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Cardiogenic Shock Teams: Past, Present, and Future Directions

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ABSTRACT: Cardiogenic shock (CS) remains a significant challenge in cardiovascular medicine, characterized by substantial morbidity and mortality. Historically, patient outcomes in CS have been varied, highly dependent on the timeliness of interventions and the expertise available at treating centers. Emerging evidence indicates that structured, team-based approaches significantly improve survival rates and diminish complications linked to CS. However, several challenges for implementing a team-based approach persist, including optimizing team composition and resource distribution. This article delves into the evolution, current implementations, and future directions of CS teams, emphasizing their crucial role in enhancing patient outcomes. We advocate for the adoption of standardized protocols to ensure uniformity of care across institutions, highlighting the critical need for prompt recognition and management strategies that integrate invasive hemodynamic monitoring and early mechanical circulatory support. Looking ahead, we propose the extension of CS team models into regional networks, broadening their impact through education, telemedicine and collaborative protocols. We also emphasize the importance of continuous research and data sharing via national registries to refine CS team strategies and substantiate their effects on patient outcomes. Ultimately, this review highlights the imperative for ongoing innovation and standardization in CS team operations to improve care delivery and enhance survival rates in CS scenarios.

Key Words: cardiovascular agents ■ hemodynamic monitoring ■ information dissemination ■ survival rate ■ telemedicine

Cardiogenic shock (CS) is a complex syndrome characterized by cardiac dysfunction and systemic hypoperfusion, often resulting in multisystem organ failure. Despite advances in acute mechanical circulatory support (MCS), it continues to be associated with high morbidity and mortality, with 30% to 50% of patients dying in the hospital. Managing patients with CS remains challenging even in well-resourced settings, often requiring multidisciplinary expertise. Complex, timely decisions must be made for therapies such as coronary revascularization, renal replacement therapies, respiratory/ventilatory support as well cardiac replacement options. Moreover, given the rapidly progressive nature of the shock spiral, these decisions often have to be made in an urgent or emergent fashion, involving highly invasive therapies while being mindful of patient wishes and available resources.[1] Long intensive care unit (ICU) and hospital stays are not uncommon, as these patients are at high risk for noncardiac complications such as bleeding, infections, multiorgan dysfunction, and deconditioning.

In recent years, there has been an increasing emphasis placed on a collaborative, team-based approach to care (the shock team) in CS.[2–4] Multiple single or multicenter initiatives have suggested that implementing CS teams in tertiary and quaternary care centers may improve patient outcomes.[5–8] The concept of these teams aligns with that of code/trauma teams and the Pulmonary Embolism Response Team—where gathering a multidisciplinary team of providers in a time-sensitive manner has been associated with improved outcomes.[9] Similarly, prompt recognition and early intervention in CS is emphasized as the key step in moving the needle on shock mortality.

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Nonstandard Abbreviations and Acronyms

CS	cardiogenic shock
HF	heart failure
ICU	intensive care unit
MCS	mechanical circulatory support
SCAI	Society for Cardiovascular Angiography and Interventions

The shock team typically includes a variety of stakeholders spanning the spectrum of cardiovascular, critical care and surgical specialties who are gathered by a collective alert (eg, paging) system—shock-call . In many cases, subspecialists in critical care cardiology, advanced heart failure (HF) and transplant cardiology, interventional cardiology, and cardiac surgery directly contribute to the care of patients, each offering a unique perspective and distinctive skill set. Based on the available information, the goal of a shock-call is to expedite clinical decision-making, triage time-critical decisions, and streamline transfers, thereby reducing delays in care. Moreover, team-based care often leads to other process improvements, which in turn support programmatic and institutional growth. As a result, this team-based approach is now being advocated by professional societies and increasingly implemented at select high-volume clinical centers.[1,5]

In this review, we will cover the concept of (and data behind) contemporary CS teams, identify key knowledge gaps, and project into the future a concept of CS teams that would be ideal in the management of patients with CS (Figure 1).

HISTORY AND EVOLUTION OF THE CS TEAM

In literature, the concept of a CS Team has been explored through 3 single-center retrospective studies and 1 multicenter retrospective study (Table 1).

In 2015, the Utah Cardiac Recovery Shock Team was organized to provide standardized, multidisciplinary assessments for patients in CS. Unlike other models, the Utah team focuses on early identification and triage by the Shock Team, while the primary cardiovascular ICU team manages ongoing care decisions. From its establishment until August 2018, 123 consecutive patients were treated under this protocol. A comparison with 121 preteam patients showed an association with lower 30-day all-cause mortality (hazard ratio, 0.61 [95% CI, 0.41–0.93]), with no significant delay in the initiation of MCS (19±5 versus 25±8 hours; P=0.52).[7]

The Inova Heart and Vascular Institute reported improvement in CS outcomes at their institution after implementation of an algorithmic approach to recognition and treatment of CS. This protocol standardized practices to rapidly identify shock state, activation of a multidisciplinary Shock Team, instructions for obtaining and interpreting necessary hemodynamic and imaging criteria, guidance to consider percutaneous MCS and

