent fever, weight loss, and fatigue for 1 month |
| 1 | Transthoracic and transoesophageal echocardiogram could not detect any signs of endocarditis |
| 2 | Multiple blood cultures grew <i>Streptococcus mitis</i> , sensitive to penicillin. Treatment with benzyl penicillin 12 million units/day was started |
| 4 | ^{18}F -fluorodeoxyglucose positron emission tomography-computed tomography and cardiac computed tomography angiogram (CTA) showed large vegetations (around 30 mm) attached to the pulmonary homograft |
| 11 | The patient developed dyspnoea and pleuritic chest due to pulmonary embolism |
| 28 | Cardiac CTA showed clear reduction in vegetation size |
| 34 | The patient was discharged home with antibiotic therapy (benzylpenicillin 12 million units/day) |
| 44 | The patient completed the 6-week antibiotic course with benzyl penicillin. We switched to oral suppression therapy with clindamycin three times daily 600 mg |
| 95 | The last date the patient was seen at the outpatient clinic. He was continuing to do well |

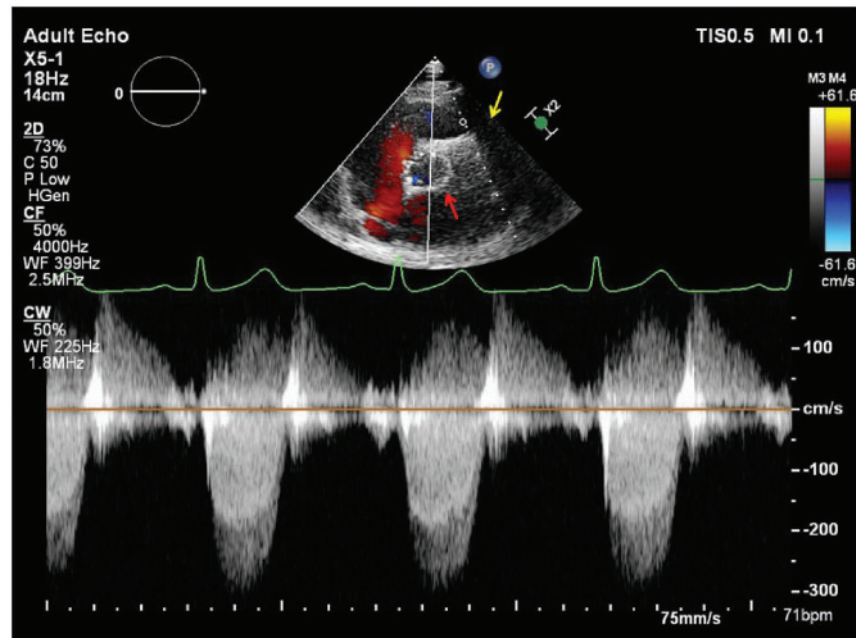


Figure 1 Continuous Doppler across the pulmonary homograft. We measured a peak gradient of 31 mmHg with continuous Doppler across the pulmonary homograft. The yellow arrow indicates the position of the pulmonary homograft. The red arrow indicates the aortic valve.

