

Aortic stenosis complicated by cardiogenic shock treated by transcatheter aortic valve replacement with extracorporeal membrane oxygenation

A case report

Jiabing Huang, MD, PhD, Pengfei Chen, MD, PhD, Xinqun Hu, MD, PhD, Jianjun Tang, MD, PhD, Zhenfei Fang, MD, PhD*

Abstract

Rationale: Cardiogenic shock secondary to aortic stenosis (AS) is a challenging problem owing to the high mortality associated with treatment, and successful treatment of such patients has been rare.

Patient concerns: A 77-year-old man presented with exercise intolerance and progressive exertional dyspnea and chest pain. The patient was suffered from cardiogenic shock after percutaneous coronary intervention.

Diagnosis: He was diagnosed by transthoracic echocardiography (TTE) and coronary angiogram. His main diagnose was AS and coronary artery disease.

Intervention: The patient received venoarterial extracorporeal membrane oxygenation (VA-ECMO) and transcatheter aortic valve replacement (TAVR).

Outcome: As of the 5-month follow-up, the patient was well, and capable of basic independent living. The TTE suggested that the left ventricular end-diastolic volume had decreased from 66 to 45 mm and the left ventricular ejection fraction had risen from 20% to 50%.

Lessons: Patients with cardiogenic shock secondary to AS are very difficult to treat medically. ECMO with TAVR may be a reasonable strategy.

Abbreviations: AR = aortic regurgitation, AS = aortic stenosis, CAD = coronary artery disease, CCU = cardiac care unit, CTA = computed tomographic angiography, IABP = intra-aortic balloon pump, LVEDV = left ventricular end-diastolic volume, LVEF = left ventricular ejection fraction, PBAV = percutaneous balloon aortic valvuloplasty, PCI = percutaneous coronary intervention, RCA = right coronary artery, SAVR = surgical aortic valve replacement, TAVR = transcatheter aortic valve replacement, TEE = transesophageal echocardiography, TTE = transthoracic echocardiography, VA-ECMO = venoarterial extracorporeal membrane oxygenation.

Keywords: aortic stenosis, cardiogenic shock, extracorporeal membrane oxygenation, transcatheter aortic valve replacement

1. Introduction

Aortic stenosis (AS) obstructs forward blood flow from the left ventricle (LV) to the aorta, causing a systolic gradient to develop

Editor: N/A.

Consent: The patient provided written informed consent for the publication of this report.

All authors declare no conflicts of interest regarding funding or any other matter.

Department of Cardiovascular Medicine, The Second Xiangya Hospital of Central South University, Changsha, China.

* Correspondence: Zhenfei Fang, Department of Cardiovascular Medicine, The Second Xiangya Hospital of Central South University, No. 139, Middle Ren-min Road, Changsha, Hunan 410011, China (e-mail: fangzhenfei@csu.edu.cn).

Copyright © 2018 the Author(s). Published by Wolters Kluwer Health, Inc. This is an open access article distributed under the terms of the Creative Commons Attribution-Non Commercial-No Derivatives License 4.0 (CCBY-NC-ND), where it is permissible to download and share the work provided it is properly cited. The work cannot be changed in any way or used commercially without permission from the journal.

Medicine (2018) 97:33(e11900)

Received: 18 April 2018 / Accepted: 17 July 2018

<http://dx.doi.org/10.1097/MD.00000000000011900>

between the LV and the aorta.^[1] In AS, intracavitary LV pressure must exceed aortic pressure to produce forward flow across the stenotic valve and produce acceptable downstream pressure. There is a geometric progression in the magnitude of the gradient as the valve area narrows. Pressure overload on the LV is compensated by LV hypertrophy. As the disease advances, reduced coronary flow reserve causes myocardial ischemia; in addition, the hypertrophic LV and excessive afterload lead to systolic and diastolic LV dysfunction. Cardiogenic shock is among the most serious complications. Patients with cardiogenic shock secondary to AS are very difficult to treat medically; hence, the high mortality and few successful outcomes.^[2] Results from PARTNER Trail suggested pharmacotherapy and balloon valvuloplasty could not improve prognosis of AS to any notable extent.^[3] Interventional therapy provides new treatment for this kind of high-risk patient, but it is still difficult to manage.^[4,5] Herein we report a case of AS complicated by cardiogenic shock that was successfully treated by venoarterial extracorporeal membrane oxygenation (VA-ECMO) and transcatheter aortic valve replacement (TAVR). We hope to provide our experience and some opinions in the management of AS-complicated cardiogenic shock.