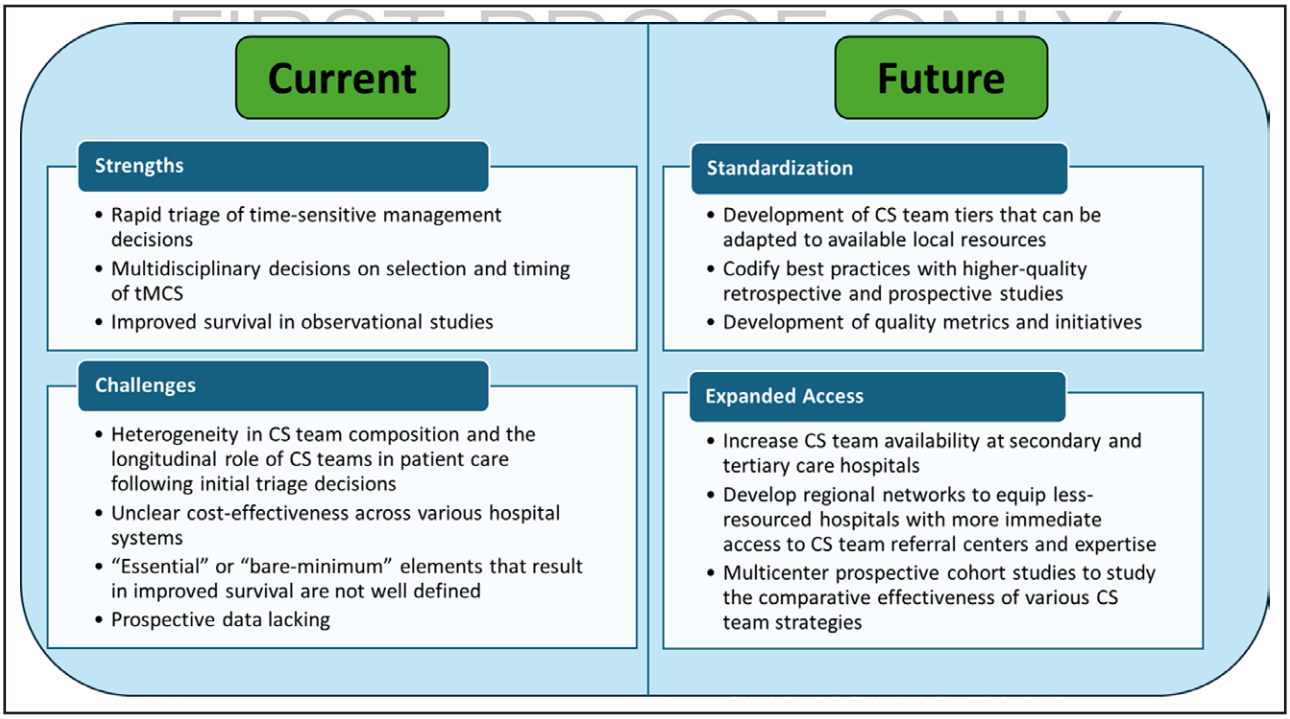

Figure 1. Cardiogenic shock: current and future directions.
CS indicates cardiogenic shock; and t-MCS, temporary mechanical circulatory support.

Table 1. Studies Investigating Outcomes of Cardiogenic Shock Teams

Study	Setting	Sample size	Team composition	Intervention/protocol	Main outcome
Utah Cardiac Recovery Shock Team (2015–2018)	Single-center retrospective study	123	HF cardiologist, a HF cardiothoracic surgeon, an interventional cardiologist, and a CVICU attending physician.	Standardized, multidisciplinary assessments for patients in CS, including early identification and triage by the Shock Team, with ongoing care managed by the primary CICU team	• Reduction in 30-day all-cause mortality (HR, 0.61 [95% CI, 0.41–0.93]) • No significant delay in the initiation of mechanical circulatory support (19±5 vs 25±8 h; P=0.52)
Inova Heart and Vascular Institute (2017–2018)	Single-center retrospective study	204	Interventional cardiology, cardiovascular surgery, advanced heart failure, and critical care	Algorithmic approach to emphasize 5 clinical goals: rapid identification of the shock state, mandatory invasive hemodynamics, minimizing use of vasopressors and inotropes, early mechanical support of the left ventricle and/or right ventricle as appropriate, and, finally, cardiac recovery	• Improved 30-day survival rates: 47% in 2016, 57.9% in 2017, and 76.6% in 2018 (P<0.01)
National Cardiogenic Shock Initiative (2016–2019)	Multicenter retrospective study (35 sites)	171	Not specified	Protocol approach with invasive hemodynamic monitoring and rapid initiation of MCS in AMI-CS	• 72% survival to discharge in AMI-CS
University of Ottawa Heart Institute (2016–2019)	Single-center retrospective study	100	HF cardiologist, cardiac surgery, intensive care, interventional cardiology	Implementation of a Shock Team protocol	• Improved long-term survival after the establishment of a Shock Team compared with standard of care • No in-hospital or 30-day survival benefit observed

AMI-CS indicates acute myocardial infarction-cardiogenic shock; CICU, cardiac intensive care unit; CS, cardiogenic shock; CVICU, cardiovascular intensive care unit; HF, heart failure; HR, hazard ratio; ICU, intensive care unit; and MCS, mechanical circulatory support.

approach to ongoing cardiac intensive care unit management. Before implementation of this standardized team-based care for CS, the Inova 30-day survival for cardiogenic shock in 2016 was 47%, which improved to 57.9% and 76.6% in 2017 and 2018, respectively (P<0.01), suggesting a standardized team-based approach may improve CS outcomes.[3,6]

In 2019, data from the National Cardiogenic Shock Initiative from 35 sites across the United States reported a 72% survival to discharge in acute myocardial infarction CS for 171 patients.[8] The unique aspect of this initiative was use of a protocol approach with invasive hemodynamic monitoring and rapid initiation of MCS in acute myocardial infarction CS. In 2020, the University of Ottawa Heart Institute published their institution's CS outcomes before and after implementation of a Shock Team protocol, showing improved long-term survival after the establishment of a Shock Team compared with standard of care. Notably, while long-term survival was improved, there was no in-hospital or 30-day survival benefit.[10] This suggests that the association of CS teams on survival may vary in different hospital settings and depend either on the specific functions it creates or the standard of care functions already in place.

