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CASE REPORT
Coronary heart disease

Successful emergent transcatheter aortic valve implantation and left ventricular unloading by Impella in a patient with severe aortic stenosis who experienced cardiogenic shock after primary percutaneous coronary intervention for ST-elevation myocardial infarction: a case report

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Background Determining the treatment strategy for cardiogenic shock following ST-elevation myocardial infarction in a patient with severe aortic stenosis remains challenging and is a matter of debate.

Case summary An 84-year-old man with chest pain was transferred to our institute and subsequently diagnosed with ST-elevation myocardial infarction and Killip class III heart failure. The patient was intubated, and urgent coronary angiography revealed severe tandem stenosis from the proximal to mid-left anterior descending coronary artery. We performed a primary percutaneous coronary intervention (PCI) and deployed drug-eluting stents from the left main trunk to mid-left anterior descending coronary artery. Although the procedure was successful, the patient went into cardiogenic shock a few hours later. Transthoracic echocardiography revealed low cardiac function and severe aortic stenosis. We decided to perform transcatheter aortic valve implantation using a self-expandable valve, followed by the insertion of a left ventricular assist device. The combination of procedures achieved haemodynamic stability.

Discussion It is difficult to treat cardiogenic shock that develops in patients with severe aortic stenosis and ST-elevation myocardial infarction. This case report demonstrates that combined transcatheter aortic valve replacement using a self-expanding valve and left ventricular assist device placement can be safe and effective after a primary PCI.

Keywords Impella CP • Transcatheter aortic valve implantation • ST-elevation myocardial infarction • Aortic stenosis • Cardiogenic shock • Case report

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Learning points

- The combined transcatheter aortic valve implantation and left ventricular assist device can be an effective treatment strategy for cardiogenic shock in a patient with aortic stenosis.
- The potential pitfalls of using the Impella CP with a transcatheter heart valve that has a supra-annular design should be fully understood.

Introduction

Cardiogenic shock following ST-segment elevated myocardial infarction (STEMI) is a complex clinical situation. Percutaneous left ventricular assist devices, such as the Impella CP (Abiomed, Inc., Davers, MA, USA), are effective in such situations but should be used cautiously if the patient has significant aortic valve disease.

We report herein the presentation and treatment of a patient with severe aortic stenosis who experienced cardiogenic shock after undergoing a successful primary percutaneous coronary intervention (PCI) for STEMI. We treated him with transcatheter aortic valve implantation (TAVI) and insertion of an Impella CP device.

Timeline

Day 1	An 84-year-old patient with severe aortic stenosis is admitted with ST-elevation myocardial infarction and Killip class III heart failure.
30 min after admission	Primary percutaneous coronary intervention is performed, with implantation of drug-eluting stents from the left main trunk to the left anterior descending coronary artery (segments 5–7).
14 h after admission	Emergent transcatheter aortic valve implantation is performed for cardiogenic shock, using a self-expandable bioprosthetic valve.
15 h after admission	An Impella CP device is inserted through the transcatheter heart valve to provide circulatory support.
8 days after admission	The Impella CP device is removed.
35 days after admission	The patient is discharged from the hospital.
3 months after admission	At his outpatient follow-up visit, the patient is in good condition, with a New York Heart Association functional class II. Transthoracic echocardiography shows improved cardiac function.

Case presentation

An 84-year-old man was admitted to the emergency department of our hospital with a diagnosis of STEMI. His medical history was significant for atrial fibrillation, hypertension, diabetes mellitus, and cerebral infarction. He had reported repeated episodes of chest pain over a period of 1 week and was referred to our hospital after complaining of chest pain lasting several hours.

Upon admission, his blood pressure was 102/66 mmHg, his heart rate was 124 beats/min, and atrial fibrillation was noted. He was in acute decompensated heart failure (Killip class III) and experiencing worsening oxygen desaturation despite the use of non-invasive positive pressure ventilation. Endotracheal intubation was performed in the emergency department.

His electrocardiogram (ECG) showed ST-segment elevation and terminal T-wave inversion in leads V1 through V5. Transthoracic echocardiogram (TTE) demonstrated severe left ventricular impairment in the anteroseptal and apical areas, together with severe aortic stenosis and moderate aortic regurgitation.

Urgent coronary angiography showed severe tandem stenosis from the proximal to mid-left anterior descending coronary artery (*Figure 1*). The patient underwent primary PCI with vasopressor support; drug-eluting stents were successfully deployed from the left main trunk to mid-left anterior descending segments of the artery. Post-intervention, the patient's systolic blood pressure gradually decreased despite the combined use of dobutamine and noradrenaline. He eventually went into cardiogenic shock, with an increasing arterial lactate value.