2. Case report

This study was approved by the Ethical Review Committee of the Second Xiangya Hospital of Central South University (Changsha, Hunan, China), and written informed consent was obtained from the patient's family. A 77-year-old man presenting with dyspnea and chest pain on exertion was diagnosed as having AS and coronary artery disease (CAD). He had suffered exercise intolerance and experienced progressive exertional dyspnea and chest pain for more than 10 years. He was also a chronic smoker with a history including CAD, previous percutaneous coronary intervention (PCI), carotid atherosclerosis, and cerebral infarction. Physical examination revealed a 3/6 systolic murmur at the second intercostal space along the right sternal border. The electrocardiogram showed sinus rhythm and ST-segment depression in both the anterior and inferior leads. Transthoracic echocardiography (TTE) indicated that the patient's left ventricular end-diastolic volume (LVEDV) was 66 mm with a preserved left ventricular ejection fraction (LVEF) of 40% to 51%; there was also severe AS (mean gradient, 69.91 mm Hg; peak velocity, 5.4 m/s) (Fig. 1) and mild mitral regurgitation as well as aortic regurgitation (AR). The coronary angiogram revealed severe coronary stenosis: 65% in-stent restenosis in the mid-left anterior descending coronary artery, 70% of the first diagonal branch, and 85% of the mid-right coronary artery (RCA) (Fig. 2).

Given the poor results of conventional medical therapy and the fact that it was difficult to determine whether the patient's symptoms were due to AS or CAD, he was referred for coronary revascularization and surgical aortic valve replacement (SAVR). The Society of Thoracic Surgeons predicts a mortality of 8.19% at 30 days following such a procedure; the heart team then concluded that the patient was at prohibitive risk for SAVR and referred him for TAVR.

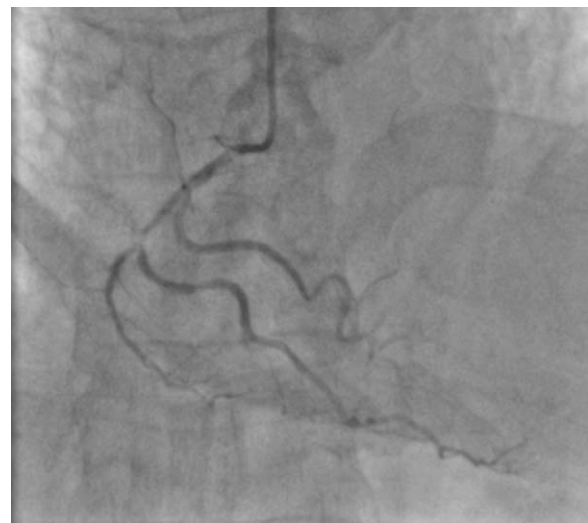


Figure 2. Angiogram showing significant stenosis of the right coronary artery.

Computed tomographic angiography (CTA) showed no tortuosity or calcification of the iliofemoral arteries but revealed severe calculus at the bicuspid aortic valve. The aortic annular area and perimeter measured 526 mm² and 94.8 mm, respectively (Fig. 3A). The diameters of the sinuses of Valsalva were 30.38, 30.6, and 33.47 mm, respectively, and the distance from the left coronary cusp to the left main ostium was 11.76 mm (Fig. 3B and C). There was no significant dilation of the aortic root. The height of the lower left coronary ostium and bulky leaflet calcifications put the patient at moderate risk of left coronary obstruction.

