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CASE REPORT
Other

Transcatheter aortic valve replacement in a patient with critical bicuspid aortic stenosis and cardiogenic shock: case report

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Background Cardiogenic shock (CS) is associated with significant morbidity and mortality (27–51%). Little is known about the feasibility and safety of emergency transcatheter aortic valve replacement (TAVR) for critical aortic stenosis (AS) in acute myocardial infarction (AMI) with CS.

Case summary A 57-year-old male with history of tobacco dependence and diabetes mellitus presented with acute posterior ST-segment elevation myocardial infarction and CS. The patient initially underwent successful primary percutaneous intervention to an anomalous circumflex artery coming off the right cusp. It was noted to have advanced CS out of proportion to his coronary anatomy. Echocardiographic assessment noted critical AS. Heart team decided to perform percutaneous aortic balloon valvuloplasty under support of extracorporeal membrane oxygenation. Percutaneous aortic balloon valvuloplasty was performed and was complicated by severe aortic regurgitation (AR). A balloon-expandable transcatheter heart valve was then placed with resolution of AR and stabilization of the patient. Then, the patient was subsequently decannulated within a week then was able to go home after 47 days (32 days intensive care unit). His course was notable for a minor stroke due to initial period of hypotension and CS. He was extubated and remained hospitalized for several weeks participating in rehabilitation. Follow-up echo showed a well-seated and functioning transcatheter heart valve. His left ventricular systolic function improved from 21% to 45%.

Conclusion Emergency TAVR is feasible and can be performed in a patient with AMI and CS. Early initiation of mechanical support allowed the patient to receive definitive treatment. The multidisciplinary heart team is essential and reflected in the ultimate outcome of our patient.

Keywords Case report (CR) • Emergency transcatheter aortic valve replacement (TAVR) • Cariogenic shock (CS) • Aortic stenosis (AS)

ESC Curriculum 3.2 Acute coronary syndrome • 4.2 Aortic stenosis • 6.4 Acute heart failure • 7.3 Critically ill cardiac patient

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Learning points

- Emergency transcatheter aortic valve replacement (TAVR) is feasible and can be performed in a patient with acute myocardial infarction and cariogenic shock.
- Early initiation of mechanical circularity support before emergency TAVR allowed the patient to receive definitive treatment.
- The multidisciplinary heart and shock team is essential for decision-making and is reflected in the ultimate outcome of our patient.

Introduction

Cardiogenic shock (CS) is associated with significant in-hospital morbidity and mortality (27–51%).[1] Little is known about the incidence and mortality of CS in a patient with acute myocardial infarction (AMI) and critical aortic valve stenosis (AS). Transcatheter aortic valve replacement (TAVR) has become a well-established treatment option for patients with severe AS in different risk groups.[2,3] However, there is limited data on the use of TAVR in patients with CS and acute ST-segment elevation myocardial infarction.

Timeline

Time point	Medical event
Long history	Smoking and diabetes mellitus
Day 0	Typical severe chest pain for 7 h
Day 0	Acute posterior ST-elevation myocardial infarction
Day 0	Primary percutaneous intervention to circumflex artery
Day 1, 2343 h	Ongoing cardiogenic shock
Day 1, 0430 h	Right heart catheter
Day 1, 0500 h	Echocardiography
Day 1, 0800 h	Heart/shock team meeting
Day 1, 1000 h	Veno-arterial extracorporeal membrane oxygenation (VA-ECMO)
Day 1, 1030 h	Computed tomography angiogram chest, abdomen and pelvis
Day 1, 1130 h	Transcatheter aortic valve replacement
Day 1, 1400 h	Follow-up echocardiography
Day 8	ECMO decannulation
Day 15	Extubation
Day 19	Follow-up echocardiography
Days 0–32	32 days in coronary care unit, then transferred to the floor
Days 32–47	Rehabilitation
Day 47	Home

Case presentation

A 57-year-old male with a past medical history of tobacco dependence and diabetes mellitus with no history of valvular heart disease presented to an outside facility with 8 h of severe central, crushing chest pain associated with diaphoresis and shortness of breath. Initial examination showed the patient to be hypotensive with a systolic blood pressure of 92 mmHg. He had a raised jugular venous pressure and a pan systolic ejection murmur best heard in the right upper sternal border.

