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Management and Outcomes of Cardiogenic Shock in Cardiac ICUs With Versus Without Shock Teams

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ABSTRACT

BACKGROUND Single-center studies suggest that implementation of multidisciplinary cardiogenic shock (CS) teams is associated with improved CS survival.

OBJECTIVES The aim was to characterize practice patterns and outcomes in the management of CS across multiple centers with versus without shock teams.

METHODS The Critical Care Cardiology Trials Network is a multicenter network of cardiac intensive care units (CICUs) in North America. All consecutive medical admissions to each CICU ($n = 24$) were captured during annual 2-month collection periods (2017-2019; $n = 6,872$). Shock management and CICU mortality among centers with versus without shock teams were compared using inverse probability weighting.

RESULTS Ten of the 24 centers had shock teams. Among 1,242 CS admissions, 44% were at shock team centers. The groups were well-balanced with respect to demographics, shock etiology, Sequential Organ Failure Assessment score, biochemical markers of end organ dysfunction, and invasive hemodynamics. Centers with shock teams used more pulmonary artery catheters (60% vs 49%; adjusted odds ratio [OR]: 1.86; 95% CI: 1.47-2.35; $P < 0.001$), less overall mechanical circulatory support (MCS) (35% vs 43%; adjusted OR: 0.74; 95% CI: 0.59-0.95; $P = 0.016$), and more advanced types of MCS (53% vs 43% of all MCS; adjusted OR: 1.73; 95% CI: 1.19-2.51; $P = 0.005$) rather than intra-aortic balloon pumps. The presence of a shock team was independently associated with lower CICU mortality (23% vs 29%; adjusted OR: 0.72; 95% CI: 0.55-0.94; $P = 0.016$).

CONCLUSIONS In this multicenter observational study, centers with shock teams were more likely to obtain invasive hemodynamics, use advanced types of MCS, and have lower risk-adjusted mortality. A standardized multidisciplinary shock team approach may improve outcomes in CS. (J Am Coll Cardiol 2021;78:1309–1317) © 2021 by the American College of Cardiology Foundation.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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ABBREVIATIONS AND ACRONYMS

AMI-CS = acute myocardial infarction-related cardiogenic shock

CCCTN = Critical Care Cardiology Trials Network

CICU = cardiac intensive care unit

CS = cardiogenic shock

ECMO = extracorporeal membrane oxygenation

ICU = intensive care unit

IPW = inverse probability weighted

MCS = mechanical circulatory support

OR = odds ratio

PAC = pulmonary artery catheter

SCAI = Society for Cardiovascular Angiography & Interventions

SOFA = Sequential Organ Failure Assessment

VA-ECMO = venoarterial extracorporeal membrane oxygenation

Cardiogenic shock (CS) is a highly morbid clinical syndrome of low cardiac output and consequent end organ hypoperfusion (1). Despite therapeutic advancements, mortality from CS remains high (30%-50%) (1-4). Given the time-sensitive nature of the complex medical, catheter-based, and surgical treatments used in caring for patients with CS, some centers have developed and implemented multidisciplinary "shock teams" that include representation from critical care cardiology, advanced heart failure and transplant cardiology, interventional cardiology, extracorporeal membrane oxygenation (ECMO), and cardiac surgery specialties. The purpose of such a shock team is to facilitate early shock recognition and expedite multidisciplinary discussions regarding evaluation and management, including the need for timely mechanical circulatory support (MCS) and appropriate device selection when indicated. Single-center observational studies have suggested that the implementation of multidisciplinary shock teams may be associated with improved CS outcomes; however, these reports are limited in size, and multi-institutional data exploring the association with treatment practices, critical care resource use, and outcomes are lacking (5-8).

The objective of this analysis was to evaluate contemporary practice patterns and outcomes in the treatment of CS among advanced cardiac intensive care units (CICUs) with versus without shock teams in a well-characterized cohort from a large multicenter North American registry.

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TABLE 1 Center and Overall Patient Characteristics

	Shock Team	No Shock Team	*P* Value
Number of centers	10	14	
Hospital size, number of beds			
≤500	0 (0)	5 (36)	0.084
>500-≤1,000	8 (80)	6 (43)	
>1,000	2 (20)	3 (21)	
Academic	10 (100)	11 (79)	0.12
Urban	10 (100)	9 (64)	0.053
CCCTN population during study period (not restricted to cardiogenic shock)	2,898	3,974	
Average number of CICU admissions per center	290	284	
Patients admitted with cardiogenic shock	546 (19)	696 (18)	0.16
Duration of CICU stay, days	2.2 (1.1-4.8)	2.3 (1.2-4.9)	0.026
SOFA score	4 (2-7)	3 (1-6)	<0.0001
Overall CICU mortality	283 (9.8)	348 (8.8)	0.15

Values are n, n (%), or median (interquartile range). The Wilcoxon rank sum test was used for continuous variables, and the chi-square test or Fisher exact test was used for categorical variables.

