jove

Mechanical Circulatory Support For Cardiogenic Shock – Where Do We Stand?

Muhammad Asim Shabbir[1], **Aditya S. Bharadwaj**[2], **Poonam Velagapudi**[1]

[1] Division of Cardiovascular Disease, University of Nebraska Medical Center [2] Division of Cardiology, Loma Linda University Health

Corresponding Author

Muhammad Asim Shabbir
asimshabbir202@gmail.com

Citation

Shabbir, M.A.,Bharadwaj, A.S.,Velagapudi, P. Mechanical Circulatory Support For Cardiogenic Shock – Where Do We Stand?. *J. Vis. Exp.* (193), e65024, doi:10.3791/65024 (2023).

Date Published

March 3, 2023

DOI

10.3791/65024

URL

jove.com/video/65024

Editorial

Cardiogenic shock (CS) has a high (~40%–50%) in-hospital mortality rate that has largely remained unchanged for more than a decade[1,2]. Several percutaneous mechanical circulatory support (pMCS) devices have been developed to treat CS acutely, as well as to serve as a bridge to the use of advanced therapies such as a surgical ventricular assist device (VAD) or a heart transplant when native heart recovery fails. As a group, pMCS devices improve end-organ perfusion by augmenting the cardiac output (CO). **Table 1** compares various types of pMCS devices. In this editorial, we discuss the following pMCS devices: intra-aortic balloon pump (IABP)[3], Impella[4], TandemHeart[5], right ventricular assist device (RVAD)[6], and veno-arterial extracorporeal membrane oxygenation (VA-ECMO).

The intra-aortic balloon pump (IABP) is an easy-to-insert pMCS device that works on the principle of counterpulsation. It improves coronary blood flow and systemic perfusion and reduces the left ventricular (LV) afterload. Based on the results of the IABP-SHOCK II trial[7], which showed no mortality benefits of IABP use in acute myocardial infarction (AMI)-associated CS, the 2013 ACC/AHA guidelines give a class 2a recommendation for IABP use in these patients[8]. The 2020 ESC NSTE-ASC guidelines discourage the routine use of IABP in AMI and CS (class 3b) but recommend considering it in select patients with the mechanical complications of AMI (class 2a)[9].

The Impella device utilizes an axial flow Archimedes screw pump to propel blood from the LV to the aorta, thereby unloading the LV and increasing the CO and tissue perfusion[4]. Previous trials have shown no difference in mortality between Impella and IABP in patients with AMI-associated CS[10,11]. More recently, the National Cardiogenic Shock Initiative (NCSI), a single-arm study, showed 72% survival to discharge with a protocol-based treatment of patients with CS associated with AMI[12]. The NCSI utilized a standardized protocol that emphasized the importance of early recognition of CS, the utilization of Impella before percutaneous coronary intervention (PCI), and the use of right heart catheterization to assess the hemodynamics. Thus, patient selection and a protocol-based approach may be key to obtaining the maximum benefit from the use of this device in AMI patients with CS. Complications associated with the use of the Impella device include the risk of access site bleeding

and acute limb ischemia from the use of large bore 14F sheaths. Careful patient selection after weighing the risks and benefits is key for obtaining the best results with Impella use in AMI patients with CS.

The TandemHeart (TH) bypasses the LV by shunting blood from the left atrium (LA) to the femoral artery (FA)[5]. The TH can provide flow up to 4.5 L/min and may help in CS refractory to IABP. A multicenter randomized control trial (RCT) showed improved hemodynamics with TH but failed to show any difference in 30 day mortality compared with IABP in patients presenting within 24 h of CS development due to AMI and decompensated heart failure[13]. Kar et al.[14] showed an improvement in the cardiac index from a median of 0.52/min/m^2 to 3.0L/min/m^2 in 117 patients with severe CS refractory to IABP and/or vasopressors. However, both the 30 day and 6 month mortality rates were high (~40%) in these patients. Most of these trials were single arm, with few patients and without long-term follow-up. In addition, TH requires larger cannulas compared with IABP and Impella, which exposes patients to a higher risk of access site bleeding and limb ischemia. The positioning of the LA cannula requires transeptal puncture, which adds to the complexity of the device insertion. RCTs are needed to provide more definitive data to guide the use of TH, and until then, careful patient selection involving weighing the risks against the benefits is important. Some specific uses for TH include situations in which there is an LV thrombus, as this device bypasses the LV.

Commonly used percutaneous right ventricular assist devices (pRVAD) include Impella-RP and ProtekDuo. Impella-RP helps to augment the RV output by propelling blood from the RV into the pulmonary artery (PA), thereby reducing the right-sided filling pressure. ProtekDuo is a dual lumen device that shunts blood from the right atrium (RA) to the PA, essentially bypassing a failing right ventricle (RV). It can be used with or without an external oxygenator as a part of ECMO. There is a paucity of data on the mortality benefits of pRVADs because of the novelty of these devices, and well-planned RCTs are needed to validate their benefits.

Veno-arterial (VA) ECMO consists of an inflow cannula, a centrifugal pump, an oxygenator, and an outflow cannula and usually provides flows up to 3–4 L/min. The inflow cannula drains deoxygenated blood from the central vein, which is cycled through an oxygenator and pumped into a central artery *via* the outflow cannula. Survival to hospital discharge with the use of VA-ECMO in refractory CS ranges between ~30%–70%[15] depending on the etiology of the CS[16]. Moreover, due to the use of large bore cannulas, the hemodynamic benefits of ECMO may be offset by its significant bleeding complications[17]. An ECMO-CS trial of 117 patients did not show a benefit of immediate VA-ECMO use over early conservative therapy in severe or rapidly deteriorating CS[18]. In the absence of large-scale RCTs, the use of ECMO is usually reserved for critically ill patients for whom other modes of pMCS have failed.

