Journal of Shock and Hemodynamics

Volume 1
Issue 2 *Volume 1, Issue 2 (2022)*

Article 4

2022

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November 1, 2022 https://doi.org/10.57905/josh/e2022124

Editorial

SCAI SHOCK: Does the Stage Help with Management Decisions?

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Received September 30, 2022
Published November 1, 2022

The original Society for Cardiovascular Angiography and Intervention (SCAI) SHOCK Classification statement was presented at the Houston Shock Symposium in 2019, shortly before its official publication.[1] This generated substantial discussion among the conference attendees, and it was immediately apparent that validation studies were needed to demonstrate the utility of this new staging system for defining the severity and prognosis of cardiogenic shock (CS). Together with several other attendees who were coauthors on the SCAI SHOCK Classification statement, we started planning a retrospective analysis to explore how to assign the SCAI SHOCK Classification using clinical data objectively. To achieve this, we met as a group to develop a consensus definition for each SCAI Shock stage using clinical, laboratory, and vital sign data available in the Mayo Clinic cardiac intensive care unit (CICU) database. The SCAI Shock Classification provided surprisingly robust mortality risk stratification in this population of 10,000 CICU patients with or at risk for CS, even after adjusting for established markers of illness severity and other prognostic variables.[2] The results held true in patients with acute coronary syndromes or heart failure, and cardiac arrest conferred incremental risk at each SCAI SHOCK stage consistent with the proposed "A" modifier from the SCAI SHOCK Classification statement.[3]

The manuscript was published later that year, quickly followed by several additional publications confirming and expanding upon these findings. These studies uniformly demonstrated that the SCAI SHOCK Classification provided incremental mortality risk stratification for patients across the spectrum of shock severity, regardless of the population studied.[4-7] Furthermore, additional potential risk modifiers emerged that could provide a graded prognostic assessment at each SCAI SHOCK stage.[8] This led to the development and publication of a revised SCAI SHOCK Classification earlier this year, which we were both fortunate to participate in writing.[9] This new statement highlighted the validity of the original SCAI SHOCK Classification and provided subtle modifications and clarifications while, by and large, maintaining the same structure. Based on studies published since the original SCAI SHOCK Classification statement, age was added as an established risk modifier, and the arrest modifier was changed to reflect only those post-arrest patients with possible neurologic compromise (i.e., coma).[8-11]

The revised SCAI SHOCK Classification statement underscores the practical application of the SCAI SHOCK Classification for mortality risk stratification, yet several unanswered questions remain. Chief among these is the need to leverage the SCAI SHOCK Classification to provide risk-tailored treatment strategies for individual patients with CS. To date, no randomized clinical trial has demonstrated clear evidence of heterogeneity of response to treatment in CS patients according to baseline mortality risk. To some extent, this may result from the inclusion of both shock-related and non-modifiable risk factors in established mortality prediction scores.[12, 13] However, the SCAI SHOCK Classification could provide a unique opportunity to provide individualized management of CS patients by matching the degree of support to the severity of CS. While this approach remains speculative, it seems logical to evaluate this strategy objectively.

Our first attempt to address this question utilized the Mayo Clinic CICU database. It examined the propensity-adjusted association between intra-aortic balloon pump (IABP) use and mortality across the SCAI SHOCK stages in patients with CS

from diverse etiologies.[14] This analysis suggested an association between the use of the IABP and lower mortality, an effect that may have been more prominent at lower shock severity. This finding was conceptually appealing considering the modest hemodynamic support provided by the IABP, particularly when compared to the high severity of CS observed in randomized clinical trials evaluating this therapy. These findings are speculative based on the observational nature of this analysis but stress the potential to utilize the SCAI SHOCK Classification to tailor hemodynamic support. We have proposed an incremental approach to hemodynamic support according to the SCAI SHOCK Classification, recognizing that prior studies have not demonstrated improvements in outcomes when temporary mechanical circulatory support (MCS) devices are used uniformly.[15, 16] The impetus to use the SCAI SHOCK Classification to guide therapy is supported by the surprisingly minimal differences in most standard hemodynamic measurements across the SCAI SHOCK stages despite dramatic differences in the severity of shock and critical illness.[4, 7] CS is too heterogeneous a disease to realistically create a formulaic one-size-fits-all care strategy that applies to all patients with CS, but a structured approach to evaluation and management tailored to shock severity is feasible.[16]

