Cardiogenic Shock Management: International Survey of Contemporary Practices

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ABSTRACT: Background. Limited data exist on current cardiogenic shock (CS) management strategies. **Methods.** A 48-item open- and closed-ended question survey on the diagnosis and management of CS. **Result.** A total of 211 respondents (3.2%) completed the survey, including 64% interventional cardiologists, 14% general cardiologists, 11% advanced heart failure cardiologists, 5% intensivists, 3% cardiothoracic surgeons; the remainder were internists, emergency medicine, and other physicians. Nearly half (45%) reported practicing at sites without advanced heart failure support/resources, with neither durable ventricular assist devices nor heart transplant available; 16% practice at sites without on-site cardiac surgery and 6% do not offer 24/7 percutaneous coronary intervention (PCI) coverage. The majority (70%) practice in closed intensive care units with multidisciplinary rounding (73%), cardiologists frequently involved in patient care (89%), and involving cardiology-intensivist co-management (41%). Over half (55%) reported use of CS protocols, 61% reported routine arterial line use, 25% reported routine use of pulmonary artery catheter use to guide management and 9% did not. The preferred vasopressor and/or inotrope was norepinephrine (68%). For coronary angiography and PCI, 53% use transradial access, 72% only revascularize the culprit vessel, and 44% institute mechanical circulatory support (MCS) prior to revascularization. Percutaneous MCS availability was as follows: intra-aortic balloon pump (92%), Impella (78%), peripheral veno-arterial extracorporeal membrane oxygenation (66%), and TandemHeart (28%). Most respondents (58%) do not use a scoring system for risk stratification and most (62%) reported that CS-specific cardiac rehabilitation programs were unavailable at their sites. **Conclusion.** Wide variation exists in the care delivered and/or resources available for patients with CS. Our survey suggests opportunities for standardization of care.

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Cardiogenic shock (CS) is a complex, low cardiac output state resulting in critical end-organ hypoperfusion. It remains the leading cause of in-hospital mortality following acute myocardial infarction (AMI).[1-6] Despite advances in therapeutic options and recent studies suggesting improved outcomes using a standardized-team based approach to patient care, variations exist in time to diagnosis, management, and resource availability, such as hemodynamic monitoring, mechanical circulatory support (MCS), and treatment by multidisciplinary teams.[7-14] We performed an online survey to better understand contemporary diagnostic and treatment strategies for CS patients.

Methods

We designed an open- and closed-ended survey and circulated a link to a 48-item questionnaire (Supplemental Table S1) via email (the email list was obtained from the Cardiovascular Innovations Foundation, which is a non-profit organization) and social media (Twitter), including interventional cardiologists, general cardiologists, advanced heart failure cardiologists, intensivists, and cardiovascular surgeons. The survey was open between March 2019 and May 2019. Following study completion, anonymized summary data and individual responses were examined using an online survey development cloud-based software (SurveyMonkey, Inc). Funding for SurveyMonkey was provided by the Minneapolis Heart Institute Foundation.

Results

The survey was circulated to 6683 physicians, of whom 211 (3.2%) completed the survey. Respondents were mostly interventional cardiologists (64%), followed by general cardiologists (14%), advanced heart failure cardiologists (11%), intensivists (or pulmonary critical care specialists) (5%), cardiothoracic surgeons (3%), and other (3%). The location of practice for the participants was not obtained due to institutional review board restriction. Summary data for the entire completed survey are provided in Supplemental Table S1.

Over half of the respondents (68%) care for CS patients on a regular basis (at least once every 1-2 weeks). Approximately 40% have access to all types of hemodynamic support, including inotropes, intra-aortic balloon pump (IABP), Impella, durable ventricular-assist device (VAD), as well as heart transplantation. Approximately 21% practice at centers in which only percutaneous coronary intervention (PCI) and IABP are available. Regarding CS patient transfers from

