

Catheter-based embolectomy prior to right ventricular mechanical circulatory support placement after heart transplantation

Vikrant S. Jagadeesan* , Laura J. Davidson, Andrei Churyla and Keith H. Benzuly

Bluhm Cardiovascular Institute, Northwestern Memorial Hospital, Northwestern University Feinberg School of Medicine, Chicago, IL, USA

Abstract

Severe acute isolated right ventricular failure has limited dedicated percutaneous temporary mechanical circulatory support options, especially after orthotopic heart transplantation. The advent of the Impella RP device provides a newer option, though an absolute contraindication to device placement is thrombus within the right heart. We present a novel case where catheter-based embolectomy was used to evacuate right heart thrombus before Impella RP placement in a patient with severe acute right ventricular failure due to primary graft dysfunction after orthotopic heart transplantation.

Keywords Thrombectomy; Mechanical circulatory support; Cardiogenic shock; Transplantation

Received: 17 May 2020; Revised: 27 June 2020; Accepted: 16 July 2020

**Correspondence to: Vikrant Jagadeesan, Arkes Family Pavilion, Northwestern Memorial Hospital, 676 N Saint Clair, Suite 700 Chicago, IL 60611, USA. Tel: 630-687-4403; Fax: 312-926-8620.*

Email: vikrant.jagadeesan@northwestern.edu

Introduction

Primary graft dysfunction (PGD) is the leading cause of 30 day mortality after orthotopic heart transplantation (OHT).¹ Isolated right ventricular (RV) failure due to PGD when left ventricular (LV) function is preserved is challenging due to limited available options for dedicated percutaneous RV temporary mechanical circulatory support (MCS). One option is the Tandem Heart RV assist device, essentially a strategy of veno-venous extracorporeal membrane oxygenation (ECMO) commonly using the Tandem Protek Duo cannula (LivaNova, London, UK). This 29F or 31F system consists of a dual-lumen cannula with inflow consisting of a series of vents within the superior vena cava and right atrium (RA). The inflow drains blood into an extracorporeal centrifugal pump before flowing through a second lumen serving as the outflow cannula to the proximal segment of the main pulmonary artery. Food and Drug Administration approval of the Impella RP device (Abiomed, Danvers, MA, USA) provides another percutaneous option—a 22F intracorporeal axial motor mounted on an 11F catheter that propels blood from inflow in the RA to outflow in the main pulmonary artery.²

An absolute contraindication to Impella RP placement is thrombus within the inferior vena cava (IVC)/RA due to risk for pump failure from obstructing inflow, as well as thrombo-embolic complications. This concern also theoretically extends to the Tandem Protek Duo, especially with respect to circuit/oxygenator obstruction or malfunction from thrombus entering through the inflow cannula. Herein, we present a case of a patient after OHT with isolated severe RV-PGD who was found to have multiple mobile right heart thrombi (RHT). In order to facilitate placement of the Impella RP, catheter-based embolectomy (CBE) was performed using the AngioVac (AngioDynamics, Latham, NY, USA) system.

Case report

The patient is a 38-year-old man with a history of non-ischaemic cardiomyopathy secondary to viral myocarditis with an ejection fraction (EF) by transthoracic echocardiography estimated to be 10–15%. The patient's heart failure became progressively refractory to maximal medical therapy and cardiac re-synchronization therapy for concurrent left

bundle branch block, leading to LV assist device implantation as a bridge-to-transplant strategy. At the time of his LV assist device implantation, the RV was noted to be moderately dilated with mildly reduced systolic function. The patient underwent OHT approximately 8 months later.

Within 24 hours after OHT, the patient had persistently high vasopressor requirements concerning for acute biventricular graft dysfunction necessitating urgent veno-arterial ECMO cannulation. Transoesophageal echocardiogram (TEE) revealed thrombus surrounding the LV laterally and inferiorly. In addition, the RV was noted to have severely reduced systolic function and appeared to be compressed during diastole. Because of concern for haemodynamically significant tamponade physiology, the patient was emergently taken back to the operating room for mediastinal exploration and washout. TEE post-operatively demonstrated improvement in LVEF to 40% and adequate RV decompression. Acute anti-rejection therapies including anti-thymocyte globulin and high doses of intravenous methylprednisolone were initiated in addition to continued therapy with mycophenolate mofetil and tacrolimus. Retrospective donor-specific cross-match was negative, and no donor-specific antibodies were identified. Endomyocardial biopsy was negative for acute cellular or antibody-mediated rejection. In the ensuing 3–4 days, lower pressor requirements and overall clinical stability led to veno-arterial ECMO decannulation.