Despite data demonstrating implementation of a CS Team may improve mortality, it remains unknown which specific functions of the Shock Team are associated with improvements in mortality. Some data may provide clues, though individual elements of CS team care have never been rigorously studied in isolation. Notably, multicenter observational data from the Critical Care Cardiology Trials Network demonstrated that hospitals with Shock Teams were less likely to use MCS overall, but when they used MCS it was more likely to be an advanced form of MCS including more transvalvular micro-axial flow devices or trans-septal unloading devices and less intra-aortic balloon pumps.[11] Shock teams were also associated with increased utilization of invasive hemodynamic monitoring, and collectively, these variations contributed to enhanced survival rates, particularly in patients with Society for Cardiovascular Angiography and Interventions (SCAI) stage D and E shock, resulting in lower risk-adjusted mortality.[11] Beyond this, CS teams generally expedite recognition and diagnosis of CS, to initiate appropriate therapies in a timely fashion, to standardize best practices, to define goals of therapy, and to minimize bias in decision-making. This may permit the implementation of targeted interventions in CS before the development of more refractory or irreversible systemic pathophysiologic changes, when interventions stand more chance of interrupting the cascading consequences of the initial CS insult. As such, to clearly understand the specific impacts of CS Team functions on patient outcomes, it is essential to conduct detailed and comparative studies, including prospective designs. These studies should aim to assess overall efficacy and cost-effectiveness, as well as to meticulously analyze the distinct elements of their care protocols and directly determine their contributions to reducing mortality.

CURRENT PRACTICES AND CHALLENGES

Despite the evolution of CS teams in health care settings, several knowledge gaps persist, hindering the optimization of CS team efficacy and resource allocation (Table 2). Addressing these gaps is paramount to improving patient outcomes and streamlining health care delivery.

Patient Selection and Team Composition

The critical question is not just which patients require a CS team, but rather how each patient can best be served based on the severity of their condition and the hospital's existing resources. There is evidence suggesting that patients benefit from some level of CS team involvement[6,8,10]; however, the extent and composition of this team might vary significantly based on the hospital's resources and the patient's specific needs, and the composition of the team plays a critical role in optimizing patient outcomes and resource allocation.

One of the key questions is whether a CS team always requires the involvement of advanced HF specialists, cardiac critical care physicians, cardiac surgeons, or interventionalists, or if these roles are necessary only in specific scenarios. The decision of who should be involved in initial assessments versus those responsible for executing treatment tasks is central to the operational framework of CS teams. At referring centers, this often raises the question of whether the absence of certain expertise (eg, advanced HF specialists) hinders decision-making or whether familiarity with CS management protocols is sufficient to guide initial care.

The CS team composition should be flexible and scalable, tailored to the specific capabilities and resources of each hospital. While tertiary care centers might field a full-scale CS team with a range of specialists including cardiac surgeons and critical care cardiologists, smaller hospitals may not require or have access to such specialized roles. Instead, these hospitals could benefit from initial management of patients with CS with a more targeted CS team—potentially a cardiologist and an intensivist (or emergency physician)—or professionals with additional expertise to perform essential functions of CS management—assessing severity and predicting clinical trajectories. This allows for efficient initial care and informed referral decisions.

To facilitate uniform communication and decision-making across CS teams, there is a need for a universal language for CS management. Reporting using the SCAI classifications and applying prognostic scores such as SAVE (Survival After Veno-Arterial ECMO) or APACHE (Acute Physiology and Chronic Health Evaluation) can help standardize the assessment of patients' conditions and inform early decision-making. Key data needed during the initial triage should include hemodynamic parameters, imaging results, and relevant comorbidities to allow for prompt and effective team activation.

Risk stratification models that incorporate patient demographics, comorbidities, and clinical presentations can help identify patients who are most likely to benefit from CS team intervention. Clear guidelines and protocols for CS team activation across health care settings are crucial for consistency in patient selection. In addition, leveraging telemedicine can broaden the reach of CS teams, enabling them to provide consultative support to smaller hospitals and thus extend their impact. Moreover, the core members of CS teams, regardless of the hospital's size, should be proficient in obtaining and interpreting primary data to form a cohesive plan of care. By fostering multidisciplinary collaboration and tailoring team composition to match institutional resources and patient needs, hospitals can optimize both efficiency and outcomes in CS management.

Operational Framework

The operational framework of CS teams is crucial for delivering high-quality care and optimizing resource allocation in health care settings. Given the significant heterogeneity in how shock teams function across institutions, it is essential to recognize that no single

Table 2. Current Practices and Challenges in Cardiogenic Shock Teams

	Key Points	Goals
Patient selection and team composition	• Emphasize the need for flexible and scalable CS team compositions tailored to each center's capability • Incorporate risk stratification models and telemedicine to extend CS team reach and impact	Optimizes both efficiency and outcomes in CS management by matching team resources with patient needs
Operational framework	• Highlight the importance of a clear operational framework addressing patient ownership and billing responsibilities • Include the need for harmonization across disciplines and optimization of rounding frequencies	Ensures effective patient care and resource utilization through improved care coordination and comprehensive analysis
Cost and resource effectiveness	• Consider conducting rigorous cost-benefit analyses to evaluate the financial implications of maintaining CS teams • Outline the development of resource allocation models tailored to individual hospital capabilities • Emphasize adopting value-based care approaches	Enhances the economic viability and operational efficiency of CS teams, promoting high-value care

CS indicates cardiogenic shock.

operational framework will be universally applicable. Some CS teams focus primarily on early triage after initial diagnostic assessment, while others emphasize serial reassessment protocols, ongoing multidisciplinary management, or immediate escalation to MCS in deteriorating patients. This variability in team mandates and structures underscores the importance of standardizing key operational components where feasible, particularly in decision-making, resource allocation, and team communication.