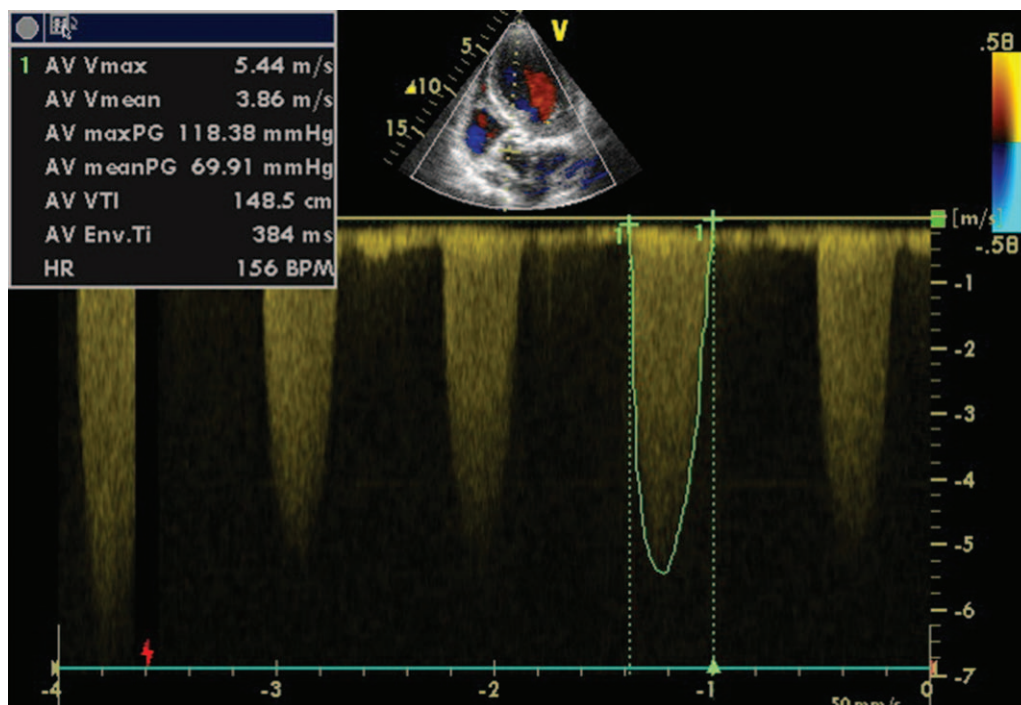


Figure 1. Transthoracic echocardiogram measuring aortic transvalvular gradients and velocity.

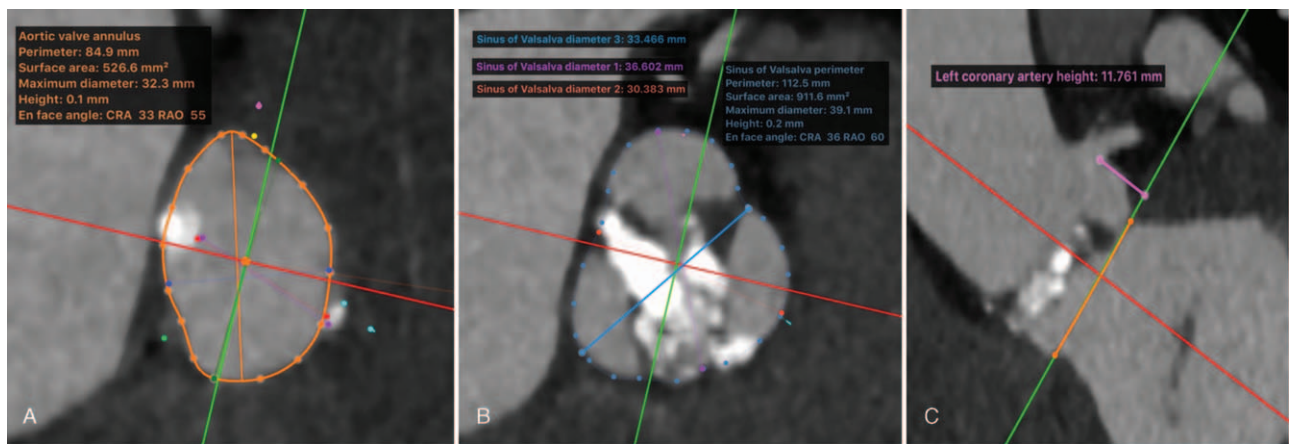


Figure 3. The aortic annular area (A), diameter of the sinuses of Valsalva (B), and height of the left coronary ostium (C) measured using computed tomographic angiography.

