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Transcatheter aortic valve replacement: A potential option for aortic insufficiency management in patients with left ventricular assist device

Left ventricular assist device (LVAD) has become a popular therapeutic option for end stage heart disease (ESHD) [1,2]. Initially, this mechanical circulatory assist device was invented for ESHD patients awaiting heart transplant (bridge to transplant or BTT) [2]. Indications for using LVAD have expanded and are routinely utilized in heart transplant ineligible ESHD patient as destination therapy (DT). Irrespective of BTT or DT, patients may require LVAD support for an extended duration given wait time for heart transplant [3]. Newer generation continuous flow (CF) LVADs have gained popularity because of lesser side effects compared to older pulsatile one [4]. However, CF-LVAD has its unique sets of challenges and complications that were not observed with pulsatile LVADs [5]. Incidence of denovo aortic insufficiency (AI) in CF-LVAD patients can be as high as 30–40% and worsens with time [6–8]. LVAD efficacy diminishes in the presence of moderate to severe AI [7]. Surgical closure of the aortic valve (AV) or AV replacement in a patient with LVAD can be highly complex and high risk procedure. Transcatheter AV replacement (TAVR) may be a useful option in this scenario. Though its use for AI is off label, isolated case reports exist. We present a case of TAVR for AI in a patient who

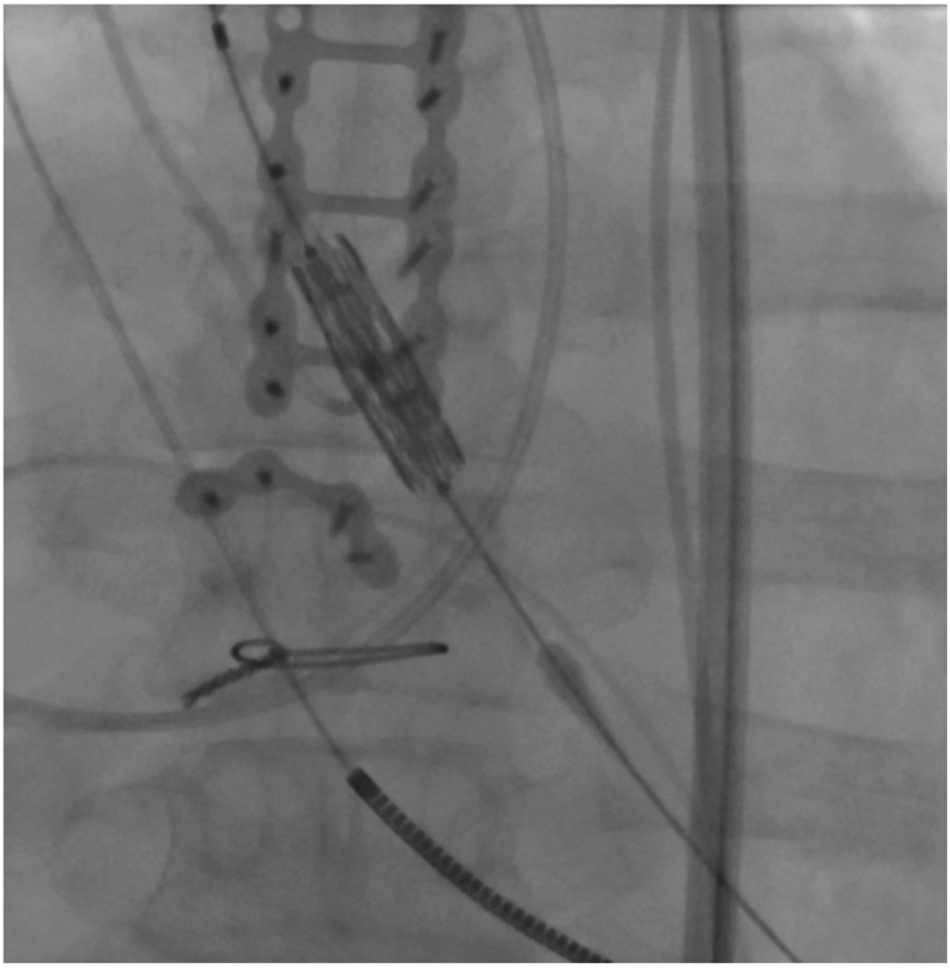

Fig. 1. Positioning of the first Edwards Sapien valve.

