# Cardiogenic Shock Protocols and Teams

Alejandro Lemor, MD, MS*, Gabriel A. Hernandez, MD

**KEYWORDS**

• Cardiogenic shock • Mechanical support • Shock team • Infarction-related cardiogenic shock
• ST-Elevation myocardial infarction • Shock protocols

**KEY POINTS**

- A standardized cardiogenic shock protocol, with early diagnosis and prompt intervention, improves outcomes.
- The presence of a cardiogenic shock team using a collaborative approach for the management of cardiogenic shock has shown to be associated with better outcomes.
- The combination of a shock team and a protocolized management of cardiogenic shock has become the standard of care for treating shock.

There have been significant changes in the field of cardiogenic shock (CS) in the past decade, from early recognition to adequate mechanical support and escalation; however, one key aspect that has improved outcomes has been the implementation of CS best practice protocols and the importance of having a dedicated shock team. Several recently published studies have demonstrated the importance of protocolizing care to improve outcomes (Table 1),[1,2] which includes being able to promptly recognize those patients at risk of worsening shock, providing them with adequate support, either revascularization with or without mechanical support, and with an efficient transfer service for escalation of care to a tertiary center, if needed.

## CARDIOGENIC SHOCK PROTOCOLS

Despite advances in pharmacotherapy and device-based therapies, no standalone intervention has been shown to improve outcomes in CS, except perhaps the implementation of protocolized CS management. The most significant practice change that has improved outcomes in acute myocardial infarction-related CS has been the early, routine, and widespread use of percutaneous coronary intervention (PCI) in ST-elevation myocardial infarction (STEMI). Almost 2 decades ago, the Early Revascularization in Acute Myocardial Infarction Complicated by Cardiogenic Shock (SHOCK trial) study randomized 252 patients with acute MI (ST elevation without or without Q waves, new left bundle branch block or posterior MI with anterior depression) and CS (defined by systolic blood pressure of less than 90 mm Hg for at least 30 minutes or the need for supportive measures to maintain a systolic blood pressure (SBP) of $\geq$90 mm Hg and end-organ hypoperfusion (cool extremities or a urine output of $<$30 mL per hour, and a heart rate of $\geq$60 beats per minute) with onset of shock within 36 hours of infarction. The trial showed no significant 30-day survival benefit (46.7% for the revascularization group vs 56.0% for the medical therapy group (CI –20.5% to 1.9%; $P = .11$). However, there was statistically significant survival at 6 months (50.3% vs 63.1% CI –23.2 to −0.9; $P = .027$). This was one of the first studies to demonstrate the value of a protocolized approach to shock management, where early intervention and hemodynamic surveillance became crucial.

Around this time, the use of pulmonary artery catheterization (PAC) was in decline, despite limited evidence regarding its role in managing CS. A study using the nationwide inpatient sample (2004–2014) suggested improved outcomes

Division of Cardiology, University of Mississippi Medical Center, 2500 North State Street, Jackson, MS 39216, USA
* Corresponding author.
*E-mail address:* alejandrolemor@hotmail.com

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| Abbreviations | |
|---|---|
| CPO | cardiac power output |
| CS | cardiogenic shock |
| LVAD | left ventricular assist device |
| MAP | mean arterial pressure |
| MCS | mechanical circulatory support |
| NCSI | National Cardiogenic Shock Initiative |
| PAC | pulmonary artery catheterization |
| PAPI | pulmonary artery pulsatility index |
| PCI | percutaneous coronary intervention |
| SBP | systolic blood pressure |
| STEMI | ST-elevation myocardial infarction |

when PAC was used, with an absolute mortality of 39.9% in patients with PAC compared with 20.5% in those without.[3] Similarly, a more contemporary multicenter study by the Cardiogenic Shock Working Group found a lower adjusted in-hospital mortality (22.2% vs 29.8%) in patients with non-AMI related CS when PAC was used, and further suggested that its use should occur within 6 hours.[4]

The 2 decades since the SHOCK trial was published have highlighted the challenges in advancing the field of CS—namely, high mortality rates, difficulties with rapid randomization, the presence of diverse phenotypes, the need to "rescue" patients across study arms, and confounding data due to the inclusion of other shock types or heart failure, as well as the absence of protocolized management. These factors have hindered the development of standardized CS protocols and multidisciplinary teams. However, in the last decade, the creation of dedicated shock teams has become increasingly recognized—not as an easy task, but as a necessary standard of care. Each hospital will have its own limitations to have a protocol in place, but overall, in order to improve outcomes, a CS team should focus on early diagnosis, promptly treatment and ongoing assessment of weaning or escalation of inotropes, vasopressors and early implementation of mechanical circulatory support (MCS). The Detroit Cardiogenic