CS is associated with a high mortality rate despite significant advances in pMCS devices. These pMCS devices may be used to provide hemodynamic support in CS either acutely or as a bridge to more definitive therapy, such as the use of a durable VAD or cardiac transplant. The use of pMCS devices is plagued by the dearth of large-scale RCTs showing a mortality benefit. Moreover, the use of large bore access for these devices increases the risk of access site complications. Thus, careful case-by-case patient and device selection by evaluating the risks against the benefits and an algorithmic approach are essential to obtain the best possible outcomes

until data from large-scale RCTs provide definitive guidance regarding their use.

Table 1: Comparison of different modalities of percutaneous mechanical circulatory support.

Disclosures

Poonam Velagapudi is part of the speaker's bureau at Abiomed, Medtronic, Opsens, and Shockwave Medical and part of the advisory board at Abiomed and Sanofi. Aditya S. Bharadwaj is a speaker and consultant at Abiomed, Cardiovascular Systems Inc, and Shockwave Medical.

Acknowledgments

The authors have no acknowledgments.

References

1. Thiele, H. et al. One-year outcomes after PCI strategies in cardiogenic shock. *New England Journal of Medicine.* **379** (18), 1699-1710 (2018).
2. Thiele, H. et al. Percutaneous short-term active mechanical support devices in cardiogenic shock: a systematic review and collaborative meta-analysis of randomized trials. *European Heart Journal.* **38** (47), 3523-3531 (2017).
3. Gajanan, G. et al. The intra-aortic balloon pump. *Journal of Visualized Experiments.* (168), e62132 (2021).
4. Nandkeolyar, S., Velagapudi, P., Basir, M. B., Bharadwaj, A. S. Utilizing percutaneous ventricular assist devices in acute myocardial infarction complicated by cardiogenic shock. *Journal of Visualized Experiments.* (172), e62110 (2021).
5. Sundaravel, S., Velagapudi, P., Mamas, M., Nathan, S., Truesdell, A. Use of a percutaneous ventricular assist device/left atrium to femoral artery bypass system for cardiogenic shock. *Journal of Visualized Experiments.* (174), e62140 (2021).
6. Brown, K. N., Castleberry, A., Velagapudi, P. Insertion, maintenance, and removal of the percutaneous dual lumen cannula right ventricular assist device. *Journal of Visualized Experiments.* (185), e62951 (2022).
7. Thiele, H. et al. Intraaortic balloon support for myocardial infarction with cardiogenic shock. *New England Journal of Medicine.* **367** (14), 1287-1296 (2012).
8. O'Gara, P. T. et al. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction. A report of the American College of Cardiology Foundation/ American Heart Association Task Force on Practice Guidelines. *Circulation.* **127** (4), e362-e425 (2013).
9. Collet, J.-P. et al. 2020 ESC Guidelines for the management of acute coronary syndromes in patients presenting without persistent ST-segment elevation. *European Heart Journal.* **42** (14), 1289-1367 (2021).
10. Seyfarth, M. et al. A randomized clinical trial to evaluate the safety and efficacy of a percutaneous left ventricular assist device versus intra-aortic balloon pumping for treatment of cardiogenic shock caused by myocardial infarction. *Journal of the American College of Cardiology.* **52** (19), 1584-1588 (2008).
11. Karami, M. et al. Long-term 5-year outcome of the randomized IMPRESS in severe shock trial: percutaneous mechanical circulatory support vs. intra-aortic balloon pump in cardiogenic shock after acute myocardial infarction. *European Heart Journal Acute Cardiovascular Care.* **10** (9), 1009-1015 (2021).

12. Basir, M. B. et al. Improved outcomes associated with the use of shock protocols: Updates from the National Cardiogenic Shock Initiative. *Catheterization and Cardiovascular Interventions.* **93** (7), 1173-1183 (2019).

13. Burkhoff, D., Cohen, H., Brunckhorst, C., O'Neil, W. W. A randomized multicenter clinical study to evaluate the safety and efficacy of the TandemHeart percutaneous ventricular assist device versus conventional therapy with intraaortic balloon pumping for treatment of cardiogenic shock. *American Heart Journal.* **152** (3), 469.e1-8 (2006).

14. Kar, B., Gregoric, I. D., Basra, S. S., Idelchik, G. M., Loyalka, P. The percutaneous ventricular assist device in severe refractory cardiogenic shock. *Journal of the American College of Cardiology.* **57** (6), 688-696 (2011).

15. Rao, P., Khalpey, Z., Smith, R., Burkhoff, D., Kociol, R. D. Venoarterial extracorporeal membrane oxygenation for cardiogenic shock and cardiac arrest. *Circulation: Heart Failure.* **11** (9), e004905 (2018).

16. Acharya, D. et al. Extracorporeal membrane oxygenation in myocardial infarction complicated by cardiogenic shock: Analysis of the ELSO registry. *Journal of the American College of Cardiology.* **76** (8), 1001-1002 (2020).

17. Combes, A. et al. Extracorporeal membrane oxygenation for severe acute respiratory distress syndrome. *New England Journal of Medicine.* **378** (21), 1965-1975 (2018).

18. Ostadal, P. et al. Extracorporeal membrane oxygenation in the therapy of cardiogenic shock: Results of the ECMO-CS randomized clinical trial. *Circulation.* 10.1161/CIRCULATIONAHA.122.062949 (2022).