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JACC REVIEW TOPIC OF THE WEEK

Cardiac Shock Care Centers

JACC Review Topic of the Week

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ABSTRACT

Despite advances over the past decade, the incidence of cardiogenic shock secondary to acute myocardial infarction has increased, with an unchanged mortality near 50%. Recent trials have not clarified the best strategies in treatment. While dedicated cardiac shock centers are being established, there are no standardized agreements on the utilization of mechanical circulatory support and the timeliness of percutaneous coronary intervention strategies. In some centers and prospective registries, outcomes after placement of advanced mechanical circulatory support prior to reperfusion therapy with percutaneous coronary intervention have been encouraging with improved survival. Here, we suggest systems of care with a treatment pathway for patients with acute myocardial infarction complicated by cardiogenic shock. (J Am Coll Cardiol 2018;72:1972–80) © 2018 by the American College of Cardiology Foundation.

While impressive gains have been made with a 21% mortality reduction in ST-segment elevation myocardial infarction (STEMI) treated by primary percutaneous coronary intervention (PCI) (1), acute myocardial infarction complicated by cardiogenic shock (AMI-CS) has not seen similar successes and continues to have a high mortality near 50% (2). In the recent FITT-STEMI (Feedback Intervention and Treatment Times in ST-Elevation Myocardial Infarction) trial (3), there was a significant decrease in survival for patients presenting with AMI-CS more than 90 min after first medical contact (FMC), with 3.3% additional deaths for every 10-min delay.

Access to appropriate care is limited to a few centers and is particularly lacking in rural America. A total of 8% of patients with acute myocardial infarction (AMI) (or 60,000 patients) develop cardiogenic shock (CS) every year (4). Even in tertiary care centers, survival is poor (5). In the NCDR (National Cardiovascular Data Registry), mechanical circulatory support (MCS) was used in 3.1% of cases, with advanced support in only 0.7% of cases (6). Of those cases, MCS was initiated in 27.7% before PCI, 49.9% during the procedure, and 22.4% post-procedure. To improve survival for these patients, we advocate for establishment of cardiac shock care centers and suggest a pathway to optimize outcomes.

In acute STEMI, the adage "time is muscle" was quickly transformed into a concept of a door-to-balloon time goal of ≤90 min, with a median time of 59 min reported in the NCDR registry in 2014 (6). This success led to retiring this metric, with a focus now on first medical contact (FMC)-to-device time of ≤90 min in both European and American guidelines for STEMI (7). We suggest that similar metrics are warranted to improve outcomes in AMI-CS, such as pre-PCI implantation of MCS devices with "door-to-support" time ≤90 min and consistent use of invasive hemodynamics to manage such patients.

Listen to this manuscript's audio summary by *JACC* Editor-in-Chief Dr. Valentin Fuster.

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The care of patients with AMI-CS is a national issue, declared as a priority by the Institute of Medicine. Historically, recruitment in clinical trials of CS has been difficult, with a low number of enrollees preventing implementation of evidence-based therapies.

In April 2016, the U.S. Food and Drug Administration–approved a percutaneous transvalvular continuous-flow microaxial MCS device (Impella, Abiomed, Danvers, Massachusetts) for use in AMI-CS. This device may have a major role in the care of patients with AMI-CS as PCI had for STEMI. The Detroit Cardiogenic Shock Initiative (CSI) (8), now the National Cardiogenic Shock Initiative (NCSI), provides an algorithm to maintain consistency and reproducibility that may provide insights into the best practices associated with the use of such devices. Given the heterogeneous cohort of patients who present with AMI-CS, this single-arm prospective registry is composed of patients who met the inclusion and exclusion criteria of prior randomized control trials (**Table 1**). The NCSI algorithm emphasizes rapid triage to the cardiac catheterization laboratory for patients presenting with AMI-CS, early delivery of MCS, and the use of invasive hemodynamic measurements to guide therapy post-procedure. These best practices were all associated with improved survival in observational registries, including the cVAD (catheter ventricular assist device) registry and Impella Quality database (9,10). Initial results demonstrated significant improvement in survival when compared with historical controls and when compared with prior randomized control trials in AMI-CS. As of September 2018, approximately 56 sites have treated 104 patients according to the protocol, with survival to hospital discharge at 77% (personal communication W.O., September 2018).