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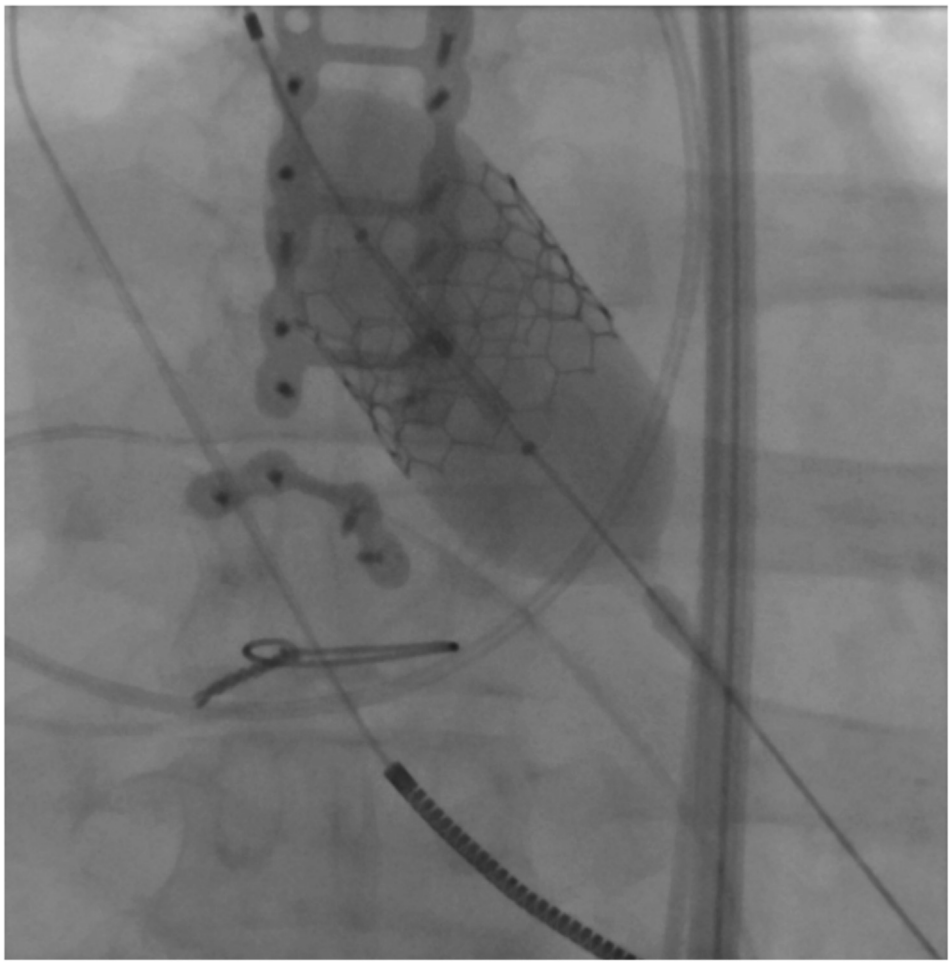
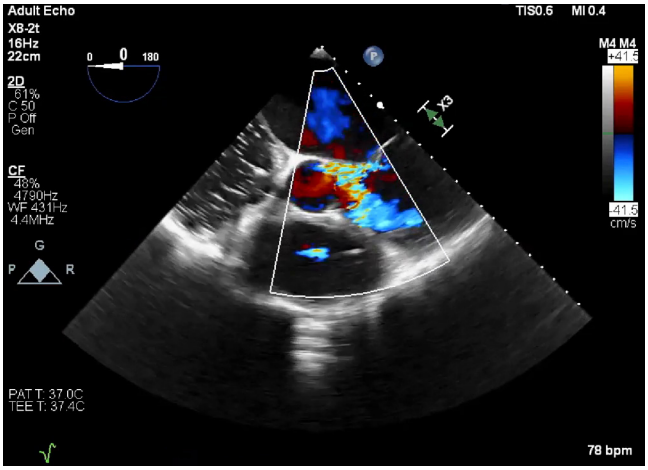