Repeat TTE revealed that peak aortic jet velocity was 4.2 m/s, aortic valve area was 0.5 cm^2, and the left ventricular ejection fraction was 30% (*Figure 2A*). We decided that intervention was necessary to improve the patient's haemodynamic state. We obtained ECG-gated cardiac computed tomography and decided to perform TAVI using a transfemoral approach (*Figure 2B* and *C*). We anticipated that some form of mechanical circulatory support would be necessary if, after TAVI, shock was sustained.

First, balloon aortic valvuloplasty (BAV) was performed to facilitate the insertion and deployment of the aortic bioprosthesis, with a 20-mm Inoue balloon (Toray Medical Co. Ltd, Tokyo, Japan) which does not require rapid ventricular pacing during dilatation. Then, a 29-mm CoreValve Evolut PRO (Medtronic, Minneapolis, MN, USA) transcatheter aortic valve was smoothly inserted and deployed without repositioning (*Figure 3A* and *B*). Despite the successful TAVI, the patient remained in cardiogenic shock requiring considerable catecholamine support. The Impella CP device was deemed to be appropriate because it significantly augments cardiac output and has a high efficacy in left ventricular unloading. We inserted the Impella CP device into the left ventricle, paying careful attention not to interfere with the new valve, by using fluoroscopy and transoesophageal echocardiography guidance to ensure that the device was positioned properly (*Figure 3C* and *D*).

After insertion of the left ventricular assist device, the patient achieved haemodynamic stability, and his catecholamine dosage was gradually reduced. Weaning of the patient from the Impella CP was successful on the 8th day post-admittance, and he was extubated on