Team member alignment and buy-in are imperative to minimize the sense of loss of autonomy, promote consistency in decision-making and promote equity of workload. Challenges such as the unclear delineation of patient ownership within the team and billing responsibilities need rigorous analysis to ensure seamless care coordination and equitable reimbursement distribution. In addition, optimizing rounding frequency and ensuring harmonization across disciplines are essential for effective patient care delivery and resource utilization. Given the diversity in team structures, standardized communication protocols—especially regarding patient handoff and decision-making authority—are crucial to harmonize care delivery across institutions with varying resources and team compositions. The decision-making process regarding the scalability of CS teams within hospital systems versus referrals to higher-level centers also requires a comprehensive analysis to balance patient outcomes, resource use, and cost-effectiveness. For example, institutions with limited resources may focus on initial stabilization and transfer decisions, whereas larger centers with dedicated shock teams can implement ongoing multidisciplinary management strategies.

Furthermore, the timing of CS team activation is a critical area for scientific inquiry. It is vital to determine whether teams should convene immediately upon receiving primary data, such as echocardiograms and hemodynamic assessments, or if their involvement should start during the patient transfer process to referring centers. Prospective studies examining different activation protocols are needed to provide evidence-based guidance to enhance operational efficiency and patient outcomes. These studies should account for the wide variability in how teams are activated across institutions, recognizing that smaller centers may require a more streamlined activation protocol compared with large tertiary centers with established CS teams.

The role of the CS team often extends beyond the initial assessment and deployment of MCS, affecting the entire continuum of care. While some CS team protocols focus on ongoing management in the cardiac ICU, including hemodynamic assessment and neurovascular checks, others are structured to provide primarily acute stabilization, with ICU management per a single ICU staff, not the multidisciplinary shock team. The actual impact on CS mortality involves both the escalation and de-escalation of support, alongside management of associated complications throughout the ICU stay. Conditions like ICU-acquired infections, delirium, and other complications significantly influence patient morbidity and hospital stay, requiring skilled critical care beyond initial stabilization and could benefit from ongoing multidisciplinary engagement.[12] The DanGer Shock trial underscores the complexities involved in CS management; over 65% of patients required mechanical ventilation, and a substantial portion faced noncardiac complications.[13] This emphasizes the importance of a well-integrated approach that combines the expertise of shock teams with critical care providers to ensure comprehensive management of both CS and its concomitant critical illnesses.[13]

Cost and Resource Effectiveness

CS teams require substantial resources, including specialized personnel, equipment, and infrastructure, to provide timely and comprehensive care to patients experiencing CS. However, the allocation of these resources must strike a balance between the associated costs and the potential benefits, including improved patient outcomes, cost-effectiveness, and resource savings.

Assessing the cost-effectiveness and resource utilization of CS teams is essential for informing resource allocation decisions and optimizing health care delivery efficiency in this specialized area. Rigorous cost-benefit analyses comparing the financial implications of maintaining CS teams versus the potential savings from improved patient outcomes offer invaluable insights into the economic viability of specialized CS care. By quantifying both the direct costs of CS team implementation and the potential savings from reduced length of hospital stays, decreased readmission rates, and improved patient outcomes, such analyses provide evidence-based guidance for resource allocation decisions specific to CS care.

Developing resource allocation models that are tailored to the capabilities of individual hospitals is essential for optimizing the deployment of dedicated CS teams. These models should assess hospital resources, technological capacities, and staff expertise to determine which patients can be effectively treated on-site and which should be referred to more specialized centers. This approach ensures that resource allocation is aligned with the practical abilities of the hospital, enhancing the efficiency of care delivery and the utilization of CS teams.

Furthermore, embracing value-based care approaches that prioritize patient outcomes and resource efficiency can incentivize investments in CS teams based on their demonstrated impact on quality of care and cost savings. By incentivizing providers to focus on delivering high-value care that improves patient outcomes while minimizing costs, value-based care frameworks promote the efficient use of resources and drive continuous improvement in CS care delivery.

FUTURE DIRECTIONS AND INNOVATIONS

Heterogeneity in the treatment of CS reflects a paucity of high-quality evidence to inform optimal care strategies, and thus each center is left to devise its own unique strategies for CS care based on experience and available resources. A tiered approach to CS team composition, modeled after the American Heart Association levels of cardiac intensive care units, can help standardize care by aligning team structure and interventions with the specific resources and capabilities of each hospital, ensuring that care is flexible and scalable to patient needs. In addition, 3 processes are likely to advance the care of patients with CS from a systems of care standpoint: First, there should be efforts to codify best practices within hospitals and, ultimately, at a national level, producing standardized protocols and algorithms for each step in CS care. Second, CS teams can expand their reach outside of their individual institutions to serve as a regional CS teams. Third, participants in CS teams can generate data on their own efficacy, outcomes, impact, and cost-effectiveness. Such data can be used locally for quality improvement and to justify their value and cost-effectiveness to hospital systems (Table 3). These data can be pooled as part of national initiatives to promote the implementation science of CS teams.

Tiered Model of CS Teams

As CS management evolves, a tiered model for shock teams offers a novel approach to optimize care delivery across institutions with varying levels of resources (Figure 2). This model, aligned with the American Heart Association levels of cardiac intensive care units,[14] provides a structured framework for institutions to tailor their shock team composition and mandates based on their capabilities. The core principle of this model is that CS team composition should be flexible and scalable, tailored not only to the specific resources available at each hospital but also to the unique needs of each patient. This ensures that all hospitals, regardless of size, can effectively manage patients with CS while providing personalized, need-based care.