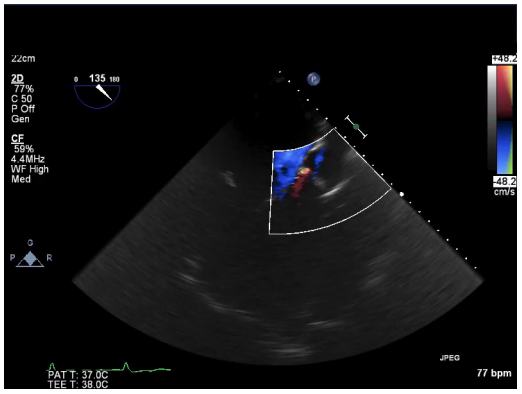
Fig. 2. Deployment of the first Edwards Sapien valve.

received LVAD as DT. Written informed consent was obtained from the patient.

Patient was a 35-year old gentleman who suffered from nonischemic cardiomyopathy and received a LVAD as DT 7 years ago. He was admitted to the intensive care unit (ICU) with severe, eccentric AI (Video 1, Video 2) complicated by cardiogenic shock with a rising lactate. As he was not a surgical AVR candidate due to his complicated medical history, cardiogenic shock and morbid obesity, a multi-disciplinary decision was made to proceed with TAVR.



Video 1. Pre procedure TEE loop of LV outflow (5 chamber view) showing denovo severe and eccentric AI.



Video 2. Pre procedure TEE loop of LV long axis view showing denovo eccentric AI.

Anesthetic management of the case played a vital role in this hemodynamically unstable patient. Although common anesthetic trend for TAVR procedure is becoming monitored anesthesia and sedation, this procedure required general endotracheal anesthesia (GETA). Ongoing hemodynamic instability, high inotrope and vasopressor support requirement, baseline obesity and anticipated difficult airway prompted use of controlled ventilation. General anesthesia was induced with fentanyl, lidocaine, etomidate and rocuronium; the trachea was intubated using a glidescope. Hemodynamic stability was maintained by infusing low dose nore-

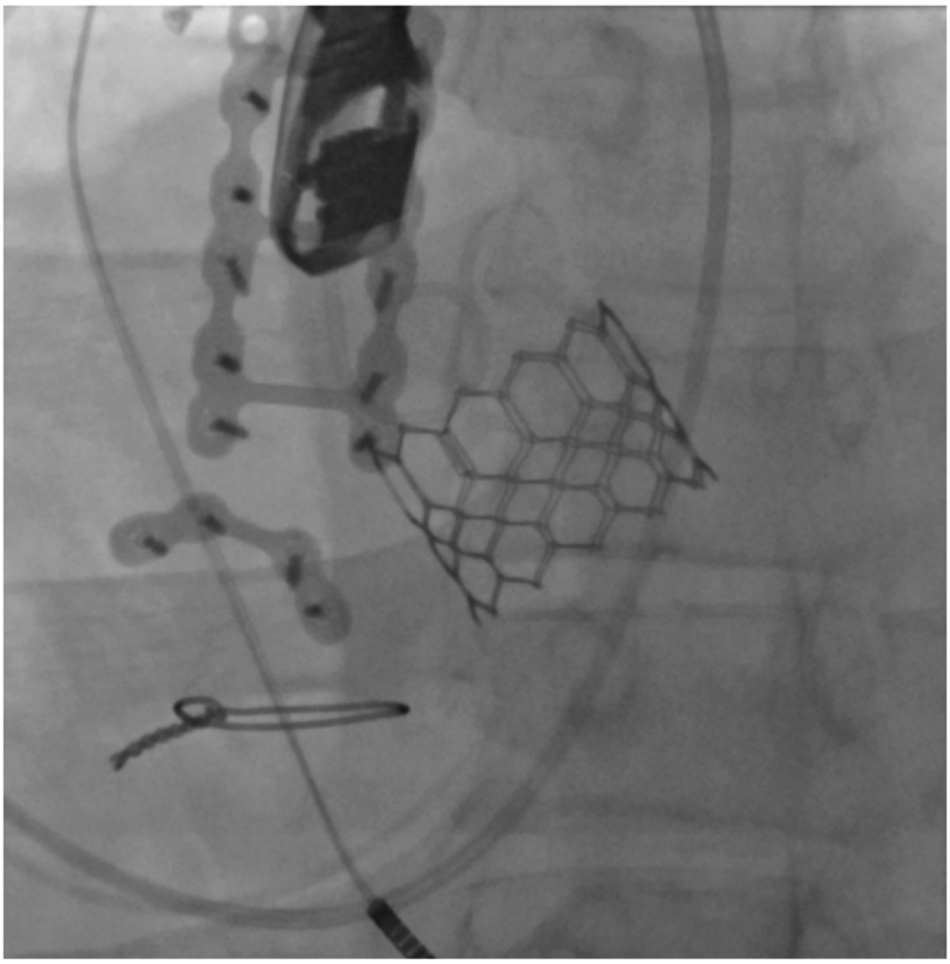
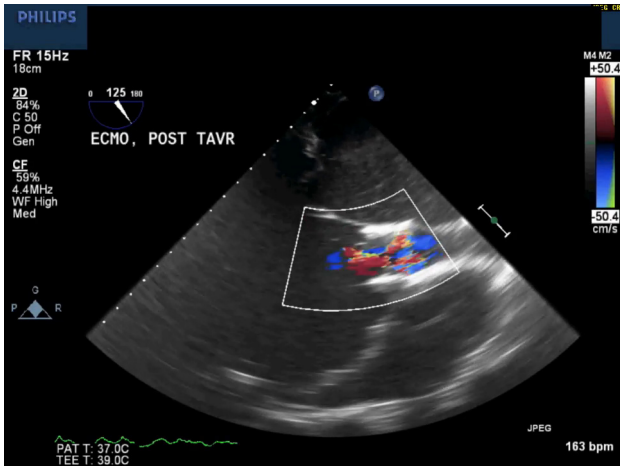