**Table 1**
**Summary of recent studies evaluating cardiogenic shock protocols and teams**

| Study/Location Year of Publication | Description | Patients | Outcomes |
|---|---|---|---|
| National Cardiogenic Shock Initiative Basir et al,[1] 2023 | Single-arm, prospective, multicenter study | 406 AMICS | 71% hospital survival and 53% 1 y survival with the use of early MCS and routine use of invasive hemodynamics. |
| Critical Care Cardiology Trials Network Papolos et al,[9] 2021 | Multicenter network of cardiac intensive care units | 1242 CS admissions (546 with shock team vs 696 without a shock team) | Shock teams were more likely to obtain invasive hemodynamics, use advanced types of MCS, and have lower risk-adjusted mortality |
| University of Ottawa Lee et al,[8] 2020 | Retrospective, single-center, pre-intervention and post-intervention | 100 CS patients | A multidisciplinary Code Shock Team approach is feasible and may be associated with improved long-term survival. (67% vs 42% before shock team implementation) |
| INOVA Heart and Vascular Institute Tehrani et al,[2] 2019 | Prospective, single-center, pre-intervention and post-intervention | 204 (81 AMICS + 122 HF-CS) | Improved survival from 47% to 77% with implementation of a shock team |
| Utah Cardiac Recovery Shock Team Taleb et al,[7] 2019 | Prospective, single-center, pre-intervention and post-intervention | 123 CS patients | Improved in-hospital survival with a Shock Tea (61.0% vs 47.9%; $P = .041$). |

*Abbreviations:* AMICS, acute myocardial infarction cardiogenic shock; HF-CS, heart failure cardiogenic shock; MCS, mechanical circulatory support.

Shock Initiative established their shock protocol and expanded it to 35 sites across the United States through the National Cardiogenic Shock Initiative (NCSI). They reported a survival to discharge survival of 72% in patients with acute myocardial infarction CS.[1] These protocols highlight 3 key items: rapid identification and activation of the catheterization laboratory; early utilization of MCS to minimize the use of vasopressors, and routine use of invasive hemodynamics with a right heart catheterization.[1] This concept of early MCS support in AMICS was demonstrated in a randomized controlled trial by the DanGer Shock investigators, which showed a higher survival with the use of Impella when compared with standard of care alone.[5]

## Cardiogenic Shock Protocol: Early Phase in Management

There are multiple versions of CS protocols available and each center has a personalized protocol based on their hospital capacities and availability of MCS. Nonetheless, a general protocol starts with early diagnosis, using specific parameters such as blood pressure, heart rate, lactic acid, and cold extremities (Fig. 1).

Following that initial assessment, the CS team should be activated and it is crucial to classify shock based on the SCAI Shock Stages[6] as this will guide management and prognosis. Patients in SCAI Class B, can have more stable parameters and less need of immediate intervention, nonetheless, they should be cautiously monitored for deterioration. Active monitoring and early interventions to prevent progression in the shock ladder is the best approach in these patients. Among patients in SCAI Class C, with presence of hypoperfusion (lactic acid $>$ 2 mmol/L, SBP $<$ 90 mm Hg), and probably with a inotrope or vasopressor infusion, a right heart catheterization should be performed early to guide treatment and identify the need for left ventricular support (with Impella CP or IABP) or the need for biventricular support with the addition of right ventricular support using Protek-Duo or Impella-RP. Patients with worsening deterioration, elevated lactic acid (usually $>$ 4–5 mmol/L) with escalating pressor requirement and evidence of deteriorating renal or liver dysfunction, meet criteria for SCAI Class D, and rapid assessment should be done to identify the need for further escalation of MCS with a high level of support (either with Impella 5.5 or VA-ECMO with or without venting). Patients in SCAI Class E, with refractory hypotension and multiorgan failure, should be considered for further MCS escalation with VA-ECMO. Ideally, these patients should be promptly evaluated in collaboration with an advanced heart failure and transplant program (if not available in the center) to assess candidacy for heart transplantation or durable MCS, such as a left ventricular assist device (LVAD), in order to establish a definitive exit strategy. Initiating high-level temporary support without a clearly defined treatment trajectory, including goals of care and identified barriers to advanced therapies, may inadvertently prolong the dying process.

These steps of assessing shock stages and determining specific treatments can change quickly, and patients should be assessed continuously for either escalation or weaning of MCS (Fig. 2). Through ongoing evaluation of hemodynamics in the ICU and avoiding prolonged use of mechanical support without weaning attempts, and planning an exit strategy (bridge to recovery or transplant/LVAD).

