


Intraoperative ECMO assistance during TAVI for aortic insufficiency in an Asian patient with LVAD support

Hsiao-Huang Chang^{1,2*} , Po-Lin Chen^{1,3}, Ying-Hwa Chen^{3,4}, Hsin-Bang Leu^{3,4,5}, Chia-Cheng Kuo¹ and Nai-Yuan Wu⁶

¹Division of Cardiovascular Surgery, Department of Surgery, Taipei Veterans General Hospital, No. 201, Sec. 2, Shipai Rd., Beitou District, Taipei, 11217, Taiwan; ²Department of Surgery, School of Medicine, College of Medicine, Taipei Medical University, Taipei, Taiwan; ³School of Medicine, National Yang-Ming University, Taipei, Taiwan; ⁴Division of Cardiology, Taipei Veterans General Hospital, Taipei, Taiwan; ⁵Division of Healthcare and Management, Healthcare Center, Taipei Veterans General Hospital, Taipei, Taiwan; and ⁶Institute of Biomedical Informatics, National Yang-Ming University, Taipei, Taiwan

Abstract

A 69-year-old male underwent concomitant left ventricular assist device (LVAD) implantation and aortic valve repair procedure for moderate aortic insufficiency (AI). Due to recurrence of symptomatic heart failure and post-repair AI deterioration from trivial to moderate-to-severe insufficiency 2 months later, transcatheter aortic valve implantation (TAVI) was arranged. During TAVI, intraoperative extracorporeal membrane oxygenation was used to maintain stable haemodynamics and to ensure a safe environment for prosthesis deployment. Postoperative 5 month follow-up revealed no AI and no paravalvular leakage.

Keywords Aortic insufficiency; Extracorporeal membrane oxygenation; Left ventricular assist device; Transcatheter aortic valve implantation

Received: 20 January 2021; Revised: 6 April 2021; Accepted: 2 May 2021

*Correspondence to: Hsiao-Huang Chang, Division of Cardiovascular Surgery, Department of Internal Medicine, Taipei Veterans General Hospital, No. 201, Sec. 2, Shih-Pai Rd, Taipei 11217 Taiwan. Email: shchang@vghtpe.gov.tw

Introduction

Currently, transcatheter aortic valve implantation (TAVI) devices are designed and indicated for aortic stenosis. Non-conventional use of TAVI for managing aortic insufficiency (AI) in left ventricular assist device (LVAD)-supported patients is a technically challenging procedure.^{1,2} Patients on LVAD support are usually young and have insufficient aortic valve complex calcification for prosthesis anchoring. The dilated aortic root in AI may aggravate this problem and increase the risk of paravalvular regurgitation.³ Suction from the *in situ* LVAD pump may disturb prosthesis deployment and increase the risk of prosthesis migration.³

In this case report, TAVI was successfully performed in a patient who had deteriorated AI 2 months after undergoing concomitant LVAD implantation and aortic valve repair procedure. Herein, we demonstrate in detail how extracorporeal membrane oxygenation (ECMO) was used to maintain stable haemodynamics during TAVI and to ensure a safe environment for prosthesis deployment.

Case report

A 69-year-old male (body surface area: 1.5 m²) with history of ischaemic heart disease and congestive heart failure was admitted due to severe pulmonary oedema. He was mechanically ventilated, and an intra-aortic balloon pump (IABP) was inserted. LVAD was deemed appropriate due to the patient's end-stage heart failure (NYHA class IV, INTERMACS scale 1–2, LVEF/RVEF: 18%/58%). Intraoperative transesophageal echocardiography (TEE) showed pure, non-calcified moderate AI, and repair of aortic valve by pledgeted 4-0 prolene stitches (modified Park's stitch) was performed concomitantly with LVAD implantation (HeartMate III, Abbott Vascular, Inc., USA). LVAD was smoothly implanted, and postoperative echocardiography showed trivial AI.