Fig. 3. Final positioning of the first Edwards Sapien valve after deployment.

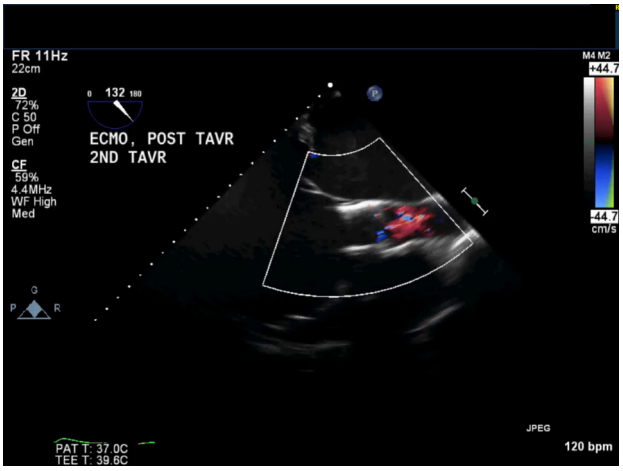
pinephrine infusion during induction. Pre-operative milrinone and furosemide infusions were continued after uneventful induction. Transesophageal echocardiography (TEE) probe was inserted without difficulty. In order to have adequate access in case emergent resuscitation were required, an 8Fr femoral venous sheath was obtained. Subsequently, femoral arterial access for the procedure was also obtained.

After confirmatory TEE and aortogram diagnosis of severe AI, TAVR was planned. Detailed perioperative interrogation of native AV, aortic root measurement by 3D CT and echocardiography resulted in a 29 mm Edwards Sapien 3 valve being chosen for its ability to be overexpanded as patients with pure AI tend to have a dilated aortic annulus and lack calcification to serve as an anchor for the prosthesis (Fig. 1).