1. Tier 1 Shock Teams (Comprehensive Centers): At the highest tier, comprehensive centers (typically found in tertiary and quaternary care institutions) would have fully integrated shock teams with advanced multidisciplinary capabilities. These teams would include specialized HF cardiologists, interventional cardiologists, cardiac surgeons, intensivists, and critical care nurses with expertise in managing complex CS cases. While these centers have access to a full range of specialists, not all patients in Tier 1 necessarily require the presence of every team member during a shock activation. For patients with less complex needs, the activation might only involve a subset of the shock team, such as an HF cardiologist and an interventional cardiologist, with the rest of the team on standby should the situation escalate. This scalable approach ensures that resources are used efficiently, and patient care is tailored to the specific severity of the shock event. Tier 1 centers also serve as referral hubs, providing consultative services and receiving transfers from lower-tier institutions. With access to the most advanced diagnostic and therapeutic technologies, Tier 1 centers can manage the full spectrum of CS, including the most critically ill patients in SCAI Stage D/E shock. This tier would lead regional and national initiatives in CS research and quality improvement, contributing data on outcomes and protocol efficacy to drive future advancements in the field.

Table 3. Future Directions and Innovations in Cardiogenic Shock Management

	Key Points	Goals
Standardized CS protocols	• Development of standardized protocols for CS care to organize and implement therapies effectively. This includes revascularization strategies, use of vasoactive medications, and management of extra-cardiac pathologies, among others • Protocols aim to standardize care across different hospital systems and facilitate effective pretransfer and transfer care strategies	Achieve greater consistency in the management of CS, improve inter-hospital communication and coordination, and ensure timely initiation of therapies
Quality metrics	• Consider metrics beyond mortality • Include patient-centered outcomes, major adverse cardiovascular events, readmission rate, safety outcomes, and process measures	Provide a multifaceted assessment that extends beyond mortality rates to capture a broad spectrum of patient care and team performance
Expansion to regional care models	• Expansion of CS care into regional models involves developing standardized protocols shared with regional hospitals before patient transfer • Efforts should support the initial stabilization of patients at local hospitals and facilitate more informed and timely transfers to specialized centers • It can involve virtual consultations by CS teams, enhancing care continuity	Enhance access to specialized care and expertise for patients with CS at local levels, reduce diagnosis and management delays, and promote early and effective therapy initiation
National CS team research initiatives	• Encourage CS teams to contribute to research initiatives to advance global CS care • Establishing collaborative networks and registries can accelerate knowledge production and improve care strategies • Multicenter studies to assess the efficacy and cost-effectiveness of CS teams and care protocols should also be proposed	Generate robust data sets that inform the efficacy and cost-effectiveness of CS teams, standardize care protocols across centers, and identify best practices for the deployment and operation of CS teams

CS indicates cardiogenic shock.