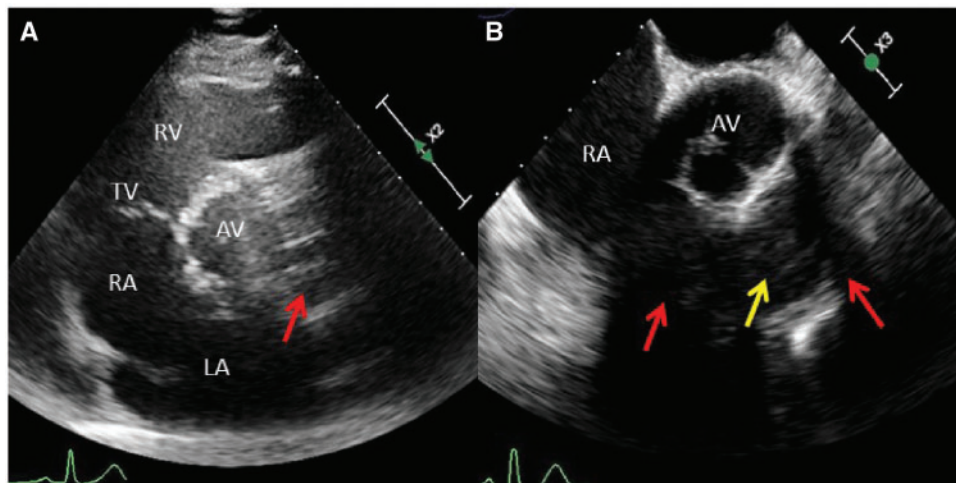


Figure 2 (A) Transthoracic parasternal short-axis view showing reverberations (red arrow). (B) Transoesophageal view showing acoustic shadowing (red arrows) caused by fibrotic scarring of his native pulmonary valve in aortic position. The yellow arrow indicates the position of the pulmonary homograft. AV, aortic valve; LA, left atrium; RA, right atrium; RV, right ventricle; TV, tricuspid valve.

known from previous echocardiography. The pressure half time was 130 ms. However, we were aware that we might have overlooked an endocarditis due to reverberations and acoustic shadowing caused by fibrotic scarring of his native pulmonary valve in aortic position (as already observed during the reoperation in 2016) and the prosthetic material in situ (aortic root prosthesis and calcified pulmonary homograft) (Figure 2, [Supplementary material online, Videos S2 and S3](#)).

We, therefore, performed an ^{18}F -fluorodeoxyglucose positron emission tomography-computed tomography (FDG-PET/CT) and cardiac computed tomography angiogram (cardiac CTA). Both imaging modalities showed large vegetations, around 30 mm, attached to the pulmonary homograft (Figure 3). Additionally, FDG-PET/CT did not show any other possible source of infection. We think that the time frame of three months between the dental procedure and the