It should be recognized that advanced MCS devices are currently available in only 4 countries: United States, Germany, United Kingdom, and Japan. However, extracorporeal membrane oxygenation (ECMO) has been used as primary MCS in many other centers worldwide.

SUGGESTED CARE PATHWAY

The **Central Illustration** is a suggested algorithmic approach to systems of care with minimal required standards and time frame (**Figure 1**) for treatment of patients with AMI-CS in both pre- and in-hospital settings based on current evidence in 2018. (Note that intra-aortic balloon pump [IABP] is not recommended for patients with CS or cardiac arrest in this pathway.)

EMERGENCY MEDICAL SERVICES

"KEY IS EARLY RECOGNITION." Management of AMI-CS starts with an early recognition of CS. AMI-CS should be recognized by emergency medical service personnel at FMC. CS can be difficult to evaluate due to lack of agreement on a consistent definition. However, from the SHOCK (Should We Emergently Revascularize Occluded Coronaries for Cardiogenic Shock) trial (11), IABP SHOCK (12), and European guidelines (7), CS is defined as systolic blood pressure <90 mm Hg for >30 min, heart rate <60 or >90 beats/min, and with signs and symptoms of end organ hypoperfusion such as cool extremities and diaphoresis (13). Once CS is diagnosed or suspected, the field activation should include notification of the nearest dedicated CS center with MCS capabilities with goals of FMC-to-support time of ≤90 min. Transport to a center not capable of PCI and not a dedicated CS center should be avoided. Transport to a PCI-capable center that is not a CS center may be considered if transfer time is >120 min so as not to delay reperfusion therapy with primary PCI (14) (**Figure 1**).

Key to the success in achieving door-to-balloon time in STEMI has involved engagement, education, and training of emergency medical service personnel, and this should be undertaken for early recognition of CS as well. Patients with signs of impending shock, such as hypotension and hypoperfusion, require prompt intervention as appropriate to prevent shock.

CARDIAC SHOCK CARE CENTER

While most hospitals in the United State have acute cardiac care, there are fewer centers that have the capability for shock care with advanced MCS, support personnel, dedicated interventionalists, and critical care specialists. The cost and complexity of supporting MCS is prohibitive in smaller centers where procedural volumes are small.

Shock care should be categorized to 3 levels of care analogous to trauma care (15) (**Figure 2**). The states of Washington and Arizona have by law established acute cardiac care centers. A similar proposal has been approved in Georgia (16). The suggested levels of shock care are outlined in the following text.

LEVEL I: DEDICATED CARDIAC SHOCK CARE CENTERS. These are tertiary care centers with cardiac catheterization and angioplasty facilities with

ABBREVIATIONS AND ACRONYMS

AMI = acute myocardial infarction

AMI-CS = acute myocardial infarction-related cardiogenic shock

CS = cardiogenic shock

ECMO = extracorporeal membrane oxygenation

FMC = first medical contact

IABP = intra-aortic balloon pump

MCS = mechanical circulatory support

OHCA = out-of-hospital cardiac arrest

PCI = percutaneous coronary intervention

STEMI = ST-segment elevation myocardial infarction

advanced MCS available 24 h, 7 days/week, with on-site cardiothoracic surgery capability. These sites should also have established protocols for therapeutic hypothermia for out-of-hospital cardiac arrest (OHCA) patients.

A multidisciplinary "cardiogenic shock team" composed of the interventional cardiologist, critical care specialist, cardiothoracic surgeon, and advanced heart failure specialist should be available in Level I acute shock care centers. CS should alert a STEMI activation of the cardiac catheterization laboratory with alerts to other team members for rapid consultation, shared decision making, and initiation of advanced MCS (15,17) and transplant options.

LEVEL II: STEMI RECEIVING AND PCI-CAPABLE HOSPITAL WITHOUT ADVANCED MCS. These hospitals have cardiac catheterization and angioplasty facilities available 24 h, 7 days a week, but no on-site cardiothoracic surgery capability. These facilities as a minimum will have an IABP, but will rarely have advanced MCS devices. Established protocols for therapeutic hypothermia with OHCA should be maintained with a written transfer plan to 1 or more dedicated Level I shock care centers for patients who need advanced MCS or cardiothoracic surgery. If the patient remains in CS despite reperfusion therapy, rapid transfer to a dedicated Level I shock care center should be undertaken.