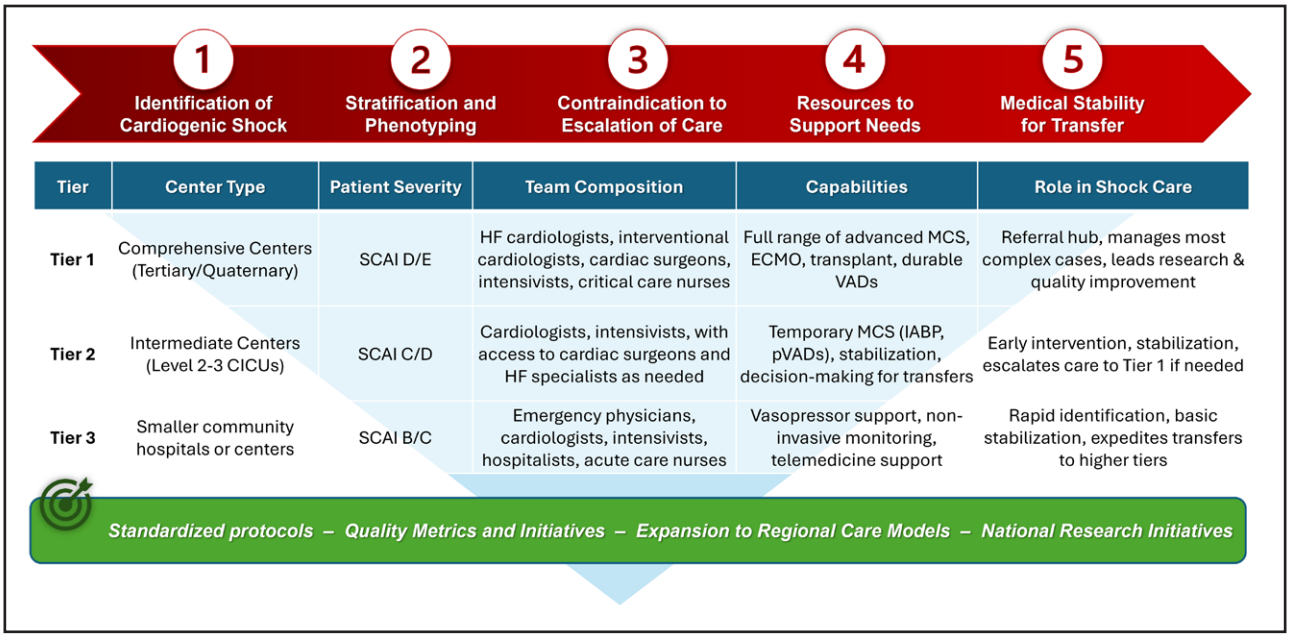

Figure 2. Tiered approach to cardiogenic shock team structure.
Cardiogenic shock team activation should include identification, stratification, contraindication assessment, resource evaluation, and ensuring medical stability for transfer. A tiered-based approach categorizing centers into Tier 1 (Comprehensive Centers) for advanced care, Tier 2 (Intermediate Centers) for stabilization and transfer coordination, and Tier 3 (smaller community hospitals or centers) for early identification and initial management, could optimize team composition, operational framework, cost-effectiveness, and resource utilization. Moving forward, the overarching aim should be to develop standardized protocols, quality metrics, regional care expansion, and national research initiatives. CICU indicates cardiac intensive care unit; CS, cardiogenic shock; ECMO, extracorporeal membrane oxygenation; HF, heart failure; IABP, intraaortic balloon pump; MCS, mechanical circulatory support; pVAD, percutaneous ventricular assist device; and SCAI, Society for Cardiovascular Angiography and Interventions

2. Tier 2 Shock Teams (Intermediate Centers): Intermediate centers, corresponding to American Heart Association Level 2 cardiac intensive care units, would manage SCAI C/D CS cases but with a more limited scope of advanced interventions compared with Tier 1 centers. These institutions have access to temporary MCS devices such as intraaortic balloon pumps and percutaneous ventricular assist devices, with a focus on early stabilization and decision-making regarding patient transfers. The flexibility of shock team composition in Tier 2 is particularly important, as the team must scale its involvement based on the complexity of the patient's condition. For example, a patient in SCAI C CS might be managed by a core team of cardiologists and intensivists, while more advanced cases (SCAI D) could involve cardiac surgeons and HF specialists. This tier's primary mandate is to initiate prompt diagnosis, provide early intervention, and coordinate transfers to Tier 1 centers if necessary. For patients who cannot be immediately transferred, Tier 2 teams can manage temporary MCS and provide ongoing critical care, stabilizing patients for eventual escalation to a higher-tier facility.
3. Tier 3 Shock Teams: At the most basic level, Tier 3 shock teams would be implemented in smaller community hospitals or centers with limited critical care resources. Here, the scalability and adaptability of team composition is essential, as these teams must adjust to both the available resources and the needs of individual patients. For example, a SCAI B/C CS case might only require the involvement of an emergency physician and a cardiologist, while more severe cases might warrant consultation with a higher-tier center. Typically consisting of cardiologists, emergency physicians, intensivists, and acute care nurses, these teams are proficient in initiating life-saving interventions such as vasopressor support and noninvasive hemodynamic monitoring. The mandate for Tier 3 shock teams is straightforward: rapidly identify CS, provide basic stabilization, and expedite transfers to Tier 2 or Tier 1 centers where advanced therapies can be initiated. Telemedicine support from higher-tier centers could further enhance their ability to manage more complex cases without overextending their resources.

Standardized CS Protocols

Protocols for CS care may help standardize the organization and implementation of necessary therapies. CS is a time-sensitive condition in which multiple high-stakes diagnostic and treatment decisions must be made in rapid succession across multiple domains,

including: revascularization strategies for acute myocardial infarction CS; use of vasoactive medications to optimize blood pressure and perfusion; escalation and de-escalation of temporary MCS; management of extra-cardiac pathophysiology as well as iatrogenic complications; application and interpretation of invasive hemodynamic measurements and noninvasive cardiac imaging; decisions about goals of care, and exit strategies including advance therapies or palliative approaches. Moreover, as previously mentioned, CS care is provided in-hospital systems with varying degrees of resources. Patients may present initially to hospitals with limited resources for the care of CS, variable access to diagnostic modalities, variable access to interventional and surgical strategies, and limited availability of temporary MCS or other time-sensitive therapies. Yet, time to diagnosis, risk stratification, and therapeutic initiation is equally important to all patients with CS, irrespective of where a patient initially presents.

There is a role for CS referral centers to develop protocols to standardize each of the above elements of CS care and to work with regional hospitals to develop and implement network protocols even before inter-hospital transfer. For example, CS teams receiving a referral can delineate a set of desired clinical information conveyed in standardized forms to supplement pretransfer verbal conversations (Table 4). This can improve the thoroughness of information transfer, and it could also prompt referring centers to collect such information if possible. The same could apply to the interfacility transport team itself. CS teams can develop appropriate use criteria for transfer, with the primary goal to promote earlier recognition and more timely transfer of patients before significant irreversible deterioration occurs. In addition, such criteria may also help to avoid transferring patients where a higher-level of care is futile. In this pretransfer evaluation, teams can help to gather information about surrogate decision makers and to begin conversations about acceptable interventions, which would facilitate treatment initiation immediately upon arrival.

At a CS team hospital, several standardized protocols would be useful, including indication and exclusion criteria for invasive hemodynamic monitoring, indication and exclusion criteria for various forms of temporary MCS, escalation and de-escalation strategies for MCS, and dynamic strategies for anticipating and selecting pathways toward durable left ventricular assist device, transplant, recovery, or end-of-life comfort care. Several practical criteria ought to be developed and implemented as well to guide daily bedside care of CS, including guidelines for anticoagulation, management of MCS complications such as bleeding or acute limb ischemia, decannulation strategies for MCS, and criteria for extracorporeal life support. In addition, there is an expanding population of patients requiring convalescent care after recovering from CS, which require dedicated resources to avoid CS relapse, to rehabilitate the patient, and to address common comorbidities and psychological complications. Comprehensive post-CS care could be addressed with the implementation of standardized protocols, but the complexity of this space may also require the development of dedicated post-CS discharge clinics for centers to be able to provide the entire panoply of necessary services.

