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CASE REPORT
Valvular heart disease

Emergency transcatheter aortic valve implantation with a self-expandable valve under extracorporeal membrane oxygenation for cardiogenic shock due to bicuspid aortic stenosis: a case report

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Background Transcatheter aortic valve implantation (TAVI) is an established treatment for patients with severe aortic stenosis (AS). However, the effectiveness of TAVI for patients with cardiogenic shock due to severe bicuspid AS, who require mechanical circulatory support, needs further investigation.

Case summary A 64-year-old male patient was admitted to the hospital with congestive heart failure secondary to severe AS and severe left ventricular dysfunction. After admission, he developed cardiogenic shock, further worsening his condition. The patient was placed on veno-arterial extracorporeal membrane oxygenation support and an intra-aortic balloon pump and transferred to our hospital. Cardiac computed tomography revealed a severely calcified type 1 bicuspid valve. The patient was deemed inoperable by our heart team. Therefore, an emergency transfemoral TAVI with a self-expandable valve was performed on Day 2. It significantly improved his haemodynamic stability. The patient was finally discharged on Day 29 without any neurological sequelae.

Discussion Cardiogenic shock due to severe AS has poor prognosis. However, this case report demonstrates that TAVI could be the optimal treatment for haemodynamically unstable patients with severe AS who require mechanical circulatory support.

Keywords Aortic valve stenosis • Bicuspid valve • Cardiogenic shock • Mechanical circulatory support • Transcatheter aortic valve implantation • Case report

ESC curriculum 4.2 Aortic stenosis • 6.2 Heart failure with reduced ejection fraction

Learning points

- To recognize transcatheter aortic valve implantation (TAVI) with mechanical circulatory support as an optimal treatment for severe aortic stenosis complicated by cardiogenic shock.
- To verify whether a severely calcified type 1 bicuspid aortic valve can achieve adequate dilation following TAVI with a self-expandable valve.

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Introduction

Transcatheter aortic valve implantation (TAVI) is a recognized therapy for patients with severe aortic stenosis (AS),[1,2] with its indications expanding to include even low-risk surgical patients.[3,4] However, the presence of bulky, asymmetric leaflet calcification in bicuspid AS makes TAVI challenging. Co-existing severe AS and cardiogenic shock lead to poor outcomes in the acute phase.[5] Therefore, the efficacy of TAVI for patients with severe bicuspid AS and cardiogenic shock, who require mechanical circulatory support, has not been well studied. Herein, we report a case where successful treatment of cardiogenic shock secondary to severe bicuspid AS and left ventricular dysfunction was achieved with emergency TAVI with a self-expandable valve under veno-arterial extracorporeal membrane oxygenation (VA-ECMO) support and intra-aortic balloon pumping (IABP).

Summary figure

Day −21	Admission to the previous hospital with congestive heart failure secondary to severe aortic stenosis and severe left ventricular dysfunction
Day −7	Worsening of heart failure
Day −2	Intubation
Day −1	Veno-arterial extracorporeal membrane oxygenation (VA-ECMO) and intra-aortic balloon pumping (IABP) were inserted to manage cardiogenic shock
Day 0	Transfer to our hospital
Day 2	Transcatheter aortic valve implantation under VA-ECMO IABP was replaced with 18-Fr sheath
Day 5	VA-ECMO decannulation
Day 6	Extubation
Day 29	Discharge from our hospital