Investigations

Electrocardiogram showed sinus rhythm and ST-segment depression in V1–V3 with positive T wave suggestive of posterior myocardial infarction (*Figure 1*). Posterior leads confirmed the diagnosis with 1 mm ST-segment elevation in leads V7–9. Basic blood tests were remarkable for PH 7.29 (reference 7.31–7.42), NT-pro-B-type natriuretic peptide 30 255 ng/L (reference 0.0–485.0 ng/L), troponin T 93 mcg/L (reference 0.00–0.05 mcg/L), eGFR 36 mL/min/1.73 m^2 (reference ≥60 mL/min/1.73 m^2), creatinine 176 micromol/L (reference 59–104 micromol/L), serum lactate 3.5 mmol/L (reference 0.40–0.80 mmol/L), and mixed venous oxygen Sat 50.2% (reference ≥70.0 %).

Transthoracic echocardiography showed severe concentric left ventricular (LV) hypertrophy. Left ventricular systolic function was severely decreased with an ejection fraction of 21%, with an LV stroke volume index of 18.1 mL/m^2. Regional wall motion abnormality was seen in the territory of the left circumflex. Severe AS with an aortic valve area of 0.55 cm^2 (0.34 cm^2/m^2) was documented with a dimensionless valve index of 0.14 and a mean gradient of 44 mmHg (*Figure 2*, *Video 1*).

Patient management

The patient was initially treated with primary percutaneous coronary intervention (PPCI) to an anomalous circumflex artery (CX) coming off the right coronary sinus with 100% proximal stenosis (culprit) (Supplementary material online, *Figure S1*). The patient received PPCI to CX with one drug-eluting stent and supported by intra-aortic balloon pump (IABP) and pressors, including epinephrine, norepinephrine, dobutamine, and vasopressin. The procedure was successful with the restoration of thrombolysis in myocardial infarction flow 3. The patient was noted to have advanced cardiogenic shock out of proportion to his coronary anatomy that could be only explained by critical bicuspid aortic valve stenosis. He was started on guideline-directed medical therapy and due to refractory CS, he was transferred to our hospital for further management. Right heart catheterization showed severe CS with cardiac output of 2.4 L/min, cardiac index of 1.5 L/min/m^2, systemic vascular resistance of 2010 (dyne*s)/cm^5, and pulmonary vascular resistance 150 (dyne*s)/cm^5 and central venous pressure 15 mmHg. The patient continued to deteriorate and manifested haemodynamic and electrical instability.

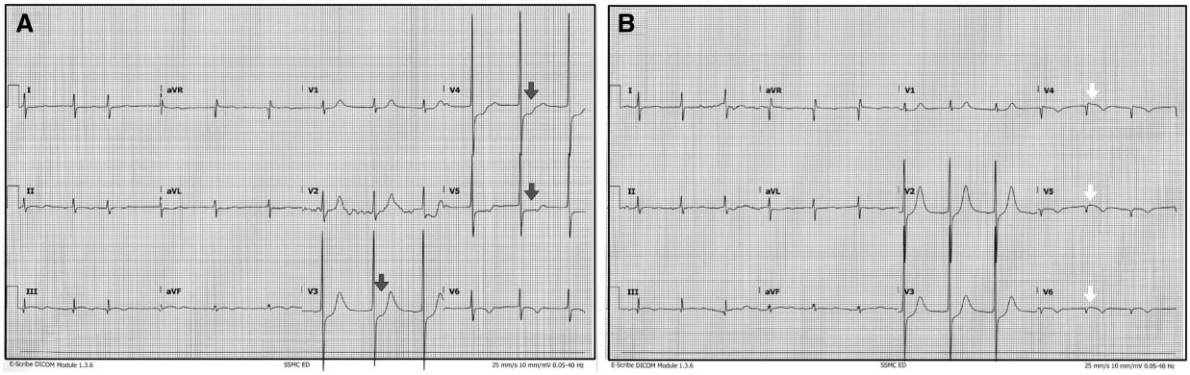


Figure 1 Electrocardiogram. Twelve-lead electrocardiogram: (*A*) atrial fibrillation, ST-depression with positive T in leads V2–V6 (black arrow), this is concerning of posterior wall ST-elevation myocardial infraction. (*B*) Mild ST-elevation in posterior leads V7–9 (white arrow).

