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CASE REPORT
Other

Use of extracorporeal membrane oxygenation as a bridge to transcatheter aortic valve replacement in a patient with aortic stenosis and severe coronary artery disease: a case report

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Background Patients with severe aortic stenosis (AS) often present with multiple comorbidities and suffer from critical coronary artery disease (CAD). Transcatheter aortic valve replacement (TAVR) has become the therapy of choice for moderate to high-risk patients. Venoarterial extracorporeal membrane oxygenation (v-a-ECMO) offers the possibility of temporary cardiac support to manage life-threatening critical situations.

Case summary Here, we describe the management of a patient with severe AS and CAD with impaired left ventricular ejection fraction (LVEF). We used v-a-ECMO as an emergency strategy in cardiogenic shock during a high-risk coronary intervention to stabilize the patient, and as a further bridge to TAVR.

Discussion Very high-risk patients with severe AS are unlikely to tolerate the added risk of surgical aortic valve replacement. Using ECMO may help them to benefit from TAVR as the only treatment option available.

Keywords Transcatheter aortic valve replacement • Extracorporeal membrane oxygenation • Aortic stenosis • Cardiogenic shock • Mechanical circulatory support • Percutaneous coronary interventions • Case report

Learning points

- Using extracorporeal membrane oxygenation may help to expand the number of potential candidates who would benefit from transcatheter aortic valve replacement (TAVR).
- In haemodynamically unstable patients with aortic stenosis with a high risk of surgery, balloon valvuloplasty should also be regarded as a bridge to TAVR.

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Introduction

Transcatheter aortic valve replacement (TAVR) has become the treatment of choice for elderly patients with severe aortic stenosis (AS) and with high and intermediate operative risk.[1–3] Patients undergoing TAVR usually have multiple comorbidities, such as coronary artery disease (CAD) and impaired left ventricular function. These relevant comorbidities lead to increased risk and potentially life-threatening situations.[4] Cardiogenic shock is one of the most serious complications. Treatment of patients with cardiogenic shock secondary to AS is complicated and associated with a high mortality rate.[5] Venoarterial extracorporeal membrane oxygenation (v-a-ECMO) offers the possibility of temporary cardiac support. Previous studies have reported the use of ECMO during high-risk percutaneous coronary interventions (PCI) or TAVR as a prophylactic or emergency strategy for peri-procedural complications.[2,3,6] Beyond that, there are only a few studies reporting the use of ECMO in two subsequent high-risk procedures.[7] In this study, we report on a patient who required ECMO for stabilization of cardiogenic shock during high-risk PCI and subsequently TAVR under continued ECMO support.

Timeline

Day 0	Day of admission
Day 0	High-risk percutaneous coronary interventions with extracorporeal membrane oxygenation
Day 4	Computed tomography
Day 5	Transcatheter aortic valve replacement under extracorporeal membrane oxygenation support
Day 10	Extubation
Day 13	Transfer to normal station
Day 20	Discharge from our hospital
Day 154	Follow-up

Case presentation

An 81-year-old man with severe AS was admitted for further diagnosis and therapy planning. He was very active in everyday life, but he had been noticing worsening of exertional dyspnoea for a month (New York Heart Association III), which is why a further cardiological assessment was initiated by his general physician. Except for arterial hypertension, no previous cardiac diseases are known. Outpatient transthoracic echocardiography showed left ventricular ejection fraction (LVEF) of 20% and high-grade AS with a peak velocity of 4.8 m/s and an aortic valve area of 0.7 cm^2. On the morning of admission, he suffered from a presyncope. Physical examination revealed mild systolic hypertension (140/80 mmHg), systolic cardiac murmurs with no evidence of heart failure. The laboratory chemistry revealed a significant rise in troponin values. Therefore, immediate cardiac catheterization was carried out. Severe CAD with high-grade stenosis of the left main coronary artery and the bifurcation of the left anterior descending artery (LAD) and the left circumflex artery (LCX) (Medina 1-1-1) was diagnosed (*Figure 1A, B*). An immediate heart team was formed. Due to the patient's age and operational risk, the decision was made to proceed with immediate PCI. The implantation of an Impella® was waived due to high-degree AS. After a discussion among the heart team, we decided against using a v-a-ECMO to keep the intervention as short as possible. Therefore, an unprotected left main intervention was planned. The bifurcation of the LAD and LCX was stented using the mini-crush technique (*Figure 1C*). During the intervention of the left main coronary artery, the patient developed cardiogenic shock and consecutive ventricular fibrillation. The return of spontaneous circulation was achieved 11 min after multiple external defibrillations. The patient was orally intubated. To stabilize the patient and to proceed with the intervention, v-a-ECMO via the right femoral artery (17 Fr) and the left femoral vein (21 Fr) (Maquet Cardiohelp®) was implanted (*Figure 2A, B*). The patient was stabilized under v-a-ECMO and transferred to our intensive care unit.