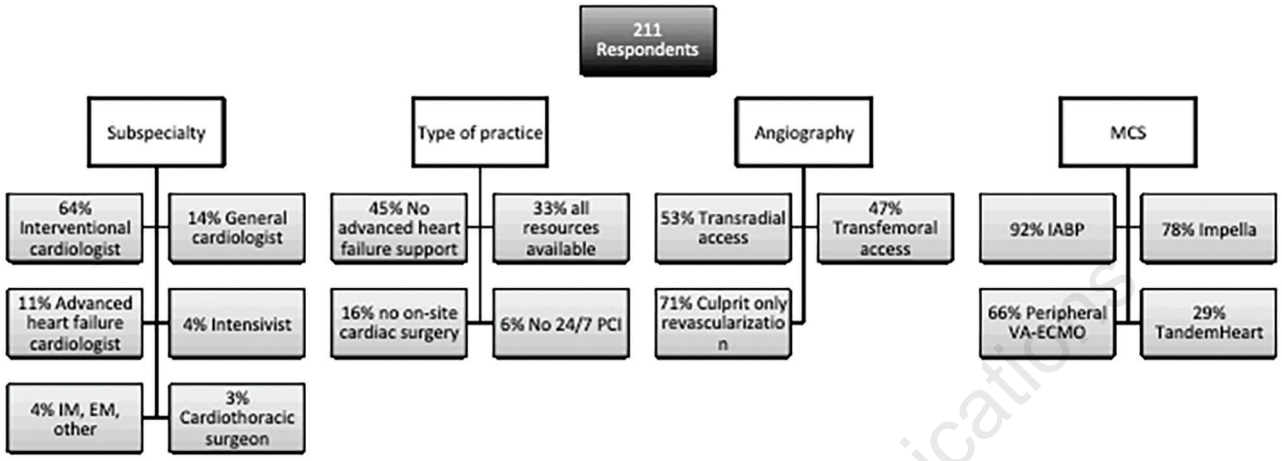

FIGURE 1. Summary of the survey findings. EM = Emergency Medicine; IABP = intra-aortic balloon pump; IM = Internal Medicine; MCS = mechanical circulatory support; PCI = percutaneous coronary intervention; VA-ECMO = venous-arterial extracorporeal membrane oxygenation.

other centers, 63% of respondents stated that such patients are always accepted, whereas 30% indicated selective acceptance. Almost 70% of respondents practice in closed intensive care units (ICUs) and 78% work in cardiovascular-specific ICUs. CS patients are managed mainly by cardiologists (32%) or by a team of intensivists and cardiologists (41%). Multidisciplinary rounds were conducted in 73%.

General management. Most respondents (94%) practice at centers where 24-hour percutaneous coronary intervention (PCI) is available and 84% have cardiac surgery on site. Approximately half of the respondents (55%) have an established CS algorithm or protocol for management. Only 25% routinely use invasive circulatory monitoring systems (eg, pulmonary artery catheter [PAC]); however, an additional 36% report use in most, but not all patients. Similarly, 61% report routine use of an arterial line for guidance, with an additional 28% reporting use in most, but not all patients. Hemodynamic indices, such as cardiac power output (CPO), pulmonary artery pulsatility index (PAPi), or tricuspid annular plane excursion (TAPSE), are calculated routinely by 57% of respondents. Lactate measurements are used by 87% to guide management. More than half of the respondents use a mean arterial pressure (MAP) of 60 mm Hg as a threshold for initiating hemodynamic support. Norepinephrine is the first-line vasopressor for 68%, followed by dobutamine (15%) and dopamine 8%. Over half of the respondents (58%) do not use any scoring system for predicting clinical outcomes in CS patients; among those who do, the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) score is preferred in 28%, followed by the Acute Physiology And Chronic Health Evaluation (APACHE) II score in 10%. Beta-blockers or angiotensin-receptor inhibitors are initiated by approximately half of respondents (49%) within the first 24 hours after resolution of CS and statins in 68%. Regarding cardiac arrest, the majority of respondents (82%) have resuscitation time cut-offs when considering MCS.

Revascularization. Radial artery is the preferred access site for PCI in 53%. When revascularization is needed, 72% perform culprit-lesion only revascularization. In patients presenting with ST-segment elevation myocardial infarction (STEMI) and CS, 66% initiate MCS (Impella, extracorporeal membrane oxygenation [ECMO], or IABP) prior to performing revascularization.

Mechanical circulatory support. Forty-five percent of respondents consider MCS when response is not optimal with 2 vasopressors and 43% consider MCS based on PAC measurements of cardiac output (or cardiac power). Regarding types of MCS, Impella is the preferred device in 48% of respondents, IABP in 44%, and veno-arterial (VA)-ECMO in 8%. MCS is initiated before PCI in 44% and its initiation is dependent of hemodynamics. VA-ECMO is placed by interventional cardiologist in the cardiac catheterization laboratory in 29%, by surgeons in the operating room in 24%, and in the ICU or emergency department by cardiologists, intensivists, or emergency physicians in the remaining centers. If left ventricular venting is needed in CS-ECMO, 41% prefer Impella and 24% prefer IABP.