The Sapien 3 valve was deployed through transfemoral approach successfully after rapid pacing at the rate of 180/min (Figs. 2, 3). Transesophageal echocardiography demonstrated a well seated prosthetic valve without any AI or paravalvular leak. Subsequently, the patient became hemodynamically unstable despite having a functional LVAD in situ. TEE showed severely depressed right ventricle (RV), likely from the pacing run. Immediate cardiopulmonary resuscitation (CPR) with chest compression was initiated. Patient was emergently placed on veno arterial extracorporeal membrane oxygenation (VA-ECMO). AV was reevaluated with TEE after ECMO institution and achievement of hemodynamic stability. Severe AI was noted likely because of dislodgement of the bioprosthetic valve into LV (Video 3) from CPR. A second 29-mm Edwards Sapien 3 (Figs. 4 and 5) was deployed slightly higher to create a broader seal range. Reassessment of AV prosthesis demonstrated mild AI with trace paravalvular leak (Video 4). Mild AI was considered an acceptable result especially considering patient's critical condition and the procedure was terminated. The patient remained on ECMO and transferred to intensive care unit. Subsequently, patient suffered multiple medical complications requiring prolonged hospital stay and passed away.



Video 3. TEE loop of LV long axis view showing severe AI after the first TAVR Edwards Sapiens valve replacement.



Video 4. TEE loop of LV long axis view showing Mild AI after the second TAVR.

LVAD has become a standard management modality in ESHD patients resistant to conservative management and/or awaiting heart transplant. CF LVAD has gained popularity because of its smaller size, increased tolerability and durability. However, CF LAVD has unique side effects including denovo AI [5,7]. Preexisting AI worsens over time. One explanation for this complication is that reduced AV opening combined with aortic root dilation from LVAD outflow blood in the ascending aorta results in abnormal collagen deposition and valve cusp fusion, resulting in AI or worsening of preexisting AI [9]. Depending on the severity of AI, LVAD function can be affected significantly. Moderate to severe AI warrants urgent attention as per International Society of Heart and Lung Transplant (ISHLT) guidelines as a significant portion of blood flow from outflow cannula in the proximal ascending aorta can return back to left ventricle (LV) [7,10]. Increase in pump output can temporize the situation but at the cost of potentially increasing AI [6]. Unintervened AI not only reduces systemic perfusion, but also leads to LV distension, increased work load on the pump and eventually increased right heart afterload and right ventricular failure. Therapeutic options to manage AI include replacement or repair of the native AV, making a bicuspid orifice or complete suturing of AV or outflow tract, or using an Amplatzer Closure device to percutaneously seal the valve [11]. AI can be eliminated by suturing the AV or outflow tract but at the risk of fatal complication in face of device (LVAD) malfunction. It is also recommended to replace or repair the AV rather than completely suturing it in young patients who have the possibility of myocardial recovery [12].

Surgical intervention to manage AI can be high risk in patients with LVAD. Reopening the sternum in a previously sternotomized patient poses many risks. Additionally, these patient populations have multiple comorbidities – cardiogenic shock with moderate to severe AI, coagulopathy, poor vascular access to name a few. Rao et al described a high operative mortality (18%) and perioperative death rate (7%) in surgeries in patients with LVAD [11].

TAVR may be a feasible option in this unique situation because of its minimally invasive nature but data is lacking. D'Ancona et al