During the next hours (days), the initially increased catecholamine requirement could be reduced with a slightly positive balance. The patient was quickly weaned from the ECMO. Due to a reduced clinical condition and reduced LVEF of 20%, along with the previously challenging course (EuroScore: 48.5%, STS Score: 7.3%), we decided to carry out TAVR under the same ECMO protection. Unloading was not necessary due to reduced catecholamine support and stabilization of the circulation. Computed tomographic angiography was performed to evaluate the vascular access. It showed no tortuosity or calcification of the iliofemoral arteries, and it revealed severe calculus at the aortic valve. The aortic annular area and perimeter measured 502 mm^2 and 80 mm, respectively. Five days later, we performed TAVR. A 5-Fr pigtail catheter was inserted via the left radial artery for the contrast media visualization of the aortic root. Besides, a pacemaker wire was inserted via the right jugular vein for rapid ventricular pacing, and a 14-Fr sheath was inserted via the left common femoral artery for balloon valvuloplasty and valve implantation. After balloon valvuloplasty (20 mm Edwards® transfemoral balloon catheter) (*Figure 3A*), the decision was made to implant an Edward S3 Ultra 26 mm. The prosthesis was advanced into the desired position and implanted under rapid pacing with 200 beats per minute and with a very good primary implant result (*Figure 3B, C*). Extracorporeal membrane oxygenation was successfully weaned immediately after the intervention. The patient demonstrated significant haemodynamic improvement immediately after TAVR. Transthoracic echocardiography showed good results and improvement of LVEF from 20% to 42%. The patient remained in the intensive care unit for 8 days and was finally discharged to rehabilitation after an additional 7 days. The patient was seen in follow-up at 5 months, and he was free of symptoms. Transthoracic echocardiography revealed good results after TAVR and LVEF of 38%.

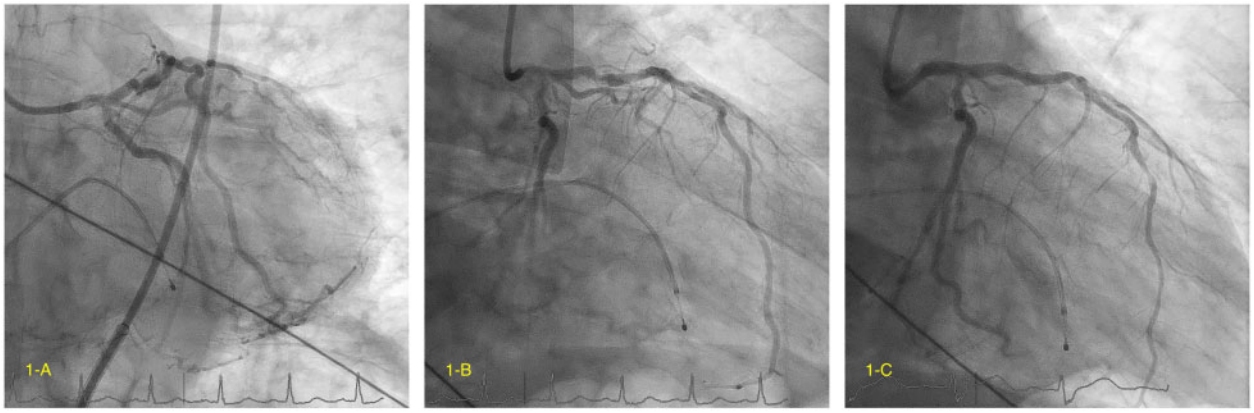

Figure 1 (High-risk percutaneous coronary intervention). (*A*, *B*) Severe coronary artery disease with high-grade stenosis of the left main coronary artery and bifurcation of left anterior descending artery/left circumflex artery. (*C*) Result after coronary intervention.