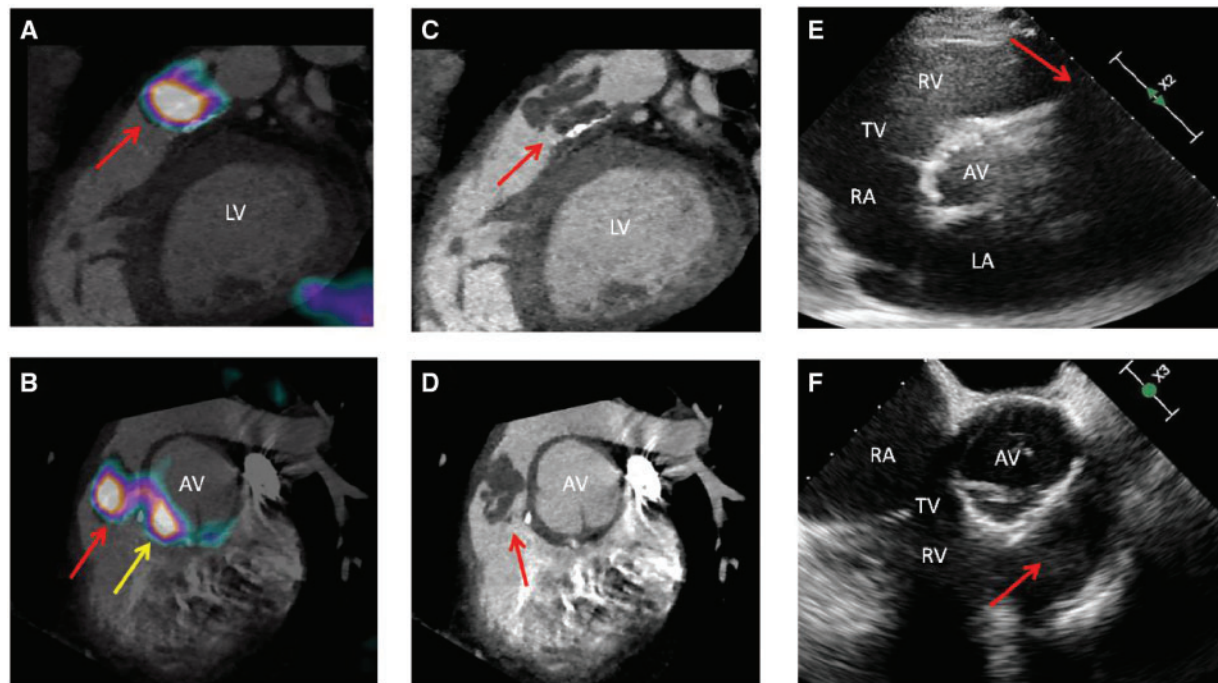


Figure 3 Fusion computed tomography/ ^{18}F -fluorodeoxyglucose positron-emission tomography images (A, B) and retrospectively ECG-gated computed tomography angiogram of the pulmonary and aortic valve (C, D). Sagittal (A, C) and semi-coronal (B, D) reconstructions through the right ventricular outflow tract showing moderate to intense fluorodeoxyglucose avid vegetations attached to the pulmonary homograft (red arrows) and around the wall of the pulmonary valve in aortic position (yellow arrow). Transthoracic (E) and transoesophageal (F) echocardiogram could not detect any signs of endocarditis. AV, aortic valve; LA, left atrium; LV, left ventricle; RA, right atrium; RV, right ventricle; TV, tricuspid valve.

endocarditis is too long to be causal. We supposed a high risk of surgery due two important reasons: (i) the patient would undergo re-surgery in an active endocarditis and (ii) concerns about possible endocarditis of the native pulmonary valve in aortic position as there was significant FDG uptake around the aortic root (yellow arrow, Figure 3B), this would insist a major operative procedure: both the pulmonary homograft and the aortic root including his native pulmonary valve in aortic position should be replaced. Therefore, a conservative approach was initially proposed. Shortly after, he developed dyspnoea and pleuritic chest pain, suspicious of pulmonary embolism. A CT scan confirmed the diagnosis of pulmonary embolism in the right pulmonary artery with arterial occlusion towards the right lower lobe, and signs of pulmonary infarction (Figure 4). As the pulmonary embolism may be a mix of vegetations and thrombus we started treatment with low-molecular-weight heparin followed by a non-vitamin K-dependent oral anticoagulant (apixaban 5 mg two times daily). Due to the high risk of surgery we continued a conservative approach with antibiotics. During follow-up cardiac CTA showed clear reduction in vegetation size (Figure 5). At day 34, the patient was discharged home with continuing antibiotic therapy (benzyl penicillin 12 million units/day). After the patient completed the 6-week antibiotic course with benzyl penicillin, we switched to oral suppression therapy with clindamycin three times daily 600 mg. The last blood tests (44 days post diagnosis of IE) were as follows: a C-reactive protein level of 7 mg/L (normal <8), leucocytosis of $6.2 \times 10^9/\text{L}$

(normal $<10.0 \times 10^9$), and a haemoglobin level of 6.9 mmol/L (normal >8.0). During his last outpatient clinic visit (95 days post-diagnosis of IE), he was continuing to do well. As we fear a relapse of his endocarditis, oral suppression therapy with clindamycin was still continued. We have not yet decided on the duration of this suppression therapy.

Discussion

We presented a *S. mitis* endocarditis of the pulmonary valve in a patient who had undergone a Ross procedure in the past. The definite diagnosis of endocarditis was based on two major criteria (blood culture and imaging) and two minor criteria (fever and predisposing heart condition).¹¹ An interesting finding is that both transthoracic and transoesophageal echocardiogram could not detect any signs of endocarditis, while FDG-PET/CT and cardiac CTA revealed large vegetations of the pulmonary homograft.

Right-sided infective endocarditis (RSIE) is an uncommon diagnosis, accounting for less than 10% of cases of IE.⁷ However, the incidence is likely to increase due to the increasing use of implantable cardiac devices.^{4,5} Common presentations of RSIE include fever, bacteraemia, and pulmonary embolism with accompanying symptoms such as chest pain and coughing.^{11,12} Isolated right heart failure is rare and may be caused by increased pulmonary pressure due to large vegetations causing obstruction in the pulmonary arteries.^{12,13} Right-