Discussion

Our survey offers novel insights into the contemporary management of CS, demonstrating significant variation in diagnostic and treatment strategies and access to resources.

A substantial proportion of respondents have limited or no access to several resources that are part of the contemporary CS armamentarium. Over 20% of respondents indicated

that they practice at sites in which only inotropes and IABP are available, approximately 6% practice at hospitals that do not provide around-the-clock PCI coverage, and 16% do not have cardiac surgery back-up. Hence, several hospitals likely do not meet the 2017 American Heart Association CS center designation.[4]

Several respondents do not routinely care for CS patients. Only approximately half of the respondents use invasive hemodynamics (PAC) to guide management, with only 25% reporting routine use and 57% reporting use of a validated hemodynamic indices such as CPO or PAPi. Most contemporary CS management algorithms recommend a multidisciplinary approach and integration of invasive hemodynamics in the care of CS patients. In addition, only half of the respondents report use of an established algorithm in the care for CS patients, and over half (58%) do not use a scoring system to predict clinical outcomes.

Most respondents manage CS patients on a regular basis, have access to MCS devices, and treat CS patients in closed ICUs. The treatment team consists of a cardiologist or a cardiologist working together with an intensivist. Prior studies have reported improved outcomes in a closed-unit model, and delivery of care by dual-trained cardiologist-intensivists.[15,16]

When revascularization is needed for CS patients, the preferred arterial access is the radial artery in 53% and culprit-only revascularization is performed by 72% of respondents following the results of the CULPRIT-SHOCK (Culprit Lesion Only PCI vs Multivessel PCI in Cardiogenic Shock) trial.[17] In those presenting with STEMI-CS, 66% of respondents place MCS prior to revascularization.

Approximately half of respondents use MCS when hemodynamic response to 2 vasopressors/inotropes is inadequate, whereas the other half place MCS based on cardiac output goals. Impella is used more often (48%), followed by IABP (44%) and VA-ECMO (8%). The need and type of MCS for CS patients remains controversial. The IABP-SHOCK II (Intraortic Balloon Support for Myocardial Infarction With Cardiogenic Shock) trial found no difference with routine IABP use in CS patients; hence, IABP use was downgraded to a class IIIA recommendation in the most recent European revascularization and non-ST elevation acute coronary syndromes guidelines.[1,16,18–20] Data on MCS are quite limited. Outcomes were worse among CS patients treated with Impella in a recent retrospective study.[21] The DanGer Shock (Danish-German Cardiogenic Shock; NCT01633502) trial is randomizing CS patients to conventional circulatory support or the Impella CP device. VA-ECMO may be required due to cardiac failure, respiratory failure, or a combination of both. In our survey, VA-ECMO is used by 8% of the respondents and is usually placed by interventional cardiologists (29%) or by surgeons in the operating room (24%). Relative contraindications and potential complications of VA-ECMO must be taken into consideration.[22] Currently, there are no published randomized control trials assessing the clinical effectiveness of VA-ECMO in CS, although 3 trials are currently ongoing: (1) Euro-Shock (Testing the Value of Novel Strategy and its Cost Efficacy in Order to Improve the Poor Outcomes in Cardiogenic Shock; NCT03813134), (2) ANCHOR (Assessment of ECMO in Acute Myocardial Infarction Cardiogenic Shock; NCT04184635); and (3) ECLS-SHOCK (Extracorporeal Life Support in Cardiogenic Shock; NCT03637205).

Study limitations. Our study has a few limitations. First, the questionnaire for this survey is not validated. Second, the response rate was low. Third, 64% of the respondents are interventional cardiologists, so the findings may not fully reflect the practices of other key members of the multidisciplinary CS team. Fourth, most of the respondents (68%) treat CS patients on a regular basis, so the results may not apply to physicians treating CS patients infrequently. Fifth, the countries of origin of the participants were not collected.

Conclusion

Our survey suggests wide variation in the care delivered to CS patients, highlighting the need for consensus building and standardization. The limited use of CS treatment protocols and frequent lack of a full complement of advanced heart failure therapy options in centers treating CS patients indicates the need for educational efforts to inform clinicians on contemporary, multidisciplinary strategies to manage CS patients, and highlights the importance of developing hub and spoke models for transferring patients to centers able to provide advanced therapies for patients who do not respond to initial management.

