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EDITORIAL COMMENT

The SCAI Cardiogenic Shock Staging System Gets Taken for a Test Drive*

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The Society for Cardiovascular Angiography and Interventions (SCAI) recently assembled an expert panel to develop a system for classifying disease severity in patients with cardiogenic shock (CS) (1) that was also endorsed by 4 other American medical societies. The effort was motivated by the intensification of research aimed at improving outcomes in patients with CS. It was built on the principle that the overall population of patients diagnosed with CS on the basis of classical criteria (i.e., systolic blood pressure <90 mm Hg or mean blood pressure <60 mm Hg for ≥30 min or the requirement for pharmacological support to achieve or maintain that blood pressure and evidence of end-organ hypoperfusion) actually includes patients with wide degrees of clinical, biochemical, and hemodynamic compromise. The proposed staging system was intended to provide a simple means of communicating disease severity among clinicians and potentially for risk stratification in the context of research studies. The classification system is summarized using a 5-stage "ABCDE" acronym: At risk for CS, Beginning phase of CS, Classical CS, Deteriorating CS, and Extremis CS. A subscript "A" modifier is included to signify patients who have experienced cardiac arrest (e.g., stage C_A). As such, the ABCDE stages are akin to the 4 American College of Cardiology/American Heart Association heart failure stages (ABCD) or the 7 Interagency Registry for Mechanically Assisted Circulatory Support profiles that were quickly adopted and are now firmly integrated in clinical practice for classifying disease severity in patients with chronic heart failure being considered for durable mechanical circulatory support. Like the American College of Cardiology/American Heart Association heart failure stages and the Interagency Registry for Mechanically Assisted Circulatory Support profiles, one of the basic tenets of the SCAI staging system is its broad applicability in any hospital setting and rapid assignment on the basis of simple clinical observations (see Table 1 in Baran et al. [1]).

In this issue of the *Journal*, Jentzer et al. (2) describe the first study demonstrating the utility of the SCAI CS staging system on the basis of a retrospective analysis of 10,004 patients admitted to the Mayo Clinic's cardiac intensive care unit. SCAI stages were assigned on the basis of a combination of database-derived values of blood pressures, biochemical markers (e.g., lactate, serum creatinine), urine output, and the number and intensity of inotrope and vasoactive drug therapy. Clinical deterioration was indexed by changes in drug therapy through the 1st and 24th hours of admission and their peak values during hospitalization. The study showed that mortality increased in relation to SCAI stage (3.0% in stage A vs. 67.0% in stage E), that the occurrence of cardiac arrest prior to admission significantly increased mortality for any given SCAI class (odds ratio: 3.99), and that these observations applied to patients with CS due to acute myocardial infarction (AMI) as well as to patients with CS due to decompensated chronic heart failure. These findings thus provide the first confirmation that, as proposed, the SCAI CS classification system stratifies patients with CS according to disease severity as quantified by mortality risk. Even considering just patients in SCAI stages C, D, and E (all of whom meet

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the standard CS definition), mortality increased progressively, from 12.4%, to 40.4%, to 67.0%, respectively.

The goal of risk stratification of patients experiencing or at risk for hemodynamic compromise dates back to 1967, with the introduction of the Killip classifications on the basis of the clinical assessment of pulmonary congestion and hypotension (3). There have since been more than 20 different quantitative scores introduced to prognosticate the risk for mortality in patients with CS. Why then is there a need for a new classification system, and what does the present study add to our understanding of the SCAI CS classification system?

Most prior risk scores were developed on the basis of retrospective, stepwise, backward elimination, multiple regression analysis starting with a large number of candidate clinical, hemodynamic, and biochemical parameters. An equation is generated that includes clinical parameters that survive the statistical elimination process, with each finally being weighted according to the magnitude of its regression coefficient or hazard ratio. Most of these scores were developed and tested exclusively in patients with AMI CS, though some were developed from more general shock populations encountered in medical intensive care units, including septic shock (e.g., Acute Physiology, Age and Chronic Health Evaluation score, sequential organ failure assessment score). Most recently, the CardShock (4) and IABP-SHOCK II (Intra-Aortic Balloon Pump in Cardiogenic Shock II) (5) scores, which correlated with 12- and 30-day mortality, respectively, in the setting of AMI CS have received the most attention, having been developed and validated from relatively large cohorts of patients. The potential advantage of such scores is their apparent ability to provide relatively precise quantification of risk. However, by definition, different scores are based on different parameters (some of which are not readily available in routine clinical practice upon presentation), and calculated risks are not always in close agreement. Additionally, such scores are generally derived from cohorts obtained years prior to their availability and may need refinement as standards of clinical practice evolve. Finally, when used for research purposes, parameters required to calculate some scores from established databases are not always available. For example, required data were not available to calculate CardShock and IABP-SHOCK scores from the Mayo Clinic database.

In contrast, the SCAI CS stages are intended to be based on standard clinical evaluation and can generally be assigned during the initial phase of intensive care unit admission. That said, Jentzer et al. (2) assigned stages on the basis of retrospective analysis of data obtained from a patient's entire hospitalization, not only data available during the early phase of hospital admission, as would be the case in actual practice. Thus, their analysis did not assess risk based only on SCAI class at the time of admission. Nor did the analysis evaluate the frequency with which SCAI class worsens during a hospitalization. Still, in addition to mortality, almost every index of disease severity worsened with increasing SCAI stage (see Tables 3 and 4 in Jentzer et al. (2)). Another acknowledged limitation of the analysis is that the Mayo Clinic database was queried between 2007 and 2015, a time period when intra-aortic balloon pump was by far the dominant form of mechanical circulatory support. Circumstances have changed dramatically, with the widespread use of percutaneous ventricular assist devices (e.g., Impella and TandemLife/LivaNova) and a dramatic rise in the use of extracorporeal membrane oxygenation. Accordingly, further refinement and/or introduction of additional SCAI classification modifiers may further risk-stratify patients. For example, modifiers could consider not only the number, total equivalent doses, and escalations of drug therapy but also the presence and number of device-based therapies.

Despite its limitations, the study by Jentzer et al. (2) is an important initial step toward validating the SCAI CS classification system. First, it provides practical information on using this system to analyze existing databases for research purposes. Second, one clear message that reinforces observations from the CardShock and IABP-SHOCK II scores is that it is inappropriate to group all patients diagnosed with CS together for the purpose of reporting mortality statistics or for developing and evaluating CS treatment algorithms. Rather, patients should be grouped according to risk at the time of presentation as well as the underlying disease process. For example, as pointed out by Jentzer et al., patients falling into low-risk groups (stages A and B) may not benefit from advanced forms of mechanical circulatory support. In contrast, in patients in stage E, such therapies may be futile. Another potential advantage of this staging system is its applicability across the care spectrum. For example, first responders can easily apply the SCAI classification and could triage the most critically ill patients to designated shock centers. Another example would apply to patients who

transition from stage C to D (signifying a substantial increase in mortality risk) being cared for in primary hospitals; consideration could be given to transferring such a patient to a center with more resources to treat CS.

In summary, the SCAI classification system is distinguished from prior CS risk scores in that it is intended to provide a practical, rapid and clinically relevant means of risk-stratifying patients with CS. Jentzer et al. (2) highlight the potential of some of these virtues. Inclusion of this system in studies involving AMI and heart failure shock will provide prospective validation of reproducibility of staging among clinicians, determination of if and how staging can influence clinical practice, and confirmation of the correlation of stage with mortality.

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