CCCTN = Cardiac Critical Care Trials Network; CICU = cardiac intensive care unit; SOFA = Sequential Organ Failure Assessment.

METHODS

STUDY POPULATION. The Critical Care Cardiology Trials Network (CCCTN) is an investigator-initiated collaborative research network of American Heart Association level 1 CICUs located in the United States and Canada. The methods of recruitment and data acquisition have been previously described in detail (9). Scientific oversight of the CCCTN is conducted by its academic executive and steering committees, and the data are submitted to a central data coordinating center (TIMI [Thrombolysis In Myocardial Infarction] Study Group, Boston, Massachusetts). For this analysis, each participating center (n = 24) contributed annual 2-month "snapshots" of all consecutive medical admissions to the CICU from 2017 to 2019. Cardiogenic shock was defined as sustained hemodynamic impairment (ie, systolic blood pressure of <90 mm Hg or the need for inotropic or vasopressor support) with evidence of end organ hypoperfusion determined to be due to a primary cardiac etiology by the site investigator (1). Similarly, a determination of the predominantly failing ventricle (left, right, or both) was made by each site investigator. Each center also provided center-level information regarding hospital characteristics during the study period (eg, size, academic affiliation). Centers that self-identified as having established shock teams completed questionnaires describing shock team membership, structure, and operations.

The CCCTN Registry protocol and waiver of informed consent were approved by the Institutional Review Board at Brigham and Women's Hospital (Data Coordinating Center), MedStar Washington Hospital Center, and each of the participating centers. No personal identifying health information is collected in the Registry database.

CLASSIFICATION OF MCS. Advanced MCS was defined as Impella (2.5, CP, 5.0, 5.5 or RP; Abiomed), TandemHeart (LivaNova), venoarterial ECMO (VA-ECMO), or temporary or durable surgical ventricular assist devices implanted for the management of CS (10).

The initial MCS device used as well as the total number and types of MCS devices used during CS admissions were identified. In cases where the temporary MCS strategy involved multiple concurrent devices (eg, VA-ECMO with Impella as a left ventricular venting mechanism), a hierarchical classification scheme was used to identify the device providing the highest level of hemodynamic support (temporary surgical ventricular assist device > VA-ECMO > TandemHeart > Impella > intra-aortic balloon pump). In cases of outside hospital transfer patients who underwent escalation to a device with a higher level of hemodynamic support at the CCCTN center, the device selected following transfer to the CCCTN center was defined as the initial MCS device. In cases where patients were transferred on a specific MCS device and there was no escalation at the CCCTN center, the device placed at the referring center was defined as the initial device.

STATISTICAL ANALYSIS. Continuous variables were compared with the Wilcoxon rank sum test, and categorical variables were compared using the chi-square or Fisher exact tests, where appropriate. Inverse probability weighted (IPW) modeling was used to compare key elements of shock management, such as the use of pulmonary artery catheters (PACs) and MCS, and the primary outcome of CICU mortality between centers with versus without shock teams. The IPW model was based on a priori variables of clinical relevance and included covariates for age, sex, Sequential Organ Failure Assessment (SOFA) score, in-hospital and out-of-hospital cardiac arrest preceding shock presentation, hospital size (dichotomized at 750 beds), CS phenotype (left ventricular predominant, right ventricular predominant, biventricular failure, or other) and Society for Cardiovascular Angiography and Interventions (SCAI) stage of CS (4). Standardized differences before and after IPW adjustment were examined graphically (Supplemental Figure 1). A standardized difference of <10% was considered an acceptable balance of measured baseline variables between centers with and without shock teams.

All tests were 2-sided, and a *P* value of <0.05 was considered statistically significant. Analyses were performed with SAS, version 9.4 (SAS Institute Inc), and R, version Q10 3.4.3 (R Core Team).