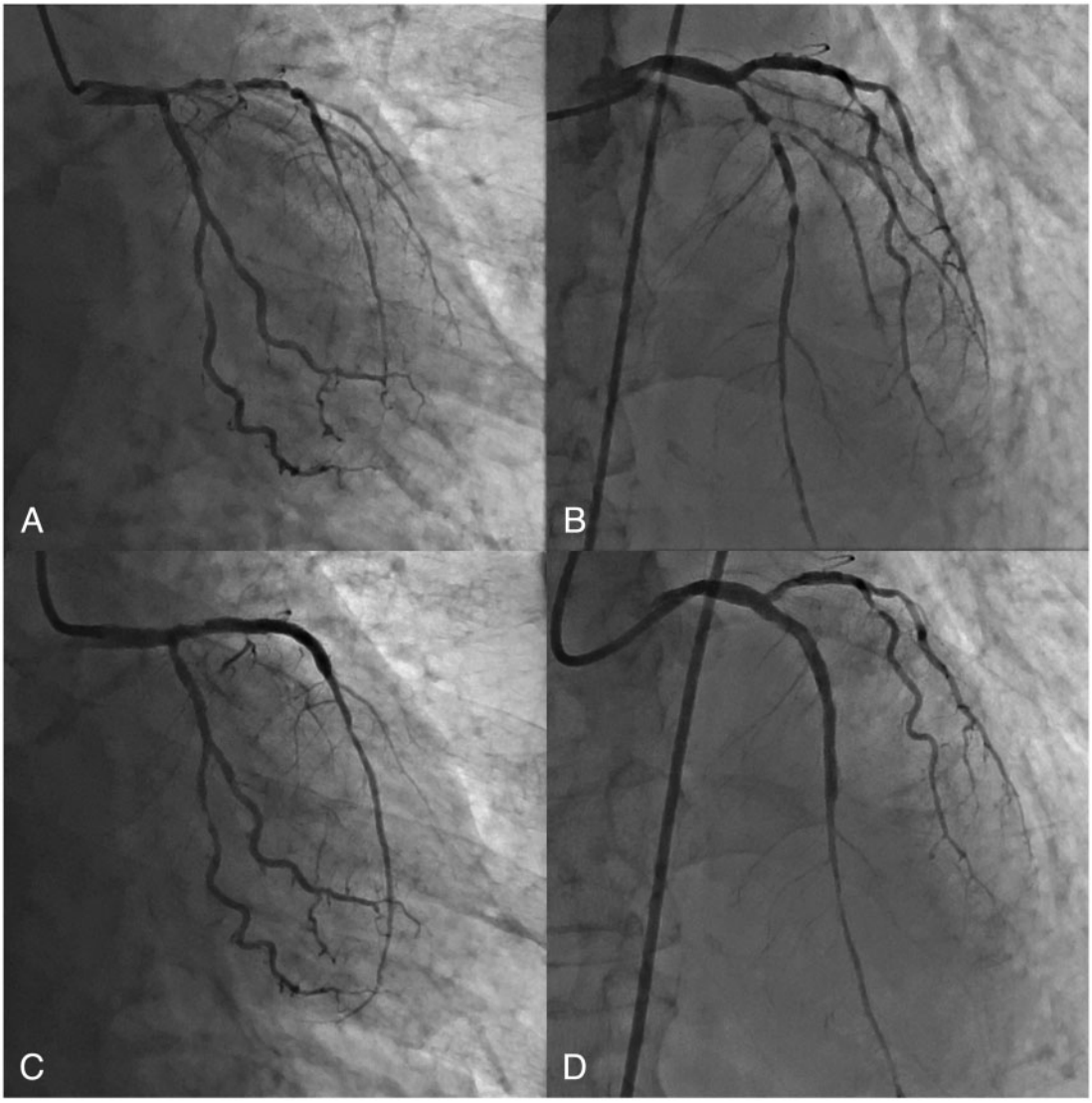

Figure 1 (*A* and *B*) Coronary angiography shows severe stenosis from the proximal to mid-left anterior descending coronary artery. (*C* and *D*) Drug-eluting coronary stents are deployed from segments 5–7.

the following day. He required continued hospitalization for bacteraemia and *Clostridium difficile* colitis, but he was transferred to a community hospital for rehabilitation 35 days after admission.

The patient visited our outpatient clinic 3 months after admission and reported no symptoms of heart failure. Follow-up TTE showed improvement of the left ventricular ejection fraction and normal functioning of the aortic bioprosthesis.

Discussion

Patients with severe aortic stenosis who experience STEMI can easily go into cardiogenic shock. Although the treatment strategy for cardiogenic shock has dramatically changed with the advent of the Impella device,[1] it is still challenging to treat patients with severe aortic stenosis. There are few reports describing the use of the Impella device in patients with severe left ventricular dysfunction and severe aortic valve disease.

Because surgical aortic valve replacement is too risky, transcatheter therapeutic options are usually considered. Fortunately, ECG-gated cardiac computed tomography suggested that the patient's anatomy would allow transfemoral TAVI; however, we suspected that, even after successful TAVI, he could remain haemodynamically unstable because of impaired left ventricular dysfunction induced by the myocardial infarction. Therefore, we discussed the possible need for mechanical support post-TAVI.

A balloon-expandable bioprosthesis might be preferable to a self-expandable bioprosthesis in terms of the ease of access to the coronary arteries and the device-device interaction with the Impella device. However, a balloon-expandable bioprosthesis had the potential risk of microcirculatory arrest and further haemodynamic deterioration caused by rapid ventricular pacing.[2] From