When developing standardized protocols, the implementation of auto-accept policies should be carefully considered where appropriate. The severity of CS, particularly in SCAI Stage D/E, can make timely

Table 4. Guide for Cardiogenic Shock-Call Discussion

	Information	Details
Patient background	Brief HPI	Focus on chronic end organ dysfunction
	Baseline functional status	Status before index hospitalization
	Potential barriers to escalation of care	Focus on medical, surgical and psychosocial risk factors (eg, lack of social support, mental health issues, substance abuse, financial constraints), alongside discussions about the goals of care, all of which can significantly influence care decisions
Current clinical status	Vital signs	Recorded within the last 1 h
	Hemodynamics via PA catheter	If available (eg, CVP, PAP, PCWP, CI, SvO_2)
	Current vasoactive medication doses	Current doses
	Current ventilator or oxygen settings	Current settings
	Current mechanical circulatory support	Specify level of support
Diagnostic data	Objective data	ABG and lactate within last 2 h, creatinine and liver function tests within last 12 h, other significant abnormal laboratory findings (INR and CBC), TTE with assessment of biventricular function within last 24 h
	Left heart Cath results	If available
Post-call actions	At conclusion of call	(1) Accepting physician, (2) Unit/bed, (3) Transfer modality (air vs ground; lifeflight or other service), (4) Recommendations for immediate interventions

ABG indicates arterial blood gas; CBC, complete blood count; CI, cardiac index; CVP, central venous pressure; HPI, history of present illness; INR, international normalized ratio; PA, pulmonary artery; PAP, pulmonary artery pressure; PCWP, pulmonary capillary wedge pressure; SvO_2, venous oxygen saturation; and TTE, transthoracic echocardiogram.

decision-making critical, especially when waiting for a multidisciplinary team could delay urgent interventions. Auto-accept policies can address this by allowing patients who meet specific criteria to be transferred to higher-level centers without the need for full committee review. While this can expedite access to advanced therapies, it also risks bypassing essential discussions about whether further escalation is truly beneficial, potentially leading to futile interventions. To mitigate this, clear criteria must be established to determine when auto-acceptance is appropriate and when a full multidisciplinary review is necessary. In addition, capacity limitations must be factored in. High-volume centers, already operating near capacity, may struggle to manage an influx of complex cases without proper triage, leading to delays in care for other patients. Auto-accept protocols should be integrated into a comprehensive resource management strategy, accounting for bed availability, staffing, and the ability to provide timely care. Without these safeguards, expedited transfers may result in delays or suboptimal care due to resource limitations at the receiving center.

In all, CS teams will have an instrumental role to play in the implementation and continued evaluation of these protocols, noting that most protocols and algorithms will require frequent updates to align with novel evidence or national guidelines in a rapidly evolving field. Ultimately, the goal of these protocols would be to (1) allow greater consistency in the management of patients with CS, (2) facilitate inter-hospital communication and timing of transfers, and (3) to promote timely initiation of therapies to protect the critical first 24 hours of CS care and all care thereafter.[15]

Quality Metrics and Initiatives

In assessing the quality of CS teams, it is vital to consider a variety of metrics beyond mortality. These should include patient-centered outcomes such as quality of life post-intervention, functional status at discharge, and patient satisfaction. In addition, clinical outcomes such as the incidence of major adverse cardiovascular events, time to intervention, and readmission rates are critical. Process measures, including adherence to evidence-based protocols and timeliness of interventions, reflect operational effectiveness. Safety metrics, such as rates of procedure-related complications and hospital-acquired conditions, and resource utilization metrics like length of stay and critical resource use, also play crucial roles in assessing care quality.

Furthermore, an integral component of quality assessment should be the incorporation of a structured internal review process. Regular multidisciplinary debriefings, in which shock teams evaluate recent cases, provide a platform to critically assess decision-making, adherence to protocols, and outcomes. These debriefings not only help identify areas for improvement but also promote team cohesion, ensuring that all members are aligned in delivering high-quality, evidence-based care.

Process measures, including adherence to evidence-based protocols and timeliness of interventions, reflect operational effectiveness and are key elements that should be scrutinized during these internal reviews. The systematic analysis of each team's response times, diagnostic accuracy, and early therapeutic interventions during debriefings can lead to continuous quality improvements, particularly in centers with variable levels of experience.

Safety metrics, such as rates of procedure-related complications and hospital-acquired conditions, must also be regularly reviewed. In particular, metrics like the incidence of ICU-acquired infections, bleeding events, or device-related complications can help refine protocols aimed at minimizing harm. The internal review process allows teams to identify and address the root causes of safety issues, leading to the implementation of targeted strategies to reduce these events.

Finally, resource utilization metrics like length of stay, critical resource use, and cost-effectiveness provide insight into the team's operational efficiency. Evaluating these metrics in the context of case debriefings encourages a more holistic view of care, where the balance between clinical outcomes and resource management can be optimized. By incorporating both patient-centered and process-focused measures into routine evaluations, CS teams can continuously refine their approach, ensuring that quality care is delivered consistently across varying levels of patient acuity and institutional resources.

Expansion to Regional Care Models

Not all hospitals can or should develop CS teams, but all patients with CS will benefit from appropriate and timely CS interventions. Centers with fewer resources to care for patients with CS will nevertheless care for critically ill patients during the first hours and days of their treatment, and it is essential that these patients have timely access therapies and ready availability of medical, interventional, and surgical expertise when necessary. Currently, all quaternary care CS referral centers receive transfer requests for patients with CS, during which >1 providers may take part in triage, accepting or declining the patient for transfer, and providing preliminary advice for patient stabilization before transfer. This process, however, could be improved via 2 mechanisms: (1) involvement of the entire CS team in the initial transfer intake call, and (2) more deliberate collaboration with referring hospitals to develop shared protocols and more frequent communication with updates on a patient's clinical status and trajectory before transfer.