TABLE 2 Characteristics of Patients With Cardiogenic Shock

	Shock Team (n = 546)	No Shock Team (n = 696)	*P* Value
Age, y	65 (54-75)	63 (54-72)	0.007
Female	195 (35.7)	219 (31.5)	0.12
Race			
White	353 (64.7)	390 (56.0)	0.001
African American	120 (22.0)	162 (23.3)	
Other	73 (13.4)	144 (20.7)	
Transfers from outside hospitals	250 (45.8)	338 (48.6)	0.080
Out-of-hospital cardiac arrest	61 (12.0)	77 (11.8)	0.96
In-hospital cardiac arrest	67 (13.1)	83 (12.7)	
Prior history of heart failure	288 (52.8)	401 (57.6)	0.087
SOFA score	7 (5-11)	8 (5-11)	0.82
LVEF during shock presentation, %			
≥50	87 (17.09)	88 (13.79)	<0.001
20-<50	267 (52.46)	255 (39.97)	
<20	155 (30.45)	295 (46.24)	
Cardiogenic shock etiology			
AMI-CS	147 (26.9)	193 (27.7)	0.75
Non–AMI-CS	399 (73.1)	503 (72.3)	
Cardiogenic shock phenotype			
LV failure	261 (47.9)	288 (41.4)	0.0096
RV failure	46 (8.4)	51 (7.3)	
Biventricular failure	140 (25.7)	240 (34.5)	
Other (arrhythmia, valvular, tamponade, and so on)	98 (18.0)	116 (16.7)	
SCAI stage of CS			
C	124 (29.5)	142 (25.04)	0.1232
D	144 (34.29)	228 (40.21)	
E	152 (36.19)	197 (34.74)	
End organ injury			
Admission lactate, mmol/L	2.3 (1.4-4.6)	2.3 (1.4-4.4)	0.92
Admission creatinine, mg/dL	1.5 (1.1-2.3)	1.6 (1.1-2.3)	0.98
Peak lactate, mmol/L	3.0 (1.8-6.3)	3.2 (1.8-6.4)	0.73
Peak creatinine, mg/dL	1.8 (1.3-3.1)	2.1 (1.4-3.3)	0.060
Peak AST, mmol/L	94 (36-403)	126 (47-457)	0.007
Peak ALT, mg/dL	62 (29-256)	73 (32-316)	0.067
Lowest pH, arterial blood gas	7.33 (7.22-7.41)	7.32 (7.21-7.40)	0.41

Values are median (interquartile range) or n (%). The Wilcoxon rank sum test used for continuous variables, and the chi-square test or Fisher exact test was used for categorical variables. Determination of cardiogenic shock phenotype was missing in one patient from each group. Proportions of LVEF tertile and SCAI stage are reported as percent of available data.

ALT = alanine aminotransferase; AM-ICS = acute myocardial infarction-related cardiogenic shock; AST = aspartate aminotransferase; CS = cardiogenic shock; LV = left ventricle; LVEF = left ventricular ejection fraction; non-AMI-CS = nonacute myocardial infarction-related cardiogenic shock; RV = right ventricle; SCAI = Society for Cardiovascular Angiography & Interventions; SOFA = Sequential Organ Failure Assessment.

RESULTS

CENTER AND SHOCK TEAM CHARACTERISTICS. Ten of 24 centers (42%) reported having a shock team. Characteristics of the centers are reported in Table 1. Shock teams were present only in medium and large (>500 beds), urban, academic medical centers. Centers with shock teams had higher-acuity patients overall (ie, not restricted to CS, median SOFA score 4 versus 3; *P* < 0.001). During the study period, there were 2,898 admissions to shock team centers and 3,974 admissions to centers without a shock team, of which 19% and 18% were for CS, respectively. Survey data provided by the 10 centers with shock teams showed that the service-line representation, structure, and operations of the teams were similar across centers (Supplemental Table 1).

PATIENT CHARACTERISTICS. The sample included 1,242 patients admitted with CS, 546 (44%) of whom

TABLE 3 Hemodynamics of Patients With Cardiogenic Shock

	Shock Team (n = 546)	No Shock Team (n = 696)	*P* Value
Pulmonary artery catheter use	330 (60.4)	341 (49.0)	<0.001
Heart rate, beats/min	88 (76-105)	93 (80-110)	0.022
MAP, mm Hg	74 (66-86)	73 (65-83)	0.18
Right atrial pressure, mm Hg	15 (10-20)	13 (9-18)	0.019
PAPI	1.58 (1.00-2.45)	1.78 (1.13-2.58)	0.23
PCWP, mm Hg	25 (19.0-30.0)	22 (17.5-28.0)	0.060
Cardiac index, L/min/m^2	1.89 (1.55-2.28)	2.01 (1.60-2.50)	0.069
Cardiac power output, W	0.62 (0.49-0.84)	0.64 (0.47-0.84)	0.76

Values are n (%) or median (interquartile range). The Wilcoxon rank sum test was used for continuous variables, and the chi-square test or Fisher exact test was used for categorical variables. Invasive hemodynamics were reported in 281 patients in the Shock Team group and 262 patients in the No Shock Team group.