Transfer process should occur rapidly, and strong consideration should be given to direct transfer after PCI from the cardiac catheterization laboratory to the dedicated Level I shock care center's cardiac catheterization lab. Although the PCI-capable hospitals will have an IABP, trials have shown no survival benefit (18). However, in current practice, placement of an IABP is likely to continue by most providers and remains an unresolved issue.

Some Level II centers may have the capability of MCS support with the Impella device. It is our opinion that these devices be placed prior to performing PCI. The patient should then be transferred for further care to a dedicated Level I shock care center.

LEVEL III: NON-PCI CAPABLE HOSPITAL (GENERALLY RURAL HOSPITAL). As a minimum, these should be ACLS (Advance Cardiovascular Life Support) capable with a written plan for emergent transfer to a dedicated shock care center and have established protocols for therapeutic hypothermia for comatose OHCA patients. CS patients should be transported to CS centers directly from the field or promptly from a non-PCI-capable hospital.

TABLE 1 Inclusion and Exclusion Criteria for Cardiogenic Shock Treatment (From the National Cardiogenic Shock Initiative)

Inclusion

• AMI
  ○ Ischemic symptoms of AMI
  ○ ECG and/or biomarker evidence of STEMI or NSTEMI
• Cardiogenic shock
  ○ SBP <90 mm Hg at baseline or use of inotropes or vasopressors to maintain SBP >90 mm Hg
  ○ Evidence of end organ hypoperfusion (cool extremities, oliguria, lactic acidosis)
  ○ Cardiac index <2.2 or cardiac power output <0.6 W

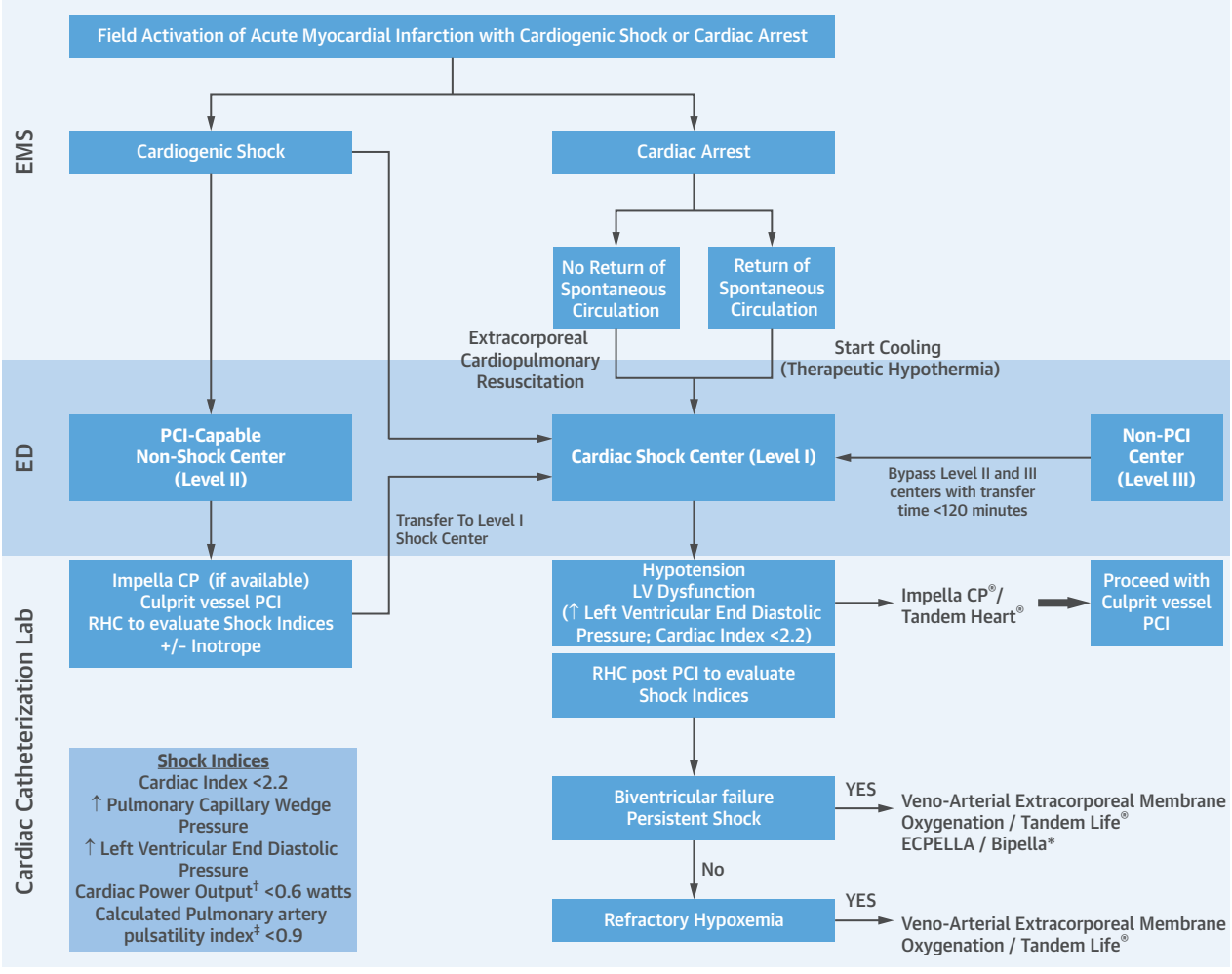
Exclusion
• Evidence of anoxic brain injury • Unwitnessed out-of-hospital cardiac arrest or any cardiac arrest in which ROSC is not achieved in 30 min • Intra-aortic balloon pump placed prior to mechanical circulatory support • Septic, anaphylactic, hemorrhagic, and neurological causes of shock • Nonischemic causes of shock/hypotension (pulmonary embolism, pneumothorax, myocarditis, pericardial tamponade, and so on) • Active bleeding • Mechanical complications of AMI (ventricular septal defect, acute papillary muscle rupture) • Known left ventricular thrombus • Patient who did not receive revascularization • Mechanical aortic prosthetic valve • Contraindication to intravenous systemic anticoagulation