Clinically, each of these strategies makes sense. Delays in the diagnosis or management of patients with CS will contribute to deterioration, multiorgan dysfunction, or even

death as patients await transfer, contributing to a higher mortality rate of CS in transferred patients compared with those initially managed at a CS referral center.[16] Even when transfer is desired, it cannot always happen immediately based upon bed availability or transfer conditions. Initial consultation with a CS team, including specialists that may not exist at a referring hospital or who have greater familiarity with CS care, can help guide initial pretransfer management and improve the selection of patients for transfer. In so doing, additional therapies may already be implemented by the time transfer occurs, or there may be more useful diagnostic information collected necessary to inform next steps without delay upon arrival.

The infrastructure necessary to operate a local CS team lends itself naturally to a regional CS team, as it requires the same staffing and similar conversations that can happen virtually or over the phone. One drawback is that CS teams would be unable to assess patients directly at bedside or to implement procedural or surgical therapies directly, though the local team may have the capability to implement critical therapies such as improved vasoactive medication strategies or temporary MCS at the recommendation of the CS team. From a financial compensation standpoint, these efforts could generate revenue through improved catchment of regional patients with CS and by improved relationships with referring teams, although there exists no direct reimbursement pathway as yet for such services. In the United States, CS teams may not be located in the same state as referring centers, which creates an additional barrier to virtual consultation. Ultimately, despite their clinical utility, medical-legal issues would need to be resolved from the perspective of both the referring and referral centers, given that formal consultative advice begins to assume medical liability. Nevertheless, such regional CS teams are aspirational and could extend the impact of local CS teams to patients who arrive initially to centers with fewer dedicated CS resources.

With an insufficient supply of intensivists able to manage the day-to-day care of patients with CS, and with limited space available at existing quaternary care CS referral centers, there could also be a role in some regions for virtual critical care of patients with CS. In this model, centralized CS experts could deliver care recommendations off-site with telemedicine technologies and remote monitoring capabilities and advise local teams on care management as well as the decision to escalate care to another facility. However, this model has not been widely utilized or studied specific to CS. Because several of the plausible benefits of CS team care require early utilization of therapies that may not be available at many sites, arguably the utility of virtual CS ICU to overcome barriers in care in the day-to-day management of CS may be small. While the potential for telemedicine and virtual critical care in expanding the reach of CS teams has been increasingly recognized, there is an unmet need to explore these virtual models further to bridge the gap between resource-limited settings and specialized care centers.[2,17] Regional care models utilizing telemedicine could provide real-time consultative support to smaller hospitals, improving the early recognition and stabilization of patients with CS while expediting transfer decisions and improving overall outcomes.

National CS Team Research Initiatives

With the expansion of CS teams, one of the most impactful ways to advance the care of CS world-wide would be for CS teams to contribute data and expertise to research endeavors. There have been proposals to develop a CS Team Collaborative, similar to the Pulmonary Embolism Response Team Consortium, to accelerate the production of knowledge in this space.[2] The creation of a CS Team Collaborative could be instrumental in promoting the development and dissemination of these standardized protocols. A collaborative model would bring together key stakeholders to share best practices, foster research, and facilitate the education of both health care providers and patients.[2]

Multiple CS registries now exist to promote the study of CS itself, including the CS Working Group, the American Heart Association CS Registry, the Critical Care Cardiology Trials Network, and the VANQUISH (Multicenter Collaborative to Enhance Biological Understanding, Quality, and Outcomes in Cardiogenic Shock Registry) Shock consortium. However, there remains a need to study and develop the implementation of CS teams and to better understand how bundles of care offered by CS teams impact outcomes in a pragmatic fashion. Notably, as centers themselves standardize their own care of patients with CS and improve institutional homogeneity of treatment strategies, this will create a natural experiment to compare the impact of different protocols between institutions. Basic questions, such as how often CS teams ought to be involved in the care of patients (eg, daily rounds, twice daily rounds, or just at the initial intake or other critical timepoints) have not been answered. These questions could be addressed through a multicenter registry. Such a registry would also ideally address questions of cost-effectiveness and help to understand the impact of various roles assigned to the CS team, with generalizability that single-center studies cannot demonstrate. CS survival would be the primary outcome of many studies, but a CS team registry could also evaluate several essential but pragmatic end points such as length of stay, hospital readmission, and utilization of various resources. Ultimately, the pragmatic aspects of CS team rollout and maintenance warrant their own analysis, since the direct benefit to patients of a CS team can only be extended through a better understanding of what it takes for a center to begin a CS team and what elements are critical for its success.

CONCLUSIONS

While considerable progress has been made in the establishment and efficacy of CS teams, there is a need to enhance their operational frameworks, expand their reach, and continuously evaluate their impact on patient outcomes. Through these efforts, the health care community can better address the complexities of CS, ultimately leading to more standardized care and better outcomes for patients across various settings. The potential strategies to enhance the continuum of care include fostering close partnerships between shock teams and critical care providers, expanding critical care cardiology service lines to integrate cardiology with critical care expertise, or formalizing the role of CS teams for continued patient involvement post-stabilization. These approaches can help standardize care pathways, clarify financial policies, and ultimately improve the scientific foundation and efficacy of CS team operations in a way that is adaptable to the capabilities and resources of each hospital.

ARTICLE INFORMATION

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