Case presentation

A 64-year-old man was diagnosed with a systolic murmur during a routine medical check-up 5 years ago. However, he had not undergone further detailed investigations or been hospitalized for heart failure. His medical history included well-controlled hypertension, hyperlipidaemia, and chronic obstructive pulmonary disease. The patient presented to the hospital with progressive dyspnoea on exertion, ongoing since several months, and was admitted with congestive heart failure. Transthoracic echocardiography revealed left ventricular ejection fraction (LVEF) of 20%, severe AS, and left ventricular thrombus (LVT) (*Figure 1*). The patient became haemodynamically unstable because of cardiogenic shock during his pre-operative work-up. He was intubated and treated with a high dose of inotropes, with no haemodynamic improvement. Veno-arterial extracorporeal membrane oxygenation was inserted through the right femoral artery and vein, and IABP was inserted through the left femoral artery. Thereafter, the patient was transferred to our hospital for further therapeutic planning. On admission, a transthoracic echocardiogram demonstrated impaired LVEF of 20%; mild-to-moderate aortic regurgitation (AR); and severe AS with a peak velocity of 4.9 m/s, mean pressure gradient of 59 mmHg, and aortic valve area of 0.54 cm^2 (see Supplementary material online, *Video S1A*). Echocardiograms confirmed anticoagulation-induced LVT disappearance (see Supplementary material online, *Video S1B*). Laboratory data revealed elevated levels of brain natriuretic peptide (BNP, 3586.4 pg/mL, reference 0.0–18.4 pg/mL), ischaemic hepatitis (aspartate aminotransferase [AST], 3670 U/L, reference 8–38 U/L; alanine aminotransferase [ALT], 2196 U/L, reference 4–44 U/L), and renal failure (serum creatinine, 1.81 mg/dL, reference 0.61–1.04 mg/dL). Cardiac computed tomography (CCT) confirmed a calcified type 1 bicuspid valve (*Figure 2*; Supplementary material online, *Video S2*). The aortic annular area and perimeter measured 530 mm^2 and 85.3 mm, respectively (*Figure 2A*). The ascending aorta was dilated, with a diameter of 41 mm. Due to the patient's worsened clinical condition and high surgical risk (EuroSCORE II: 46.8%, STS score: 17.1%), TAVI was deemed as a feasible alternative to surgical aortic valve replacement (SAVR). The CCT-assessed virtual aortic annular perimeter was 74.7 mm (*Figure 2B* and *C*). Hence, a 29 mm Evolut self-expandable prosthetic aortic valve (Medtronic, Minneapolis, MN, USA) was implanted. The TAVI procedure was carried out on Day 2 under general anaesthesia and with transoesophageal echocardiography. Left femoral venous (6F) and left radial artery (6F) accesses were obtained for the temporary pacemaker wire and the pigtail catheter, respectively. Considering the access routes, the IABP from the left femoral artery was replaced with an 18-Fr sheath. Pre-dilatation was performed using a 20 mm balloon (Z-MED 20 mm, NuMED, Hopkinton, NY, USA) (*Figure 3A*). Based on aortic angiography, a self-expandable prosthetic 29 mm valve was deployed with a pigtail catheter in the non-coronary sinus (*Figure 3B*). However, its expansion was hampered due to extensive calcification. The nose cone was then gently pulled back into the ascending aorta using rotational fluoroscopy (*Figure 3C*; Supplementary material online, *Video S3A and B*). Transoesophageal echocardiography (TEE) and aortography demonstrated mild-to-moderate paravalvular AR after post-dilatation of a 20 mm balloon (*Figure 3D*). The aortic peak-to-peak pressure gradient improved from 71 to 12 mmHg after the procedure (*Figure 3E*).

The patient was successfully weaned off VA-ECMO after TAVI. He demonstrated significant haemodynamic recovery following the procedure. After the resolution of pulmonary congestion, VA-ECMO was discontinued on Day 5. The post-procedural transthoracic echocardiogram demonstrated improvement of LVEF to 38% from the initial 20%, mild AR, and a peak velocity of 2.3 m/s (see Supplementary material online, *Video S4A and B*). Cardiac computed tomography 4 months after TAVI revealed a self-expandable prosthesis with flattened spreading (*Figure 4A* and *B*; Supplementary material online, *Video S5*).

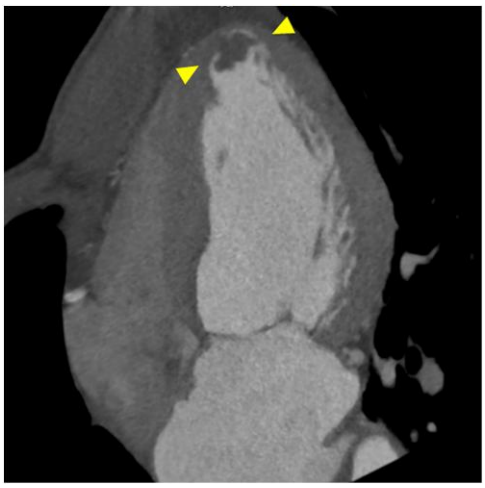

Figure 1 Left ventricular thrombosis detected by cardiac computed tomography. Cardiac computed tomography demonstrates left ventricular thrombus.

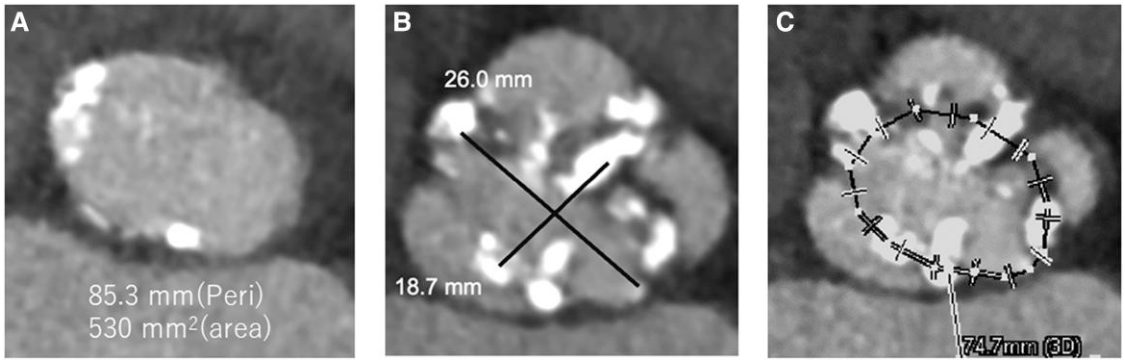

Figure 2 Cardiac computed tomography before the procedure. (*A*) Aortic annular area and perimeter measurements are 530 mm^2 and 85.3 mm. (*B*, *C*) Virtual aortic annular perimeter and annulus measurements are 74.7 mm and 18.7 mm × 26.7 mm, respectively.

