openheart

Facility-based approach for the management of acute ST segment elevation myocardial infarction with cardiogenic shock in a rural medical centre: the Durango model

Andrew Joseph Carter ,[1] Jad Raffoul,[1] Linden Lane,[1] Leah LeSage,[1] Shelley Langenhorst,[1] Matthew Smolin,[1] Michael Dempsey,[2] David Hughes,[3] Michael Gleason,[3] Steven Weiss,[2] William D Anderson[4]

To cite: Carter AJ, Raffoul J, Lane L, *et al*. Facility-based approach for the management of acute ST segment elevation myocardial infarction with cardiogenic shock in a rural medical centre: the Durango model. *Open Heart* 2023;**10**:e002299. doi:10.1136/openhrt-2023-002299

Received 14 June 2023
Accepted 14 November 2023

[1]Cardiology, Mercy Regional Medical Center, Durango, Colorado, USA
[2]Critical Care, Mercy Regional Medical Center, Durango, Colorado, USA
[3]Emergency Department, Mercy Regional Medical Center, Durango, Colorado, USA
[4]Centura Health, Englewood, Colorado, USA

Correspondence to
Dr Andrew Joseph Carter; ajcarter@communitymed.org

ABSTRACT

Introduction Cardiogenic shock (CS) complicates 5%–15% of cases of acute myocardial infarction (AMI) with inpatient mortality greater than 40%. The implementation of standardised protocols may improve clinical outcomes in patients with AMI-CS.

Methods and analysis The Durango model is a prospective single-centre registry designed to enable early identification of patients with STEMI-CS to facilitate primary reperfusion therapy with a shock team management algorithm in a rural level II heart attack centre. This prospective registry includes all patients >18 years of age presenting with STEMI with or without CS beginning on 1 February 2023. The primary outcome measures are adherence to model-based documentation of SCAI shock Classification prehospital and in the ED with appropriate STEMI shock alert for AMI and stages C, D, E shock; use of mechanical circulatory support Pre-PCI and door to support time <90 min.

Ethics and dissemination This study was approved by the Institutional Review Board with a waiver of informed consent. The findings will be submitted for publication in a peer-review open access journal on completion of the study.

Conclusions The Durango model will demonstrate that the implementation of a STEMI shock team can be feasible in a rural medical centre through comprehensive education of a diverse group providers with different levels of experience, continuous model/device proficiency training and performance feedback.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The feasibility of a shock team approach for the management of acute myocardial infarction-cardiogenic shock (CS) is documented from prospective registries conducted at tertiary care centres.

WHAT THIS STUDY ADDS

⇒ The Durango model documents the feasibility of a shock team approach in the management of STEMI-CS in a rural medical centre with EMS SCAI shock classification and activation from the field.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The Durango model may serve as a template for other rural medical centres to implement a shock team approach, improve early detection and management of STEMI-CS in geographically isolated regions.

INTRODUCTION

Cardiogenic shock (CS) complicates 5%–15% of cases of acute myocardial infarction (AMI).[1] CS is a haemodynamically complex multiorgan system disorder associated with a high inpatient morbidity, mortality and poor long-term prognosis. Despite more than 2 decades of ongoing research to improve clinical outcomes for patients with AMI-CS, in-hospital mortality remains greater than 40%.[2] The advent of new technologies designed to provide access to haemodynamic support in the field or cardiac catheterisation laboratory, such as an intravascular microaxial left ventricular assist device (pLVAD) and venous-arterial extracorporeal membrane oxygenation (VA ECMO), have enabled the development of standardised shock protocols and networks of care intended to improve clinical outcomes in patients with AMI-CS.[3–5]