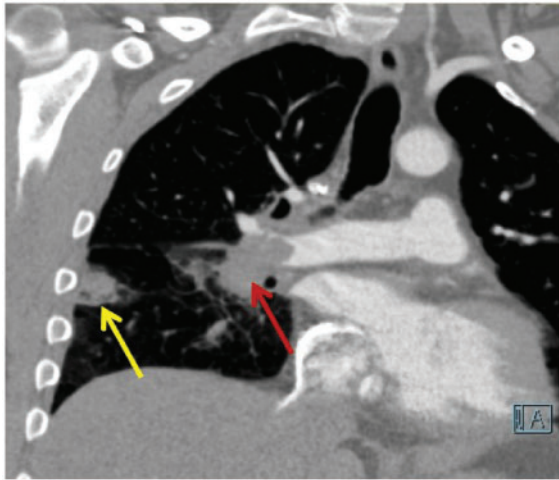


Figure 4 Semi coronal reconstruction of the computed tomography angiogram of the pulmonary arteries demonstrates emboli in the right pulmonary artery (red arrow) and a small infarction in the peripheral right lower lobe (yellow arrow).

sided infective endocarditis usually involves the tricuspid valve rather than the pulmonary valve.^{13,14} Morbidity and mortality of RSIE are generally reported as less severe than left-sided endocarditis with a mortality rate ranging from 3% to 30%.^{15,16} According to the guidelines, surgery for RSIE is recommended in case of right heart failure secondary to severe tricuspid regurgitation with poor response to diuretic therapy, failure of antimicrobial therapy and tricuspid valve vegetations >20 mm that persist after recurrent pulmonary emboli with or without concomitant right heart failure.^{11,17} It is recommended that pulmonary valve replacement should be avoided, but if judged necessary, use of a pulmonary homograft is preferred.¹¹

Echocardiography is regarded as the technique of choice for the diagnosis of IE.^{10,11} According to the current guideline transthoracic echocardiography (TTE) must be performed as soon as IE is suspected.¹¹ Transoesophageal echocardiography (TOE) must be performed in case of negative TTE when there is a high index of suspicion for IE, particularly when TTE is of suboptimal quality. Transoesophageal echocardiography is recommended by the guidelines in patients with clinical suspicion of IE, when a prosthetic heart valve or an intracardiac device is present. The sensitivity for the diagnosis of vegetations in native and prosthetic valves is 70% and 50%, respectively, for TTE and 96% and 92%, respectively, for TOE.^{10,11,18} Specificity has been reported to be around 90% for both for both