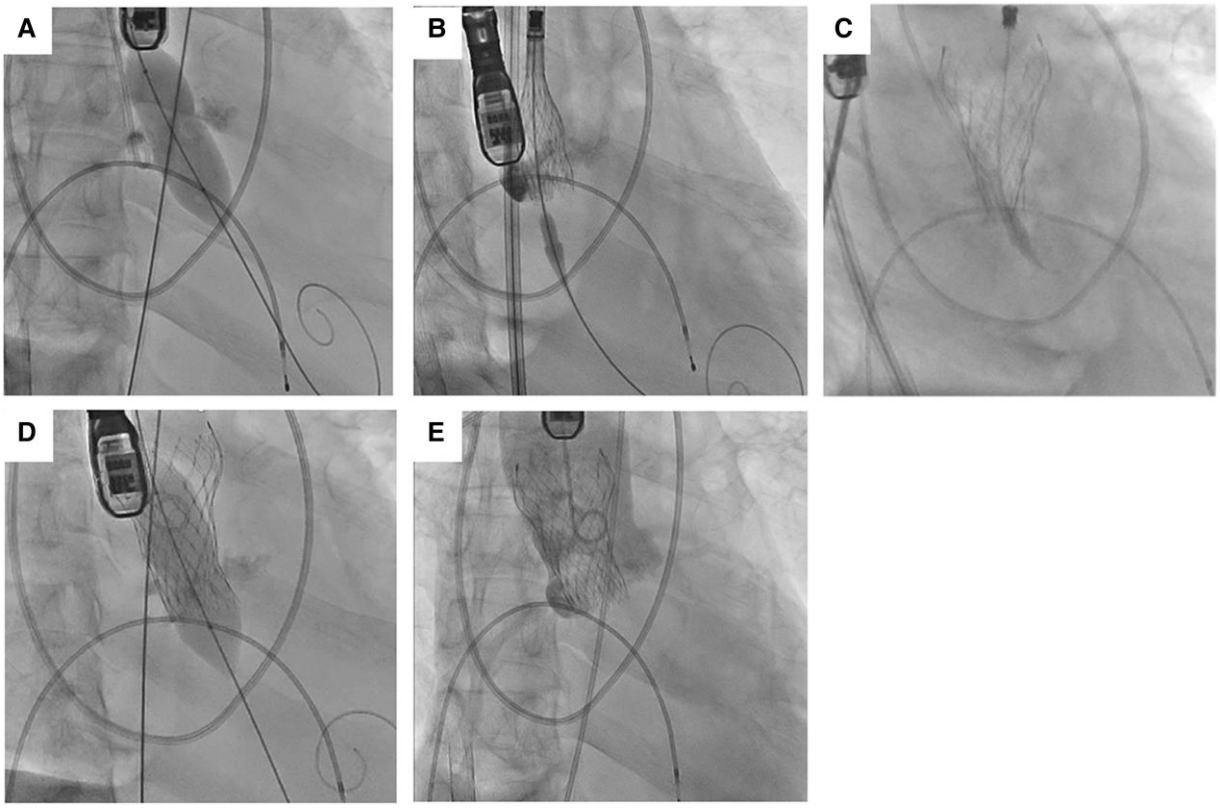

Figure 3 Fluoroscopic view during transcatheter aortic valve implantation. (*A*) Pre-dilation using a 20 mm balloon. (*B*) Deployment of the self-expandable prosthesis. (*C*) Pulling of the nose cone from the left ventricle. (*D*) Post-dilation of a 20 mm balloon. (*E*) Fluoroscopic view of the self-expandable prosthesis after post-dilatation.

The patient was prescribed medications including angiotensin-converting enzyme inhibitors, β-blockers, and diuretics. He was discharged on Day 29 without neurological sequelae. Transthoracic echocardiography revealed LVEF of 50%, peak aortic velocity of 2.95 m/s, and mild-to-moderate AR at 8 months after the procedure. One year later, the patient remained in good clinical condition, with no re-admission for heart failure.

