https://doi.org/10.3329/jicc.v6i2.93325

EDITORIAL

MCS in CHIP Procedures- The New Hemodynamic Paradigm

Afzalur Rahman, Farah Naz Huq

J Inv Clin Cardiol 2024; 6(2): 31-34

As interventionalists push the boundaries of revascularization by approaching increasingly complex coronary lesions, the use of mechanical circulatory support (MCS) devices has evolved from being a last resort to a fundamental component of the treatment algorithm. This brings us to the pivotal clinical question: how do we optimally select the right device for the right patient at the right time to reduce the high mortality rate in these cohorts? This article is an overview of MCS devices and presents a simplified analysis and algorithm for complex, High-risk interventions (CHIP) and cardiogenic shock.

A Brief Look into MCS Devices

The rationale for deploying temporary MCS devices in high-risk PCI and cardiogenic shock is clear. They function by unloading the ventricles, improving systemic perfusion and providing the hemodynamic stability necessary to achieve complete revascularization. They are typically categorized based on the ventricles requiring assistance: Left Ventricular (LV) assist devices (eg, Intra-Aortic Balloon Pump [IABP], Impella CP/5.5, TandemHeart), Right Ventricular (RV) assist devices (eg, Impella RP, ProtekDuo), or Biventricular devices (eg, Venoarterial extracorporeal membrane oxygenation [VA-ECMO]). The table below gives an overview of the various MCS devices currently being used.

Determinants of MCS in CHIP

Although different operators follow different approaches to the use of MCS, this figure briefly states the clinical, hemodynamic and technical determinants that mandate the use of MCS. Older age (75 years), frailty, chronic kidney disease (CKD), acute coronary syndrome (ACS), and surgical turndown are some of the clinical determinants, whereas severe aortic stenosis, severe mitral regurgitation, systolic dysfunction (LVEF,35%), and cardiac index < 2 L/m/m^2 with LVEDP> 5 mmHg are the hemodynamic determinants. Technically complex procedures like multivessel PCI, PCI of the last remaining vessel, atherectomy for high calcium burden (possible slow or no-reflow) and retrograde CTO PCI through the last remaining vessel should be supported by MCS devices.

The Evolution of MCS and the Evidence Paradox

The first-generation MCS devices include the Intra-Aortic Balloon Pump (IABP), which offers a modest increase in cardiac output, but its routine use in Acute Myocardial Infarction (AMI) complicated by cardiogenic shock (AMI-CS) was not shown to reduce 30-day mortality in the landmark IABP-SHOCK II trial. This accelerated the transition toward utilizing higher-powered percutaneous ventricular assist devices (pVADs), notably the Impella micro axial flow pump.

A clinical paradox characterized the evidence for these advanced devices. While observational studies and meta-analysis have suggested that pVADs (like Impella) may be associated with lower early mortality and reduced risk of post-procedural cardiogenic shock compared to IABP, concurrent large-scale registry data that compared Impella to IABP in the setting of AMI-CS reported a higher in-hospital mortality rate and major bleeding for Impella. This disparity could, however, be attributed to selection bias, the more critically ill patients being selected for higher-level support devices, skewing the outcomes.

From Evidence to Algorithm: Future Directions in Optimizing Care

The DanGer Shock Trial represents the most recent and rigorous evidence to have entered this debate. This randomized trial, which compared micro-axial left

1. Senior Consultant, Continental Hospital PLC, Dhaka, Bangladesh
2. Specialist Cardiologist, Continental Hospital PLC, Dhaka, Bangladesh

Address of Correspondence: Prof. Afzalur Rahman, Senior Consultant, Department of Cardiology, Continental Hospital PLC, Plot 15, Rd No 71, Gulshan-2, Dhaka-1212, Bangladesh. Email- afzalur.bit@gmail.com