The American Heart Association policy statement for the management of patients with acute ST segment elevation myocardial infarction (STEMI) advocates a systems of care approach intended to improve access to timely reperfusion therapies and advanced technologies in the setting of mechanical complication such as CS.[6] This system of care

is designed to facilitate entry into a network of acute heart attack ready (level III) facilities to identify patients with ST segment elevation MI, initiate optimal guideline-directed medical therapy and administer fibrinolytic therapy as the reperfusion strategy for eligible patients when the facility cannot achieve transfer for primary PCI within 90 min. These level III facilities serve as critical points of triage for patients to a primary heart attack centre (level II) for PCI or a comprehensive heart attack centre (level I) for PCI, mechanical circulatory support (MCS) or cardiac surgery. The model advocates transfer of STEMI patients requiring advanced haemodynamic support devices to a level I comprehensive heart attack centre. The limited applicability of this model to rural hospitals, geographically isolated regions or areas prone to adverse weather conditions mandates alternative strategies to optimise timely reperfusion therapy, facilitate early recognition and management of patients at risk for or with mechanical complications such as CS in the setting of AMI.

Mercy Hospital (MRMC) is an 82-bed regional medical centre located in Southwest Colorado that serves a geographic location of approximately 250 square miles, population of greater than 250 000 full-time residents. The facility is a level II primary heart attack centre with advanced circulatory support, 24/7/365 PCI capability, 24/7 intensivist staffed critical care unit, engaged in a regional system of care with onsite aeromedical transport. The facility serves multiple distinct community-based EMS units and several acute heart attack ready facilities. The level III heart facilities supported by MRMC each have unique challenges in the management of STEMI patients based on available local resources, access to reliable network communications, diverse geographical distances and topography, while operating in a region prone to adverse weather conditions. These factors can have a profound impact on the hub and spoke triage of patients with AMI and CS to level I heart facilities.

The Durango model was designed to enable early identification of patients with STEMI and CS to facilitate primary reperfusion therapy with a shock team management algorithm intended to optimise initial medical therapy, utilisation of percutaneous haemodynamic support and serve as a guide to identify patients suitable for recovery in a level II heart attack facility.

METHODS

Prehospital care

The primary objectives of prehospital care are early recognition and management of AMI-CS. All patients require intravenous access, high-flow oxygen administered by mask and cardiac monitoring. A 12-lead ECG is performed in the field to decrease door-to-PCI times and/or time to the administration of thrombolytics by early identification of STEMI. The EMS and emergency medical department staff were trained to use the SCAI staging classification for CS at first medical contact (FMC) (figure 1).[7] The first responders were trained to identify shock in patients with cool, clammy, pale skin, confusion/anxiety, rapid shallow breathing, systolic blood pressure (SBP) <90 mm Hg, heart rate greater than 100 bpm or supplemental oxygen requirement >5 L/min via NC. The emergency medical department and EMS staff will activate STEMI shock alert for patients with stages C, D or E shock using existing telephone-text provider notification system. The prehospital patient care will otherwise follow prescribed guideline directed medical management for STEMI and ACLS resuscitation protocols.[8 9] The emergency department (ED) staff will escalate the STEMI alert to STEMI shock alert for patients with stages C, D or E shock with or without cardiac arrest after initial assessment in the ED. The STEMI shock team is multidisciplinary group composed of the attending or on-call physician providers (ED attending physician, interventional cardiology, critical care, nephrology), ED charge nurse, lead nurse cardiac catheterisation laboratory, CV tech cardiac catheterisation laboratory (cardiovascular laboratory, CVL), facility nursing supervisor and aeromedical transport team. The STEMI shock team will complete ad hoc case review within 72 hours of case presentation and participate in institutional quality improvement meetings on a quarterly basis to review processes of care and outcomes.