MAP = mean arterial pressure; PAPI = pulmonary artery pulsatility index; PCWP = pulmonary capillary wedge pressure.

were treated in centers with shock teams. Patients with CS at shock team centers were older and more commonly White (Table 2). Sex, prior history of heart failure, illness severity by SOFA score, and rates of both in-hospital and out-of-hospital cardiac arrest were not different between groups (Table 2). Similarly, laboratory measures of end organ dysfunction on CICU admission (lactate and creatinine) did not significantly differ between cohorts.

The etiology of shock was well balanced between groups, including the proportion related to acute myocardial infarction (27% vs 28%) (Table 2). Left ventricular-predominant failure was most common, followed by biventricular failure, other causes (arrhythmia, valvular, tamponade, etc), and right ventricular-predominant failure. In the subset of CS admissions with available invasive hemodynamic data (n = 543), cardiac power output, and pulmonary artery pulsatility index were similar between groups (Table 3).

SHOCK MANAGEMENT. Institutions with shock teams had significantly higher rates of PAC use (60% vs 49%; adjusted odds ratio [OR]: 1.86; 95% CI: 1.47-2.35; $P < 0.001$) (Central Illustration), which were typically placed in less than one-half of the time (0.3 vs 0.66 days; $P = 0.019$) (Table 4). The median number of inotropic agents per patient was lower at shock team centers. Centers with shock teams had lower rates of overall MCS use (35% vs 43% of CS cases; adjusted OR: 0.74; 95% CI: 0.59-0.95; $P = 0.016$), used more advanced types of MCS overall (53% vs 43% of all MCS; adjusted OR: 1.73; 95% CI: 1.19-2.51; $P = 0.005$), and more commonly chose advanced types of MCS as their initial device (42% vs 28% of CS patients who received MCS; $P = 0.002$) (Figure 1).

RESOURCE USE AND OUTCOME. Within the CS cohort, patients treated at shock team centers had a shorter median CICU length of stay (4.0 vs 5.1 days; $P < 0.001$) (Table 4) and were less frequently treated with mechanical ventilation (41% vs 52%; $P < 0.001$) or new renal replacement therapy (11% vs 19%; $P < 0.001$).

Among all CICU admissions (ie, not restricted to admissions for CS; n = 6,872), there was no significant difference in CICU mortality between those admitted to CICUs at centers with versus without a shock team (9.8% vs 8.8%; $P = 0.15$). However, among admissions for CS (n = 1,242), CICU mortality was lower in those admitted to CICUs at centers with versus without a shock team (23% vs 29%; $P = 0.025$) (Central Illustration). Furthermore, the presence of a shock team was independently associated with lower CICU mortality in the IPW adjusted analysis (adjusted OR: 0.72; 95% CI: 0.55-0.94; $P = 0.016$).