Two months later, the patient was admitted again for pulmonary oedema. Transthoracic echocardiography showed an enlarged left ventricle and moderate AI despite intact stitches on the repaired aortic valve and no valve laceration (*Figure 1* and Supporting Information, *Video S1*). Computed tomography (CT) revealed downward sinus of Valsalva of

non-coronary cusp and a fissure between left and right coronary cusps, which remained open during diastole (Supporting Information, *Video S2*). Despite the optimization of LVAD settings and maximal intensification of medical therapy, AI had deteriorated to moderate-to-severe insufficiency. Due to his co-morbidities and high risk of surgical valve replacement, the decision was made to perform TAVI. Prior to TAVI, the speed and flow of LVAD was set at 4200 revolutions per minute (rpm) and 2.8 L/min, respectively.

Three and half months later, the patient was prepared and monitored in a standard manner under general anaesthesia. After administration of heparin 3000 U, the IABP in left femoral artery was replaced by venoarterial ECMO. The TAVI device was inserted through right femoral artery, and a pigtail catheter (5 Fr) was inserted via right brachial artery. Heparin 12 000 U was administered to achieve full heparinization and activated clotting time was kept above 400 s throughout the procedure. The ECMO pump (RotaFlow, Maquet, Germany) was turned on and flow was set at 1.7 L/min, and the flow and speed of LVAD were tapered down from 2.8 to 1.7 L/min and from 4200 to 3200 rpm, respectively. Confida® guidewire (Medtronic, USA) was smoothly inserted into the left ventricle. Because the aortic valve was previously repaired, we presumed that the self-expandable prosthesis might not be able to fully expand. Pre-dilatation with a 20 mm/4 cm balloon was performed under rapid pacing of 180 b.p.m. without fully opening the aortic valve (*Figure 2A*). Pre-dilatation was performed again with a 22 mm/4 cm balloon, and the aortic valve was fully opened (*Figure 2B*). During pre-dilatation, ECMO flow was reduced to 1.2 L/min, and LVAD speed was slowed to 3000 rpm.

After pre-dilatation, the self-expandable prosthesis (29 mm, Evolut R, Medtronic, USA) was deployed 4 mm beneath the annulus under controlled pacing of 140 b.p.m. (*Figure 3*). The size of prosthesis was determined according to preoperative CT evaluation (aortic annulus diameter 24.5 mm, annulus perimeter 77.1 mm). During prosthesis

deployment, the LVAD was paused, and ECMO flow was reduced to 0.8 L/min.

After prosthesis deployment, ECMO flow was gradually increased to 1.5 L/min followed by 10 min of observation. Then, we proceeded the LVAD, slowly increased the LVAD speed to 4200 rpm, and turned off the ECMO pump. The ECMO catheters were clamped, disconnected from the ECMO pump, and infused with diluted heparin solution but were not removed from the patient. The arterial and venous ECMO circuits were connected to generate auto-circulation in order to place the ECMO pump on standby.

Subsequent TEE revealed that the prosthesis had migrated toward the left ventricle by 1 mm. The patient was observed for an additional 20 min after which both aortography and TEE showed only trivial AI without paravalvular leakage and unchanged depth of prosthesis (*Video S3*). All ECMO and TAVI catheters were then removed and closed with Proglide® (Abbott Vascular, USA). The patient was transferred to the intensive care unit (ICU) under support of LVAD and mechanical ventilation.

The patient recovered well and was discharged on postoperative day 17 in stable condition. At discharge, LVAD speed was set at 4200 rpm, and flow was set at 3.0 L/min. At the postoperative 5 month follow-up, echocardiography showed no AI, no paravalvular leakage, decreased left ventricular size, and improved left ventricular function.

Discussion

To the best of our knowledge, this is the first report of an Asian patient successfully undergoing TAVI for LVAD-associated AI. We implemented several strategies to ensure the success of the TAVI procedure. Firstly, the prosthesis was deployed 4 mm beneath the aortic annulus. Secondly, the prosthesis was deployed under controlled pacing of 140 b.p.m.. Thirdly, LVAD was paused, and ECMO flow was

Figure 1 Transthoracic echocardiography showed moderate AI (A), but the stitches on the repaired aortic valve were intact and no valve laceration (B).