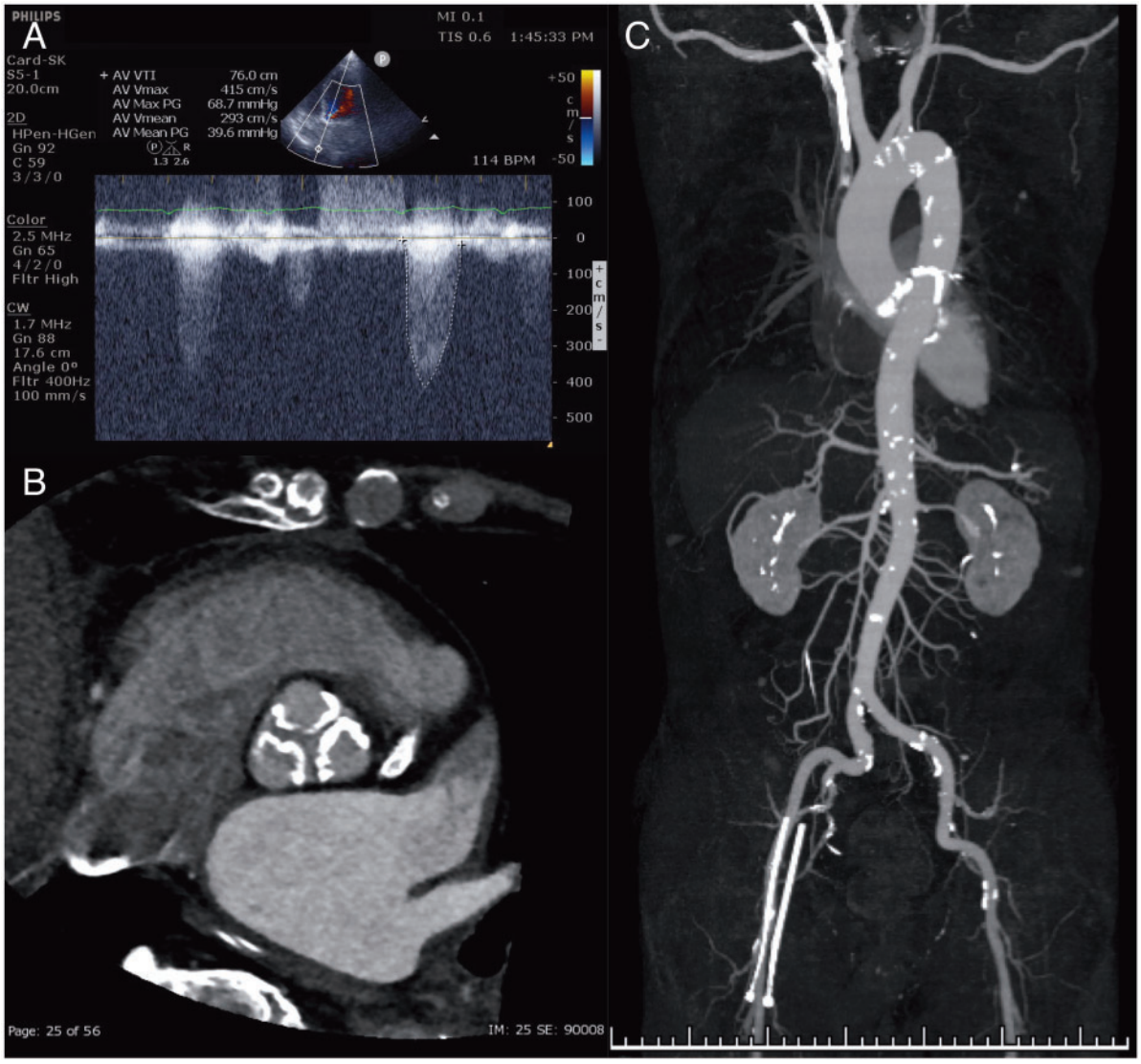

Figure 2 (*A*) Transthoracic echocardiography shows severe aortic stenosis with a peak velocity of 4.2 m/s and an aortic valve area of 0.5 cm^2. (*B* and *C*) Electrocardiography-gated cardiac computed tomography demonstrates severe calcification of all aortic leaflets. Contrast computed tomography demonstrates the full body access route.

the state of the patient's cardiac function and haemodynamic state, we decided to use a self-expandable bioprosthesis in this case. Given that the patient's left ventricular ejection fraction was only 30%, aortic valve stenosis could have potentially been more severe than that estimated from peak aortic jet velocity. Pre-BAV was deemed necessary to facilitate the introduction of the bioprosthesis within the calcified aortic valve and well-placed deployment without slippage during expansion. Then, we used the Inoue balloon which does not require rapid ventricular pacing during dilatation for pre-BAV[3] and achieved successful bioprosthesis deployment without further haemodynamic deterioration.

Mechanical support was necessary because the patient remained in cardiogenic shock. It is well known that intra-aortic balloon pumping is not useful in improving the prognosis of patients with acute myocardial infarction[4] nor for irregular tachycardia.[5] Although routine use of the Impella device for cardiogenic shock remains a matter of debate,[6,7] the Impella CP has the advantage of being less susceptible to being affected by irregular tachycardia because of its steady flow system, and it provides greater augmentation of cardiac output than intra-aortic balloon pumping.[8] It also has the advantage of left ventricular unloading, which leads to a reduction of left ventricular end-diastolic pressure and an improvement of pulmonary congestion.[9,10] Venoarterial extracorporeal membrane oxygenation was considered unsuitable because the patient's oxygenation was sufficiently maintained by mechanical ventilation, and it has the disadvantage of increasing left ventricular afterload. Based on these discussions, we decided to insert the Impella CP, and we were able to haemodynamically stabilize the patient.