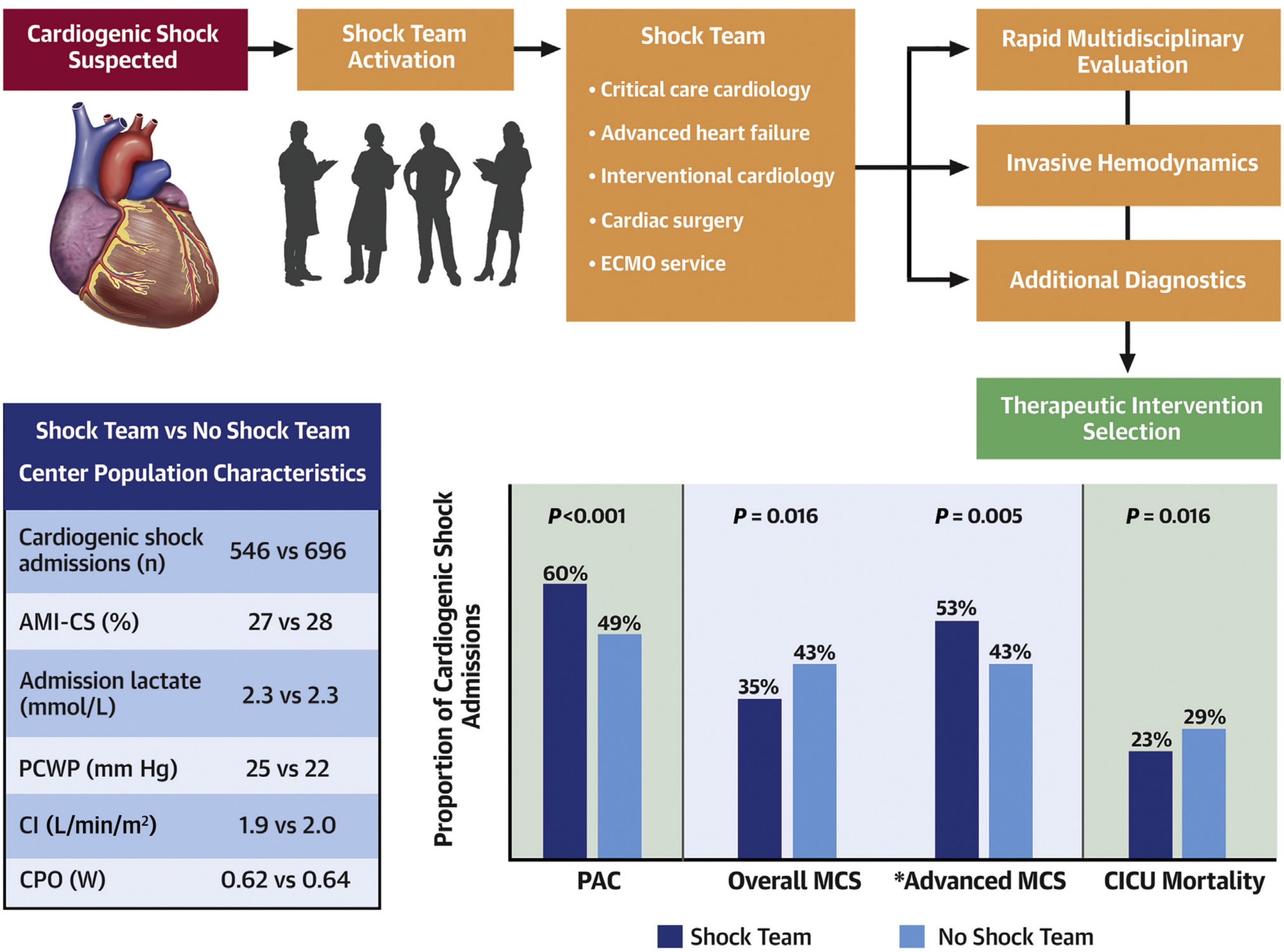
SUBGROUPS. The pattern of greater use of PACs, more advanced MCS, and lower mortality at shock team centers remained after stratifying groups by acute myocardial infarction-related CS (AMI-CS) versus non-AMI-CS (Figure 2). Among admissions with AMI-CS, centers with a shock team used more PACs (adjusted OR: 2.38; 95% CI: 1.48-3.82; $P < 0.001$) and more advanced MCS (adjusted OR: 2.62; 95% CI: 1.44-4.75; $P = 0.002$). In the non-AMI-CS cohort, shock team centers also used more PACs (adjusted OR: 1.62; 95% CI: 1.23-2.13; $P = 0.001$); however, there was no difference in the use of advanced MCS (adjusted OR: 1.34; 95% CI: 0.81-2.23; $P = 0.26$). The favorable patterns of association with lower CICU mortality among centers with shock teams persisted (P-interaction = 0.11) among patients with AMI-CS (adjusted OR: 0.79; 95% CI: 0.48-1.29; $P = 0.344$) (Figure 2) and non-AMI-CS presentations (adjusted OR: 0.67; 95% CI: 0.49-0.93; $P = 0.017$).

Among the subgroup of patients who received PACs, CICU mortality was lower at shock team centers (21.2% vs 26.4%). In this subpopulation, we observed that the shock team centers used less overall MCS (43.6% vs 57.5%) and more commonly used advanced forms of MCS (55.6% vs 45.9%).

DISCUSSION

This study provides a novel multicenter analysis of advanced CICU practice patterns and outcomes in the treatment of CS in centers with versus without a shock team. We found that medical centers with shock teams used significantly more PACs and advanced types of MCS while using less MCS overall, which was driven by less frequent use of intra-aortic balloon pumps. This preference toward advanced MCS was observed with regard to both initial and

CENTRAL ILLUSTRATION **Prototypical Shock Team Workflow and Associated Outcomes**