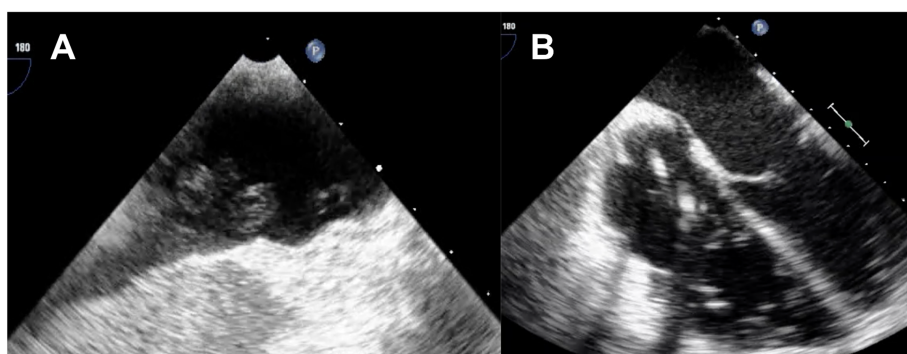
On post-operative Day 4, the patient again began to have escalating vasopressor requirements. TEE revealed improving LV function with an estimated EF of 70% and no evidence for pericardial effusion. However, severe RV systolic dysfunction was noted concerning for RV-PGD. In addition, new severe tricuspid regurgitation with systolic hepatic venous flow reversal and new multiple mobile thrombi at the IVC–RA junction were discovered without evidence of pulmonary embolism (PE; *Figure 1A*). The patient became progressively oliguric necessitating renal replacement therapy and had worsening markers of end-organ perfusion including rising lactic acid levels and liver function tests despite escalations

in vasopressor doses. Consequently, multidisciplinary discussions took place between interventional cardiology, advanced heart failure, and cardiothoracic surgery in order to discuss optimal MCS treatment options.

A major concern was the potential for complications due to the large IVC–RA thrombus burden with any form of MCS. Systemic or catheter-directed pharmacologic thrombolysis was deemed too high risk for life-threatening haemorrhage especially in the context of recent OHT and surgical re-exploration for haemorrhagic pericardial effusion causing tamponade physiology. For the same reasons, open surgical reoperation for thrombus extraction was also deemed high risk. Thus, CBE for thrombotic burden debulking prior to dedicated RV MCS placement was considered the lowest risk available option. Given concomitant concern for internal jugular venous thrombi, the Impella RP system was utilized as the dedicated percutaneous RV MCS option utilizing the right common femoral vein.

Catheter-based embolectomy was performed utilizing the AngioVac device followed by Impella RP placement under fluoroscopic and TEE guidance. The AngioVac system is a veno-venous extracorporeal circuit with a centrifugal pump and thrombus filter. After RHT is aspirated, it is filtered and trapped within a reservoir. The filtered blood can be transfused back to the patient to avoid excess blood loss. Large bore (26 Fr) access was obtained in the left femoral vein for aspiration cannula placement and 17 Fr access in the right common femoral vein for the cannula for blood return. After systemic heparinization with activated clotting time greater than 250 s, the AngioVac catheter was advanced over a wire into the IVC, and the circuit was connected and de-aired. The circuit was turned on with flow 2–3 L/min at about 3000–4000 rpm. The petals were opened, and several passes into the RA (*Figure 1B*) were performed with thrombus captured within the filtered reservoir. The AngioVac device was subsequently removed, and the blood remaining in the circuit was returned to the patient. The 17 Fr AngioVac return cannula was removed over an extra stiff guidewire and exchanged

FIGURE 1 Transoesophageal echocardiogram images depicting (A) modified dedicated inferior vena cava–right atrium view showing multiple mobile thrombi and (B) mid-oesophageal four-chamber view showing the AngioVac device within the right atrium.



for the Impella RP sheath. Then, the Impella RP device was inserted in the usual fashion (*Figure 2*). Large pieces of organized thrombus (*Figure 3*) were collected and confirmed on pathologic examination from the AngioVac system.

