

Timing and treatment strategies according to SCAI classification in cardiogenic shock

Giuseppe Tarantini¹, Giulia Masiero¹, Holger Thiele², Mario Iannaccone³, Benedikt Schrage^{4,5}, Christian Hassager^{6,7}, Felix Woitek⁸, Alaide Chieffo^{9,10}, and Jacob Eifer Møller^{11,12*}

¹Department of Cardiac, Thoracic, Vascular Sciences and Public Health, University of Padua Medical School, Padua, Italy;

²Department of Cardiology, Heart Center Leipzig at University of Leipzig and Leipzig Heart Science, Leipzig, Germany;

³Division of Cardiology San Giovanni Bosco Hospital, ASL Città di Torino, Turin, Italy; ⁴Department of Cardiology, University Heart and Vascular Centre Hamburg, Hamburg, Germany; ⁵German Center for Cardiovascular Research (DZHK), Partner Site Hamburg/Lübeck/Kiel, Hamburg, Germany; ⁶Department of Cardiology, Copenhagen University Hospital, Rigshospitalet, Copenhagen, Denmark; ⁷Department of Clinical Medicine, University of Copenhagen, Copenhagen, Denmark; ⁸Department of Internal Medicine and Cardiology, Technische Universität Dresden, Herzzentrum Dresden, University Clinic, Dresden, Germany; ⁹Vita-Salute San Raffaele University, Milan, Italy; ¹⁰Interventional Cardiology Unit, San Raffaele Scientific Institute, Milan, Italy; ¹¹Cardiac Intensive Care Unit, Heart Center, Copenhagen University Hospital, Rigshospitalet, Blegdamsvej 9, 2100 Copenhagen, Denmark; and ¹²Department of Cardiology, Odense University Hospital, JB Winsløvsvej 4, 5000 Odense, Denmark

KEYWORDS

Cardiogenic shock;
Acute myocardial infarction;
Timing;
Mechanical circulatory support

In patients with cardiogenic shock (CS), particularly those with acute myocardial infarction (AMI), evidence suggests that timely diagnosis and treatment interventions are critical in the prevention of haemo-metabolic compromise. Temporary mechanical circulatory support (tMCS) has shown potential in facilitating revascularization and recovery of patients with acute myocardial infarction cardiogenic shock (AMI-CS). Timing of treatment strategies for CS patients needs to be optimized for use of tMCS devices that are applicable to this heterogeneous patient population. Here, the latest evidence as well as the gaps in knowledge surrounding the role of time in the management of patients with CS is summarized.

Introduction

In cardiogenic shock (CS), a loss of myocardial contractility, as seen in patients with acute myocardial infarction (AMI), triggers a vicious circle of tissue hypoperfusion, inflammation, and other detrimental compensatory mechanisms, ultimately leading to end-organ failure and death.¹ Temporary mechanical circulatory support (tMCS) may, in theory, slow down this deadly cascade by restoring oxygen delivery to the body, reducing myocardial workload and oxygen consumption, facilitating revascularization,

and recovery of the patient. However, robust evidence on their efficacy and safety is currently lacking, and these devices are themselves associated with an increased risk of complications and significant costs for health care systems.^{2,3} Although the benefit has yet to be confirmed by randomized trials, a timely diagnosis and treatment of acute myocardial infarction cardiogenic shock (AMI-CS) patients seems to be a critical element for success in preventing the downward spiral of hemo-metabolic compromise. Therefore, we critically appraise current evidence and gaps in knowledge on the role of time in the management of AMI-CS, proposing best practices and future research goals.

