ESC European Society of Cardiology

European Heart Journal – Case Reports (2021) **5**(7), 1–6
doi:10.1093/ehjcr/ytab229

CASE REPORT
Cardiac imaging

Transoesophageal echocardiography-guided 'primary' valve-in-valve technique in cardiogenic shock: a case report

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Received 7 September 2020; first decision 14 October 2020; accepted 18 May 2021

Background Transcatheter aortic valve implantation inside a previously implanted bioprosthesis is an alternative treatment for patients with degenerated surgical aortic bioprosthesis (AB) at high surgical risk. Pre-operative computed tomography (CT) scan provides essential information to the procedure planning, although in case of acute presentation it is not always feasible.

Case summary A 32-year-old man with history of surgical treatment of aortic coarctation and Bio-Bentall procedure was transferred to our department in cardiogenic shock with a suspected diagnosis of acute myocarditis. A transthoracic echocardiogram (TTE) revealed a severely impaired biventricular function and AB degeneration causing severe stenosis. It was decided to undertake an urgent trans-apical valve-in-valve (ViV) procedure. Due to haemodynamic instability, a preoperative CT scan was not performed and transoesophageal echocardiography (TOE) was the main intraprocedural guiding imaging technique. Neither intraprocedural nor periprocedural complications occurred. Serial post-procedural TTE exams showed good functioning of the bioprosthesis and progressive improvement of left ventricular ejection fraction. Patient was discharged from the hospital 8 days after the intervention.

Discussion A patient with cardiogenic shock due to severe degeneration of the AB was treated with urgent transapical ViV procedure. In this case, where urgent ViV technique was needed, TOE appeared to be a crucial alternative to CT scan and allowed us to perform a successful procedure.

Keywords Cardiogenic shock • Aortic bioprosthesis • Valve-in-valve • Transoesophageal echocardiography • Case report

Learning points

- Bioprosthetic valve dysfunction should always be suspected in a patient with bioprosthesis and heart failure presentation; a transoesophageal echocardiography should be encouraged in case of significant left ventricular ejection fraction reduction.
- Performing a computed tomography (CT) scan before valve-in-valve implantation is advisable, however not always feasible.
- Transoesophageal echocardiography could be the only guiding imaging tool in urgent/emergent transcatheter aortic valve interventions when CT scan is not feasible or contraindicated.

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Handling Editor: Søren Skott-Schmiegelow
Peer-reviewers: Luigi Biasco; Richard Alexander Brown and Arvind Singh
Compliance Editor: Reshma Amin
Supplementary Material Editor: Elhosseyn Guella

Introduction

Transcatheter aortic valve (TAV) implantation inside a previously implanted bioprosthesis is an established, less invasive, treatment for patients with degenerated surgical aortic valve bioprosthesis (SAV)[1–3] at high surgical risk; it is referred to as TAV in SAV or valve-in-valve (ViV) technique. Surgical bioprosthetic valves have a limited durability and deteriorate over time (usually in 10–20 years)[4–6] presenting with stenosis, as a consequence of calcification, pannus or thrombosis, or regurgitation, secondary to wear and tear, infection, or both.[4,7] Repeat open heart surgery carries an inherent high risk of morbidity and mortality[8,9]; moreover, advanced patient age, comorbidity, and technical issues increase the risk of a redo surgical aortic valve replacement.

In elective patients undergoing ViV procedure, performing a preoperative computed tomography (CT) scan is of paramount importance: it provides fundamental information, such as real internal diameter of SAV and coronary ostia height, and guides us on the most appropriate access. Here, we present a case of a 32-year-old man with cardiogenic shock due to severe degeneration of SAV, submitted to urgent transoesophageal echocardiography (TOE)-guided procedure of percutaneous aortic ViV implantation.