After Impella RP insertion, the patient had improving lactic acid levels and liver function tests with decreasing requirements of vasoactive medications. Serial transthoracic echocardiography showed improvement in RV function that ultimately led to Impella RP removal 4 days later. The patient's RV function continued to improve as vasopressor support was ultimately weaned completely. The patient had complete renal recovery and was discharged 1 month later to rehabilitation without complication and is doing well now more than 2 years after OHT.

Discussion

We present a case of severe RV-PGD after OHT complicated by significant RHT. These patients are critically ill, and RHT can preclude the use of available percutaneous haemodynamic support devices. The Impella RP is placed with the inflow just below the junction of the IVC and RA. In this particular case, serial imaging clearly demonstrated multiple mobile thrombi within the RA/IVC junction. We performed CBE with the AngioVac system to decrease thrombotic burden sufficiently to avoid potential complications prior to placing dedicated RV MCS. This situation may be uncommon, but advanced imaging is not always performed before MCS placement, and imaging may be insensitive. Thus, RHT may also be under-recognized as a potential mechanism of device failure. In the MAUDE database report of 35 Impella RP complications, 17% of device failures were related to thrombus.³

When considering therapeutic strategies for RHT not related to PE, treatment options include systemic anticoagulation, systemic or catheter-directed pharmacologic thrombolysis, and open surgical or catheter-based mechanical embolectomy. In the setting of cardiogenic shock and

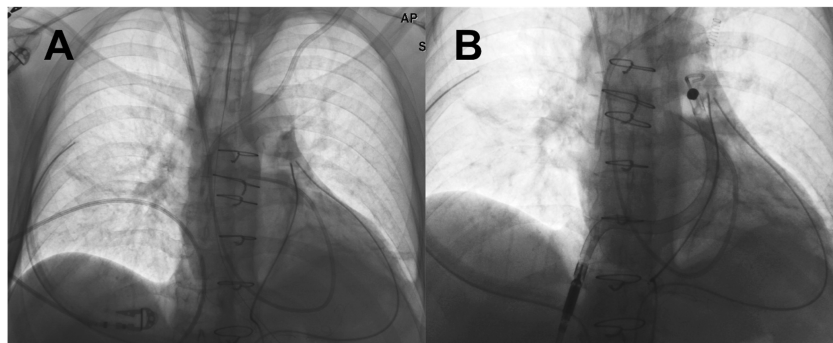
FIGURE 3 Photograph of the aspirated thrombotic material at the conclusion of the procedure.



haemodynamic instability, systemic anticoagulation is not an effective strategy. When systemic or catheter-directed pharmacologic thrombolysis and open surgical embolectomy are too high risk, as in this case, CBE can be considered. Randomized studies comparing the efficacy of various CBE devices for RHT are lacking. A single-centre experience utilizing the AngioVac system across the contexts of PE, RHT, and ilio caval thrombus demonstrated a 60% complete success rate and 20% partial success rate.⁴ FLARE, a single-arm study evaluating the FlowTrieve System (Inari Medical, Irvine, CA, USA), demonstrated a reduction in RV/LV ratio by 0.39 48 h after the procedure; however, this study was in PE and not PE complicated by RHT.⁵

When contemplating percutaneous dedicated RV MCS options, the Tandem Protek Duo and Impella RP each offer certain unique advantages and disadvantages. Both offer the convenience of a single venous access site. The Tandem

FIGURE 2 Fluoroscopic images (A) prior to and (B) after Impella RP placement.