*Corresponding author. Tel: +45 3545 3545, Email: jacob.moeller1@rsyd.dk

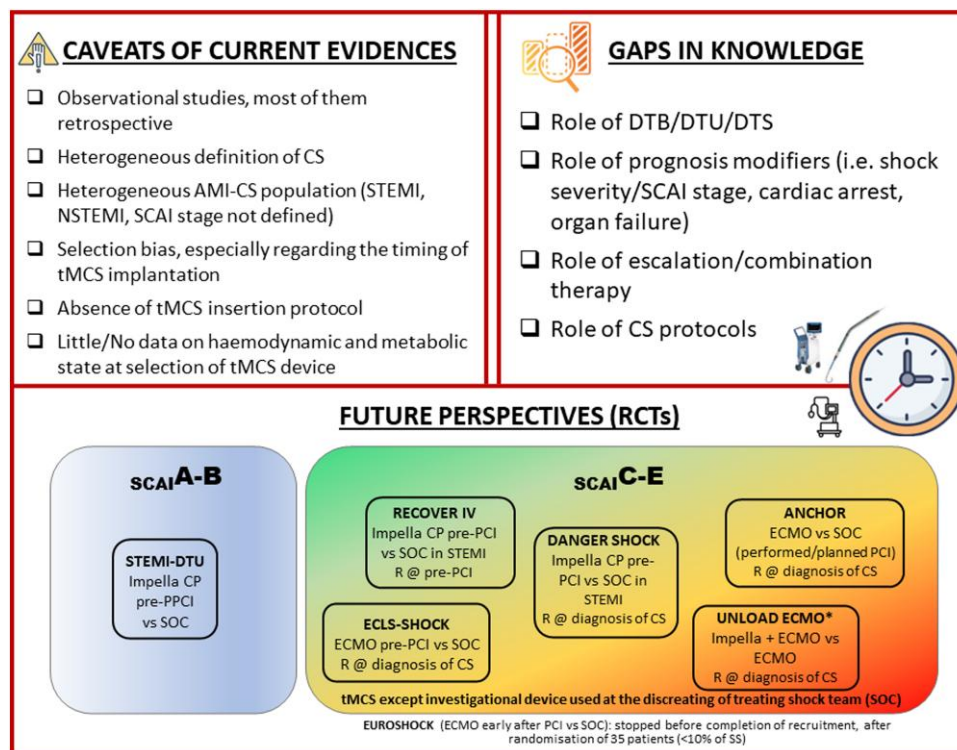


Figure 1 Understanding the interplay between the time of tMCS implantation and outcomes in AMI-CS. AMI, acute myocardial infarction; CS, cardiogenic shock; DTB, door-to-balloon; DTS, door-to-support; DTU, door-to-unload; ECMO, ExtraCorporeal Membrane Oxygenation; ECLS, Extra Corporeal Life Support; tMCS, temporary mechanical cardiac support; NSTEMI, non-ST elevation myocardial infarction; PCI, percutaneous coronary intervention; PPCI, primary percutaneous coronary intervention; R, Randomization; SOC, standard of care; STEMI, ST elevation myocardial infarction. *overall CS aetiology.

Shock phenotyping and device selection

An early diagnosis and accurate assessment of CS likely contributes to optimization of the use of these devices, as it can help to identify patients in whom the risk from the disease outweighs the risk from the device. To achieve this, clinicians should speak the 'same language' when assessing patients with CS. Since its first publication in 2019, the Society for Cardiovascular Angiography and Interventions (SCAI) CS classification has provided a frame for assessment of CS and has repeatedly shown that it is applicable to a heterogeneous patient population.⁴⁻⁷ This classification system can then be further enhanced by the application of specific risk scores, which provide additional granularity in terms of individual risk assessment.^{8,9} Additionally, factoring in phenotypic clusters of CS, e.g. patients presenting with predominantly non-congested vs. cardiorenal vs. cardiometabolic phenotypes, might provide further information about the risk of disease progression.¹⁰ The use of haemodynamic assessments is debated for patients with CS, especially in terms of diagnosis. However, the identification of hypoperfusion due to inadequate cardiac output is most likely of central value to guide the use of tMCS, as indicated by a recent retrospective analysis and future outcome data from an ongoing randomized controlled trial [Pulmonary Artery Catheter in Cardiogenic Shock Trial (PACCS) NCT05485376], is likely to provide clearer evidence on this soon.¹¹ An accurate assessment of a patient presenting with CS is important to assess the eligibility for different tMCS including evaluation of the vascular anatomy for the feasibility of implantation, as

well as for the bleeding and ischaemic risk. Also as important is the assessment of the overall treatment options and goals for a given patient due to other life-limiting diseases, diseases impacting the candidacy status for durable assist devices, and/or candidacy for heart transplantation should be factored into the decision process.