## Cardiogenic Shock Protocol: Weaning and Escalation

After the initial stabilization of a patient in shock using the protocol described above, it is important to have a continuous assessment of the patient's hemodynamics to evaluate the need for additional support or if the patient is ready for de-escalation (see Fig. 2). The short-term goal after MCS placement should focus on active wean of vasoactive and inotropic therapies, based on the hemodynamic profile; unless specific scenarios where there are complications with the MCS and removal is needed (hemolysis, severe bleeding, limb ischemia, etc). Along with blood pressure and heart rate, lactate and SVO2 should be monitored frequently (ie, every 2 hours) while weaning pharmacotherapy or device therapy to determine if the patient's hemodynamics are improving. Parameters of improved hemodynamics and need for weaning include a cardiac index (CI) greater than 2.2 without vasoactive support while maintaining a normal lactate level, mean arterial pressure (MAP) greater than 65 mm Hg, cardiac power output (CPO) greater than 0.6, and pulmonary artery pulsatility index (PAPI) greater than 1.

However, if the patient's hemodynamics are not favorable or they adversely change during a weaning attempt, then the need for escalation should be determined proactively, evaluating hemodynamic parameters of worsening condition, such as CI less than 2.2, MAP lower than 65 mm Hg, persistently elevated or worsening lactate, increasing dose of inotropes and pressor, CPO less than 0.6, and/or PAPI less than

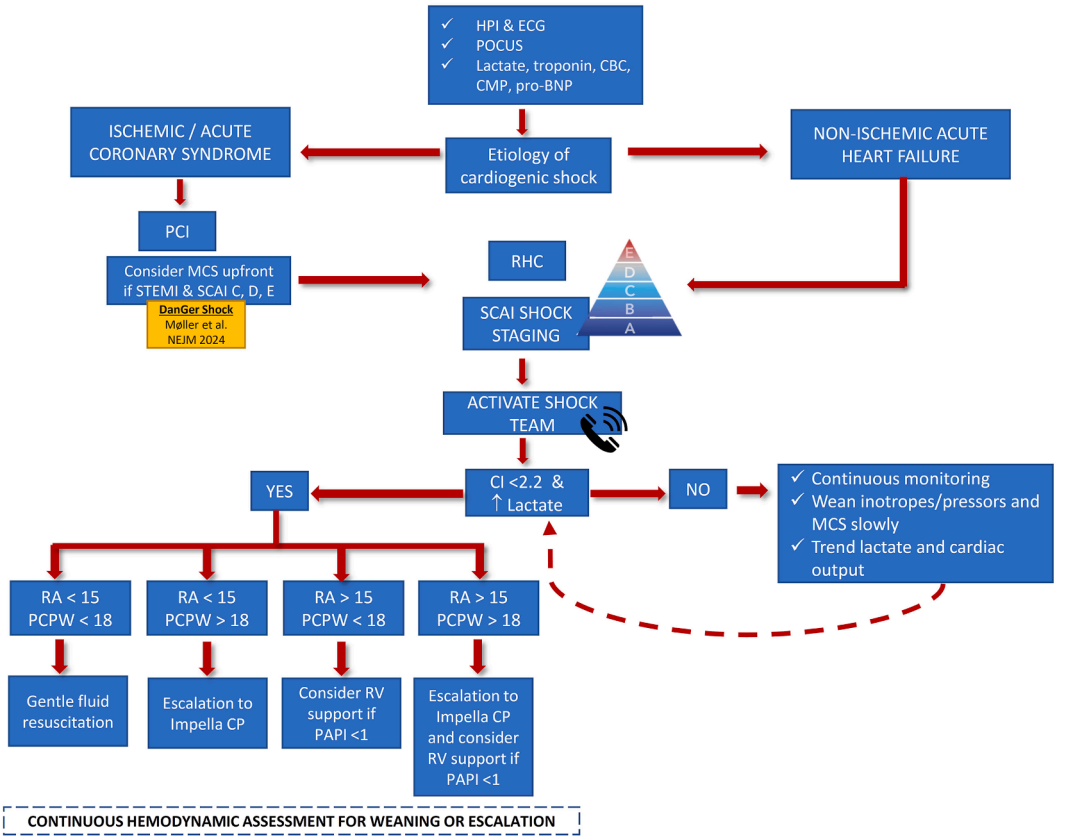


**Fig. 1.** Cardiogenic shock protocol. Algorithm for cardiogenic shock evaluation and management, incorporating early identification, SCAI shock staging, and activation of a multidisciplinary shock team. Hemodynamic assessment via right heart catheterization guides the use of MCS and ongoing monitoring for weaning or escalation. CI, cardiac index; MAP, mean arterial pressure; MCS, mechanical circulatory support; PAPI, pulmonary artery pulsatility index; PCI, percutaneous coronary intervention; PCPW, pulmonary capillary wedge pressure; RA, right atrial pressure.