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Prototypical shock team workflow and membership **(top)**. Study population characteristics **(bottom left)**. The proportion of patients admitted with cardiogenic shock (CS) who received pulmonary artery catheters, mechanical circulatory support (MCS), advanced forms of MCS, and associated cardiac intensive care unit mortality **(bottom right)**. Advanced MCS included Impella (Abiomed), extracorporeal membrane oxygenation, TandemHeart (LivaNova), and temporary or durable surgical ventricular assist devices. *P* values are adjusted for age, sex, Sequential Organ Failure Assessment score, cardiac arrest, hospital size, CS phenotype, and Society for Cardiovascular Angiography & Interventions stage using inverse probability weighted modeling. *Advanced MCS rates were reported within subjects who received MCS. AMI-CS = acute myocardial infarction-related cardiogenic shock; CI = cardiac index; CPO = cardiac power output; ECMO = extracorporeal membrane oxygenation; PCWP = pulmonary capillary wedge pressure; PAC = pulmonary artery catheter; CICU = cardiac intensive care unit.

overall MCS device selection. Patients with CS treated at centers with shock teams had shorter CICU stays and lower rates of both mechanical ventilation and new renal replacement therapy. CICU mortality was lower in adjusted analyses in centers with shock teams.

ACCUMULATING RATIONALE FOR SHOCK TEAMS. Tehrani et al (6) described the development of a shock team within a tertiary care medical center. In this model, the shock team could be activated by a single call and bring together physicians from critical care cardiology, advanced heart failure and transplant cardiology, interventional cardiology, and cardiac surgery to collaborate on patient care decisions and streamline the delivery of care. When compared to historical data from their institution, implementation of a shock team was associated with an increase in CS survivorship from 47% to 58% in the first year and

TABLE 4 Clinical Course and Outcomes of Patients With Cardiogenic Shock

Clinical Course and Outcomes	Shock Team (n = 546)	No Shock Team (n = 696)	*P* Value
Time from CICU admission to PAC, days	0.3 (0.08-1.00)	0.66 (0.15-1.58)	0.019
Median number of inotropes administered	1 (1-2)	2 (1-2)	0.008
Mechanical ventilation	223 (40.8)	363 (52.2)	<0.001
New renal replacement therapy	58 (10.6)	131 (18.8)	<0.001
Duration of CICU stay, days	4.0 (2.0-7.5)	5.1 (2.4-10.5)	<0.001
CICU mortality	126 (23.1)	200 (28.7)	0.025
MCS			
Treated with any MCS	192 (35.2)	299 (43.0)	0.005
MCS before transfer	47 (24.5)	88 (29.6)	0.22
MCS during first 24 hours	115 (59.9)	154 (51.9)	–
MCS after 24 hours	30 (15.6)	55 (18.5)	–

Values are median (interquartile range) or n (%). The Wilcoxon rank sum test used for continuous variables, and the chi-square test or Fisher exact test was used for categorical variables. MCS rates were obtained within subjects who received MCS. MCS timing was missing in 2 patients in the No Shock Team group.

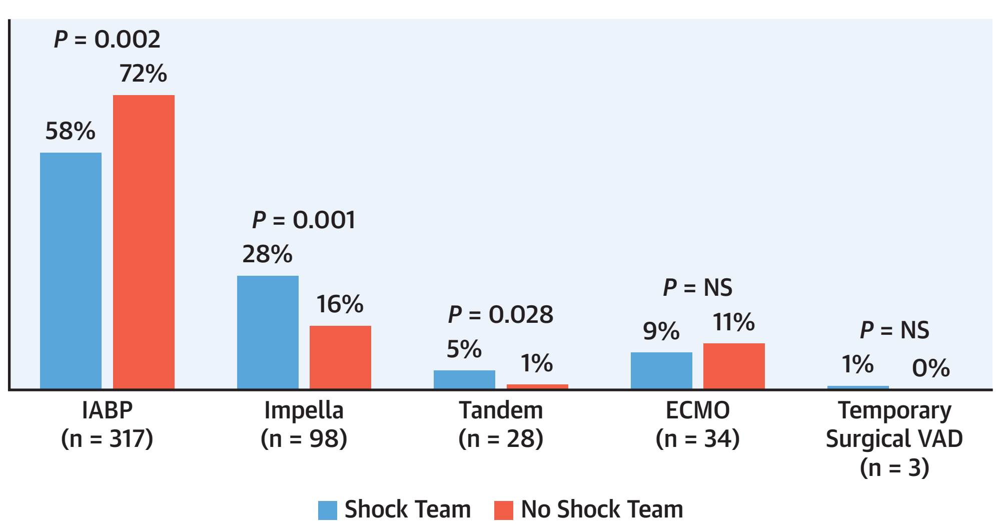
CICU = cardiac intensive care unit; MCS = mechanical circulatory support; PAC = pulmonary artery catheter.