Treatment options: focus on timing and devices

Timely goals for the treatment of AMI-CS include supporting the systemic circulation (door-to-support, DTS), unloading the left ventricle (LV) (door-to-unloading, DTU), improving myocardial perfusion and coronary revascularization (door-to-balloon, DTB). In translational studies, LV unloading with Impella during coronary occlusion, even when prolonging ischaemia time, has been associated with reduced myocardial oxygen demand, reduced LV end-systolic wall stress, and reduction in infarct size compared with immediate revascularization.¹²⁻¹⁴ Several registry-based studies and meta-analyses of these studies suggest higher survival rates in AMI-CS when Impella is placed before revascularization, rather than in patients where Impella is placed after percutaneous coronary intervention (PCI)¹⁵⁻²⁰ although not all.²¹ However, the level of evidence is low as the data are subject to significant selection bias. As such, patients who might stabilize rapidly by opening the culprit vessel, and thereby have a better prognosis, will appear in the pre-PCI group and not in the post-PCI group where only

patients who remain in shock after revascularization may appear. In patients with AMI and no shock, pre-PCI Impella has been shown to be feasible²² and the ongoing Door to Unloading trial (NCT03947619) will provide insight into the potential benefit of pre-PCI Impella in patients at early AMI-CS stages (SCAI class A and B, [Figure 1](#)). The same potential benefit of pre-PCI Impella has not been demonstrated for intra-aorta balloon pump (IABP) where pre-PCI IABP has failed to reduce infarct size in the CRISPAMI trial.²³ Moreover, the registry data and a *post hoc* analysis of the IABP-SHOCK 2 trial failed to demonstrate survival benefit of pre-PCI placement of the device in AMI-CS.^{24,25} Data on pre-PCI venous-arterial extracorporeal membrane oxygenation (V-A ECMO) is limited but bias prone registry data has also indicated lower risk of death with early placement.²⁶

Until results of ongoing randomized trials are available, timing and choice of tMCS should consider the severity of haemodynamic decay, comorbidity, and complexity of coronary lesions but also the potential delay in coronary revascularization, the only treatment proven to benefit in AMI-CS. Thus, in the SCAI C and SCAI D conditions and in patients with ongoing chest compression, tMCS should be considered when hypoperfusion is identified and before PCI when feasible. In the SCAI E situation with overt multi-organ failure, the benefit of tMCS is low and initiation of tMCS has to be evaluated on case by case by a shock team. Likewise, patients resuscitated for out-of-hospital cardiac arrest are not ideal candidates for tMCS. The arrest will create a haemodynamic state that is undisguisable from SCAI C shock but may rapidly recover after the return of circulation.²⁷ In these patients an initial wait-and-see strategy may be advisable with a preliminary attempt to stabilize with fluid and vasopressor therapy before initiating tMCS. Further questions remain open like the possible escalation or combination therapies in patients without prompt recovery of haemodynamic conditions.

Prognosis and SCAI class modifiers

Despite shock aetiology, phenotype, and actual SCAI shock stage several risk modifiers have been proposed that may affect mortality. Several factors such as age, sex, aetiology of CS, heart rate, systolic blood pressure, glucose and lactate levels, pH, and cardiac arrest have been identified.⁸ Particular attention to co-morbidities that are non-modifiable risk factors (i.e. patient age and sex) must be considered in device selection.²⁸ Especially presentation after cardiac arrest with a high-risk of hypoxic brain injury and coma as two of the strongest negative risk modifiers, especially in patients presenting in higher SCAI shock stages.^{7,29} Extensive therapy escalation should be undertaken with caution in these cases. However, some of the cardiac arrest patients may recover quickly with conservative treatment of CS once the malignant arrhythmia and/or hypotension is resolved.²⁷ Thus, cardiac arrest *per se* is not a good predictor of mortality and confounds the selection of tMCS.³⁰

The presence or development of organ failure leads to further deterioration of shock patients.^{31,32} Some of these may be affected positively and organ failure may be treated successfully over the course of the patient's hospital stay with subsequent change of the SCAI shock stage and risk of mortality.