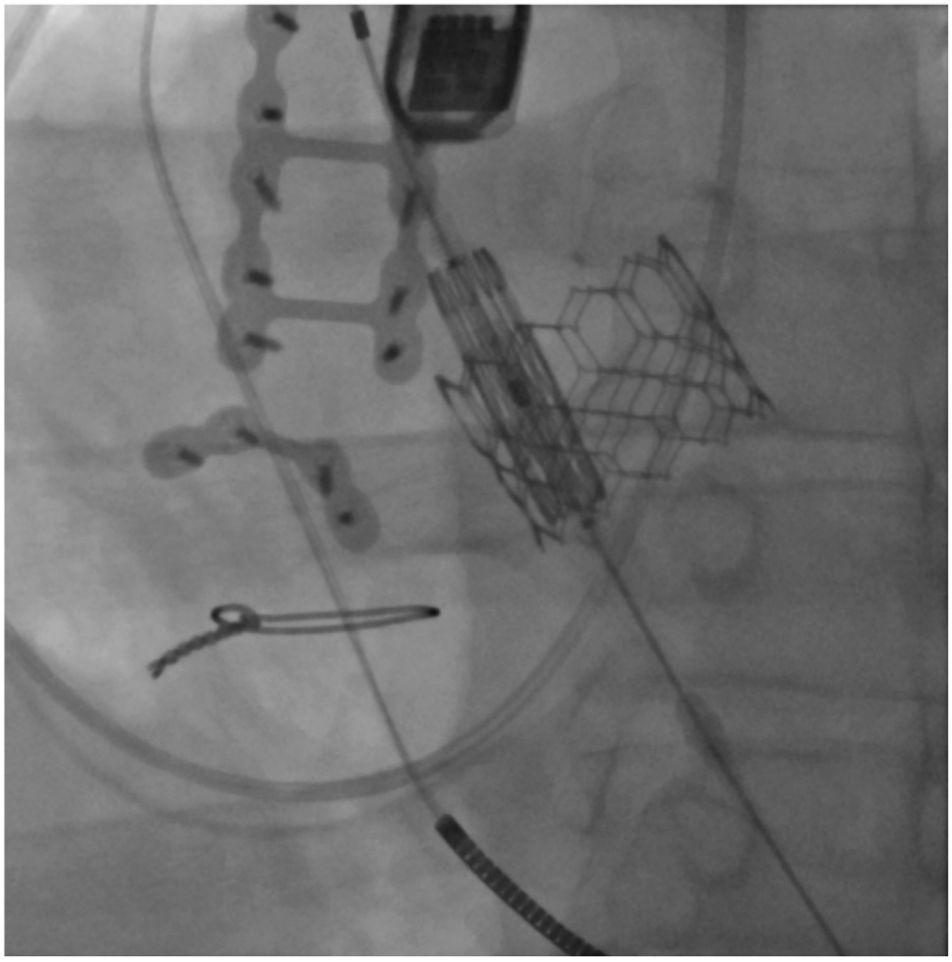


Fig. 4. Positioning of the second Edwards Sapien – valve in valve.