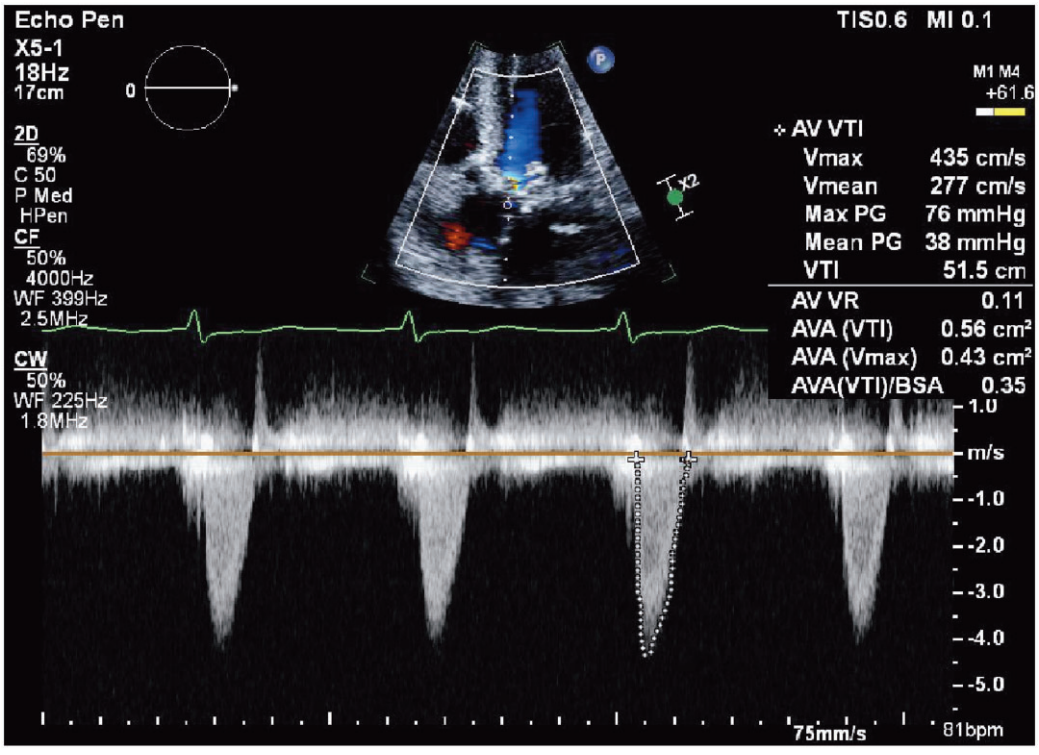


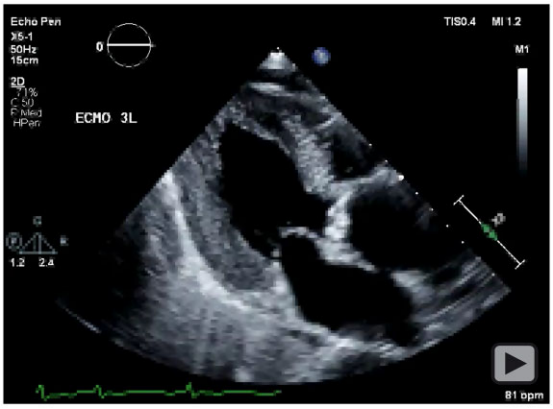
Figure 2 Transthoracic echo at initial presentation. Continue wave Doppler at apical five-chamber window showing severe aortic stenosis, peak velocity 435 cm/s, mean pressure gradient 38 mmHg, aortic valve area = 0.56 cm^2, and aortic valve area index = 0.35 cm^2/m^2.

He had an episode of pulseless ventricular tachycardia resuscitated with DDC shock 150 kJ and 1 cycle of cardiopulmonary resuscitation and escalation of vasopressors and inotropic support. Hospital heart failure and shock team decided to proceed with urgent veno-arterial extracorporeal membrane oxygenation (VA-ECMO) as a bridge to aortic valve intervention and recovery. The patient was cannulated and connected on VA-ECMO with the following parameters: femoro-femoral cannulation, right femoral venous access 23F, left femoral artery return 17F, reperfusion cannula 6F on the left side, flow 4 LPM, speed 3520 rpm, and blender 100%.

