Perioperative Medicine

EDITORIAL

Open Access

Perioperative mechanical circulatory support: transitioning from sequential to parallel recovery

Jean Deschamps[1*] and Andrew D. Shaw[1]

Keywords Cardiogenic shock, Temporary mechanical support, Perioperative, Extracorporeal membrane oxygenation, Microaxial flow pump

Mechanical circulatory support (MCS) devices, such as venoarterial extracorporeal membrane oxygenation (VA-ECMO) and micro-axial flow pumps, are increasingly employed in managing severe shock and cardiac arrest. Emerging evidence suggests that these devices could significantly improve patient outcomes. While evidence for perioperative cardiac surgery MCS is currently limited, insights from recent trials in related populations could guide future research in this area.

Perioperative MCS is generally employed as a "bridge-to-recovery" measure in patients who experience post-cardiotomy shock, a syndrome that occurs in 2–6% of patients. A large retrospective multicenter study of 2058 patients has shown a high mortality of 60.1% during the index hospitalization but with 76.4% of survivors being alive at 10 years, making it a viable strategy (Mariani et al. 2023). The high mortality noted is likely reflective of the heterogeneity of cardiac surgical patients and the increased risk of bleeding, infection, hemolysis, and vascular complications introduced by MCS, which may disproportionately affect surgical patients. As such, expert consensus recommendations are primarily based on expert opinion due to limited evidence on indications, timing, patient selection, and treatment strategies (Lorusso et al. 2021).

After two major negative studies regarding MCS in acute myocardial infarction-associated cardiogenic shock (Thiele et al. 2012, 2023), a recent breakthrough in understanding MCS's role in cardiogenic shock is the DanGer Shock trial (Møller et al. 2024). This international, multicenter, and randomized trial compared the outcomes of patients receiving micro-axial flow pump devices alongside standard medical care to those receiving standard care alone in patients with ST-elevation myocardial infarction (STEMI) complicated by cardiogenic shock. The findings are promising: at 180 days, the group receiving the micro-axial pump had a significantly lower mortality rate than the control group. Criticisms regarding the higher-than-expected mortality in the Danish centers, which were the main drivers of positive outcomes, are warranted and require careful consideration. However, the decreased mortality in the presence of increased adverse events in the micro-axial flow pump group underscores the potential of MCS devices to impact outcomes, potentially from early mitigation of shock, decreased end-organ failure, and improved cardiac recovery.

Two essential elements from DanGer Shock appear relevant to perioperative MCS.

- First, the sustained survival benefit at 180 days, beyond the early shock period, supports the idea that cardiac recovery could be improved by LV decom-

*Correspondence:
Jean Deschamps
Deschamps.jd@gmail.com
[1] Division of Surgical Critical Care, Integrated Hospital Institute, Cleveland Clinic, Cleveland, OH, USA

pression, a concept yet to be proven in human outcome-based research. Research data has consistently shown that inotropic support for cardiogenic shock leads to increased myocardial oxygen demand, which is detrimental to cardiac recovery, especially in non-revascularized patients. Postcardiotomy shock shares similar characteristics with AMI-associated cardiogenic shock, including a depressed cardiac function and a cytokine-storm-associated vasoplegic component leading to end-organ dysfunction. In both patient populations, reducing the need for vasoactive medications could minimize cardiac stress and improve recovery during the acute phase. LV decompression also decreases LV filling pressures, which could facilitate myocardial microvascular perfusion. The vasopressor and inotrope requirements of micro-axial flow pump patients in the DanGer Shock trial rapidly decreased while maintaining or improving clinical perfusion. This is undeniably beneficial in cardiac recovery if adverse events from the device that impair systemic recovery can be mitigated.