In addition, the development of systemic inflammatory response (SIRS) may affect prognosis negatively since the incidence is increasing from SCAI stage A to E, which affects in-hospital survival negatively in SCAI stages A, C, and D.³³ Patient frailty and susceptibility to complications may lead to a poor prognosis of shock patients too. It is of note that most of the risk modifiers might affect each other and promote worse outcomes. Knowledge and utilization of the risk modifier system helps to mimic the dynamic course of CS and helps to estimate the mortality risk of the presenting patient. Some of the prognostic modifiers are still not well studied or validated, with the number and relevance changing over time with the use of targeted management and treatment strategies.

Strategies (shock networks, transportation)

The CS network is a complex model based on a hub-and-spoke system (out-of-hospital network) and shock team (in-hospital network) with the main objective to provide the best care possible to patients ([Figure 2](#)). This is especially true for those who live in suburban or rural areas and aim to centralize expertise and technology, reduce healthcare cost, and improve outcomes.³⁴ The multidisciplinary team is composed of intensive care cardiologists, interventional cardiologists, cardiac surgeons, cardio-anesthesiologists, dedicated nurses, and a perfusionist to properly treat patients admitted for CS. Observational data suggest that the presence of a dedicated multidisciplinary shock team has a beneficial impact on in-hospital- and 1-month mortality in patients admitted for CS.³⁵ Furthermore, patients receiving short-term and durable left-ventricle assist devices³⁶ in the facilities with the highest volumes have been reported to have better outcomes. As such, the dedicated and standardized regionalized network of care for CS patient's, centralized in tertiary centres has been demonstrated to improve short-term outcomes.³⁷ The Hub-and-Spoke model based on the current model for ST-elevation MI, trauma, and stroke referral systems, does not always fit the CS scenario and specific protocols according to each region's capabilities should be developed and implemented. Key to the hub and spoke model's success is the close collaboration between the hub and the spoke sites to develop joint protocols and provide training for the effective implementation of these protocols at each site.³⁸ The first important step is an appropriate diagnosis of CS SCAI stage with guidelines-directed therapies and prompt identification of patients with a high likelihood of rapid deterioration in order to be ready for patient transfer. A complementary approach is identifying three distinct CS phenotypes upon presentation: non-congested, cardiorenal, and cardiometabolic among patients with AMI-CS and acute heart failure CS.¹⁰ These classifications represent important steps toward guiding early therapeutic interventions and selecting patients for the transferral. After the case discussion and bilateral agreement, a key point for a successful network is the patient's transport, which is associated with high mortality.^{39,40} In such cases, the patients should be transferred from the spoke to the hub centre according to the local protocol by a dedicated ambulance system with