Timeline

1992	Surgical treatment of aortic coarctation
2010	Bio-Bentall intervention with Carpentier-Edwards Perimount 25 mm because of degenerated bicuspid aortic valve associated with dilation of the ascending aorta
2020—transfer to our department	Patient with cardiogenic shock thought to be due to acute myocarditis
15 min after admission	Transthoracic echocardiogram (TTE) revealed severe aortic bioprosthetic degeneration
1 h later	Urgent transoesophageal echocardiography-guided trans-apical valve-in-valve (ViV) procedure was carried out, without major complications
Days after ViV	Haemodynamic stability, improvement in clinical condition
8 days later	Patient was discharged
1 month later	TTE and cardiac magnetic resonance imaging showed significant improvement in cardiac performance

Case presentation

We report on the case of a 32-year-old man with Marfan syndrome and history of surgical treatment of aortic coarctation at the age of 4 and Bio-Bentall procedure (a modified Bentall technique in which aortic root and ascending aorta are replaced using a composite graft with a biological valve prosthesis located within the vascular tube) with Carpentier-Edwards Perimount 25 mm (Edwards Lifesciences, Irvine, CA, USA) at the age of 22 because of a degenerated bicuspid aortic valve associated with dilatation of the aortic root and the ascending aorta. The patient stated he had not been undergoing routine follow-up exams for some years; however, he had been adherent to beta-blocker therapy, and that he had come to medical attention and then hospital admission in January 2020 because of dyspnoea, fatigue, and chest discomfort. Serial transthoracic echocardiographic (TTE) exams, performed as outpatient and during his first hospital admission, revealed moderate reduction in left ventricular ejection fraction (LVEF) but did not mention bioprosthetic dysfunction. In February 2020, after a new hospital admission because of worsening symptoms, he was transferred to our department with suspicion of acute myocarditis (the patient had described flu like symptoms some weeks before) determining cardiogenic shock with evidence at TTE of severe low LVEF and a 'normally' functioning bioprosthesis. The patient was tachycardic (heart rate 120 b.p.m., at electrocardiogram right bundle branch block + left anterior fascicular block), tachypnoeic (respiratory rate of 30 breaths/min; SpO_2 93%), hypotensive (blood pressure 80/50 mmHg) despite oxygen administration and infusion of inotropic and vasopressor agents, oliguric, indicating prerenal acute kidney injury (creatinine 2.6 mg/dL, reference range 0.7–1.2 mg/dL); lactate was 2.32 mmol/L (reference range <1.6 mmol/L). A TTE was performed and showed dilated hypokinetic left ventricle [end-diastolic volume (EDV) 260 mL, LVEF 19%, left ventricular outflow tract (LVOT) VTI 11 cm], pulmonary hypertension [dilated dysfunctional right ventricle, moderate tricuspid regurgitation (TR) with Vmax 3.1 m/s, inferior vena cava (IVC) 2.9 cm], and surprisingly it revealed bioprosthetic aortic valve degeneration causing severe stenosis with Vmax 4 m/s, despite a severe systolic dysfunction [mean gradient (MG) 31 mmHg, doppler velocity index (DVI) 0.16] (*Figure 1*). We decided to undertake an urgent ViV procedure. An ECMO (extra-corporeal membrane oxygenation) was placed through right femoral artery and vein and supported hemodynamics during the procedure. Due to haemodynamic instability, it was not possible to perform preoperative CT scan to assess arterial access. In the light of the patient's clinical history (previous intervention for aortic coarctation and BioBentall with positioning of an aortic graft) and our department's experience in trans-apical TAV implantation, that has shown similar clinical outcomes to transfemoral TAV implantation, we decided to perform a trans-apical access through a left lateral minithoracotomy at the fifth intercostal space under general anaesthesia (*Figure 2*). TOE was the main pre- and intra- procedural guiding imaging technique. It confirmed bioprosthetic degeneration and defined re-implanted coronary ostia height (13 mm) in order to avoid coronary ostia obstruction (*Figure 3*) (*Video 1* and *3*); indeed, although in Bentall procedure the coronary ostia are reimplanted high enough to avoid it, at the time of TOE exam, we did not have either a written report of the previous cardiac surgery or any images and we felt more confident once the exact position of the re-implanted coronary ostia were identified. TOE also allowed identification of optimal location for the apical puncture and guided the correct implantation of the Edwards Sapien 3 Ultra 26 mm (Edwards Lifesciences). All the procedure was conducted under TOE guide that assisted valve deployment (*Figure 4*). Moreover, three-dimensional (3D) TOE provided