77% in the second year (n = 130/204). These findings were recapitulated in a similar single-center observational experience (n = 123) that reported an increase in CS survival from a historical baseline of 48% to 61% after the implementation of a shock team (5).

In this study, we expand on the current evidence with an observational analysis with >1,200 admissions for CS from a multicenter network of advanced CICUs in North America. In this analysis inclusive of broad CS etiologies, the cohorts from centers with versus without a shock team were generally well balanced in terms of baseline characteristics, invasive hemodynamics, and markers of end organ damage. Centers with shock teams had an estimated 28% lower adjusted relative odds of CICU mortality.

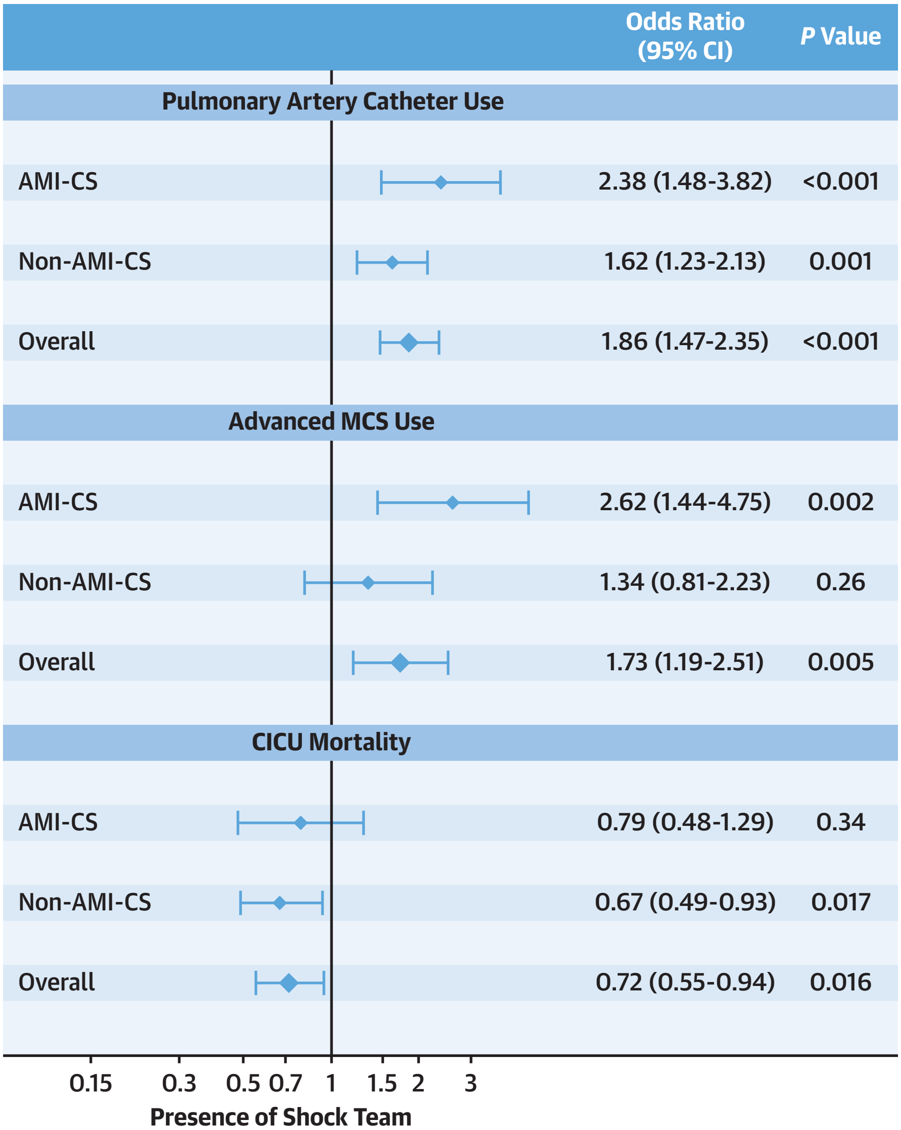
Although it is not possible to conclude a causal relationship from this observational study, our findings expand the available evidence supporting the potential value of a shock team. We speculate that any effect associated with the presence of a shock team is multifactorial in nature. First, the rapid identification and treatment of CS before the development of multiorgan dysfunction may contribute to better survival, shorter CICU length of stay, and less need for renal replacement therapy and mechanical ventilation (11). Second, the early and more common use of PACs, as evident in our study, clarifying the hemodynamic profile and severity of left, right, or biventricular failure driving the shock state may aid in therapeutic selection, MCS or otherwise (12-18). Although it is not possible for us to isolate all of the elements of care that may differ in association with a shock team, when restricted to patients who were treated with a PAC, the persistent pattern of lower mortality among shock team centers indicates that this difference is not related solely to increased use of PACs at shock team centers. It is possible that both differences in experience with the interpretation of invasive hemodynamic data and other aspects of care enhanced by the integration of