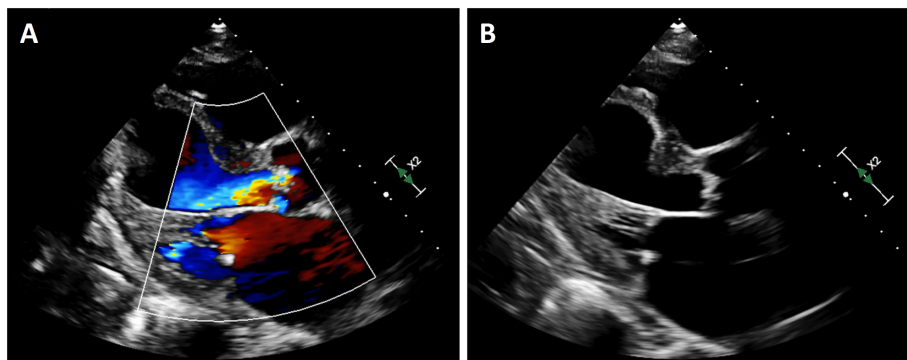


Figure 2 Aortography showed that the aortic valve was not fully opened by the 1st pre-dilatation with a 20 mm/4 cm balloon (A) but finally full opened by the 2nd pre-dilatation with a 22 mm/4 cm balloon (B).

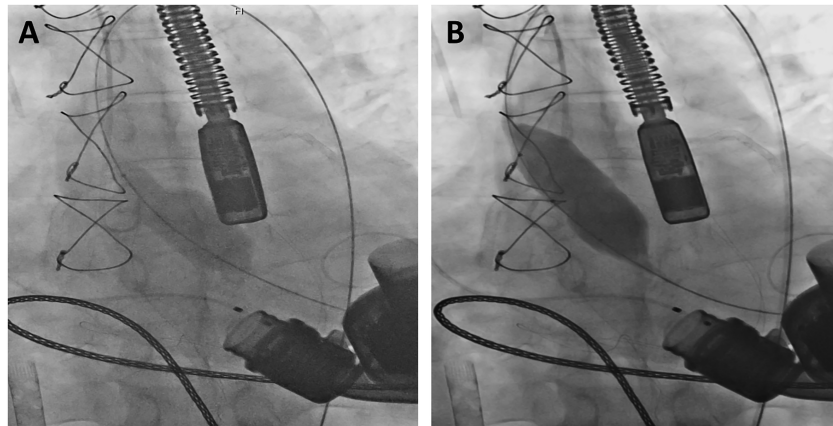
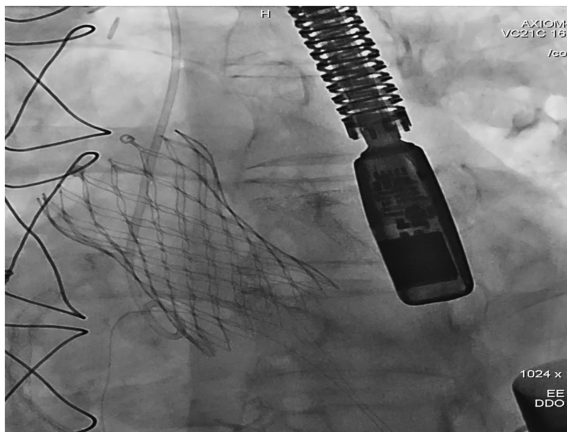


Figure 3 The self-expandable prosthesis was deployed 4 mm beneath the annulus.



tapered down to 0.8 L/min during the prosthesis deployment. Fourthly, after prosthesis deployment, we increased the LVAD speed very slowly to prevent significant hemodynamic changes and to allow the self-expandable Nitinol frame to settle. At least 60 min elapsed between deployment completion and initiation of removal ECMO catheters.^{4,5} Fifthly, the ECMO catheters were left in place until the patient was transferred to the ICU so that if the prosthesis was to suddenly migrate toward the left ventricle, the catheters could be connected to heart–lung machine for immediate open heart surgery.⁶ Sixthly, the sutured pledgets might have adhered to valvular tissue, which would help anchor the prosthesis. Seventhly, because the pledgets could dislocate during pre-dilatation or deployment resulting in embolization of pledgets to carotid or coronary arteries,⁷ LVAD was

optimized, and medical therapy was administered for one and a half months prior to TAVI to maximize pledget adhesion, rather than performing the procedure as soon as LVAD-associated AI presented.