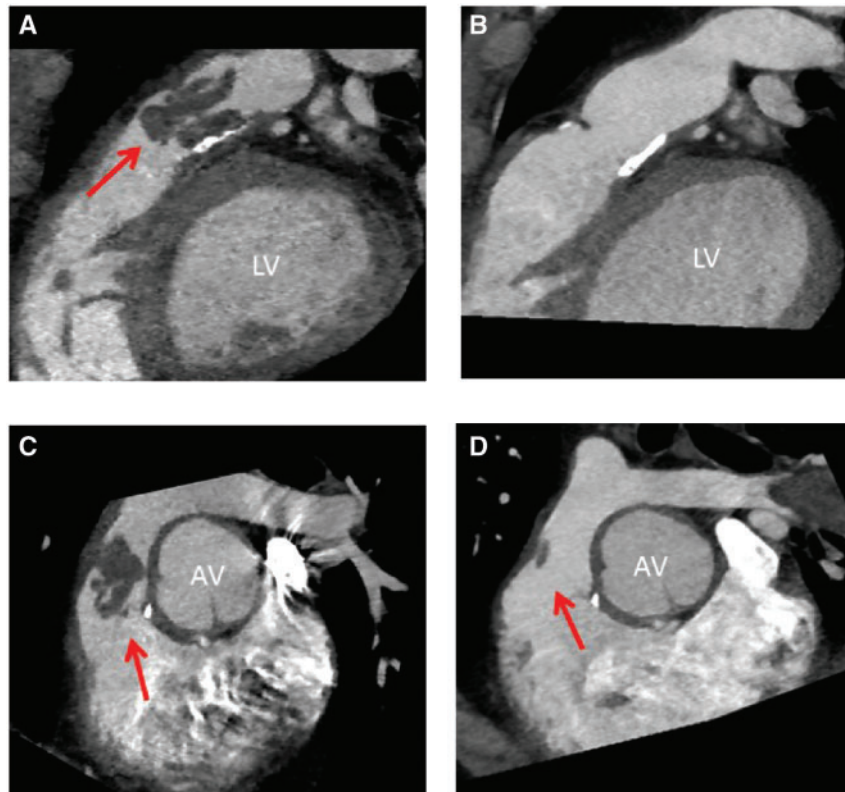


Figure 5 ECG-gated computed tomography angiogram of the pulmonary homograft at initial presentation (A and C) and during follow-up (B and D). Major reductions of the pulmonary homograft vegetations were observed during follow-up. AV, aortic valve; LV, left ventricle.

TTE and TOE. However, the value of both echocardiographic approaches in right sided endocarditis is based on older studies that included few patients and no cases of pulmonary valve endocarditis.^{19–21} The evidence in the current guidelines that transoesophageal echocardiography is more sensitive in the detection of pulmonary vegetations is based on an old study involving three patients.^{11,21} Furthermore, echocardiography of prosthetic heart valve is often hampered by acoustic shadowing and reverberations.^{22–25} Our case shows the importance of FDG-PET/CT imaging and cardiac CTA in right sided endocarditis, especially for the visualization of the pulmonary valve. The diagnostic performance of FDG-PET/CT imaging and/or cardiac CTA in comparison with echocardiography for pulmonary valve endocarditis has not been described. A previous study showed that ECG-gated CT has comparable diagnostic performance to transoesophageal echocardiography in patients with aortic prosthetic valve endocarditis.²⁶ Another study showed that the combined or even fused use of FDG-PET/CT and CTA may have complementary beneficial value in patients with prosthetic heart valve endocarditis.²⁷

In some instances it may be difficult to distinguish vegetations from thrombi. One should be aware that there are some pathological conditions that may mimic the pattern of focally increased ¹⁸F-FDG uptake that is typically observed in IE, such as active thrombi, primary cardiac tumours, cardiac metastasis from a non-cardiac tumour and post-surgical inflammation and foreign body reactions.^{11,28} Radiolabeled leucocyte scan is a promising novel emerging modality that can aid in the diagnosis of IE when there is a need for differential diagnosis between septic and sterile vegetations detected at echocardiography.^{28,29} However, all diagnostic results should always be interpreted in clinical context, taking into account the patient's clinical picture and the probability of IE.

The population of children and adults with congenital heart disease is growing due to the medical and surgical breakthroughs in the care of patients with born heart defects.^{30,31} The reported incidence of IE in congenital heart disease is 15–140 times higher than in the general population.^{32,33} The principal symptoms, complications and basis for diagnosis do not differ from IE in general.¹¹ However, one should be aware that right-sided IE is more frequent in congenital heart disease than in acquired cardiac disease.⁸ Complex anatomy and the presence of prosthetic material may make echocardiographic assessment difficult.^{11,33}

In conclusion, our case demonstrates that with echocardiography alone one may overlook a pulmonary homograft endocarditis. Therefore, if clinical suspicion is strong, one should consider additional imaging by means of cardiac CTA and/or FDG-PET/CT imaging to assess the pulmonary homograft.

Conclusion

We reported a *S. mitis* endocarditis of the pulmonary homograft in a patient who had undergone a Ross procedure in the past. Both transthoracic and transoesophageal echocardiogram could not detect any signs of endocarditis due to reverberations and acoustic shadowing. However, FDG-PET/CT and cardiac CTA revealed large vegetations of the pulmonary homograft. Therefore, if clinical suspicion of endocarditis is strong, one should consider additional imaging by means of cardiac CTA and/or FDG-PET/CT imaging to assess valves in

pulmonary position, especially in those whom have had prior surgical intervention at this location.

Supplementary material

Supplementary material is available at *European Heart Journal - Case Reports* online.

Slide sets: A fully edited slide set detailing this case and suitable for local presentation is available online as [Supplementary data](#).

Consent: The author/s confirm that written consent for submission and publication of this case report including image(s) and associated text has been obtained from the patient in line with COPE guidance.

Conflict of interest: none declared.

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