Table-I

Determinants of MCS in CHIP

	IABP	Impella CP and 5.5	TandemHeart	Impella RP	ProtekDuo	VA-ECMO
Mechanism of Action	Balloon inflation-deflation	Continuous axial flow (LV to aorta)	Continuous centrifugal flow (LA to aorta)	Continuous axial flow (RV to PA)	Continuous centrifugal flow (RA to PA)	Continuous centrifugal flow
Cardiac Output Augmentation (L/min)	0.5–1	2.5–5.5	4	2.5–5.5	4–5	Up to 7
Access	Femoral or Axillary artery	Femoral or Axillary artery	Femoral or Axillary vein	Femoral vein	Right IJV	Femoral artery and Femoral vein
Cannula Size	7–8 F arterial	13–21 F arterial	12–19 F arterial; 21 F venous	11 F venous	29 F venous	14–19 F arterial; 17–21 F venous
Advantages and Special Uses	Simple cannulation; < 8 F arterial access; Low bleeding/vascular complications; Effective in mitral regurgitation	Simple cannulation; Direct LV unloading; Physiologic antegrade flow	Direct LA unloading; Indirect LV unloading	Physiologic flow; Indirect RV unloading	IJV access; Allows ambulation	Simple cannulation; Biventricular support; Oxygenation support
Drawbacks and Contra-indications	Requires stable cardiac rhythm/native heart function; Limited support; Contraindicated in aortic regurgitation and dissection	Contraindicated with mechanical aortic valve or LV thrombus	Transseptal access requires expertise; Nonphysiologic retrograde flow	RV dysfunction and vascular complication if placed incorrectly	Safety/efficacy limited to retrospective reviews; High flow can cause LV distension and pulmonary edema	Nonphysiologic retrograde flow; High bleeding and vascular complication rates

Source: Khalil M, Mohammed HA, Cilia L, Alaswad K, Megaly M. Mechanical Circulatory Support Use in Cardiogenic Shock and Complex PCI. Cardiac Interventions Today. 2024;18(1):40–4.

Table-II

Determinants of MCS in CHIP

		Specific Determinants
High-Risk Patient:	**Clinical**	Older age (>75 years) Frailty Chronic kidney disease Presentation with acute coronary syndrome Surgical turndown
	Hemodynamics & Cardiac Function	**Structural/Valvular** Severe aortic stenosis Severe mitral regurgitation
		Functional Metrics Systolic dysfunction (LVEF <35%) Cardiac index < 2L/m/m^2 LVEDP > 15mmHg
Technically Complex Procedure	**Lesion/Vessel Profile**	Multivessel PCI PCI of the last remaining vessel High calcium burden requiring atherectomy (risk of slow/no-reflow)
	Technical Approach	Retrograde CTO PCI through the last remaining vessel

Source: Khalil M, Mohammed HA, Cilia L, Alaswad K, Megaly M. Mechanical Circulatory Support Use in Cardiogenic Shock and Complex PCI. Cardiac Interventions Today. 2024;18(1):40–4.

ventricular assist device (Impella CP) plus standard care versus standard care alone in AMI-CS patients, reported a statistically significant improvement in the primary endpoint of 180-day mortality in the MCS group. The trial also found that the MCS group experienced a substantially higher rate of complications.

The DanGer Shock Trial thus suggests that hemodynamic unloading and circulatory support can positively influence long-term survival when initiated early, but this should be balanced by meticulous procedural care to reduce access-related and bleeding risks.

The core takeaway message is therefore clear: the success of MCS relies not merely on the advanced technology, but on its strategic application by a skilled team. To avoid the progression into a full-blown, irreversible crisis, the focus has shifted to early intervention, and the prevailing paradigm now stipulates a three-pillar strategic approach:

1. Standardized Risk Stratification- The SCAI Shock classification (stages A through E) allows clinicians to categorize shock severity early, facilitating timely initiation of MCS needed for improved outcomes.
2. Invasive Hemodynamic Monitoring- The use of Right Heart Catheterization can accurately characterize the hemodynamic profile and thereby lead to proper diagnosis, device selection and better prognosis.
3. The Multidisciplinary Heart/Shock Team- An approach through a multidisciplinary shock team with specialised expertise using combined escalation strategies (eg, combining VA-ECMO and Impella in ECPELLA for biventricular support) can ensure optimal patient safety and outcome consistency.

In conclusion

MCS devices are indispensable tools for managing critical patients with Cardiogenic shock and complex PCI, a fact supported by the latest randomized trials. Their regular use is, however, debatable since the outcome benefits can be outweighed by the risks of procedural harm and complications unless supported by early detection, hemodynamic assessment, and a standardized protocol-driven approach through a dedicated multidisciplinary Heart/Shock Team.