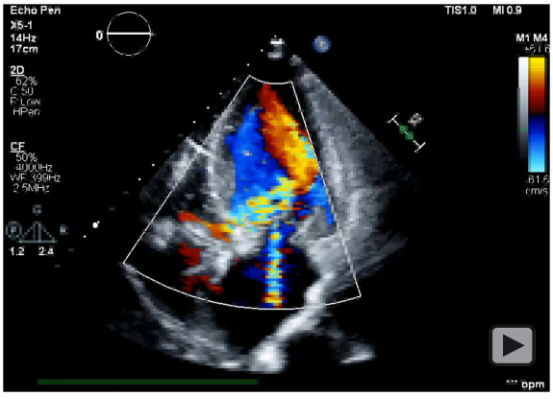
Aortic valve intervention

A multidisciplinary heart team meeting was held with decision to proceed with percutaneous aortic balloon valvuloplasty (PABV) to

better assess whether the patient would survive CS prior to committing to definitive valve therapy. The patient had profound CS and his predicted in-hospital mortality was extremely high. After coronary revascularization and initial stabilization of the patient with extracorporeal membranous oxygenation (ECMO), a computed tomography (CT) angiogram of the chest, abdomen, and pelvis was performed for procedural planning and confirmed a Sievers Type 0, a calcified bicuspid aortic valve with severe stenosis (*Figure 3*). Computed tomography was also performed knowing that PABV may be complicated by acute aortic regurgitation (AR) necessitating valve deployment.



Video 1 Transthoracic echo: apical 3 chamber window showing calcified aortic valve cusps with limited systolic excursion denoting severe aortic stenosis.



Video 2 Transthoracic echo: apical 5 chamber window showing severe aortic regurgitation after percutaneous aortic balloon valvuloplasty.

Aortic valve intervention was performed under general anaesthesia and guidance of transoesophageal echocardiography in a hybrid operating room. Right femoral artery access was obtained for the transcatheter heart valve sheath and valve delivery catheter. Left femoral venous access (6F) was obtained for the temporary pacemaker wire and central access. Our centre utilizes unilateral access with a 5F femoral artery sheath placed distal to device sheath for a 5F pigtail catheter in patients with appropriately sized femoral artery anatomy. Unilateral access in selected patients has been shown to be feasible and safe allowing for rapid treatment of vascular injury if needed.[4] Percutaneous aortic balloon valvuloplasty was performed and only marginally improved the gradient across the aortic valve but was complicated by severe AR (Supplementary material online, *Figure S2* and *Video 2*). The patient tolerated the severe AR due to the support of VA-ECMO; however, the treating team understood that survival would remain bleak without definitive treatment. The decision was then made to proceed with TAVR using a balloon-expandable valve (SAPIEN 3 Ultra, Edwards Lifesciences, Irvine, CA, USA) (*Figure 4*, Supplementary material online, *Figure S3* and *Video 3*). A balloon-expandable valve was used given our centers experience and supported by registry data showing good TAVR outcomes in patients with bicuspid anatomy without calcified raphe and/or excess leaflet calcification with a SAPIEN 3 valve.[5]

A combination of haemodynamic assessment, aortography, and echocardiography revealed a well-seated valve with no paravalvular regurgitation after valve implantation (*Figure 5*, Supplementary material online *Video S1*). Cardiac output improved to 3.2 L/min form 2.4 L/min and cardiac index 2.0 L/min/m^2 from 1.5 L/min/m^2.

Outcomes

The patient had marked improvement in his condition after TAVR with subsequent weaning and removal of IABP. Veno-arterial

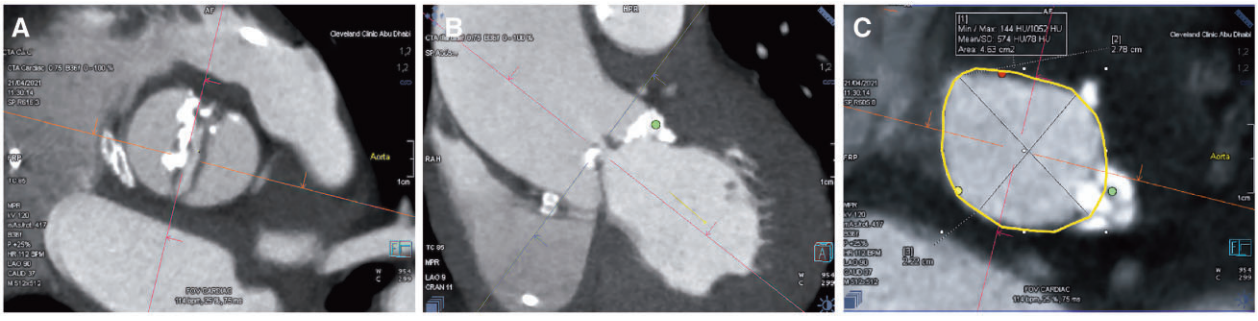


Figure 3 Contrast enhanced computed tomography. (*A*) Short axis of bicuspid aortic valve with right cusp calcification and limited systolic excursion. (*B*) Coronal view showing calcification extending to left ventricular out flow tract. (*C*) The area of the aortic annulus by planimetry = 4.3 cm^2.