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Supplemental Table S1. Cardiogenic shock survey.	
Respondent Demographics	
1. What is your specialty?	
Interventional Cardiology	63.51%
General Cardiology	14.22%
Advanced Heart Failure	10.90%
Electrophysiology	0.00%
General Internal Medicine	0.47%
Intensivist (or Pulmonary Critical Care)	4.74%
Emergency Medicine	0.47%
Cardiothoracic Surgeon	2.84%
Anesthesiology	0.00%
Other (please specify)	2.84%
2. How often do you take care of patients with cardiogenic shock on average?	
At least once per week	37.44%
At least once every 2 weeks	30.81%
At least once per month	25.12%
At least once every 6 months	6.16%
Rarely	0.47%
3. In which type of hospital do you practice?	
PCI center with inotropes and intra-aortic balloon pump	20.85%
PCI center – Impella	24.17%
PCI center with percutaneous mechanical circulatory support and durable ventricular assist device	3.32%
Hospital with all of the above except transplant	11.37%
Hospital that has it all	40.28%
Hospital Characteristics	
4. Does your hospital accept cardiogenic shock transfers from other centers?	
Always	63.03%
Selectively, if deemed appropriate and approved by consultant	30.33%
Never	6.64%
5. Is your intensive care unit (ICU) a closed-unit (only intensivists, advanced heart failure or cardiologist/interventional cardiologists as primary teams) or an open-unit (other specialties such as internal medicine, family medicine, hospitalists, etc. able to round)?	
Closed unit	69.67%
Open unit	30.33%
6. Where were the patients with cardiogenic shock admitted and treated in your hospital? (mark all that apply)	
No specific location (can be managed in different units)	0.95%
Cardiovascular (CVICU) or Coronary Care Intensive Care Unit (CCU)	78.20%
Surgical ICU	8.53%
Medical ICU	25.12%
Cardiothoracic ICU	28.44%
All of the above	7.11%
7. Who primarily manages patients with cardiogenic shock on a daily basis routinely?	
Pulmonary Critical Care or Critical Care Medicine faculty (non-Cardiology trained)	3.32%
Cardiology (any, including Interventional Cardiology)	31.75%

Continued

Supplemental Table S1. Cardiogenic shock survey.	
Intensivists AND Cardiology (any Cardiologist)	28.91%
Intensivists AND Advanced Heart Failure	12.32%
Advanced Heart Failure	10.43%
Critical Care Cardiologist (Cardiology trained)	6.64%
Cardiothoracic Surgeons	1.90%
Anesthesia	0.00%
Other (please specify)	4.74%
8. Do multidisciplinary rounds (including MDs, nurse, physical or occupational therapy, social worker, pharmacist, etc.) occur daily on patients with cardiogenic shock?	
Yes	72.51%
No	27.49%
9. Please mark all that participate in your multidisciplinary care team.	
Hospitalist	19.71%
Intensivist (or Pulmonary Critical Care)	72.12%
Cardiologist	89.42%
Surgeon	37.98%
Nurse	82.21%
PharmD or Pharmacist	64.42%
Palliative Care	22.12%
Social Worker	42.79%
Physical Therapist	30.29%
Occupational Therapist	14.90%
Dietitian	27.88%
Respiratory Therapist	45.19%
Other pertinent subspecialist (Pulmonology, Nephrology, Neurology, etc)	30.29%
Nurse Practitioners	43.27%
Residents/Fellows	66.83%
10. Does your hospital provide 24/7 percutaneous coronary intervention?	
Yes	94.29%
No	5.71%
11. Does your hospital have cardiac surgery onsite?	
Yes	84.13%
No	15.87%
12. What is the nurse-to-patient ratio in patients with cardiogenic shock?	
1:1	40.76%
1:2	49.29%
1:3	6.64%
1:4	1.90%
1:5	1.42%
13. What is the nurse-to-patient ratio in patients with cardiogenic shock who receive a mechanical circulatory support device?	
1:1	75.71%
1:2	18.57%
1:3	3.33%
1:4	1.43%