References

1. Khalil M, Mohammed HA, Cilia L, Alaswad K, Megaly M. Mechanical Circulatory Support Use in Cardiogenic Shock and Complex PCI. Cardiac Interventions Today. 2024;18(1):40–4.
2. Basir MB, Kapur NK, Patel K, et al. Improved outcomes associated with the use of shock protocols: updates from the National Cardiogenic Shock Initiative. Catheter Cardiovasc Interv. 2019;93:1173–83.
3. Telukuntla KS, Estep JD. Acute mechanical circulatory support for cardiogenic shock. Methodist Debakey Cardiovasc J. 2020;16:27–35.
4. Parissis H, Graham V, Lampridis S, et al. IABP: history-evolution-pathophysiology-indications: what we need to know. J Cardiothorac Surg. 2016;11:122.
5. Thiele H, Zeymer U, Neumann FJ, et al. Intraaortic balloon support for myocardial infarction with cardiogenic shock. N Engl J Med. 2012;367:1287–96.
6. Thiele H, Zeymer U, Thelemann N, et al. Intraaortic balloon pump in cardiogenic shock complicating acute myocardial infarction: long-term 6-year outcome of the randomized IABP-SHOCK II trial. Circulation. 2019;139:395–403.
7. Thiele H, Akin I, Sandri M, et al. PCI Strategies in Patients with Acute Myocardial Infarction and Cardiogenic Shock. N Engl J Med. 2023;389:248–57.
8. Burkhoff D, Sayer G, Doshi D, Uriel N. Hemodynamics of mechanical circulatory support. J Am Coll Cardiol. 2015;66:2663–74.
9. O'Neill WW, Kleiman NS, Moses J, et al. A prospective, randomized clinical trial of hemodynamic support with Impella 2.5 versus intra-aortic balloon pump in patients undergoing high-risk percutaneous coronary intervention: the PROTECT II study. Circulation. 2012;126:1717–27.
10. Kar B, Gregoric ID, Basra SS, et al. The percutaneous ventricular assist device in severe refractory cardiogenic shock. J Am Coll Cardiol. 2011;57:688–96.
11. Burkhoff D, Cohen H, Brunckhorst C, O'Neill WW; TandemHeart Investigators Group. 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. Am J Med. 2006;152:469.e1–8.
12. Thiele H, Sick P, Boudriot E, et al. Randomized comparison of intra-aortic balloon support with a percutaneous left ventricular assist device in patients with revascularized acute myocardial infarction complicated by cardiogenic shock. Eur Heart J. 2005;26:1276–83.
13. Megaly M, Gandolfo C, Zakhour S, et al. Utilization of TandemHeart in cardiogenic shock: insights from the THEME registry. Catheter Cardiovasc Interv. 2023;101:756–63.
14. Zein R, Patel C, Mercado-Alamo A, et al. A review of the Impella devices. Interv Cardiol. 2022;17:e05.

15. Maybauer MO, Koerner MM, Swol J, et al. The novel ProtekDuo ventricular assist device: configurations, technical aspects, and present evidence. Perfusion. 2023;38:887–93.

16. Alam A, Baran DA, Doshi H, et al. Safety and efficacy of ProtekDuo right ventricular assist device: a systemic review. Artif Organs. 2023;47:1094–103.

17. Guglin M, Zucker MJ, Bazan VM, et al. Venoarterial ECMO for adults: JACC scientific expert panel. J Am Coll Cardiol. 2019;73:698–716.

18. Jones TL, Nakamura K, McCabe JM. Cardiogenic shock: evolving definitions and future directions in management. Open Heart. 2019;6:e000960.

19. Basir MB, Lemor A, Gorgis S, et al. Early utilization of mechanical circulatory support in acute myocardial infarction complicated by cardiogenic shock: the National Cardiogenic Shock Initiative. J Am Heart Assoc. 2023;12:e031401.

20. Khalil M, Maraey A, Wahadneh OA, et al. Use of a multidisciplinary shock team and inhospital mortality in patients with cardiogenic shock. Am J Cardiol. 2023;206:200–1.

21. Megaly M, Buda K, Alaswad K, et al. Comparative analysis of patient characteristics in cardiogenic shock studies: differences between trials and registries. JACC Cardiovasc Interv. 2022;15:297–304.

22. Basir MB, Schreiber TL, Grines CL, et al. Effect of early initiation of mechanical circulatory support on survival in cardiogenic shock. Am J Cardiol. 2017;119:845–51.

23. Dangas GD, Kini AS, Sharma SK, et al. Impact of hemodynamic support with Impella 2.5 versus intra-aortic balloon pump on prognostically important clinical outcomes in patients undergoing high-risk percutaneous coronary intervention (from the PROTECT II randomized trial). Am J Cardiol. 2014;113:222–8.

24. Kearney KE, McCabe JM, Filey RF. Hemodynamic support for high-risk PCI. Cardiac Interv Today. 2019;13:44–6, 48.

25. Waldo SW, Secemsky EA, O'Brien C, et al. Surgical ineligibility and mortality among patients with unprotected left main or multivessel coronary artery disease undergoing percutaneous coronary intervention. Circulation. 2014;130:2295–301.

26. Perera D, Stables R, Thomas M, et al. Elective intra-aortic balloon counterpulsation during high-risk percutaneous coronary intervention: a randomized controlled trial. JAMA. 2010;304:867–74.