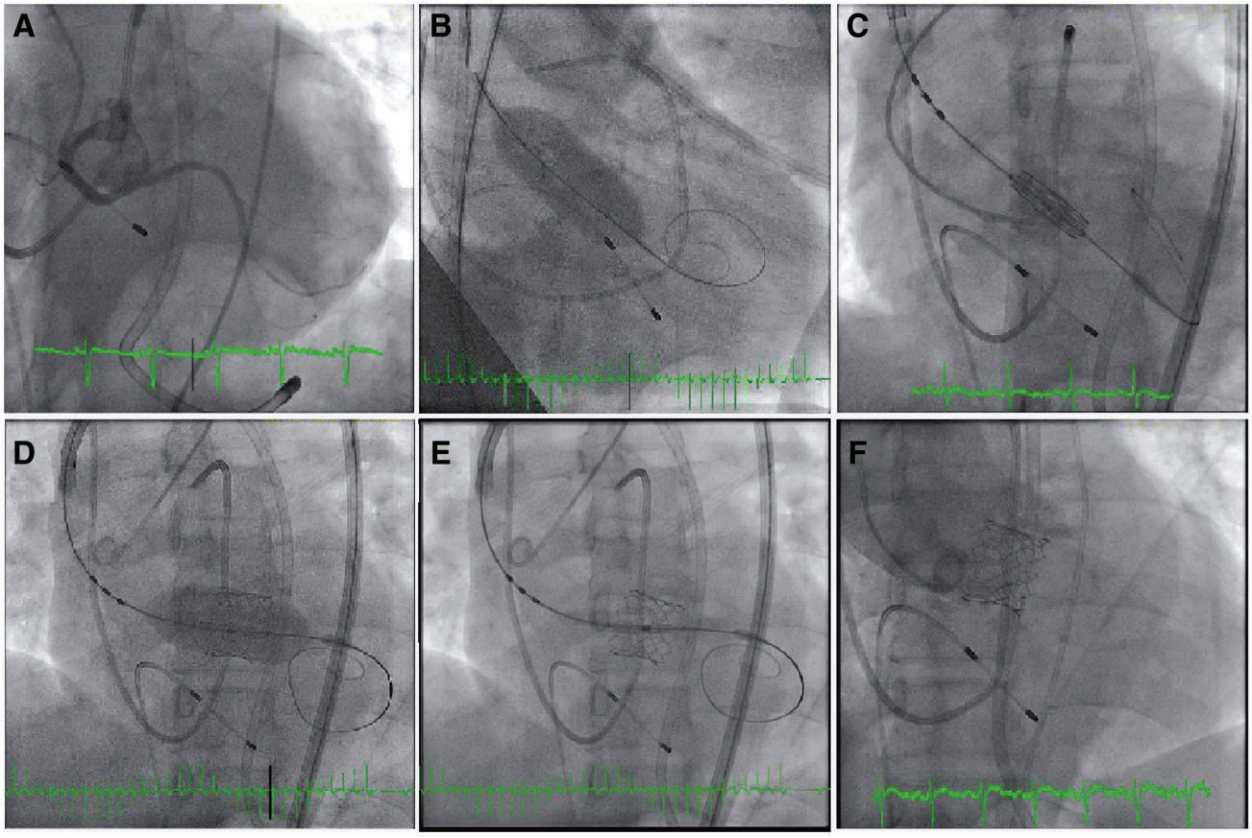
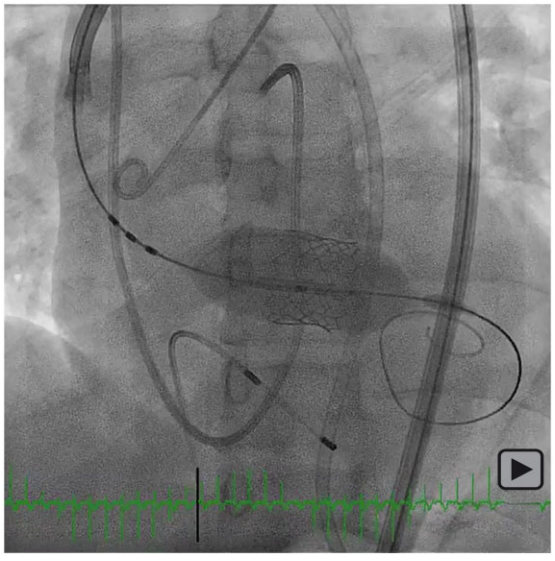