AMI = acute myocardial infarction; ECG = electrocardiogram; NSTEMI = non-ST-segment elevation myocardial infarction; ROSC = return of spontaneous circulation; SBP = systolic blood pressure; STEMI = ST-segment elevation myocardial infarction.

EMERGENCY DEPARTMENT (IN ALL 3 LEVELS OF CARE)

"KEY IS EARLY TRIAGE AND CARDIOLOGY CONSULTATION." The shock care team should be alerted without any delay after initial triage and evaluation of the patient with suspected CS by the emergency department physician. The emergency department should have a dedicated room or critical care pod for this specific type of patient. This dedicated area should have bedside echocardiography available for initial evaluation and screening. Quick, limited bedside echocardiography is emphasized and can be done by a trained emergency department physician or a cardiologist who is a part of the shock team. Echocardiography provides critical assessment of left ventricular function, right ventricular failure, and acute mechanical complications such as mitral regurgitation, papillary muscle dysfunction, ventricular septal defect, free wall and papillary muscle rupture, pericardial effusion and/or cardiac tamponade and aortic dissection. Furthermore, presence of aortic stenosis or regurgitation and left ventricular thrombus is prohibitive for placement of the Impella device. Screening echocardiography should be undertaken during the triage process and should not

CENTRAL ILLUSTRATION **Shock Care Pathway Algorithm**



Rab, T. et al. J Am Coll Cardiol. 2018;72(16):1972–80.

*Bipella = Simultaneous biventricular MCS support (27). †Cardiac power output (CPO) = (mean arterial pressure × cardiac output)/451. ‡Pulmonary artery pulsatility index (PAPI) = (systolic pulmonary arterial pressure − diastolic pulmonary pressure)/right atrial pressure. ECPELLA = Simultaneous Impella and ECMO support. ED = emergency department; EMS = emergency medical services; LV = left ventricular; PCI = percutaneous coronary intervention; RHC = right heart catheterization; RV = right ventricular.

delay transportation to the cardiac catheterization laboratory.

INOTROPIC SUPPORT. Although inotropic support is important (norepinephrine being the preferred drug [19,20]) in maintaining blood pressure, stroke work and myocardial oxygen consumption increase, and there is impairment of the microcirculation. Mortality increases exponentially with the number of inotropes, with only a 26% survival when 4 inotropes are used (9). In the acute phase, this is detrimental to cardiac recovery. It is our opinion that escalating doses of inotropes should not be favored, as the rapid initiation of MCS is paramount.