At the time that this patient with heart failure and moderate AI status post concomitant LVAD implantation and aortic valve repair procedure presented, the pledgeted stitches were intact without valve laceration. However, CT and echocardiography images showed downward sinus of Valsalva of non-coronary cusp contributing to de novo AI (Supporting Information, *Videos S1* and *S2*). The geometric change in non-coronary cusp might explain the rapid development of AI following successful aortic valve repair.

In conclusion, TAVI is a feasible option for managing AI in patients supported with LVAD. As LVAD-supported patients have higher risk of prosthesis migration toward the left ventricle, intraoperative ECMO assistance could be used to ensure a safer environment for prosthesis deployment and to maintain hemodynamic stability during TAVI.

Conflict of interest

None declared.

Author contribution

H.H.C., P.L.C., and C.C.K. performed the surgical procedures. Y.H.C. and H.B.L. provided medical treatment and consultation. H.H.C., P.L.C., Y.H.C., H.B.L., and C.C.K. participated in clinical care. H.H.C., C.C.K., and N.Y.W. participated in data collection, article writing, and article revision. All authors gave final approval of the submitted article.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Video S1. Transthoracic echocardiography showed moderate AI, but the stitches on the repaired aortic valve were intact and no valve laceration.

Video S2A. Pre-TAVI CT (A) and three-dimensional reconstructed CT (B,C) revealed downward sinus of Valsalva of non-coronary cusp and a fissure between left and right coronary cusps, which remained open during diastole.

Video S2B. Aortography showed trivial AI without paravalvular leakage.

Video S2C. Supporting information.

Video S3. Supporting information.

References

- Deo SV, Sharma V, Cho YH, Shah IK, Park SJ. De novo aortic insufficiency during long-term support on a left ventricular assist device: a systematic review and meta-analysis. *ASAIO J* 2014; **60**: 183–188.
- Yehya A, Rajagopal V, Meduri C, Kauten J, Brown M, Dean L, Webster J, Krishnamoorthy A, Hrobowski T, Dean D. Short-term results with transcatheter aortic valve replacement for treatment of left ventricular assist device patients with symptomatic aortic insufficiency. *J Heart Lung Transplant* 2019; **38**: 920–926.
- Sawaya FJ, Deutsch MA, Seiffert M, Yoon SH, Codner P, Wickramarachchi U, Latib A, Petronio AS, Rodes-Cabau J, Taramasso M, Spaziano M, Bosmans J, Biasco L, Mylotte D, Savontaus M, Gheeraert P, Chan J, Jorgensen TH, Sievert H, Mocetti M, Lefevre T, Maisano F, Mangieri A, Hildick-Smith D, Kornowski R, Makkar R, Bleiziffer S, Sondergaard L, De Backer O. Safety and efficacy of transcatheter aortic valve replacement in the treatment of pure aortic regurgitation in native valves and failing surgical bioprostheses: results from an international registry study. *JACC Cardiovasc Interv* 2017; **10**: 1048–1056.
- Bayram Z, Dogan C, Gurcu E, Kaymaz C, Ozdemir N. Development of acute severe right heart failure after transcatheter aortic valve implantation in patient with left ventricle assist device-acquired aortic regurgitation. *Turk Kardiyol Dern Ars* 2020; **48**: 545–551.
- Mondal S, Dawood M, Bandyopadhyay D, Taylor BS, Tanaka K, Gupta A. Transcatheter aortic valve replacement: a potential option for aortic insufficiency management in patients with left ventricular assist device. *Int J Cardiol Heart Vasc* 2020; **26**: 100425.
- Ong BH, Chiam PT, Sim DK, Tan TE. Post-implantation transcatheter aortic valve migration in a left ventricular assist device patient with severe aortic insufficiency. *Eur Heart J* 2014; **35**: 1616.
- Lifschultz BD, Donoghue ER, Leestma JE, Boade WA. Embolization of cotton pledgets following insertion of porcine cardiac valve bioprostheses. *J Forensic Sci* 1987; **32**: 1796–1800.