Continued

Supplemental Table S1. Cardiogenic shock survey.	
1:5	0.95%
14. Does your hospital have an established algorithm or protocol to manage patients with cardiogenic shock and consider mechanical circulatory support?	
Yes	55.24%
No	44.76%
15. Should institutions disclose the number of cardiogenic shock patients seen and treated per year?	
Yes	81.52%
No	18.48%
Shock Management	
16. Does the care of patients with cardiogenic shock at your institution involve pulmonary artery catheter (Swan-Ganz)-guided management?	
Always	24.64%
In most but not all patients	36.02%
Often	15.17%
Sometimes	14.69%
Rarely	7.11%
Never	2.37%
17. Does your institution routinely calculate cardiac power output (CPO) and pulmonary artery pulsatility index (PAPi), or measure tricuspid annular plane (TAPSE) (or are you familiar with what they are)?	
Yes	57.35%
No, but familiar with these measurements	37.44%
No, but not familiar with these measurements	5.21%
18. Does the care of patients with cardiogenic shock at your institution involve arterial line placement?	
Always, routinely	60.95%
In most, but not all patients	28.10%
Often	7.62%
Sometimes	2.86%
Rarely	0.48%
Never	0.00%
19. Is the monitoring of cardiac output (or index) in patients with cardiogenic shock at your institution performed using pulmonary artery catheter (Swan Ganz), arterial line (eg, FloTrac), or both?	
Preferably by Swan-Ganz	70.62%
Preferably using arterial line (eg, FloTrac)	10.90%
Both	18.48%
20. Do you use serial lactate concentrations to guide your management?	
Yes	87.68%
No	12.32%
21. What is the lowest acceptable mean arterial blood pressure target threshold during the patient's management?	
>70 mm Hg	7.58%
>65 mm Hg	37.91%
>60 mm Hg	51.18%
Other (please specify)	3.32%
22. What is your first-line preferred vasopressor for cardiogenic shock?	
Dopamine	8.06%
Norepinephrine	68.25%

Continued

Supplemental Table S1. Cardiogenic shock survey.	
Epinephrine	5.21%
Phenylephrine	2.37%
Vasopressin	0.95%
Dobutamine	15.17%
23. What is your second line preferred vasopressor for cardiogenic shock?	
Dopamine	16.19%
Norepinephrine	19.52%
Epinephrine	15.24%
Phenylephrine	3.33%
Vasopressin	25.24%
Dobutamine	20.48%
24. For deep venous thrombosis prevention/prophylaxis, which is your preferred approach?	
Subcutaneous low-molecular-weight heparin	61.61%
Subcutaneous unfractionated heparin	32.23%
Compression devices	4.74%
Other parenteral anticoagulant (eg, thrombin inhibitors)	1.42%
25. Do you use a scoring system to predict clinical outcomes in patients with cardiogenic shock? (mark all that apply)	
I do not use a scoring system	58.29%
APACHE II	10.43%
SAPS II	2.37%
APACHE III	2.37%
SOFA	8.06%
IABP-SHOCK II score	4.74%
GRACE	9.95%
INTERMACS scale	21.80%
SHOCK trial score	4.27%
IABP shock II score	3.79%
SAVE score	6.16%
ENCOURAGE score	0.47%
Modified SHOCK index	1.42%
ACC NCDR risk score	2.84%
Other (please specify)	1.90%
26. Should centers without cardiac surgery on site offer receive patients with ST-segment elevation myocardial infarction and cardiogenic shock or these patients be transferred to "shock" centers?	
All PCI centers (with and without cardiac surgery on-site) can receive patients	36.97%
Centers without on-site cardiac surgery should receive patients only when there is no nearby "shock" center, but otherwise patients should be preferably transferred directly to the closest "shock" centers able to provide advanced care	63.03%
27. Do you initiate beta-blockers or angiotensin-receptor inhibitors in the first 24 hours after resolution of cardiogenic shock?	
Yes	49.05%
No	50.95%
28. Do you initiate statins in the first 24 hours after diagnosis of cardiogenic shock?	
Yes	68.42%
No	31.58%