1.0. The use of electronic medical record and nursing alert are critical for real time assessment of worsening hemodynamic profile; for example, escalation of pressor should trigger an automatic alert to the shock team Escalation should be done based on each hospital's capacity for additional MCS, such as VA-ECMO. In centers without ECMO, patients who meet criteria for escalation should be transferred to a tertiary center with ECMO and heart transplant capabilities within 24 hours at most, to prevent worsening multiorgan failure and cardiac arrest.

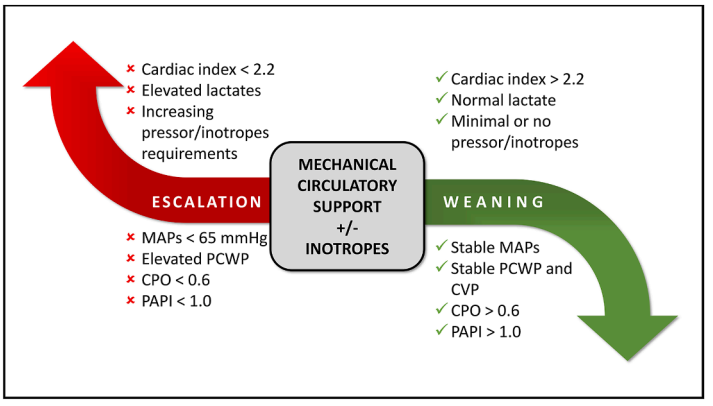


**Fig. 2.** Escalation and weaning protocol. Hemodynamic criteria guiding escalation or weaning of MCS in cardiogenic shock patients. Escalation is indicated with worsening cardiac output and perfusion markers, while weaning is considered when stable hemodynamics and minimal inotropic support are achieved. CPO, cardiac power output; CVP, central venous pressure; MAP, mean arterial pressure; MCS, mechanical circulatory support; PAPI, pulmonary artery pulsatility index; PCPW, pulmonary capillary wedge pressure.

One key element when evaluating CS patients is to determine if there are any absolute contraindications to escalation of treatment (patient wishes such as do not resuscitate status, terminal illness with a life expectancy <1 year, etc.). Having protocols for escalation and weaning in CS is crucial and should be used in combination with a multidisciplinary CS team to improve patients' outcomes.

## A MULTIDISCIPLINARY TEAM

A shock team comprises a multidisciplinary group of health care professionals with specialized expertise and a shared commitment to the comprehensive management of CS. This collaborative model typically includes subspecialists in cardiology—such as interventional cardiology, advanced heart failure, and general cardiology—tailored to the institutional structure and available resources (Fig. 3). In addition, critical care physicians, cardiothoracic surgeons, and emergency medicine providers play essential roles in initial stabilization and ongoing management. The team is further supported by clinical pharmacists, nurse practitioners, physician assistants, respiratory therapists, and experienced critical care and nursing staff. Each discipline brings a distinct and complementary skill set, contributing to timely decision-making, hemodynamic monitoring, pharmacologic management, and advanced support interventions. The coordinated efforts of this diverse team are essential to optimize outcomes in critically ill patients with shock, particularly in time-sensitive, high-acuity settings.

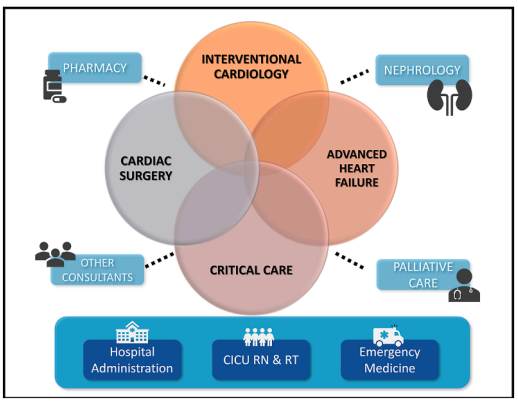


Fig. 3. Multidisciplinary shock team. Multidisciplinary structure of a cardiogenic shock team, highlighting core specialties, interventional cardiology, advanced heart failure, cardiac surgery, and critical care, with overlapping roles in patient management. Supporting services, including pharmacy, nephrology, palliative care, emergency medicine, and hospital administration, contribute to a coordinated and comprehensive patient care.