THERAPEUTIC HYPOTHERMIA IN PATIENTS WITH CS WHO ARE COMATOSE AFTER CARDIAC ARREST. In all 3 levels of care, therapeutic hypothermia (TH), a guideline recommendation (21), cannot be overemphasized in comatose patients with CS and OHCA who have achieved return of spontaneous circulation (ROSC). In cardiac arrest patients secondary to AMI who have ROSC but remain in CS (44% of patients in the FITT-STEMI trial [3]), an Impella should be

FIGURE 1 Care Pathways for the Management of Cardiogenic Shock in Acute Myocardial Infarction Setting

FMC

FMC-to-Support/Device

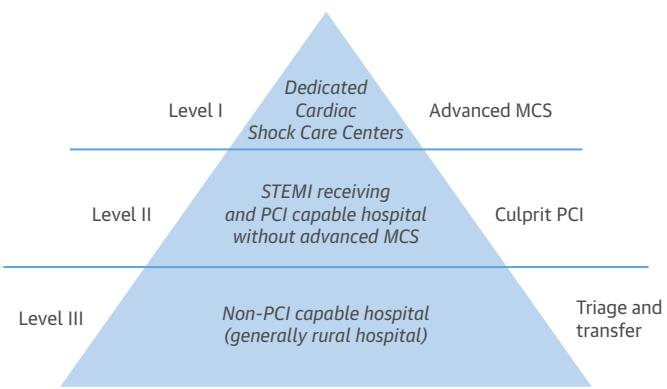
Hypothermia protocol

90 minutes

Level of Care	Goal	Parameter	Intervention	Consideration
EMS	- Early recognition of cardiogenic shock - Early recognition of AMI/STEMI - Transfer patient to PCI and cardiac shock care center	- SBP <90 mm Hg - HR >100 or <60 beat per minute - Sign/symptom of poor organ perfusion - Oxygen saturation <90% - Abnormal EKG - Abnormal POC labs, lactate level, arterial blood gas	- Onsite ETT intubation	Bypass non-shock and non-STEMI center if estimated FMC-to-Device time <120 minutes.
Emergency Department	- Identification for cardiogenic shock secondary to AMI - Early activation of shock care team - Therapeutic hypothermia in comatose patients with ROSC after cardiac arrest		- ETT Intubation - Echocardiography - Surface cooling devices for therapeutic hypothermia	Dedicated pod for shock patients in emergency room for initial evaluation.
Advanced MCS Initiation	- Establish adequate circulation and perfusion - FMC-to-Support time ≤90 minutes - CT surgery for advanced MCS	Shock Indices: - C.I. <2.2 - PCWP >15 mm Hg - LVEDP >15 mm Hg - CPO† <0.6 Watts - Calculated PAPI‡ <0.9	Advanced MCS - Impella® - Tandem Heart® - ECMO/Tandem Life® - Bipella*	MCS strategy is individualized.
Early Cardiac Intervention	- Establish coronary blood flow - FMC-to-Device time ≤90 minutes		- Radial>femoral access for PCI - Establish central venous access and right heart catheterization. - Internal catheter-based cooling devices for therapeutic hypothermia	PCI strategy: Culprit only
Post Intervention Care	- Post PCI and MCS care - Prevent post PCI and MCS complication - LVAD evaluation - Cardiac transplant evaluation - Palliative care	- Shock Indices - Labs: CBC, CMP, lactate level - Arterial blood gas	- Invasive hemodynamic monitoring - CRRT - Mechanical Ventilation	- MCS weaning off and escalation. - Consider early transfer to LVAD/heart transplantation facility for early transplant evaluation.

*Bipella = simultaneous biventricular MCS support (27). †Cardiac power output (CPO) = (mean arterial pressure × cardiac output)/451. ‡Pulmonary artery pulsatility index (PAPI) = (systolic pulmonary arterial pressure − diastolic pulmonary pressure)/right atrial pressure. AMI = acute myocardial infarction; CBC = complete blood count; C.I. = cardiac index; CMP = comprehensive metabolic panel; CRRT = continuous renal replacement therapy; CT = cardiothoracic; EKG = electrocardiogram; EMS = emergency medicine service; ETT = endotracheal tube intubation; FMC = first medical contact; HR = heart rate; LVAD = left ventricular assist device; LVEDP = left ventricular diastolic pressure; MCS = mechanical circulatory support; PCI = percutaneous coronary intervention; PCWP = pulmonary capillary wedge pressure; POC = point of care; ROSC = return of spontaneous circulation; SBP = systolic blood pressure; STEMI = ST-segment elevation myocardial infarction.