Figure 4 X-ray fluoroscopy. Transcatheter aortic valve replacement procedure: (*A*) Patent stent of circumflex artery coming off right coronary sinus. (*B*) Percutaneous aortic balloon valvuloplasty. (*C*) Positioning of the aortic valve bio-prosthesis. (*D*) The implantation of a balloon-expandable transcatheter heart valve (SAPIEN 3 Ultra, Edwards Lifesciences, Irvine, CA, USA). (*E*) The aortic bio-prosthesis in place after deployment. (*F*) Aortogram showing a well-seated valve with no paravalvular regurgitation after valve implantation.



Video 3 X-ray fluoroscopy showing successful implantation of a balloon-expandable transcatheter heart valve (SAPIEN 3 Ultra, Edwards Lifesciences, Irvine, CA, USA).

extracorporeal membrane oxygenation was able to be weaned and the patient decannulated within a week. After 32 days in the intensive care unit, the patient was transferred to the floor and made substantial progress. He had a minor stroke due to the initial period of hypotension and CS and received a combination of neurologic and cardiac rehabilitation. Follow-up echocardiogram showed a well-seated THV with no significant gradient or paravalvular regurgitation. His left ventricular systolic function improved from an initial 21% to 45% (Supplementary material online, *Video S1*).

Discussion

A retrospective analysis by 'Huang *et al.*' demonstrated that emergency TAVR in extreme risk patients with acute decompensated heart failure or CS secondary to severe AS is associated with high in-hospital mortality.[3] According to the new ESC guidelines for the management of valvular heart disease, surgical aortic valve replacement is preferred over TAVR in low-risk patients with age less than 75 years.[6] The presented patient was at extreme risk given the recent AMI and critical bicuspid AS and CS refractory to pressors. He was deemed to be inoperable