Owing to concerns regarding ischemia and hemodynamic instability in patients with significant revascularized CAD during TAVR and the risk of left coronary obstruction, it was decided that PCI should be performed on the RCA before TAVR. After initiating intravenous heparin for anticoagulation, the RCA ostium was engaged with a 6-Fr Judkins right 4 guiding catheter (Medtronic, Minneapolis, MN) via the right radial artery using a 6-Fr arterial sheath. The stenosis in the mid-RCA was easily crossed using a 0.014-in guidewire. Another protective guidewire was placed in the second marginal branch. Subsequently—after predilation with a 2.0 × 20-mm Maverick balloon (Boston Scientific, Marlborough, MA)—we deployed a 2.5 × 24 mm EXCEL drug-eluting stent (J.W. Medical Systems, Weihai, Shandong, China) across the RCA lesion. Angiographic images revealed optimal stent expansion and apposition without significant residual stenosis and with good flow (thrombolysis in myocardial infarction grade 3) in the RCA and the marginal branch (Fig. 4).

After PCI, the patient experienced cardiogenic shock and repeated cardiac arrests; pharmacotherapy and normal life support could not keep him stable. We therefore decided to

utilize VA-ECMO for life support. No intra-aortic balloon pump (IABP) was placed owing to concerns that IABP might aggravate the AR. A repeat coronary angiogram showed that no acute event had occurred in either the left or right coronary arteries. After the procedure, the patient, reliant on full ECMO support and vasoactive drugs to maintain hemodynamics, was transferred to a cardiac care unit (CCU). TTE demonstrated that the LVEF had decreased to 20%.

Urgent TAVR was implemented to relieve the LV burden and achieve ECMO decannulation. In view of the aortic annular perimeter (94.8 mm) measured by CTA, the decision was made to implant a 29-mm Venus-A self-expandable aortic valve prosthesis (Venus MedTech, Hangzhou, China). The reserved left femoral artery sheath was exchanged for a 19-Fr sheath after standard preclosure was performed using 2 Perclose Proglide closure devices (Abbott Vascular, Minneapolis, MN). A left ventricular catheter was placed via the right femoral artery sheath and showed an LV pressure of 163/14 mm Hg and aortic blood pressure of 90/49 mm Hg (on 1.5 µg/kg per minute of norepinephrine) (Fig. 5). Preimplant balloon aortic valvuloplasty, using a 22-mm balloon, was performed with simultaneous associated aortography and rapid ventricular pacing at a rate of 120 beats per minute. The patency of both the left and right

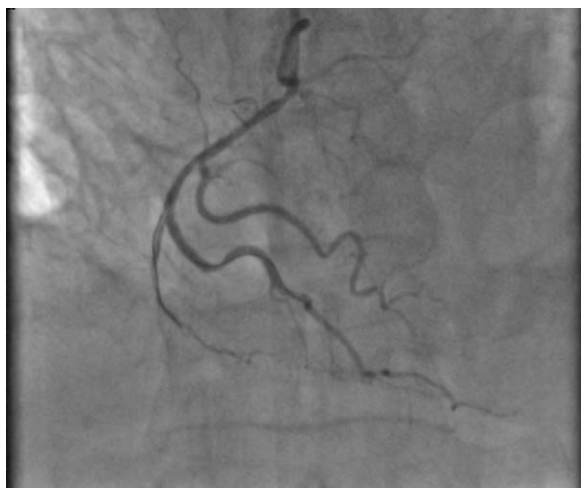


Figure 4. Angiographic image of the right coronary artery after stent implantation.



Figure 5. Invasive hemodynamics before valve deployment.