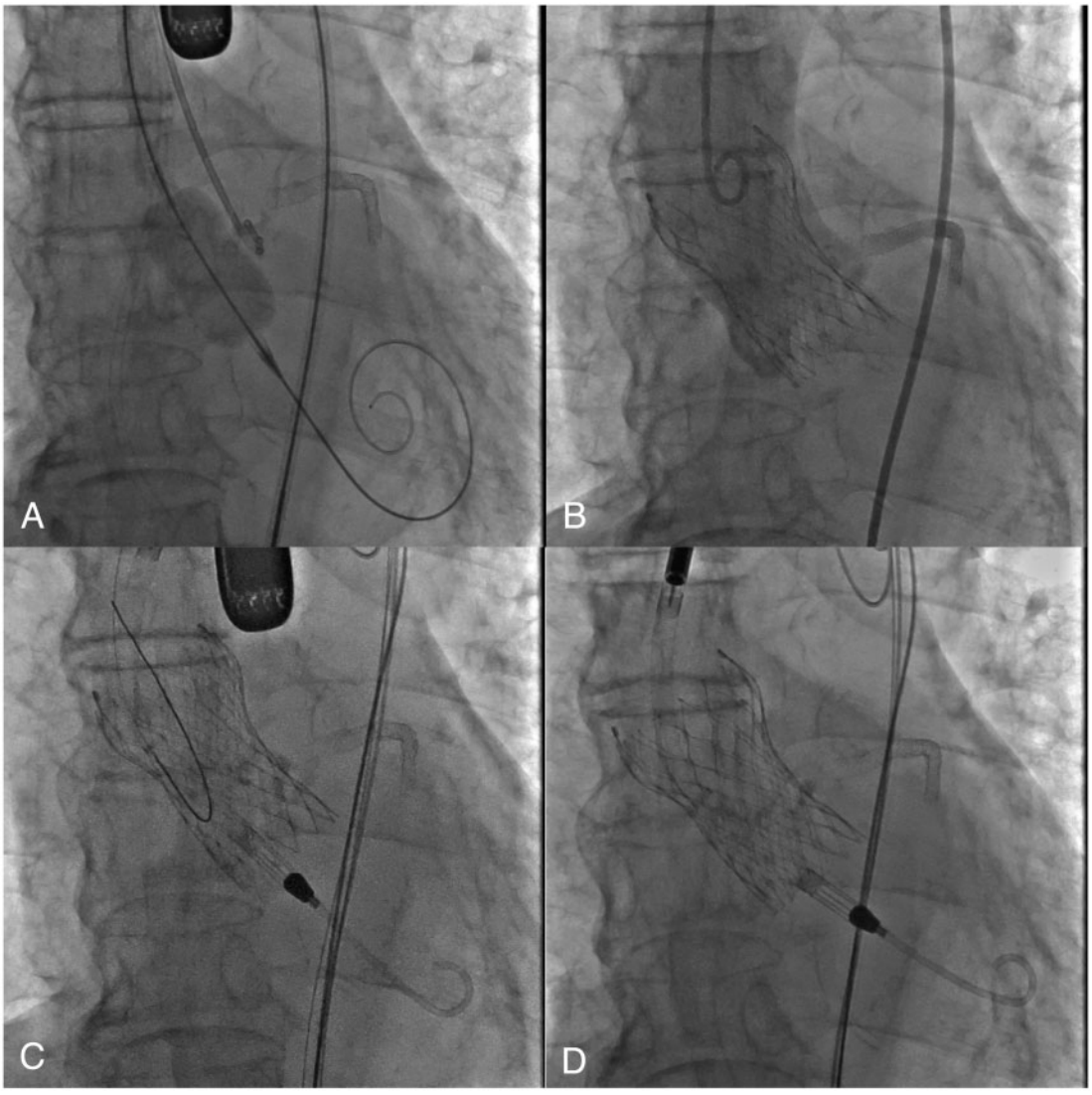

Figure 3 (*A* and *B*) Balloon aortic angioplasty was performed using a 20-mm Inoue balloon without rapid pacing, followed by deployment of a 29-mm CoreValve Evolut PRO. (*C* and *D*) The Impella CP guidewire for the left ventricle was placed onto the leaflets of the CoreValve Evolut PRO to confirm that it was in proper position; the outlet of the Impella CP device was at the proper distance from the tip of the CoreValve.

However, inserting and placing the Impella device through a CoreValve requires careful attention. The position of the Impella device outlet must be noted because the tip of the valve frame may enter the blood outlet area of the Impella device and break the rotary wing, causing not only dysfunction of the Impella device but also systemic embolism. In addition, the Impella device must not be inserted too deeply into the left ventricle because of the supra-annular design of the CoreValve. It is useful to place the Impella device guidewire for the left ventricle onto the valve leaflets so that the radiopaque marker of the Impella device is set in the proper position. With attention to these points, use of the Impella CP can be safe and effective in a patient with cardiogenic shock who is receiving a CoreValve aortic bioprosthesis.

Lead author biography

Yutaka Konami is an interventional cardiologist. He graduated from Tohoku University and received the MD degree in 2009. He had cardiology training in Department of Cardiology, Tokyo Women's Medical University, Japan. From 2018, he serves as a senior medical staff at Saiseikai Kumamoto Hospital, Japan.

Supplementary material

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

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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: 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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