Initial facility-based care

Patients with STEMI-CS will be directly transferred by EMS/aeromedical transport from the field or level III facility to the emergency department (ED). The primary goals of initial facility-based care for STEMI-CS patients are to conduct initial evaluation and screening to confirm ischaemic symptoms, ECG evidence of STEMI and stage of CS. The STEMI-CS team will implement all measures to expedite care, reduce redundancy, minimise time in the ED and facilitate transfer to CVL. The STEMI shock team will follow the RESCUE (**R**espiratory, **E**cho, **S**CAI Shock Class, **C**irculation, **U**nloading Ventricle, **E**arly Reperfusion) algorithm as outlined in figure 1 for initial management of STEMI-CS in patients with a favourable prognosis for neurological recovery. The RESCUE algorithm provides a simple systematic guideline for initial management and stabilisation in STEMI-CS. When clinically necessary, continuous or bilevel positive pressure ventilation (CPAP or BiPAP) or endotracheal intubation will be performed in the ED. A limited bedside echocardiogram will be completed to assess left and right ventricular (RV) systolic function, screen for acute mechanical complications, the presence and severity of aortic stenosis or insufficiency and left ventricular mural thrombus. The initial management in the ED will follow established guidelines for the management of patients with AMI-CS. Intravenous inotropic therapy will be initiated in the ED with norepinephrine infusion, initial rate 5 µg/min, titrated to maintain mean arterial blood pressure greater than 60 mm Hg, maximal infusion 80 µg/min.[10 11] Intravenous epinephrine infusion may be used