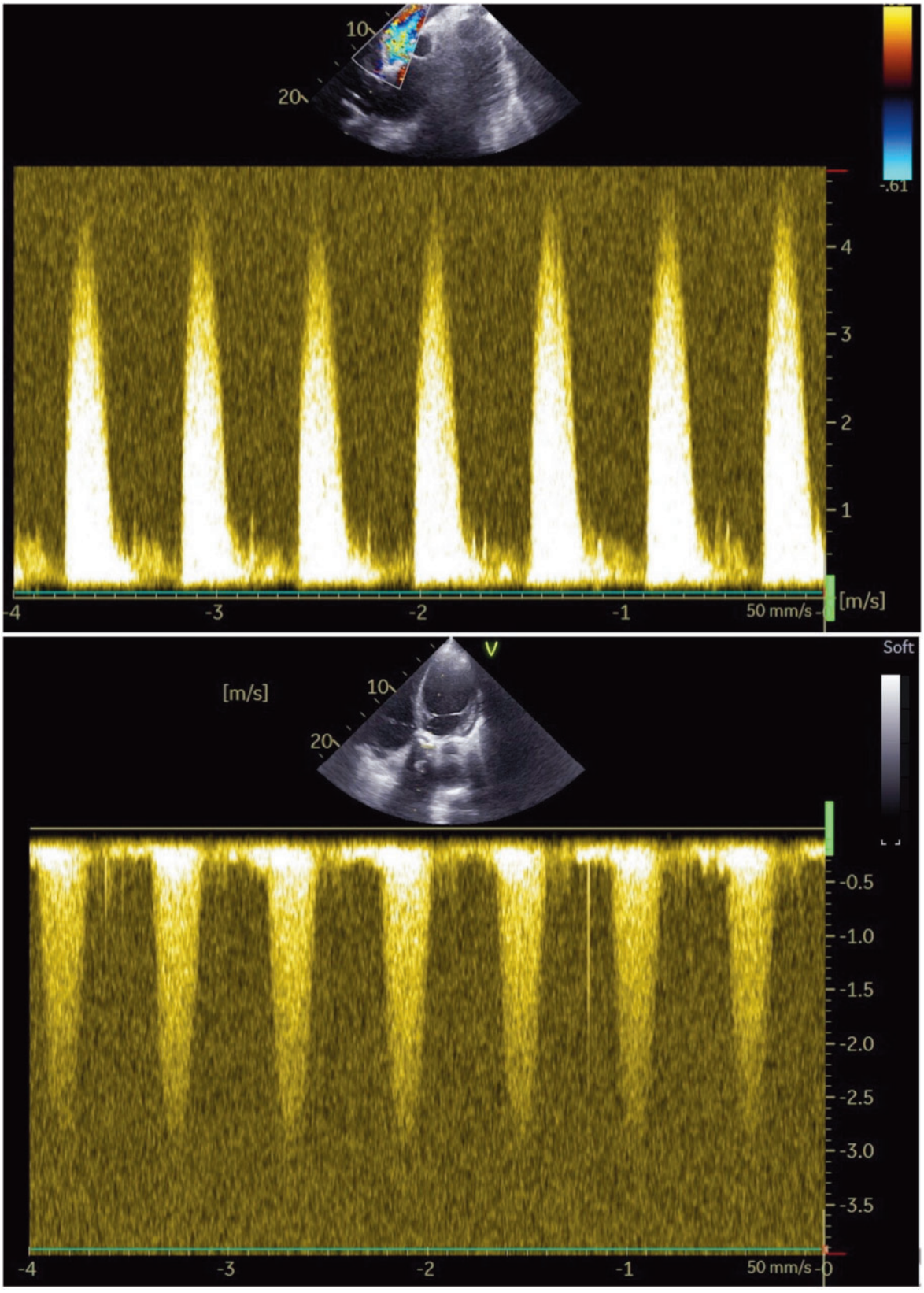


Figure 1 Transvalvular aortic continuous-wave Doppler measured through the right parasternal view (figure on top) and the apical five-chamber view (figure below). The right parasternal view shows a Vmax > 4 m/s. We suggest performing this projection since it can sometimes reveal higher Vmax and mean gradient than apical views.

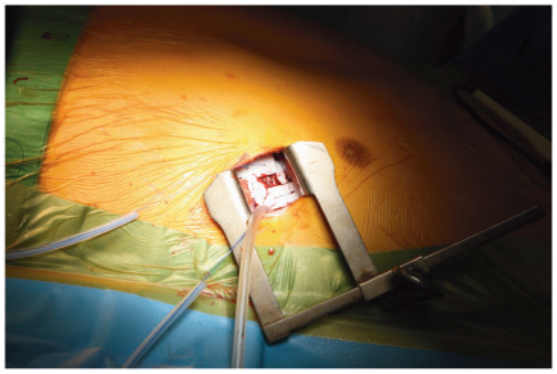


Figure 2 Left lateral minithoracotomy at the 5th intercostal space shows that trans-apical access is a mini-invasive surgery.

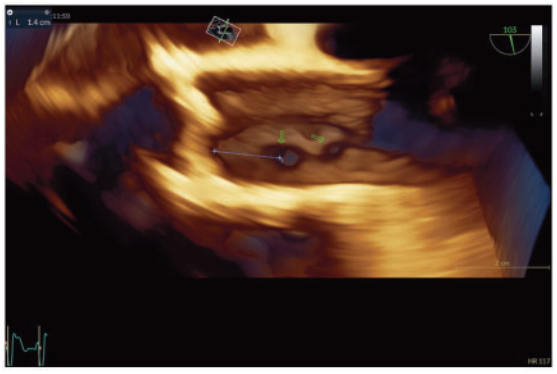


Figure 3 Three-dimensional transoesophageal echocardiography-guided localization of reimplanted coronary ostia. The green arrows show coronary ostia, while the blue line represents the distance from the annular plane.

'en face' view of the structure and confirmed fluoroscopic co-axial alignment of the delivery system to the aortic root. The post-deployment assessment revealed an optimal result with an abrupt drop of the mean pressure gradient in the absence of significant regurgitation and interference on mitral valve function (*Video 2*). TOE allowed us to reduce to a minimum the use of contrast medium, optimal in such condition of compromised renal function. Neither intraprocedural nor periprocedural complications occurred. ECMO was discontinued soon after the deployment of the bioprosthesis. In the post-operative clinical course, haemodynamics improved and the patient was weaned from inotropic support (noradrenaline and dobutamine). Post-procedural TTEs showed good functioning of the aortic bioprosthesis with Vmax 2.6 m/s, MG 15 mmHg and a progressive improvement of LVEF that reached up to 40% at discharge (confirmed also by 3D echo) with consequent increase in stroke volume.