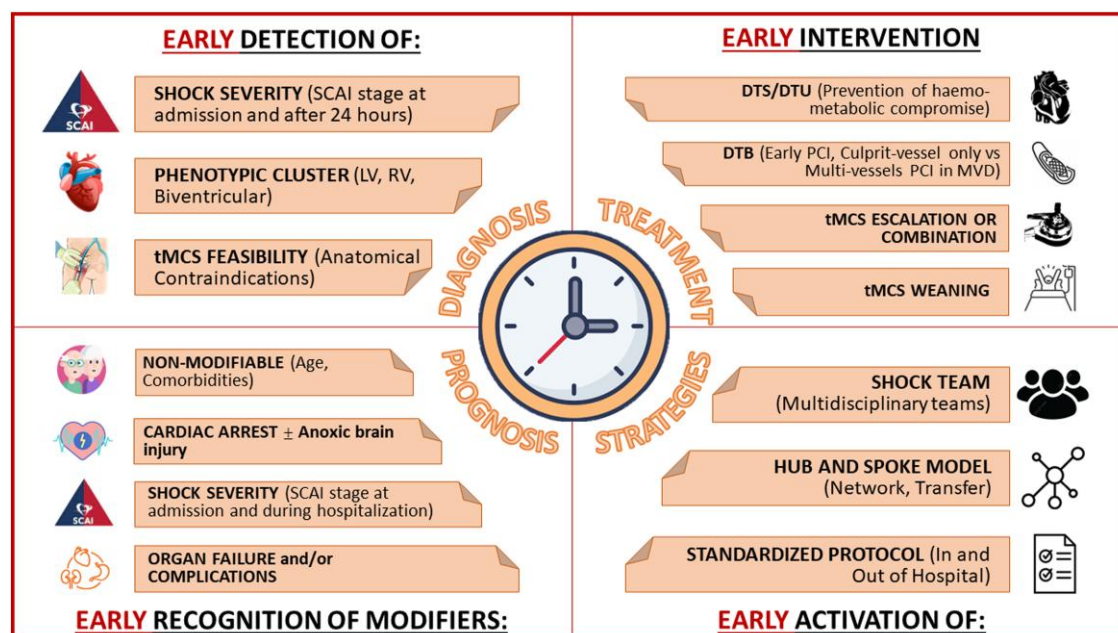


Figure 2 Time issues in AMI-CS. DTB, door-to-balloon; DTS, door-to-support; DTU, door-to-unload; LV, left ventricular; tMCS, temporary mechanical circulating support; MVD, multi-vessel disease; PCI, percutaneous coronary intervention; RV, right ventricle.

an intensivist cardiologist and/or cardio-anesthesiologist onboard. In selected cases, due to the haemodynamic instability of the patients making the transfer at a really high risk of mortality, a dedicated hub centre's team may place a percutaneous tMCS at the spoke centre for a protected transfer.⁴¹

Conclusions

The time to interventions (i.e. DTB), DTU (when unloading is considered), or DTS (for V-A ECMO) remains of utmost important to interrupt the vicious cycle of ischaemia and prevent severe haemodynamic decay and metabolic derangement of patients with CS. Thus a '4 early step' approach (Figure 2) including detection, interventions, with defined and prompt therapeutic escalation, activation of protocols, and recognition of prognosis modifiers, seems, at the current stage of knowledge, the most warranted approach to this complex subset of patients. Upcoming trials will shed more light on the required therapeutic options in AMI CS (Figure 1).

Acknowledgements

This manuscript is one of eight manuscripts published as a Supplement to address best practices in the Management of Cardiogenic Shock. JetPub Scientific Communications, LLC, supported by funding from Abiomed Europe GmbH, provided editorial assistance to the authors during the preparation of this manuscript.

Funding

This work has been supported by Abiomed Europe GmbH to cover publication costs as well as professional language editing of each manuscript. No individual fees were paid to the authors in the generation of this publication. This

paper was published as part of a supplement financially supported by Abiomed GmbH.

Conflict of interest: Giuseppe Tarantini has received lecture fees from Edwards Lifesciences, Medtronic, Abbott, Boston Scientific, Abiomed. Giulia Masiero has nothing to disclose. Alaide Chieffo has received lecture/consultant fees from Abbott, Abiomed, Biosensor, Boston Scientific, Medtronic, Menarini, Shockwave Medical. Jacob Eifer Møller has received an institutional research grant from Abiomed and Novo Nordic Foundation and lecture honorary from Abbott, Abiomed, Boehringer Ingelheim, and Orion. Christian Hassager has received lecture honorarium from Abiomed and research grants from Novo Nordisk Foundation, Lundbeck Foundation, and the Danish Heart Foundation. Benedikt Schrage has received lecture honorarium from Abbott, Abiomed, and AstraZeneca as well as research grants from Abiomed, the German Research Foundation, the Else Kröner-Fresenius-Stiftung and the University of Hamburg.