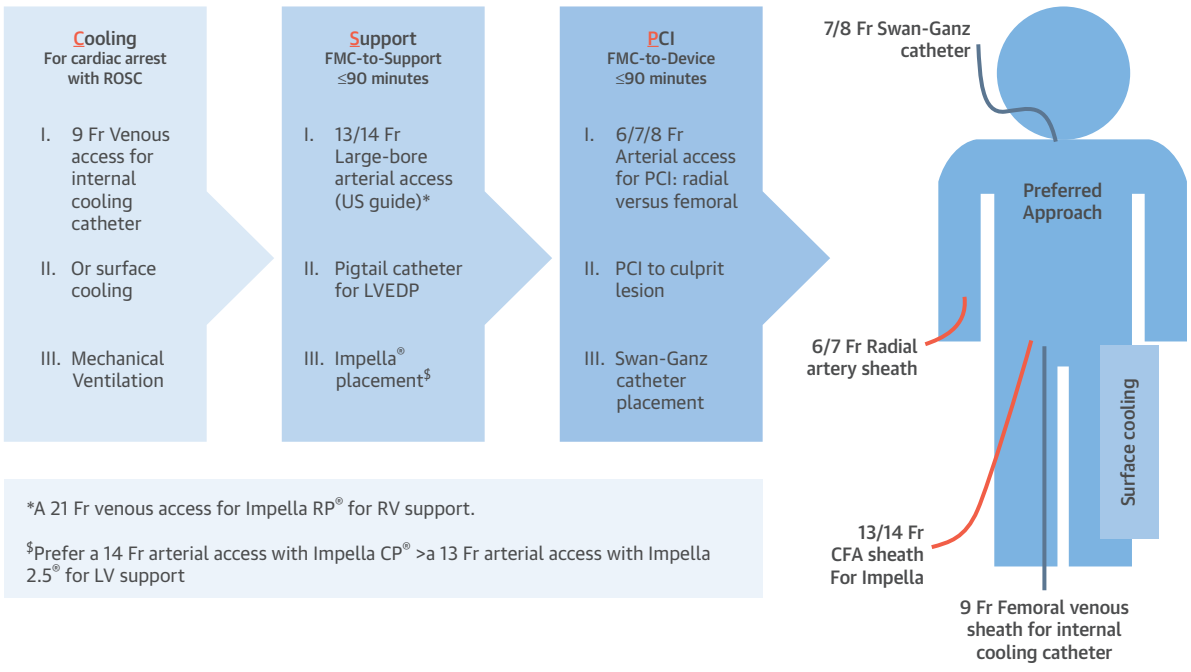
FIGURE 2 Levels of Cardiac Shock Care



Modified from Tchantchaleishvili et al. (15). Abbreviations as in Figure 1.

considered pre-PCI. Those without ROSC may benefit from veno-arterial ECMO with cardiopulmonary resuscitation or eCPR (extracorporeal cardiopulmonary resuscitation [22]) to enhance survival (23). TH for neuroprotection is essential for the patient's survival with favorable neurological function. Surface cooling in the emergency department or internal cooling using a catheter-based device should be done without delay. TH should be started before or concomitant with MCS, but before PCI. Preclinical studies have shown variable effects of cooling on myocardial function, including resultant bradycardia, and increase in vascular resistance with potential for decline in cardiac index. Left ventricular ejection fraction has been reported to increase, at least in the post-arrest patient treated with mild TH (24), although such improvement may simply be the resolution of post-arrest stunning rather than a primary

FIGURE 3 Suggested Cardiac Catheterization Laboratory Pathway (CSP)



CFA = common femoral artery; Fr = French; US = ultrasonography; other abbreviations as in Figure 1.

effect of TH (25). Small clinical series have confirmed that TH does not harm patients with CS and suggests a possible benefit (26).

CARDIAC CATHETERIZATION LABORATORY

"STRATEGIES FOR MCS AND REVASCULARIZATION." An increase in mortality from 27.6% to 30.6% was seen in patients with CS following AMI between 2005 and 2014 in the NCDR Cath/PCI registry (5). Improved understanding of the use of MCS, timing of MCS, need for invasive hemodynamics (pigtail catheter for initial assessment of left ventricular end-diastolic pressures and Swan-Ganz catheters for right heart catheterization) and implementation of shock teams should improve outcomes similar to the Detroit CSI pilot study.