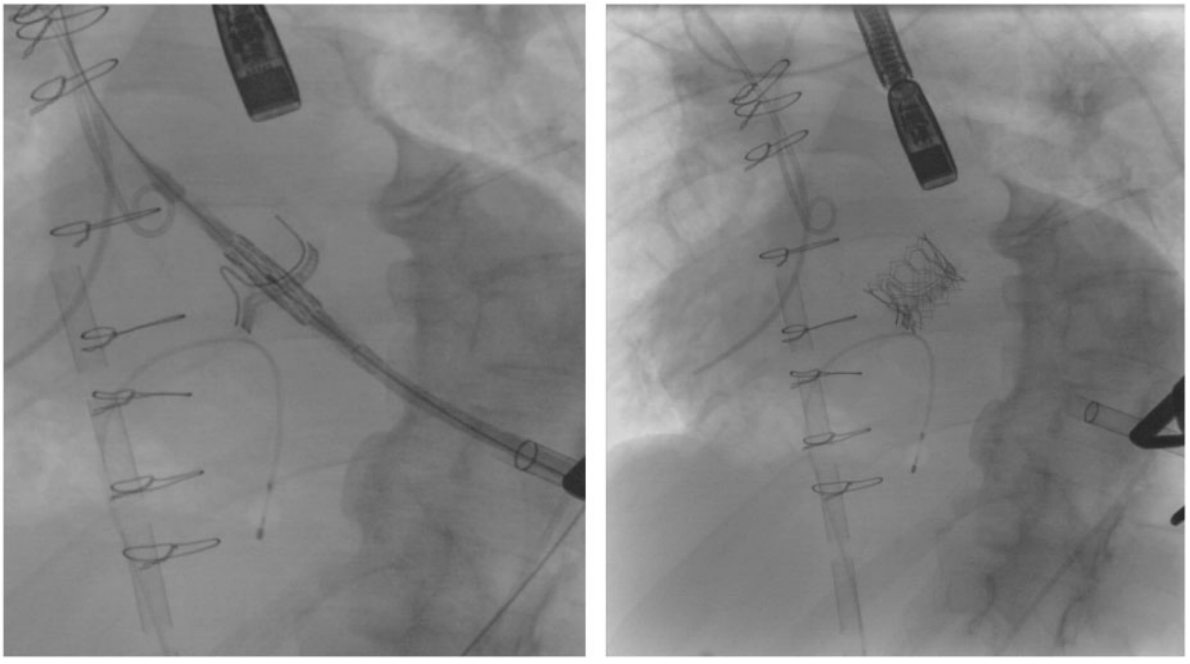
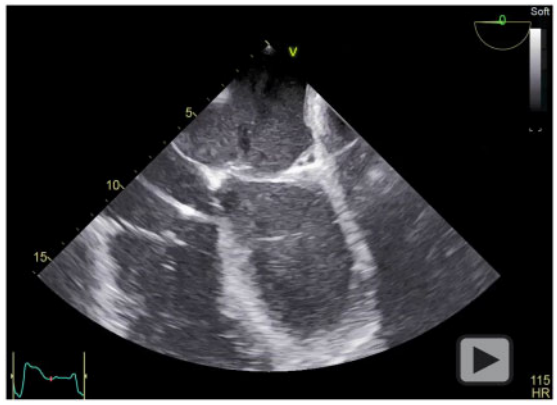
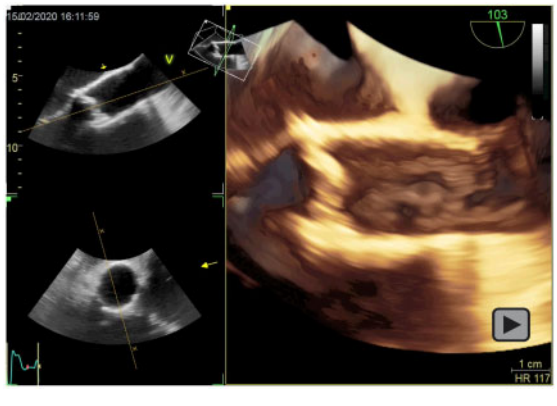


Figure 4 Fluoroscopic images of the procedure showing the presence of transoesophageal echocardiography probe, temporary pacemaker, the ring of the dysfunctional bioprosthesis, the delivery system of the percutaneous bioprosthetic valve (left), and the new bioprosthetic valve released (right).