Continued

Supplemental Table S1. Cardiogenic shock survey.	
29. Are cardiogenic shock patients referred back to the referral hospitals?	
Yes	26.54%
No *(if answer is no, SKIP question #31)*	73.46%
30. If so, when are they transferred back?	
Hemodynamically stable and off mechanical circulatory support	17.65%
Complete resolution of shock	59.80%
Other (please specify)	22.55%
31. Does your institution have specific programs for post cardiogenic shock patients (rehab), other than ST-segment elevation myocardial infarction standards?	
Yes	38.57%
No	61.43%
32. Do you have a resuscitation time cut-off when considering mechanical support in patients after cardiac arrest?	
No	82.46%
Yes	17.54%
33. Do you have a cut-off for admission lactate levels when considering mechanical circulatory support in a patient after cardiac arrest?	
No	91.47%
Yes	8.53%
Coronary Revascularization	
34. For patients referred to the cardiac catheterization laboratory for coronary angiography and possible percutaneous coronary intervention in cardiogenic shock, what is the most commonly used arterial access route?	
Radial	53.08%
Femoral	40.76%
Do not know	6.16%
35. When revascularization is performed, do you usually revascularize culprit vessel only or multivessel?	
Culprit only	71.56%
Multivessel	24.64%
Do not know	3.79%
36. If multivessel disease is found, do you discuss with cardiovascular surgery immediately to assess candidacy for coronary artery bypass grafting?	
Always, routinely	37.14%
Often	30.95%
Sometimes	18.10%
Rarely	11.43%
Never	2.38%
37. For patients with ST-segment elevation myocardial infarction and refractory cardiogenic shock, what is your preferred approach?	
Revascularization first, then support (eg, Impella, extracorporeal membrane oxygenation, etc)	33.65%
Support first (eg, Impella, extracorporeal membrane oxygenation, etc), then revascularization	66.35%
Mechanical Circulatory Support	
38. For patients WITHOUT cardiac arrest with cardiogenic shock, when do you consider mechanical circulatory support?	
If not improving/responding to 1 vasopressor/inotrope	27.96%
If not improving/responding to ≥2 vasopressors/inotropes	44.55%
Based on pulmonary artery catheter/cardiac output or cardiac power measurement	43.13%
Based on laboratory abnormalities (eg, elevated lactate levels)	28.91%
Routinely used for all cardiogenic shock patients	9.00%

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Supplemental Table S1. Cardiogenic shock survey.	
Other (please specify)	4.27%
39. Which mechanical circulatory support devices does your institution offer? (mark all that apply)	
Intra-aortic balloon pump	92.42%
Durable ventricular assist device	46.45%
Impella	78.20%
Peripheral veno-arterial extracorporeal membrane oxygenation	65.88%
Central veno-arterial extracorporeal membrane oxygenation	59.24%
TandemHeart	28.44%
40. If you consider mechanical circulatory support, do you install it preferentially before or after percutaneous coronary intervention?	
Before percutaneous coronary intervention	44.08%
After percutaneous coronary intervention	9.48%
Either before or after percutaneous coronary intervention, depending on hemodynamic situation	44.08%
Do not know	2.37%
41. For patients with acute coronary syndrome and cardiogenic shock, which is the most commonly used mechanical circulatory support device at your institution?	
Intra-aortic balloon pump	43.60%
Impella	48.34%
Veno-arterial extracorporeal membrane oxygenation	7.58%
TandemHeart	0.00%
Other (please specify)	0.47%
42. For patients who have or develop cardiogenic shock in the cardiac catheterization laboratory, is the decision to place the patient on mechanical circulatory support made solely by the Interventional Cardiologist or in consultation with a "shock" team involving other members?	
Mostly by the Interventional Cardiologist	72.51%
By a shock team	24.64%
Other (please specify)	2.84%
43. For patients requiring peripheral veno-arterial extracorporeal membrane oxygenation, where is it usually placed and who places it?	
Emergency Department by Emergency Physicians	0.49%
Emergency Department by Interventional Cardiologists or Surgeons	1.96%
Cardiac Catheterization Laboratory by Interventional Cardiologists	28.92%
Cardiac Catheterization Laboratory by Surgeons	14.22%
Intensive Care Unit by Intensivists	5.88%
Intensive Care Unit by Interventional Cardiologists or Surgeons	9.80%
Operating room by Surgeons	24.02%
Other (please specify)	14.71%
44. In patients who receive extracorporeal membrane oxygenation, what is the preferred strategy for left ventricular venting?	
Impella 2.5	9.18%
Impella CP	40.82%
Intra-aortic balloon pump	23.47%
Surgical venting through a catheter in the pulmonary vein (minimally invasive)	3.06%
Direct, surgically placed left ventricular vent	3.57%
Septostomy	1.53%
Other (please specify)	18.37%

Continued

Supplemental Table S1. Cardiogenic shock survey.	
45. Do you always consider the status of the right ventricle in patients with cardiogenic shock?	
Yes	91.47%
No	8.53%
46. How often do you use right ventricular support with extracorporeal membrane oxygenation or right ventricular Impella?	
Always	1.90%
Sometimes	36.02%
Rarely	36.49%
Never	25.59%
47. Are operators in your institution able to perform emergent trans-septal puncture for TandemHeart?	
Yes	50.71%
No	49.29%
48. Has your institution stopped using intra-aortic balloon pump for cardiogenic shock and moved to Impella instead?	
Yes, completely stopped using intra-aortic balloon pump	21.43%
No, still using intra-aortic balloon pump	78.57%