In Level I and II shock centers, rapid delivery of MCS and use of invasive hemodynamics with right heart catheterization (generally) post-PCI to guide further care, such as weaning of vasopressors and inotropes and/or possible need for MCS weaning or escalation, is strongly emphasized. Escalation of device therapy from a primarily left ventricular support to biventricular device support (27) (Bipella: Impella CP for left ventricular support and Impella RP for right ventricular support) is based on hypoxemia and indexes of right ventricular failure such as pulmonary artery pulsatility index (PAPI) <0.9 (Figure 1).

In Level II centers, persistence of CS despite reperfusion warrants immediate transfer to the cardiac catheterization laboratory in a Level I center. Those who present to a Level I shock center in refractory shock despite initial MCS devices need prudent evaluation by a heart team. A patient's age, eligibility for durable left ventricular assist device or transplant, and time from shock onset, as well as overall patient wishes, are crucial factors in the decision to escalate support. Unpublished data from the NCSI indicate that patients who remain hypoperfused (as evident by lactate levels >4 mmol/l) with ongoing shock (as evident by a cardiac power output [CPO] <0.6 W) despite 12 h of Impella support continue to have a high mortality (50%) and should be considered for escalation of support. Although there is insufficient evidence for the role of escalation of MCS in such patients, we believe that a strong consideration of escalation of support is warranted. A suggested cardiac catheterization laboratory pathway is outlined in Figure 3.

MCS DEVICES

INTRA-AORTIC BALLOON PUMP. The SHOCK II trial (12) demonstrated no benefit of IABP in the management of patients with CS complicating AMI. No survival benefit was seen in 7 randomized trials (n = 790), including 4 trials comparing IABP versus no MCS and 3 trials comparing IABP versus other MCS (18). Although stroke volume is increased by the IABP, reduction in systolic aortic pressure and an increase in diastolic blood pressure increases stroke volume, which offsets the pressure reduction (28) and contributes to the lack of improvement in hemodynamic parameters (29). Nevertheless, most cardiac catheterization laboratories worldwide have an IABP as a standby for CS cases, and the device is likely to have continued use.

ADVANCED MCS DEVICES

The predominant cause of CS in AMI is an anterior infarct due to left anterior descending artery occlusion resulting in left ventricular failure (30). Left main occlusion results in acute shock within 2 h, while shock due to left anterior descending artery occlusion occurs in <8 h. Hence, early intervention with MCS in CS patients with anterior wall MI (31) is important in unloading the left ventricle and is followed by reperfusion therapy with PCI. This early intervention may lead to quicker recovery, thereby shortening the indwelling time for the device and intensive care unit time (32).

PERCUTANEOUS TRANSVALVULAR CONTINUOUS-FLOW MICROAXIAL PUMP. The Impella (Abiomed, Danvers, Massachusetts) family of devices are temporary percutaneous left ventricular assist devices that provide support by primarily unloading the left ventricle, reducing diastolic volume, and decreasing the area of the pressure volume loop or cardiac work. The device can be placed quickly via a percutaneous approach via a 13-F sheath for the Impella 2.5 device and a 14-F sheath for the Impella CP device.

IABP versus Impella trials. In the ISAR-SHOCK (Efficacy Study of LV Assist Device to Treat Patients With Cardiogenic Shock) trial, mortality was similar in both groups with the Impella 2.5 (maximum flow 2.5 l/min) providing superior hemodynamic support (33). The IMPRESS (IMpella vs intra aortic balloon pump REduces mortality in STEMI patients treated with primary PCI in Severe and deep cardiogenic Shock) trial (34) of 48 patients compared Impella CP (maximum flow 3.5 l/min) to IABP (maximum flow 1.5 l/min) in severe CS with predominance of post-cardiac arrest patients. Most patients had device placement after PCI. There was no difference in 30-day mortality.

The ongoing prospective DANSHOCK (Danish Cardiogenic Shock Trial) is currently randomizing patients with STEMI and CS to Impella CP versus IABP and includes a 6-month follow-up (35).

Registries. In the global cVAD registry (formerly the USPELLA registry) (36), survival was 41% in patients pre-treated with IABP and inotropes versus 65% in those pre-treated with an Impella 2.5. However, the Detroit CSI with the initial 41 CS patients pre-treated with the Impella CP prior to PCI, demonstrated 74% survival to discharge (9,37). Lactate levels >4 mmol/l and cardiac power output <0.6 W had poor survival at 24 h (personal communication, WO, July 2018). Hence, when Impella is considered for MCS in CS, the increased-flow CP device should be preferred.