Video 1 Severe LV dysfunction due to degeneration of surgical aortic bioprosthetic valve.

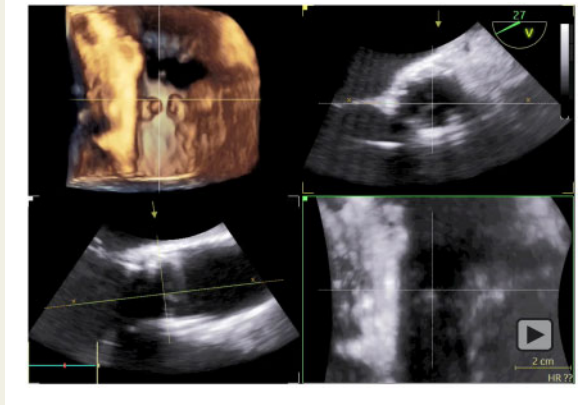


Video 2 2D-3D TOE identification of coronary ostia.

Patient was discharged from the hospital eight days after the intervention. One month later, a follow-up TTE was performed: it showed reduction in left ventricular dimension (EDV 230 mL) with improved contractility [ejection fraction (EF) 45%, LVOT VTI 23 cm] and a well performing bioprosthesis (Vmax 2.9 m/s, MG 20 mmHg, DVI 0.4), improvement of right heart performance (EF 3D 38%, TAPSE 20 mm) with decrease in pulmonary pressure (Vmax TR 2.7 m/s, IVC 1.3 cm). We also performed a cardiac magnetic resonance that confirmed good LVEF and showed no late gadolinium enhancement. We discussed with the patient the future need of a new intervention because of the foreseeable bioprosthetic degeneration and we hypothesized that an elective procedure of mechanical aortic valve replacement probably will be needed.

Discussion

The case illustrated shows a patient with cardiogenic shock erroneously attributed to acute myocarditis that indeed was caused by



Video 3 2D-3D TOE visualization of the aortic bioprosthesis after ViV technique.

severe degeneration of the aortic bioprosthesis, previously undetected, treated with urgent transapical ViV procedure. Prior to elective ViV procedure, performing a CT scan is of paramount importance: it confirms the type and the size of the SAV, provides the real internal diameter of SAV and defines the height of the coronary ostia; moreover, it helps us to decide the most appropriate access (in transapical ViV, a sharp angulation between the line that crosses left ventricle through cardiac apex and the line that passes by the middle of aortic root can make the procedure more challenging).[10] Due to haemodynamic instability, a CT scan was not carried out and TOE was the guiding imaging technique during the procedure. It assisted with correct valve deployment and was crucial in defining coronary ostia height. Three-dimensional TOE provided 'en face' view of the structure and confirmed co-axial alignment of the delivery system to the aortic root; in this specific case (previous BioBentall) being coaxial with valve also meant being co-axial with neo-root. In our case where urgent ViV procedure was needed, TOE appeared to be a crucial alternative to CT scan and allowed us to perform a successful procedure. TOE-guided procedure could be a strategy in those patients in which performing a CT scan would be not advisable. To the best of our knowledge, this is the first case report on a patient with cardiogenic shock successfully treated with urgent TOE-guided ViV technique and we do not hesitate to recommend it when a CT scan is not feasible.

Lead author biography

Vincenzo Polizzi was born in 1973 in Palermo, Italy. He received his medical training in 1997 and completed his residency in Cardiology in 2001 at the University of Palermo. Consultant Cardiologist at San Camillo Forlanini Hospital since 2002. Head Department of Diag nostic and Clinical management in the Heart Failure Unit for patients candidate to surgical and/or

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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 authors confirm that written consent for submission and publication of this case report including images and associated text has been obtained from the patient in line with COPE guidance.

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