- Second, the DanGer Shock trial emphasized the value of early MCS intervention, showing that patients who received the micro-axial flow device promptly after identifying shock had better survival outcomes than patients with recognized shock treated early with medical therapy. Devices were all inserted within 12 h of revascularization and evidence of shock, with 88 out of 179 devices inserted before revascularization. As a result, the micro-axial flow pump group normalized their lactate, on average, 12 h faster than the control group, with an initial similar starting point. Subgroup analyses of DanGer Shock do reveal an increased rate of acute kidney injury (AKI) and renal replacement therapy (RRT) in the micro-axial flow pump group despite adjusting for mortality. This contradiction may indicate device-related adverse events such as hemolysis from high-power levels or suction events. Hemolysis is an unavoidable major complication from Impella CP devices in frank cardiogenic shock with vasoplegia requiring higher-power level use. Importantly, it is a high morbidity problem in postoperative cardiac surgery patients predisposed to renal injury and coagulopathy from exposure to cardiopulmonary bypass. Suction events may be caused by under-recognized RV dysfunction, a frequent problem often recognized late in postoperative cardiac surgery settings and usually uncovered after isolated LV MCS support. New techniques such as venous excess ultrasound are increasingly finding a high rate of subclinical RV dysfunction and end-organ congestion in cardiac surgery populations, which may also independently cause renal dysfunction (Beaubien-Souligny et al. 2020).

As a result of these two points, perioperative cardiovascular teams are increasingly considering a more proactive and early approach to using MCS. The perioperative setting offers a unique opportunity for early use of devices with better adverse event profiles. The surgically implanted Impella 5.5 is characterized by increased hemodynamic support, reduced adverse events rate, and improved outcomes in postcardiotomy shock (Ramzy et al. 2021). Anecdotally, hemolysis appears much less frequent with this device, which may mitigate the AKI noted in DanGer Shock. An initial small single-center study showed a good safety profile in this population (Benke et al. 2022). Currently, the IMpella-Protected cArdiaC Surgery Trial (IMPACT) is recruiting patients with severely decreased LV function to prophylactically implant Impella 5.5 devices and assess the safety profile (Abiomed Inc. 2024). Early insertion of Impella 5.5 in patients requiring VA-ECMO post-cardiac surgery is also rapidly gaining traction, allowing early LV unloading and rapid de-escalation to single ventricle support with better LV protection during cardiac and systemic recovery. In the AMI population, this combined strategy, ECPELLA, has shown similar adverse events to VA-ECMO without a concomitant micro-axial flow device (Modi et al. 2023). Additionally, this technique offers the opportunity to transition from *sequential* to *parallel* recovery. *Sequential*, or serial, *recovery* prioritizes the patient's cardiac recovery at the expense of delayed systemic recovery. *Parallel recovery* is an evolving paradigm rendered possible by centrally inserting a micro-axial flow pump or VA-ECMO through tunneled axillary or aortic grafts. These configurations allow chest closure, rapid patient awakening, early liberation from mechanical ventilation, and early physiotherapy while heart function recovers.

Perioperative mechanical circulatory support represents a frontier in cardiac surgery that promises to improve outcomes for high-risk patients, yet substantial questions remain. Future research must address gaps in our understanding, mainly through randomized controlled trials tailored to surgical populations, to ensure MCS's safe and effective integration into perioperative cardiac surgery and to better harness the potential of these lifesaving devices.

Authors' contributions

JD and ADS participated in all components of the manuscript design, writing, and editing.

Funding

None.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
ADS is a consultant for Abiomed.

Received: 11 December 2024 Accepted: 28 January 2025
Published online: 06 February 2025

References

Abiomed Inc. (2024) IMpella-Protected CArdiaC Surgery Trial (IMPACT). clinicaltrials.gov.

Beaubien-Souligny W, Rola P, Haycock K, Bouchard J, Lamarche Y, Spiegel R, Denault AY (2020) Quantifying systemic congestion with point-of-care ultrasound: development of the venous excess ultrasound grading system. Ultrasound J 12. https://doi.org/10.1186/s13089-020-00163-w.

Benke K, Korça E, Boltjes A, Stengl R, Hofmann B, Matin M, Krohe K, Yakobus Y, Michaelsen J, Khizaneishvili L, Szabó G, Veres G. Preventive Impella® support in high-risk patients undergoing cardiac surgery. J Clin Med. 2022;11(18):5404. https://doi.org/10.3390/jcm11185404.