Data availability

No new data were generated or analysed in support of this research.

References

- Thiele H, Ohman EM, de Waha-Thiele S, Zeymer U, Desch S. Management of cardiogenic shock complicating myocardial infarction: an update 2019. *Eur Heart J* 2019;40:2671-2683.
- Thiele H, Zeymer U, Neumann F-J, Ferenc M, Olbrich H-G, Hausleiter J, *et al.* Intraaortic balloon support for myocardial infarction with cardiogenic shock. *N Engl J Med* 2012;367:1287-1296.
- Schrage B, Ibrahim K, Loehn T, Werner N, Sinning JM, Pappalardo F *et al.* Impella support for acute myocardial infarction complicated by cardiogenic shock. *Circulation* 2019;139:1249-1258.
- Coste B, Xiao B, Santos JS, Syeda R, Grandl J, Spencer KS *et al.* Piezo proteins are pore-forming subunits of mechanically activated channels. *Nature* 2012;483:176-181.

5. Baran DA, Grines CL, Bailey S, Burkhoff D, Hall SA, Henry TD *et al*. SCAI Clinical expert consensus statement on the classification of cardiogenic shock. *Catheter Cardiovasc Interv* 2019;**94**:29-37.
6. Naidu SS, Baran DA, Jentzer JC, Hollenberg SM, van Diepen S, Basir MB *et al*. SCAI shock stage classification expert consensus update: A review and incorporation of validation studies: This statement was endorsed by the American college of cardiology (ACC), American college of emergency physicians (ACEP), American Heart Association (AHA), European Society of Cardiology (ESC) Association for Acute Cardiovascular Care (ACVC), International Society for Heart and Lung Transplantation (ISHLT), Society of Critical Care Medicine (SCCM), and Society of Thoracic Surgeons (STS) in December 2021. *J Am Coll Cardiol* 2022;**79**:933-946.
7. Jentzer JC, van Diepen S, Barsness GW, Henry TD, Menon V, Rihal CS *et al*. Cardiogenic shock classification to predict mortality in the cardiac intensive care unit. *J Am Coll Cardiol* 2019;**74**:2117-2128.
8. Beer BN, Jentzer JC, Weimann J, Dabboura S, Yan I, Sundermeyer J *et al*. Early risk stratification in patients with cardiogenic shock irrespective of the underlying cause—the cardiogenic shock score. *Eur J Heart Fail* 2022;**24**:657-667.
9. Pöss J, Köster J, Fuernau G, Eitel I, de Waha S, Ouarrak T *et al*. Risk stratification for patients in cardiogenic shock after acute myocardial infarction. *J Am Coll Cardiol* 2017;**69**:1913-1920.
10. Zweck E, Spieker M, Horn P, Iliadis C, Metze C, Kavsir R *et al*. Machine learning identifies clinical parameters to predict mortality in patients undergoing transcatheter mitral valve repair. *JACC Cardiovasc Interv* 2021;**14**:2027-2036.
11. Garan AR, Kanwar M, Thayer KL, Whitehead E, Zweck E, Hernandez-Montfort J *et al*. Complete hemodynamic profiling with pulmonary artery catheters in cardiogenic shock is associated with lower in-hospital mortality. *JACC Heart Fail* 2020;**8**:903-913.
12. Kapur NK, Paruchuri V, Urbano-Morales JA, Mackey EE, Daly GH, Qiao X *et al*. Mechanically unloading the left ventricle before coronary reperfusion reduces left ventricular wall stress and myocardial infarct size. *Circulation* 2013;**128**:328-336.
13. Meyns B, Stolinski J, Leunens V, Verbeken E, Flameng W. Left ventricular support by catheter-mounted axial flow pump reduces infarct size. *J Am Coll Cardiol* 2003;**41**:1087-1095.
14. Swain L, Reyelt L, Bhawe S, Qiao X, Thomas CJ, Zweck E *et al*. Transvalvular ventricular unloading before reperfusion in acute myocardial infarction. *J Am Coll Cardiol* 2020;**76**:684-699.