Protek Duo offers the ability to splice an oxygenator within the circuit to address hypoxaemia and a lower risk of infection utilizing internal jugular as opposed to femoral venous access. However, the larger 29F–31F cannula increases the risk of access site complications and bleeding, while the Impella RP's peel-away 23F sheath can be replaced with a staged 11F–23F repositioning sheath. The Tandem Protek Duo being an extracorporeal circuit mandatorily increases the distance blood has to travel between inflow and outflow, increasing the risk of thrombus formation and/or chance of mechanical issues such as inadvertent tubing compression. The main disadvantages of the Impella RP are the inability to add an oxygenator and haemolysis from the axial impeller mechanism of its motor.

There are limited data overall in temporary MCS for RV failure after OHT. THRIVE was a retrospective study of 46 patients across various post-surgical settings examining the utility of the Tandem Heart RV assist device in post-surgical RV failure. Despite improved overall haemodynamic parameters, overall in-hospital mortality was high at 57%. Only five of the patients were post-OHT with an in-hospital mortality of 40%.⁶ The RECOVER RIGHT trial was a prospective study examining the Impella RP in 30 isolated RV failure patients.⁷ These data also showed improvement in haemodynamic

parameters with a 30 day survival of 73.3%. The limitation again in this cohort is post-OHT representation: only five patients were post-OHT and were analysed as part of a larger, heterogenous cohort consisting of mainly post-myocardial infarction and post-cardiotomy patients.

In conclusion, this case demonstrates a unique approach of using CBE for multiple RA/IVC thrombi using the AngioVac system to allow safe percutaneous dedicated RV MCS placement. We also highlight the use of the Impella RP device as a potentially effective temporary MCS option in RV-PGD after OHT, though further data in this particular context are needed.

Conflict of interest

V.S.J., L.J.D., A.C., and K.H.B. have no conflicts of interest.

Funding

None.

References

1. Singh SSA, Dalzell JR, Berry C, Al-Attar N. Primary graft dysfunction after heart transplantation: a thorn amongst the roses. *Heart Fail Rev* 2019; **24**: 805–820.
2. Kapur NK, Esposito ML, Bader Y, Morine KJ, Kiernan MS, Pham DT, Burkhoff D. Mechanical circulatory support devices for acute right ventricular failure. *Circulation* 2017; **136**: 314–326.
3. Khalid N, Rogers T, Shlofmitz E, Chen Y, Musallam A, Khan JM, Iantorno M, Gajanana D, Hashim H, Torguson R, Bernardo N, Waksman R. Adverse events and modes of failure related to Impella RP: insights from the Manufacturer and User Facility Device Experience (MAUDE) database. *Cardiovasc Revasc Med* 2019; **20**: 503–506.
4. D'Ayala M, Works B, Gulkarov I, Sista A, Horowitz J, Salemi A. Factors associated with successful thrombus extraction with the AngioVac device: an institutional experience. *Ann Vasc Surg* 2017; **38**: 242–247.
5. Tu T, Toma C, Tapson VF, Adams C, Jaber WA, Silver M, Khandar S, Amin R, Weinberg M, Engelhardt T, Hunter M, Holmes D, Hoots G, Hamdalla H, Maholic RL, Lilly SM, Ouriel K, Rosenfield K. A prospective, single-arm, multicenter trial of catheter-directed mechanical thrombectomy for intermediate-risk acute pulmonary embolism: the FLARE study. *JACC Cardiovasc Interv* 2019; **12**: 859–869.
6. Kapur NK, Paruchuri V, Jagannathan A, Steinberg D, Chakrabarti AK, Pinto D, Aghili N, Najjar S, Finley J, Orr N, Tempelhof M, Mudd J, Kiernan MS, Pham DT, DeNofrio D. Mechanical circulatory support for right ventricular failure. *JACC Heart Fail* 2013; **1**: 127–134.
7. Anderson MB, Goldstein J, Milano C, Morris LD, Kormos RL, Bhama J, Kapur N, Bansal A, Garcia J, Baker J, Silvestry S, Holman W, Douglas P, O'Neill W. Benefits of a novel percutaneous ventricular assist device for right heart failure: the prospective RECOVER RIGHT study of the Impella RP device. *J Heart Lung Transplant* 2015; **34**: 1549–1560.