FIGURE 1 Initial MCS Device by Centers With Versus Without Shock Teams



The proportion of initial mechanical circulatory support (MCS) device use at centers with versus without shock teams. Rates are reported within subjects who received MCS. ECMO = extracorporeal membrane oxygenation; IABP = intra-aortic balloon pump; NS = nonsignificant; Tandem = TandemHeart; VAD = ventricular assist device.

FIGURE 2 Outcomes in Acute and Nonacute Myocardial Infarction-Related CS



Practice patterns and outcomes in acute and nonacute myocardial infarction-related cardiogenic shock in centers with versus without shock teams. The *P* values presented are adjusted for age, sex, sequential organ failure assessment score, in-hospital and out-of-hospital cardiac arrest preceding shock presentation, hospital size, CS phenotype (left ventricular, right ventricular, or biventricular failure or other) and Society for Cardiovascular Angiography and Interventions CS stage using inverse probability weighted modeling. Advanced MCS included Impella (Abiomed), TandemHeart (LivaNova), extracorporeal membrane oxygenation, and temporary or durable surgical ventricular assist devices. AMI-CS = acute myocardial infarction–related cardiogenic shock; CICU = cardiac intensive care unit; CS = cardiogenic shock; MCS = mechanical circulatory support; non-AMI-CS = nonacute myocardial infarction cardiogenic shock.

a shock team might contribute to the observed difference in mortality. Third, a structured, team-based evaluation that incorporates patient-centric characteristics and institutional-specific capabilities may facilitate timely and optimal MCS device selection in parallel with its deployment and management strategy (19).

STUDY STRENGTHS AND LIMITATIONS. The study population was derived from a well-characterized multicenter clinical registry comprising medical CICU

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admissions, which offers higher data fidelity than administrative databases. In capturing contemporary practice patterns across a broad group of centers and being inclusive of all consecutive CICU patients with CS during the study period, the sample may offer a more realistic estimate of a possible effect size than prior studies.

This analysis is subject to the limitations of an observational study. While we have used a rigorous approach with inverse probability weighting, we cannot eliminate the possibility of residual confounding. Also, patients with CS who were not managed in the CICU were not captured in the registry. Further to this point, in many centers ECMO is exclusively managed in the cardiac surgery intensive care unit (ICU). As data collection was restricted to the CICU, total ICU resource utilization was not captured in patients transferred to other ICUs (eg, in cases of transfer to a cardiac surgery ICU for ECMO). We expect this limitation to have minimal impact given that there was no significant difference in ECMO utilization between groups.

Another consideration is that the shock teams in the current analysis were individual institutionally-driven initiatives that formed to meet the needs and limitations of the parent institutions, and as such there is no standardization from one team to another. Our dataset also does not capture the time of CS onset, and therefore the time from shock onset to circulatory support could not be directly examined. Data on inotropic strategies, sedation practices, and ventilator management were similarly limited. In addition, apart from hospital size, differences between centers were not incorporated into the primary analysis. Other study site characteristics, such as variations in catchment area, were also not captured in this registry and therefore could not be evaluated as potential confounders.

CONCLUSIONS

Centers with shock teams use more invasive hemodynamic monitoring and advanced MCS devices while using less MCS overall. Centers with shock teams appear to have higher CS-related CICU survival and reduced CICU resource use. Our data support considering the implementation of shock teams at tertiary cardiovascular centers.

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Dr Drakos has served as a consultant to Abbott. Dr Sinha has served as a consultant to the Abiomed Critical Care Advisory Board. All other authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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PERSPECTIVES

COMPETENCY IN SYSTEMS-BASED PRACTICE: Multidisciplinary, integrated shock teams may expedite evaluation and therapy of patients with cardiogenic shock, improve survival, and reduce resource utilization.

TRANSLATIONAL OUTLOOK: Further efforts are needed to identify and overcome impediments to implementation of cardiogenic shock teams in diverse communities and establish criteria for prioritizing them over other hospital initiatives.

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KEY WORDS cardiac intensive care unit, cardiogenic shock, mechanical circulatory support, pulmonary artery catheter, shock team

APPENDIX For a supplemental table and figure, please see the online version of this paper.