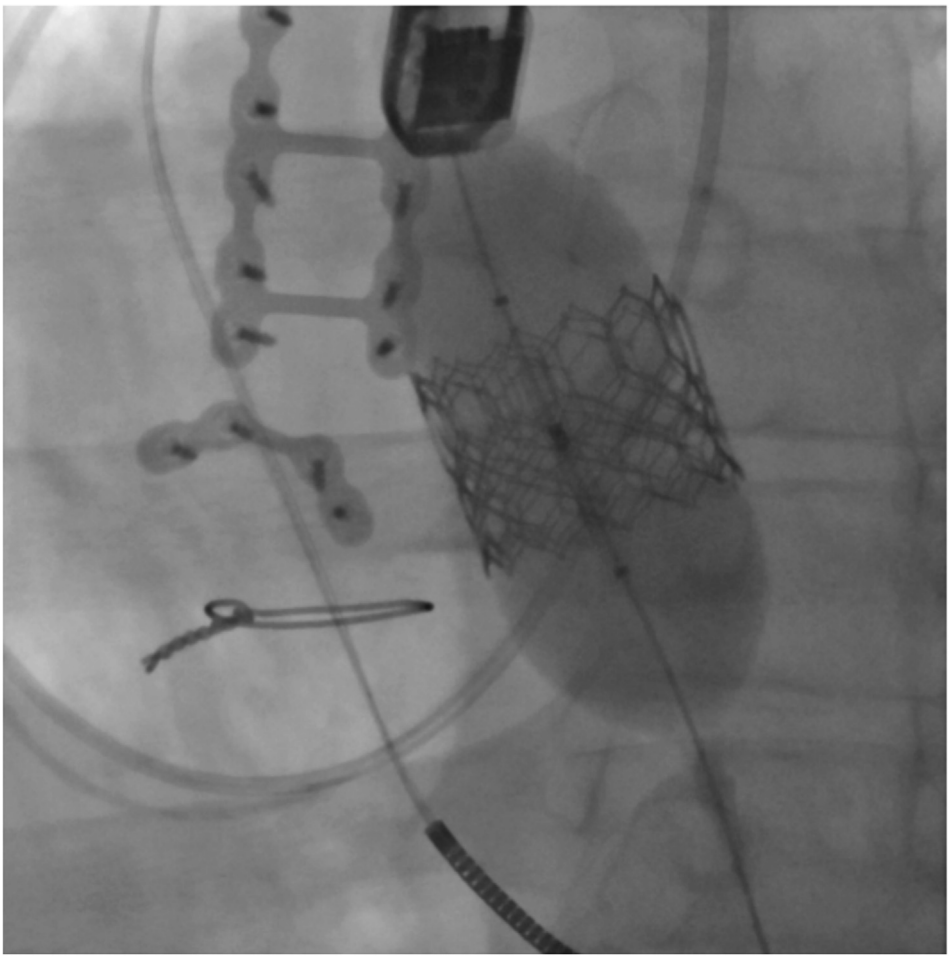


Fig. 5. Second Edwards Sapien valve deployed successfully.

reported a case where they treated AI in patient with LVAD by TAVR using an Edwards Sapien valve [13]. Yehya et al reported successful resolution of AI by TAVR in 9 patients who developed AI after long term use of CF-LVAD [14].

In our patient, hemodynamic compromise and reduced systemic perfusion prompted the cardiac team to intervene the AI. Given the acuity of the situation TAVR was a safer option. Even though the first TAVR successfully treated the AI, hemodynamic collapse requiring CPR resulted in dislodgement of the prosthetic valve, likely due to the lack of calcification of the leaflets serving as an anchor for the prosthesis. Both Rene et al and D'Ancona et al slightly oversized AV for LAVD patients since position of the inflow cannula into LV apex can impact valve position or even lead to valve migration into LV. Additionally, oversizing the valve gives more room for better anchoring the valve in the AV annulus [6,13]. Rene and coauthors have also postulated that at least 15% oversizing is necessary to avoid valve migration [6]. Similarly, we added 4 cc additional volume to 29 mm Edwards Sapien to oversize our valve. The largest currently available TAVR valve is self-expanding valve (the Medtronic Evolute 34 mmXL) which is able to achieve substantial annular size [15]. However, additional volume can be added to balloon expandable 29 mm Edward Sapien 3 to increase the size to fit to larger annulus. In addition, the expansion force of the balloon expandable valve was felt to be helpful in anchoring in less calcified leaflets. In the event of sudden hemodynamic collapse, a controlled airway and general anesthesia (GA) proved beneficial. It is unclear why the S3 dislodged. We hypothesized that CPR resulted in movement of the S3 because it appeared to be functioning normally on TEE prior. Also, one would expect the dislodgement from the LVAD to occur with the TAVR valve being forced into the ventricle– this appeared to dislodge aortic. The AI immediately after the TAVR deployed was central and may have been due to the LVAD outflow, overexpansion or both. We attribute the initial arrest immediately after deployment to RV dysfunction because this is what appeared as most problematic on TEE prior to arrest.

Continuous TEE evaluation of patient hemodynamics, diagnosis of AI and post procedural assessment TAVR were highly valuable. TEE also demonstrated severe right heart depression during sudden hemodynamic collapse and prompted immediate initiation of CPR. It also guided ECMO cannula placement and final cannula positioning. It was important to carefully evaluate position of LVAD ECMO cannula into LV apex, newly placed prosthetic AV and ECMO cannulas and functionality of each of them. TEE can be instrumental for these.

Unfortunately, our patient suffered from multiple complications and ultimately had a negative outcome. But that was not direct effect of the TAVR procedure. Our goal here is to discuss how TAVR can be a feasible option in these highly complex patient population. A multidisciplinary team based approach and close communication amongst cardiologists, cardiothoracic surgeons and cardiac anesthesiologists can lead to success.

Denovo AI after prolonged LVAD implantation requires complicated and urgent management, and will increase in frequency due to sharp increases in LVAD implantation. TAVR can be a feasible management option in this critically ill and non-surgical popula-

tion because of its less invasive nature. Dedicated studies for this indication would improve understanding of this intervention. TEE plays a vital role in many steps including hemodynamic monitoring, deploying the prosthetic valve and assessing the adequacy of the position and function of the prosthetic valve.

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We did not receive any grant or funding from any governmental or private agencies.

Declaration of Competing Interest

None.

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