Shock teams are expected to differ from each other based on hospital and community needs, local expertise, MCS availability, and 24/7 interventional or surgical coverage. It is essential to recognize this heterogeneity in how teams function across institutions, as priorities may be adjusted based on local needs—such as early triage for expedited transfer in centers without the full range of MCS, or rapid escalation and MCS allocation in more capable centers. It becomes imperative that standardized terms and algorithms are in place to serve as the core for each team; an example is the widespread use of the SCAI stages for diagnosis and management of CS, novel hemodynamic parameters (such as CPO, PAPI, CVP/PCWP) and disease severity scores that can be available both for transfer of for shock call discussion within the different specialties in the team.

The INOVA Heart Institute demonstrated improvement in CS outcomes with increase in survival to 57.9% in the earlier year (2016), and 76.6% in 2018, compared with roughly 45% in the year preceding the initiation of CS team.[2] Similarly, the Utah Cardiac Recovery Shock demonstrated that hospital survival was higher (61% vs 47.9%, $P<.04$) with the implementation of a shock team.[7] The University of Ottawa Heart Institute also showed a better outcomes with a multidisciplinary code shock team, improving long-term survival from 42% to 67% (HR 0.53, 95% CI 0.25–0.99).[8]

Furthermore, using the critical care cardiology trials network, Papolos and colleagues demonstrated better outcomes with a shock team.[9] This was one of the largest studies published regarding the benefit of a shock team, comparing 546 patients that underwent care with a shock team versus 696 patients without a shock team. Patients in the shock team cohort had a higher utilization of pulmonary artery catheter, shorter ICU length of stay, and higher survival rates.

### Key Components of a Cardiogenic Shock Team

Each subspecialty within the shock team has a defined role and contributes significantly to the management of CS. There are multiple opportunities for early recognition and intervention, beginning with pre-hospital identification of shock and appropriate routing to a comprehensive shock program. In the emergency department, early triage may prompt activation of the

shock team. The interventional cardiologist actively triaging patients with shock or at risk of shock while performing primary percutaneous intervention for the management of acute STEMI, or during a high-risk PCI, the advanced heart failure cardiologist is often consulted for acute decompensation in chronic heart failure, while the critical care team may initiate inotropic therapy outside of a dedicated cardiovascular care unit.

Once the shock team is activated, each specialty continues to provide its unique skill set throughout the patient's course. For example, advance heart failure cardiologist will play a key role in the evaluation for advanced therapies and options for recovery or heart transplant/LVAD. Cardiac surgery will be involved for the surgical placement of an Impella 5.5 via axillary cut-down. Depending on the center, critical care, cardiac surgeons, or cardiologists will be alerted for ECMO cannulation. Pharmacists are integral throughout this pathway, continuously monitoring pharmacokinetics and pharmacodynamics, adjusting drug concentrations, and managing and anticipating potential shortages. Additional subspecialties, such as nephrology, may be consulted for renal replacement therapy, while palliative care teams facilitate ongoing discussions with patients and families to align care goals and ensure appropriate end-of-life planning when needed.

## SUMMARY

In the past decade, CS management has evolved significantly, with improved outcomes largely due to protocolized care and the establishment of dedicated shock teams. Early recognition, timely intervention, appropriate MCS, and rapid transfer to tertiary centers are key components of effective management. While no standalone therapy has consistently improved CS outcomes, early revascularization—especially in acute myocardial infarction shock—has shown benefit. The NCSI demonstrated that a protocolized approach using early MCS, right heart catheterization, and rapid catheter lab activation can improve survival to more than 70%. Contemporary protocols now utilize the SCAI shock classification to guide management and prognosis, with tailored interventions based on hemodynamic profiles, including right heart catheterization and early MCS.

Shock management requires continuous reassessment to determine whether to escalate or wean support, using metrics like cardiac index, lactate levels, cardiac power output, and PAPI. Timely escalation, ideally within 24 hours, is crucial in deteriorating patients.

Multidisciplinary shock teams are critical in this approach. These teams typically include interventional and heart failure cardiologists, intensivists, cardiac surgeons, and other consultants. Each plays a unique role—from early diagnosis to advanced therapy planning. Successful examples from the INOVA Heart Institute, University of Ottawa, and Utah Cardiac Recovery Shock Program demonstrated marked improvements in survival post-implementation of dedicated shock teams.

## CLINICS CARE POINTS

- A standardized CS protocol, with early diagnosis and prompt intervention, improves outcomes.
- The presence of a CS team using a collaborative approach for the management of CS has shown to be associated with better outcomes.
- The combination of a shock team and a protocolized management of CS has become the standard of care for treating shock.

## DISCLOSURES

Both authors have nothing to disclose.

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