PERCUTANEOUS CONTINUOUS-FLOW CENTRIFUGAL PUMP (TANDEM HEART). Tandem Heart (Liva Nova. London, United Kingdom) is another percutaneous left ventricular assist device that utilizes large cannula and expertise in transseptal puncture. It has not gained wide application due to the need for transseptal access. No difference in mortality was seen in 30 days when compared with IABP (29), and there were increased vascular and hemorrhagic complications. The reconfigured Tandem-Life device acts as an ECMO system utilizing the Tandem-like continuous-flow centrifugal pump without need for transseptal access.

EXTRACORPOREAL MEMBRANE OXYGENATOR. Veno-arterial ECMO increases left ventricular systolic and diastolic pressures, reducing left ventricular stroke volume. It does not unload the ventricle, and an IABP or Impella may be required to "vent" the left ventricle (ECMO with Impella, or "ECPELLA"). Due to large arterial cannula size in the iliac artery, a distal limb perfusion cannula may be required. Surgical explantation is required to remove the cannula. Patients are at risk for cerebral hypoxemia due to upper body perfusion of hypoxemic blood from the heart while the lower body is perfused with oxygenated blood from the oxygenator. Veno-arterial ECMO is appropriate for the patient with full circulatory cardiac arrest and hypoxemia associated with CS. However, the survival rate of veno-arterial ECMO has been unchanged at approximately 40% (38).

Advanced MCS devices have been used in patients in CS with dire prognosis with limited therapeutic options. The evidence is observational through registries with small numbers of patients. Although this observational registry data for efficacy led to U.S. Food and Drug Administration approval of

the Impella devices in CS, there are currently no randomized prospective trials demonstrating mortality benefit. The NCSI appears to offer improved outcomes (8).

STRATEGIES FOR REVASCULARIZATION

Optimal PCI strategies in patients with AMI-CS remain unclear. A meta-analysis of culprit vessel versus in-hospital staged intervention for patients with STEMI without cardiac arrest or CS demonstrated lower mortality and less future revascularization with staged nonculprit vessel intervention (39).

Two registries supported multivessel PCI in the setting of CS. In a registry experience from Paris (40) of 11,530 patients with STEMI, CS and cardiac arrest were seen in 2.4% (n = ~272) of patients. Multivessel disease was seen in one-half of this group (n = ~129). Culprit-only PCI was performed in 103 patients with a 6-month survival of 20.4%. A total of 66 patients who underwent multivessel PCI at the index procedure had a survival of 43.9% in the same period. In the KAMIR-NIH (Korea Acute Myocardial Infarction-National Institutes of Health) registry, multivessel PCI was associated with a 10.4% lower 1-year all-cause death when compared with culprit-only PCI (41).

In contrast, the results of the CULPRIT-SHOCK (Culprit Lesion Only PCI Versus Multivessel PCI in Cardiogenic Shock) trial (42) demonstrated lower thirty-day mortality and renal failure requiring renal replacement therapy in patients who underwent revascularization to the culprit lesion only. PCI of a nonculprit vessel or chronic total occlusion vessel in the setting of CS was associated with increased mortality. In the EXPLORE (Evaluating Xience and Left Ventricular Function in Percutaneous Coronary Intervention on Occlusions After ST-Elevation Myocardial Infarction) trial (43), nonculprit chronic total occlusion intervention within a week after STEMI PCI did not improve left ventricular size and function. A recent meta-analysis of nonrandomized studies in CS reported no advantage of single-stage multivessel PCI compared with culprit-vessel PCI (44). We therefore recommend at this time that multivessel PCI should not be routinely performed in CS.

POST–CARDIAC CATHETERIZATION LABORATORY CARE IN THE INTENSIVE CARE UNIT

Although there are no evidence-based protocols, a Level I shock care center should have dedicated critical care specialists and nursing teams well versed in escalation and de-escalation protocols for MCS and therapeutic hypothermia. MCS should continue for at least 24 h. Escalation to a durable ventricular assist device and consideration of heart transplantation should be considered as a team decision involving advanced heart failure specialists and the cardiac surgeon.

CONCLUSIONS

Cardiac shock care centers are necessary to improve outcomes in CS. We have suggested levels of care and outlined an algorithmic approach with a care pathway based on currently available best management practices in 2018. We emphasize early recognition and transportation to dedicated Level I cardiac shock care centers, which we hope will improve survival in this difficult group of patients.

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