15. Archilietti F, Giuliani L, Dangas GD, Ricci F, Benedetto U, Radico F *et al*. Timing of mechanical circulatory support during primary angioplasty in acute myocardial infarction and cardiogenic shock: systematic review and meta-analysis. *Catheter Cardiovasc Interv* 2022;**99**:998-1005.
16. Helgestad OKL, Josiassen J, Hassager C, Jensen LO, Holmvang L, Udesen NLJ *et al*. Contemporary trends in use of mechanical circulatory support in patients with acute MI and cardiogenic shock. *Open Hear* 2020;**7**:e001214.
17. O'Neill WW, Grines C, Schreiber T, Moses J, Maini B, Dixon SR *et al*. Analysis of outcomes for 15,259 US patients with acute myocardial infarction cardiogenic shock (AMICS) supported with the impella device. *Am Heart J* 2018;**202**:33-38.
18. Tarantini G, Masiero G, Burzotta F, Pazzanese V, Briguori C, Trani C *et al*. Timing of impella implantation and outcomes in cardiogenic shock or high-risk percutaneous coronary revascularization. *Catheter Cardiovasc Interv* 2021;**98**:E222-EE34.
19. Iannaccone M, Franchin L, Hanson ID, Boccuzzi G, Basir MB, Truesdell AG *et al*. Timing of impella placement in PCI for acute myocardial infarction complicated by cardiogenic shock: an updated meta-analysis. *Int J Cardiol* 2022;**362**:47-54.
20. Schäfer A, Westenfeld R, Sieweke J-T, Zietzer A, Wiora J, Masiero G *et al*. Complete revascularisation in impella-supported infarct-related cardiogenic shock patients is associated with improved mortality. *Front Cardiovasc Med* 2021;**8**:678748.
21. Dhruva SS, Ross JS, Mortazavi BJ, Hurley NC, Krumholz HM, Curtis JP *et al*. Association of use of an intravascular microaxial left ventricular assist device vs intra-aortic balloon pump with in-hospital mortality and major bleeding among patients with acute myocardial infarction complicated by cardiogenic shock. *JAMA* 2020;**323**:734-745.
22. Kapur NK, Alkhouli MA, DeMartini TJ, Faraz H, George ZH, Goodwin MJ *et al*. Unloading the left ventricle before reperfusion in patients with anterior ST-segment-elevation myocardial infarction: a pilot study using the impella CP. *Circulation* 2019;**139**:337-346.
23. Patel MR, Smalling RW, Thiele H, Barnhart HX, Zhou Y, Chandra P *et al*. Intra-aortic balloon counterpulsation and infarct size in patients with acute anterior myocardial infarction without shock: the CRISP AMI randomized trial. *JAMA* 2011;**306**:1329-1337.
24. Fuernau G, Ledwoch J, Desch S, Eitel I, Thelemann N, Jung C *et al*. Impact of timing of intraaortic balloon counterpulsation on mortality in cardiogenic shock - a subanalysis of the IABP-SHOCK II trial. *Eur Hear J Acute Cardiovasc Care* 2021;**10**:54-61.
25. Cheng JM, Van Leeuwen MAH, de Boer SPM, Wai MCGTJ, den Uil CA, Jewbali LSD *et al*. Impact of intra-aortic balloon pump support initiated before versus after primary percutaneous coronary intervention in patients with cardiogenic shock from acute myocardial infarction. *Int J Cardiol* 2013;**168**:3758-3763.
26. Kim MC, Ahn Y, Cho KH, Sim DS, Hong YJ, Kim JH *et al*. Benefit of extracorporeal membrane oxygenation before revascularization in patients with acute myocardial infarction complicated by profound cardiogenic shock after resuscitated cardiac arrest. *Korean Circ J* 2021;**51**:533-544.