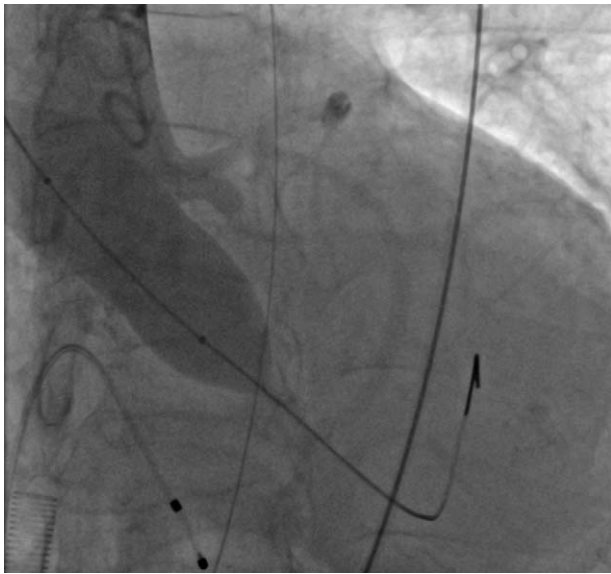


Figure 6. Aortography with the balloon fully inflated showing the patency of both the left and right coronary arteries.

coronary arteries was clearly shown when the balloon was fully inflated (Fig. 6). In order to reduce the risk of ventricular migration during valve deployment, ECMO flow was reduced to 1L/min until the valve was released. A 29-mm Venus-A self-expandable aortic valve prosthesis was positioned across the aortic valve. The ideal landing zone was identified on the basis of aortic angiography performed with a pigtail catheter in the right coronary sinus. Following aortography, transesophageal echocardiography (TEE) demonstrated severe paravalvular AR, and invasive hemodynamics showed that the peak-to-peak pressure gradient across the prosthesis valve had decreased from 73 to 2 mm Hg with a low AR index of 20. We therefore postdilated the valve using a 22-mm Z-Med Balloon (B. Braun Medical Inc,



Figure 7. Final aortography after valve deployment and dilation.



Figure 8. Invasive hemodynamics after valve deployment and dilation.

Bethlehem, PA). Final aortography and TEE demonstrated mild paravalvular AR with an AR index of 35.4 (Figs. 7 and 8). The right femoral artery site preclosures were completed and the patient was transferred back to the CCU. The patient demonstrated significant hemodynamic improvement immediately after TAVR. After successful turn-down of the ECMO flows, he was brought back to the operating room for decannulation. However, although hemodynamic stability was achieved, the patient underwent amputation of the right lower extremity because of necrosis of the foot. At the 5-month follow-up, the TTE suggested that the LVEDV had decreased from 66 to 45 mm, and the LVEF had risen from 20% to 50%.

3. Discussion

TAVR has become an attractive, less invasive treatment option for patients with symptomatic severe aortic valve stenosis and is considered superior to medical management in patients who are deemed inoperable.^[4] Despite the encouraging initial results achieved even in patients at high surgical risk, patients with hemodynamic instability requiring mechanical support devices have been excluded from many TAVR trials.^[3] Herein we have presented a case in which TAVR was used as an emergency salvage therapy in a patient with cardiogenic shock who was dependent on VA-ECMO. Although hemodynamic stability was achieved, the patient went on to suffer from amputation of a lower extremity. This suggests that although TAVR may be an optional rescue treatment for such extremely ill patients, the long-term outcome still requires further evaluation. One observational study^[5] investigated the outcome of transapical TAVR in patients with cardiogenic shock and found the presence of cardiogenic shock significantly increased the 30-day mortality after TAVR (cardiogenic shock 19% vs noncardiogenic shock 5%; $P = .02$). The mortality of TAVR in the cardiogenic shock group is, however, still lower than that following emergency conventional surgical AV replacement (19% vs 26%), suggesting that TAVR may be a feasible therapy for patients with cardiogenic shock. Notably, patients enrolling in the trial had clinical shock of a lower severity, which did not require ECMO. To our knowledge, the emergency use of TAVR as a bridge treatment in cardiogenic shock requiring ECMO has been documented in 2 prior case reports.^[6,7] Ganapathi et al^[6] described a successful use of TAVR to allow for bridging to a left ventricular assist device in a patient