Lorusso R, Shekar K, MacLaren G, Schmidt M, Pellegrino V, Meyns B, Haft J, Vercaemst L, Pappalardo F, Bermudez C, Belohlavek J, Hou X, Boeken U, Castillo R, Donker DW, Abrams D, Ranucci M, Hryniewicz K, Chavez I, Chen Y-S, Salazar L, Whitman G. ELSO interim guidelines for venoarterial extracorporeal membrane oxygenation in adult cardiac patients. ASAIO J. 2021;67(8):827–44. https://doi.org/10.1097/MAT.0000000000001510.

Mariani S, Heuts S, van Bussel BCT, Di Mauro M, Wiedemann D, Saeed D, Pozzi M, Loforte A, Boeken U, Samalavicius R, Bounader K, Hou X, Bunge JJH, Buscher H, Salazar L, Meyns B, Herr D, Matteucci MLS, Sponga S, MacLaren G, Russo C, Formica F, Sakiyalak P, Fiore A, Camboni D, Raffa GM, Diaz R, Wang I, Jung J, Belohlavek J, Pellegrino V, Bianchi G, Pettinari M, Barbone A, Garcia JP, Shekar K, Whitman GJR, Lorusso R, the PELS-1 Investigators,. Patient and management variables associated with survival after postcardiotomy extracorporeal membrane oxygenation in adults: the PELS-1 Multicenter cohort study. J Am Heart Assoc. 2023;12(14): e029609. https://doi.org/10.1161/JAHA.123.029609.

Modi SP, Hong Y, Sicke MM, Hess NR, Klass WJ, Ziegler LA, Rivosecchi RM, Hickey GW, Kaczorowski DJ, Ramanan R (2023) Concomitant use of VA-ECMO and Impella support for cardiogenic shock. medRxiv :2023.07.24.23293127. https://doi.org/10.1101/2023.07.24.23293127.

Møller JE, Engstrøm T, Jensen LO, Eiskjær H, Mangner N, Polzin A, Schulze PC, Skurk C, Nordbeck P, Clemmensen P, Panoulas V, Zimmer S, Schäfer A, Werner N, Frydland M, Holmvang L, Kjærgaard J, Sørensen R, Lønborg J, Lindholm MG, Udesen NLJ, Junker A, Schmidt H, Terkelsen CJ, Christensen S, Christiansen EH, Linke A, Woitek FJ, Westenfeld R, Möbius-Winkler S, Wachtell K, Ravn HB, Lassen JF, Boesgaard S, Gerke O, Hassager C. Microaxial flow pump or standard care in infarct-related cardiogenic shock. N Engl J Med. 2024;390(15):1382–93. https://doi.org/10.1056/NEJMoa2312572.

Ramzy D, Anderson M, Batsides G, Ono M, Silvestry S, D'Alessandro DA, Funamoto M, Zias EA, Lemaire A, Soltese E. Early outcomes of the first 200 US patients treated with Impella 5.5: a novel temporary left ventricular assist device. Innovations (Phila). 2021;16(4):365–72. https://doi.org/10.1177/15569845211013329.

Thiele H, Zeymer U, Neumann F-J, Ferenc M, Olbrich H-G, Hausleiter J, Richardt G, Hennersdorf M, Empen K, Fuernau G, Desch S, Eitel I, Hambrecht R, Fuhrmann J, Böhm M, Ebelt H, Schneider S, Schuler G, Werdan K. Intraaortic balloon support for myocardial infarction with cardiogenic shock. N Engl J Med. 2012;367(14):1287–96. https://doi.org/10.1056/NEJMoa1208410.

Thiele H, Zeymer U, Akin I, Behnes M, Rassaf T, Mahabadi AA, Lehmann R, Eitel I, Graf T, Seidler T, Schuster A, Skurk C, Duerschmied D, Clemmensen P, Hennersdorf M, Fichtlscherer S, Voigt I, Seyfarth M, John S, Ewen S, Linke A, Tigges E, Nordbeck P, Bruch L, Jung C, Franz J, Lauten P, Goslar T, Feistritzer H-J, Pöss J, Kirchhof E, Ouarrak T, Schneider S, Desch S, Freund A. Extracorporeal life support in infarct-related cardiogenic shock. N Engl J Med. 2023;389(14):1286–97. https://doi.org/10.1056/NEJMoa2307227.

Publisher's Note