An ideal opportunity to utilize the SCAI SHOCK Classification to facilitate clinical care comes in the context of the shock team. Despite different approaches utilized at various institutions, establishing a shock team has improved outcomes for patients with CS.[17-19] In addition to providing a standardized multidisciplinary evaluation for patients with CS, the shock team can facilitate consistent care tailored to each patient's needs. By assigning the SCAI SHOCK stage in an agreed-upon manner, the shock team members can communicate clearly and provide a structured approach to initiating and escalating temporary MCS that is more likely to yield benefits than use without a formal approach. Each institution can develop a consensus approach to assigning the SCAI SHOCK Classification to help specify which patients will be selected for specific temporary MCS devices, enabling streamlined care congruent with institutional best practices. While the shock team can come to these same conclusions *ad hoc* for each patient, having an established algorithm ensures that the team's composition does not impact the quality of care. This strategy allows each institution to define the preferred approach to CS management in a manner that can be used to expand beyond a single facility to build a hub-and-spoke CS care network.[20] Unfortunately, examining the effects of such an approach in a classic randomized clinical trial may not be feasible. However, an implementation science approach (eg, stepped-wedge pragmatic trial) could be effective. Nonetheless, determining which aspects of shock team management are associated with improved outcomes can be evaluated objectively to develop a set of core best practices for shock team performance.

Implementation of the SCAI SHOCK Classification can take many incarnations. Simplified approaches to the SCAI SHOCK Classification can be taught quickly and easily to providers of all training and experience, and clinician assignment of the SCAI SHOCK stage performs as well as a more complex data-driven algorithm for risk stratification.[4] Alternatively, the electronic medical record can be utilized to determine the SCAI SHOCK stage automatically using laboratory and vital sign data. The former approach in the prehospital and emergency department setting might enable better triage decisions and early management for patients with CS. The latter approach can identify hospitalized patients with established or impending CS to facilitate rapid recognition and stabilization; we are currently exploring this approach at the Mayo Clinic. Either of these assessments can be performed serially over time to assess patient trajectory, with important prognostic and treatment implications. A persistently high or rising SCAI SHOCK stage portends a poor outcome and should prompt consideration of escalation in terms of medical therapy and MCS.[4, 5]

It is essential to recognize that decision-making for patients with CS is substantially more complicated than matching the flow provided by a temporary MCS device to the hemodynamics or even the SCAI SHOCK stage. This was delineated in the revised SCAI SHOCK Classification statement, which identified three core constructs involved in prognostication and decision-making for patients with CS: shock severity, phenotype, and risk modifiers.[9] The premise is that at each level of shock severity, patients may display different patterns of cardiac, hemodynamic, and other clinical features that portend different levels of risk and necessitate different approaches to hemodynamic support, including temporary MCS. Additionally, a host of non-modifiable risk factors for mortality (including brain injury from cardiac arrest and age, among others) that are not directly related to shock severity can further impact prognosis and determine candidacy for different potential therapies. Integrating all these components is necessary for risk stratification and, more importantly, developing a management strategy for each CS patient in a manner analogous to the TNM staging system used for malignancy or the MOGE(S) or HLM classification systems proposed for heart failure.[21-23] In this way, a patient with mild shock may have a poor outcome due to ineligibility for temporary MCS in the setting of advanced age, extensive comorbidities, and severe anoxic brain injury after cardiac arrest. A different patient with severe shock may have a more favorable prognosis in the absence of these complicating factors, allowing the patient to be a candidate for advanced temporary MCS and cardiac replacement therapy if needed. These complex and nuanced decisions are difficult to operationalize, but this paradigm can be used to guide shock team discussions. The essential component to recognize is that many of the prognostically important variables in CS patients are not related to shock severity per se and may not be improved using temporary MCS, resulting in poor outcomes.

Despite the ongoing trials, there will continue to be unanswered questions.[24, 25] There is a significant role for multicenter registries such as the Cardiogenic Shock Working

Group and VANQUISH registries, as well as the planned American Heart Association Cardiogenic Shock Registry.[7, 26] The VANQUISH registry will record the team-assessed SCAI SHOCK Stage at baseline and two days, as well as collect quality of life data and biomarkers serially throughout the course of the patient with cardiogenic shock.[26] Additionally, this registry includes all cases seen by the local shock teams, whether the patient received MCS or not, to reduce selection bias. Prospective enrollment of patients in these multicenter registries with mature shock teams will enable greater insights to be gleaned, ideally including linking underlying biomarker patterns and clinical phenotypes with outcomes and treatment responses.[16]

Beyond the potential utility of the SCAI SHOCK Classification for improving patient care, our story should be particularly instructive to early career researchers. The relationships with other interested experts that are developed at small but focused meetings, such as the Houston Shock Symposium, are invaluable, and the experience is hard to replicate at larger and less intimate meetings. The impact of the research collaboration and career mentorship that grows from these chance meetings cannot be overstated. We are both grateful to have met at the Houston Shock Symposium in 2019. Due to this chance meeting, we have published a dozen (and counting) collaborative manuscripts together. Even more importantly, we believe that together, we are moving the science of CS research forward and hope that lives will be saved by a better understanding of this disease that will translate to improved care strategies.

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