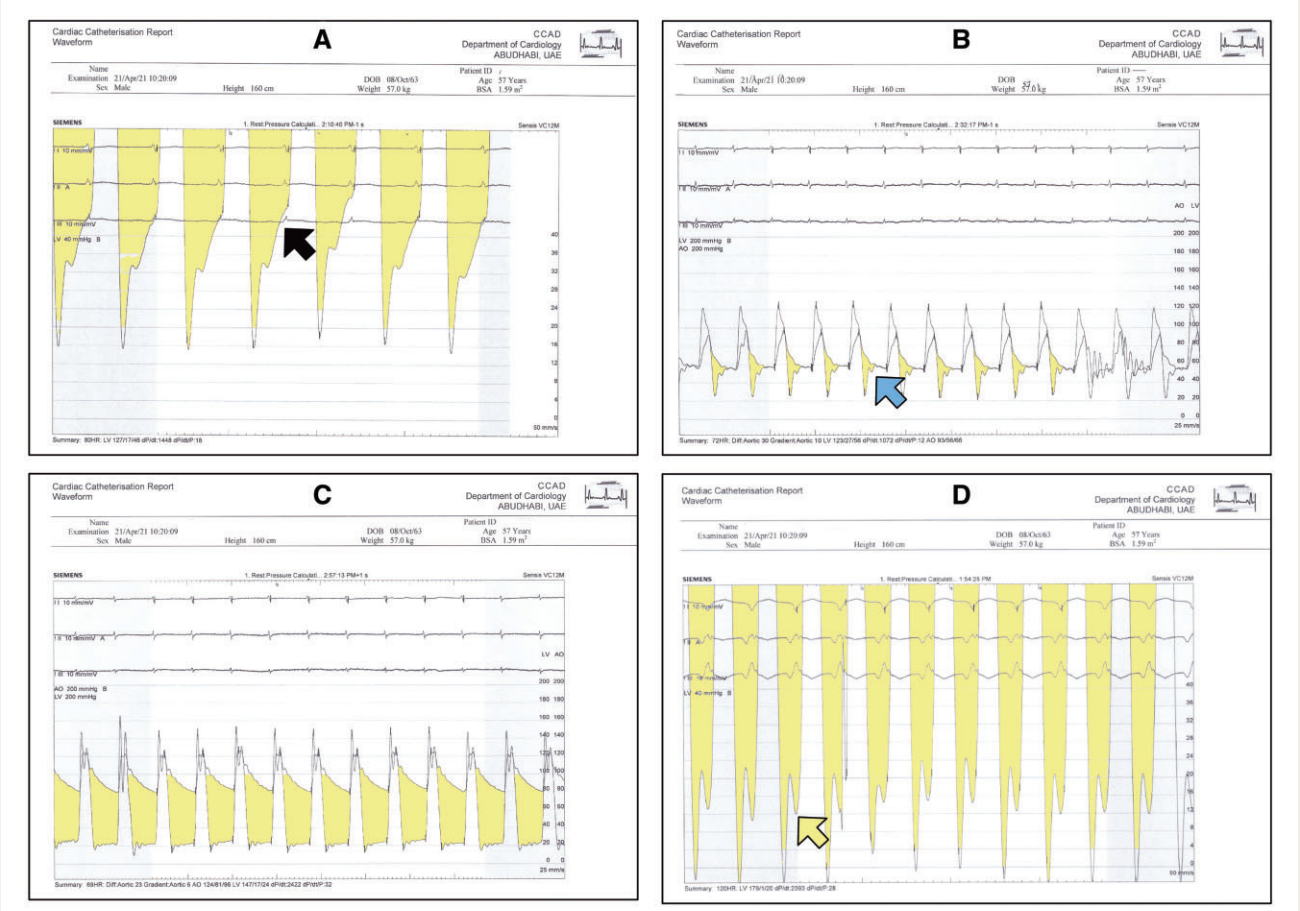


Figure 5 Haemodynamic tracing. (*A*) Elevated left ventricular end-diastolic pressure = 40 mmHg (black arrow) before transcatheter aortic valve replacement. (*B*) Post-percutaneous aortic balloon valvuloplasty showing rapid increase of left ventricular end-diastolic pressure with zero pressure gradient at the end of diastole secondary to severe aortic regurgitation (blue arrow). (*C*) Normal diastolic pressure gradient between aorta (80 mmHg) and left ventricle (12 mmHg) post-procedure. (*D*) Improvement of left ventricular end-diastolic pressure from 40 mmHg to 12 mmHg after procedure (white arrow). LVEDP, left ventricular end-diastolic pressure.

and not a candidate for open surgical intervention. Our established heart and shock team had a very rapid and effective strategic plan and the decision was for PABV with bailout TAVR if necessary. The patient was engaged in the Heart Team discussion and the recommendation was discussed with patient's family. A pre-operative cardiac CT was obtained for procedural planning in the event the patient developed severe AR as a result of balloon valvuloplasty. The decision to use mechanical circulatory support (MCS) early and pre-intervention improved the outcome and allowed the patient to not only survive the initial insult but also the severe AR after balloon valvuloplasty.

Periprocedural mortality has been shown to be higher in CS patients that were initiated on MCS after rather than before transcatheter heart interventions (50% vs. 12%, $P = 0.03$).[3] Mechanical circulatory support in the index patient allowed him to survive the initial insult and made the transcatheter intervention safer. A propensity-matched analysis of a large cohort of patients performed by Bandyopadhyay *et al.*[7] showed no difference in all-cause in-hospital mortality between emergency direct TAVR and PABV, but noted an increase in in-hospital and periprocedural adverse events. In a patient with AMI and refractory CS on VA-ECMO, the mortality is high and the outcome uncertain. Percutaneous aortic balloon valvuloplasty was performed to better understand whether the patient would recover with plan for staged valve intervention. However, PABV was complicated by severe AR and necessitated urgent TAVR noting that the patient's demise would otherwise be certain.

Conclusion

Our patient presented with AMI with refractory CS due to critical bicuspid AS. He was successfully treated with a combination of early mechanical circulatory support followed by PABV and TAVR. The indication for the procedure was established by a heart team decision.

Lead author biography

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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 has been obtained from the patient in line with COPE guidance.

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Conflict of interest: None declared.

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