27. Josiassen J, Helgestad OKL, Møller JE, Kjaergaard J, Hoejgaard HF, Schmidt H *et al*. Hemodynamic and metabolic recovery in acute myocardial infarction-related cardiogenic shock is more rapid among patients presenting with out-of-hospital cardiac arrest. *PLoS One* 2020;**15**:e0244294.
28. Padkins M, Breen T, Anavekar N, van Diepen S, Henry TD, Baran DA *et al*. Age and shock severity predict mortality in cardiac intensive care unit patients with and without heart failure. *ESC Heart Fail* 2020;**7**:3971-3982.
29. Pareek N, Dworakowski R, Webb I, Barash J, Emezu G, Melikian N *et al*. SCAI cardiogenic shock classification after out of hospital cardiac arrest and association with outcome. *Catheter Cardiovasc Interv* 2021;**97**:E288-E297.
30. Jentzer JC, Schrage B, Holmes DR, Dabboura S, Anavekar NS, Kirchhof P *et al*. Influence of age and shock severity on short-term survival in patients with cardiogenic shock. *Eur Heart J Acute Cardiovasc Care* 2021;**10**:604-612.
31. Padkins M, Breen T, Van Diepen S, Barsness G, Kashani K, Jentzer JC. Incidence and outcomes of acute kidney injury stratified by cardiogenic shock severity. *Catheter Cardiovasc Interv* 2021;**98**:330-340.
32. Beer BN, Besch L, Weimann J, Surendra K, Roedl K, Grensemann J *et al*. Incidence of hypoxic hepatitis in patients with cardiogenic shock and association with mortality. *Eur Heart J Acute Cardiovasc Care* 2023: zuad076. doi: 10.1093/ehjacc/zuad076
33. Jentzer JC, Lawler PR, Van Diepen S, Henry TD, Menon V, Baran DA *et al*. Systemic inflammatory response syndrome is associated with increased mortality across the spectrum of shock severity in cardiac intensive care patients. *Circ Cardiovasc Qual Outcomes* 2020;**13**:e006956.
34. Alvarez Vilella M, Clark R, William P, Sims DB, Jorde UP. Systems of care in cardiogenic shock. *Front Cardiovasc Med* 2021;**8**:712594.
35. Rab T, Ratanapo S, Kern KB, Basir MB, McDaniel M, Meraj P *et al*. Cardiac shock care centers: JACC review topic of the week. *J Am Coll Cardiol* 2018;**72**:1972-1980.
36. Wang JI, Lu DY, Feldman DN, McCullough SA, Goyal P, Karas MG *et al*. Outcomes of hospitalizations for cardiogenic shock at left ventricular assist device versus non-left ventricular assist device centers. *J Am Heart Assoc* 2020;**9**:e017326.
37. Tehrani BN, Sherwood MW, Rosner C, Truesdell AG, Ben Lee S, Damluji AA *et al*. A standardized and regionalized network of care for cardiogenic shock. *JACC Heart Fail* 2022;**10**:768-781.
38. Hernández-Pérez FJ, Álvarez-Avelló JM, Forteza A, Gómez-Bueno M, González A, López-Ibor J V *et al*. Initial outcomes of a multidisciplinary network for the care of patients with cardiogenic shock. *Rev Española Cardiol (English Ed)* 2021;**74**:33-43.
39. Wei L, Lang CC, Sullivan FM, Boyle P, Wang J, Pringle SD *et al*. Impact on mortality following first acute myocardial infarction of distance between home and hospital: cohort study. *Heart* 2008;**94**:1141-1146.
40. Bucholz EM, Butala NM, Ma S, Normand S-LT, Krumholz HM. Life expectancy after myocardial infarction, according to hospital performance. *N Engl J Med* 2016;**375**:1332-1342.
41. Connelly KM, Winslow SE, Smith J, Ahmad SS, Xie C, Hinckley WR *et al*. Management of patients with impella devices or intra-aortic balloon pumps during helicopter air ambulance transport in observational data. *Perfusion* 2023:2676591231158273. doi: 10.1177/02676591231158273