Discussion

The American College of Cardiology/American Heart Association and European Society of Cardiology guidelines recommend TAVI as a class I indication for high-risk surgical patients.[6,7] However, the effectiveness of TAVI in the management of cardiogenic shock with mechanical circulatory support has not been well investigated. In most TAVI studies,

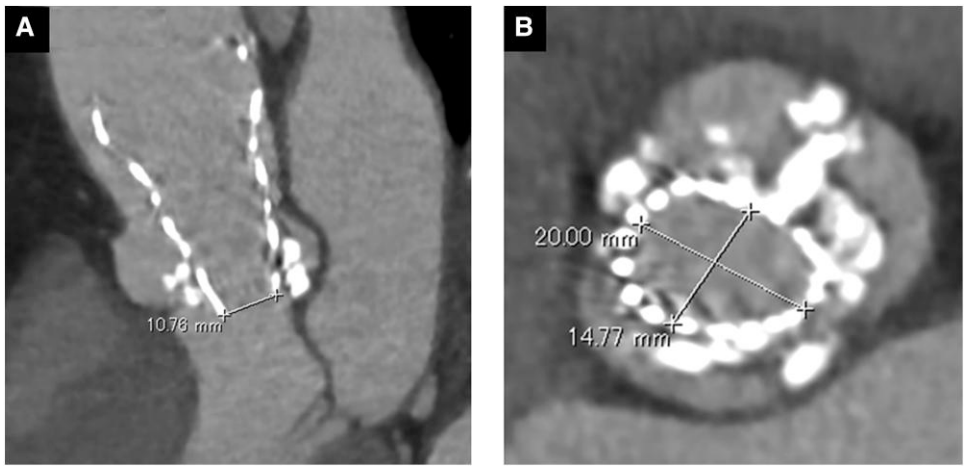

Figure 4 Cardiac computed tomography following the transcatheter aortic valve implantation procedure. Cardiac computed tomography reveals a self-expandable prosthetic valve with flattened spreading. (*A*) Coronary axis view. (*B*) Axial view.

the exclusion criteria have included severe AS with cardiogenic shock manifested by low cardiac output, vasopressor dependence, or mechanical haemodynamic support.[4] Herein, we report a successful TAVI with a self-expandable prosthesis in a 64-year-old male patient with cardiogenic shock, who required VA-ECMO support and IABP because of severe bicuspid AS and left ventricular dysfunction. Balloon aortic valvuloplasty (BAV) followed by SAVR, emergency TAVI, and emergency SAVR were considered the treatment options in this case. However, BAV could acutely exacerbate our patient's pre-existing AR and haemodynamic instability,[8] as the patient exhibited mild-to-moderate AR before the procedure. Additionally, our patient had a high surgical risk score. Before the advent of TAVI, the in-hospital mortality rate of emergency SAVR was as high as 30%.[9] Moreover, SAVR performed in the context of cardiogenic shock requiring mechanical circulatory support is associated with a high risk of complications. Therefore, we decided to perform an emergency TAVI.

Another significant aspect of this case was the presence of a bicuspid aortic valve. Transcatheter aortic valve implantation for bicuspid AS is challenging because of the bulky, asymmetrical leaflet calcifications and also the scarcity of evidence of TAVI performed in bicuspid aortic valve stenosis cases. Our patient had a severely calcified type 1 bicuspid valve. In this case, balloon dilatation was predicted to lead to insufficient expansion. Therefore, we chose the self-expandable valve with a supra-annular design, which can mitigate the effects of valve asymmetry and under-expansion, resulting in a better haemodynamic profile. Previous reports have demonstrated that self-expandable valves had a better haemodynamic profile at discharge and at 1-year follow-up with a lower mean gradient and higher effective orifice area.[10] Our patient was treated by using a self-expandable valve from cardiogenic shock requiring VA-ECMO support and IABP because of severe bicuspid AS and left ventricular dysfunction. However, CCT post-TAVI revealed a poorly spread and flat prosthesis. Hence, a future SAVR may be required due to the patient's age. Therefore, an inadequate expansion of the TAVI prosthesis should be considered in a highly calcified bicuspid valve.

In conclusion, we report a case where successful treatment of cardiogenic shock secondary to severe bicuspid AS and left ventricular dysfunction was achieved with emergency TAVI with a self-expandable valve under VA-ECMO support and IABP. Transcatheter aortic valve implantation could be the optimal treatment for severe AS with haemodynamic instability requiring mechanical circulatory support; however, further research is required to investigate long-term outcomes.

Lead author biography

Takumi Osawa is an interventional cardiologist. He graduated from National Defense Medical College and received his MD degree in 2018. From 2020, he had cardiology training in the Department of Cardiology, University of Tsukuba, and serves as a medical staff.

Supplementary material

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

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

Consent: Written informed consent was obtained from the patient for publication of this case report in accordance with COPE guidelines.

Conflict of interest: None declared.

Funding: None declared.

Data availability

The data underlying this article are available in the article and in its online supplementary material.

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