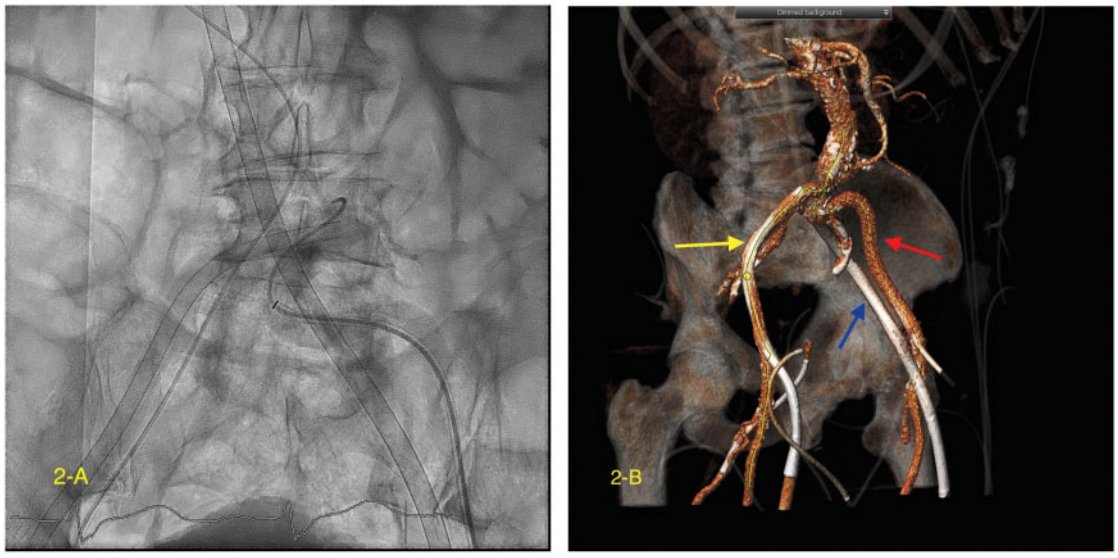

Figure 2 (Vascular access). (*A*) Implantation of venoarterial extracorporeal membrane oxygenation during coronary intervention. (*B*) 3D demonstration of femoral vessels with extracorporeal membrane oxygenation cannulas, yellow arrow: extracorporeal membrane oxygenation cannula in right femoral artery, blue arrow: extracorporeal membrane oxygenation cannula in left femoral vein, red arrow: left femoral artery that was used for balloon valvuloplasty and valve implantation.

Discussion

Transcatheter aortic valve replacement has become an alternative treatment option for a patient with severe AS with high surgical risk.[1] Over the past decade, the in-hospital mortality of patients undergoing TAVR has significantly improved.[8] However, patients with haemodynamic instability requiring mechanical support devices have been excluded from many TAVR trials.[1] Patients with known CAD often have limited myocardial reserves, especially in the presence of compromised left ventricular function, and remain a challenge with a poor prognosis after TAVR.[9]

The use of ECMO has grown exponentially from 2006 to 2011, and since 2010, it has been used as a prophylactic and emergency treatment during the TAVR procedure.[10] We recently presented an algorithm to identify patients who benefit from mechanical circulatory support (MCS) during high-risk PCI.[11] However, the elective use of MCS—including v-a-ECMO—for patients undergoing TAVR is not a routine practice.[12]

Extracorporeal membrane oxygenation support can be instituted electively before a TAVR procedure is started in the case of conceivable haemodynamic problems, or it can be used peri-procedurally in emergencies. However, the value of v-a-ECMO, either as a

Figure 3 (Transcatheter aortic valve replacement). (*A*) Balloon valvuloplasty, (*B*) valve implantation, (*C*) final position.

prophylactic strategy or in emergency scenarios, is unclear. Only a few related studies with small populations have been published. A study in 2014 reported on eight patients with prophylactic ECMO implantation in patients undergoing TAVR procedures.[13] In a single-centre study from Germany, the prophylactic placement of v-a-ECMO during TAVR was associated with 100% success (30-days mortality) compared with 44% in the emergency ECMO group.[2] Besides, another study reported that an emergency placement of MCS devices during TAVR was associated with worse short- and long-term outcomes compared to the elective use of MCS devices.[12] A PARTNER Trial sub-study in 2015 identified MCS use as a strong independent predictor of mortality in patients undergoing TAVR procedures.[14]

In the present case report, we describe a patient with a poor prognosis suffering from severe AS and CAD with highly impaired LVEF. Conventional surgical treatment is associated with a prohibitively high risk in such patients. Therefore, the minimally invasive procedure is the only feasible treatment option. To stabilize our patient in cardiogenic shock during the first procedure, we had to use v-a-ECMO as an emergency solution. Due to secondary high-risk TAVR procedure and increased mortality by placing MCS in an emergency situation, we decided to continue v-a-ECMO prophylactically for the safety of our patients in the second procedure.

The timing of PCI in patients with AS is controversial. In our patient with a symptomatic rise in troponin value, revascularization was performed before TAVR. Studies showed that in haemodynamically unstable patients with a high risk of surgery, balloon valvuloplasty should be regarded as a bridge to TAVR. In the case of concomitant CAD, valvuloplasty and PCI could be performed during the same procedure.[15] Nevertheless, in our case, neither CT-scan (to determine vascular access) nor patient consent form was obtained on patient arrival; thus, valvuloplasty was not an option.

To our knowledge, only a few studies reported the use of ECMO as a bridge to TAVR in this patient population[7] but in less-complicated settings. This is a new therapy concept and is important because very high-risk patients with end-stage heart failure, or cardiogenic shock, or the need for high-risk coronary artery revascularization are unlikely to tolerate the added risk of surgical aortic valve replacement. Therefore, TAVR may be the only treatment option available.

Lead author biography

Dr Ahsan was born in Isfahan, Iran, in 1985. He graduated in Medicine from Isfahan University in 2010 and, after a few years working in Cardiology, he decided to migrate to Germany. He started his residency in HGZ Bad Bevensen in 2016. Right now he is a resident in the Department of Cardiology at the University of Essen-Duisburg. His research interest field is valvular disease.

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 these cases 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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