with severe bioprosthetic aortic valve regurgitation and end-stage heart failure requiring ECMO. Summers et al^[7] reported a case of emergency TAVR in a patient with degenerated bioprosthetic AS and cardiogenic shock supported by ECMO. In our case, the patient was extremely ill. Conventional SAVR was deemed to pose a prohibitively high risk. Because this patient was not a candidate for cardiac transplantation, the less invasive treatment was the only option. Emergency TAVR as a definitive treatment was performed in the patient and immediately resulted in hemodynamic stability. However, his postoperative management was still challenging. Nursing care and management of ECMO and protection from ischemia of the lower extremities pose significant challenges in addition to management of heart failure and sustaining hemodynamic stability in our experience. Choosing an appropriate sheath and early performance of decannulation based on sufficient other treatment, such as cardiac burden reduction by dialysis and pharmacotherapy may decrease the possibility of amputation.

Whether percutaneous balloon aortic valvuloplasty (PBAV) would have been necessary remains uncertain. Using PBAV as a bridge therapy to stabilize the patient before TAVR may reduce the operative risk. However, in our patient, PBAV was not performed for fear of aggravating AR.

In summary, TAVR may be a suitable optional rescue treatment for patients with severe AS and cardiogenic shock on ECMO, but the long-term outcome still requires further investigation. In addition, whether coronary artery revascularization before valve replacement is necessary for patients with both AS and CAD also needs further study.

4. Conclusion

Patients with cardiogenic shock secondary to AS are very difficult to treat medically. ECMO with TAVR may be a reasonable strategy. However, optimal strategies for treating this condition still need further study.

Acknowledgments

The authors would like to thank Professor Mao Chen and Professor Yuan Feng, who were involved in the patient's surgical procedure. The authors would like to thank LetPub (www.letpub.com) for providing linguistic assistance during the preparation of this manuscript.

Author contributions

Conceptualization: Zhenfei Fang.

Formal analysis: Pengfei Chen.

Methodology: Xinqun Hu, Jianjun Tang, Zhenfei Fang.

Writing – original draft: Jiabing Huang.

Writing – review and editing: Jiabing Huang.

References

- [1] Olasinska-Wisniewska A, Trojnarzka O, Grygier M, et al. Percutaneous balloon aortic valvuloplasty in different age groups. *Postepy Kardiologii Interwencyjnej* 2013;9:61–7.
- [2] Caetano F, Almeida I, Seca L, et al. [Severe aortic stenosis and cardiogenic shock: a therapeutic challenge]. *Rev Port Cardiol* 2013; 32:701–6.
- [3] Leon MB, Smith CR, Mack M, et al. Transcatheter aortic-valve implantation for aortic stenosis in patients who cannot undergo surgery. *New Engl J Med* 2010;363:1597–607.
- [4] Baumgartner H, Falk V, Bax JJ, et al. 2017 ESC/EACTS Guidelines for the management of valvular heart disease. *Eur Heart J* 2017;38: 2739–91.
- [5] D'Ancona G, Pasic M, Buz S, et al. Transapical transcatheter aortic valve replacement in patients with cardiogenic shock. *Interact Cardiovasc Thorac Surg* 2012;14:426–30.
- [6] Ganapathi AM, Hirji SA, Wang A, et al. Bridge to long-term mechanical circulatory support with a left ventricular assist device: novel use of transcatheter aortic valve replacement. *Ann Thorac Surg* 2015;99:e91–3.
- [7] Summers MR, Mick S, Kapadia SR, et al. Emergency valve-in-valve transcatheter aortic valve replacement in a patient with degenerated bioprosthetic aortic stenosis and cardiogenic shock on veno-arterial extracorporeal membrane oxygenation. *Catheter Cardiovasc Interv* 2017;[Epub ahead of print].