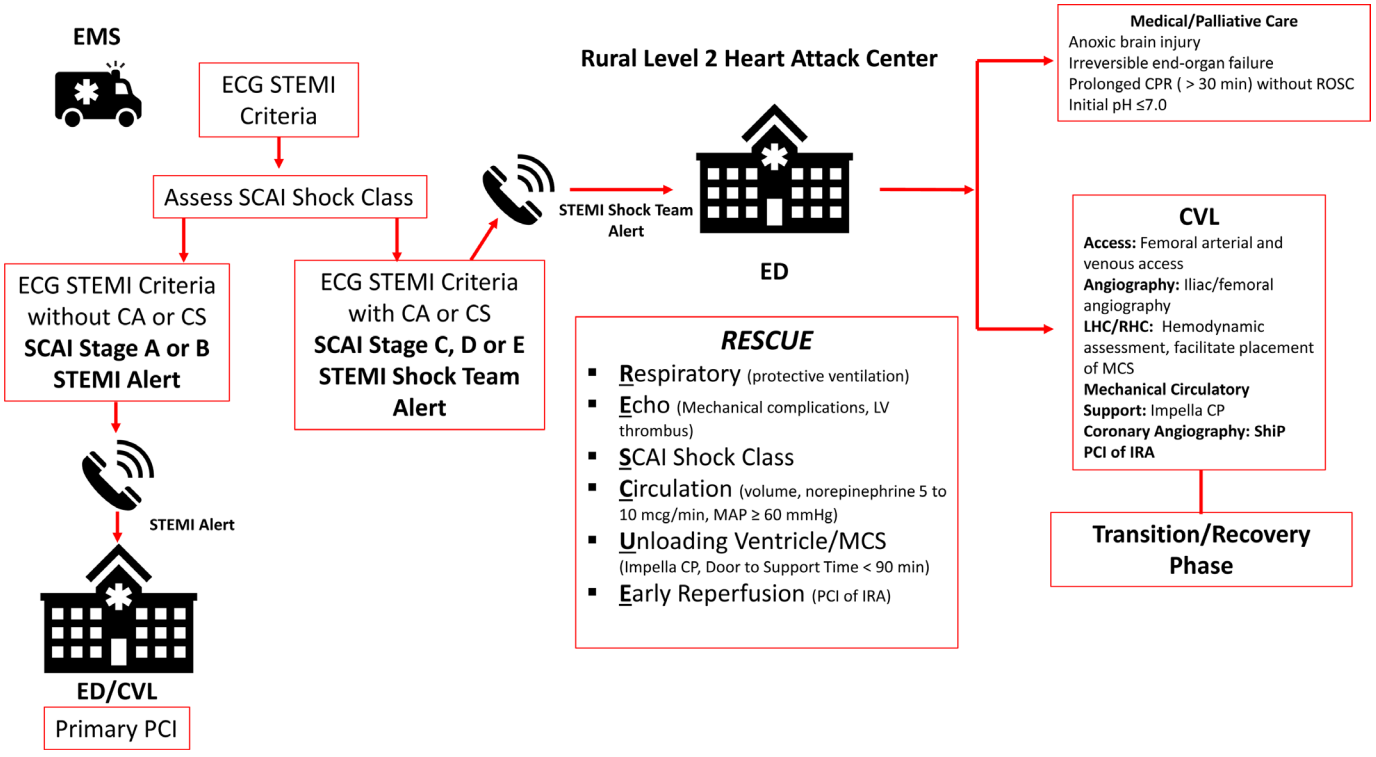

Figure 1 Treatment algorithm highlighting key considerations in the initial diagnosis and management of acute STEMI and CS. CA, cardiac arrest; CPR, cardiopulmonary resuscitation; CS, cardiogenic shock; CVL, cardiovascular laboratory; Echo, echocardiography; ED, emergency department; EMS, emergency medical services; IRA, infarct related artery; LHC, left heart catheterisation; MAP, mean arterial pressure; MCS, mechanical circulatory support; PCI, percutaneous coronary intervention; RHC, right heart catheterisation; ROSC, return of spontaneous circulation; SCAI, Society for Cardiovascular Angiography and Interventions; ShiP, single access for high risk PCI; STEMI, ST segment elevation myocardial infarction.

as an alternative to or in combination with norepinephrine, initial rate 1 µg/min, maximal rate 15 µg/min. In general, the goal is to minimise use of multiple vasoactive drugs and to facilitate prompt transfer to the CVL for placement of MCS.[12] The evaluation and management in the ED will be completed in a timely manner to avoid delay in transportation to the CVL. STEMI-CS patients who present with high probability of poor neurological recovery (initial asystole, unwitnessed cardiac arrest, no bystander cardiopulmonary resuscitation (CPR), ineffective or prolonged CPR >30 min, absence of ROSC, age ≥80, initial pH ≤7.0) requires careful consideration for termination of resuscitation or palliative care without escalation to MCS.

Procedural care

Patients with AMI-CS will be transported promptly to the CVL to enable invasive haemodynamic assessment, implementation of MCS, coronary angiography and primary PCI. The goal is to achieve FMC to MCS time less than 90 min in patients with stages C, D or E CS (figure 2). An intravascular microaxial LVAD, Impella CP (Abiomed, Danvers, Massachusetts, USA), will be inserted in the left ventricular cavity via ultrasound and fluoroscopic guided placement of a 14 French femoral arterial sheath with established techniques. Heparin anticoagulation will be administered using an intravenous weight adjusted bolus (70 units/kg) to achieve an activated clotting time (ACT) greater than 250–300 s. The patients will undergo periodic assessment of anticoagulation with ACT, additional heparin bolus dosing will be administered to maintain ACT 250–300 s during PCI. Diagnostic coronary angiography and PCI will be conducted using the single access for high-risk PCI technique.[13] Culprit vessel-only PCI is recommended as the revascularisation strategy for patients with STEMI complicated by CS who have multivessel disease. This recommendation is based on findings from observational data and one randomised trial that showed no advantage for immediate multivessel PCI in AMI-CS.[14–16] Non-culprit lesion PCI will be deferred except in cases of specific angiographic scenarios such as subtotal nonculprit lesions with reduced TIMI (thrombolysis in myocardial infarction) flow or multiple possible culprit lesions.[5 17 18] The interventional cardiologist will establish central venous access and conduct right heart catheterisation after completion of culprit lesion PCI. Therapeutic hypothermia will be initiated in patients following out of hospital cardiac arrest.

Postprocedural care

The phases of postprocedural care following MCS for patients with STEMI-CS are defined based on temporal aspects of clinical management and patient hemodynamics. The phases are divided into three distinct critical aspects of management as defined by transition, recovery and de-escalation/explant of MCS. The transition care

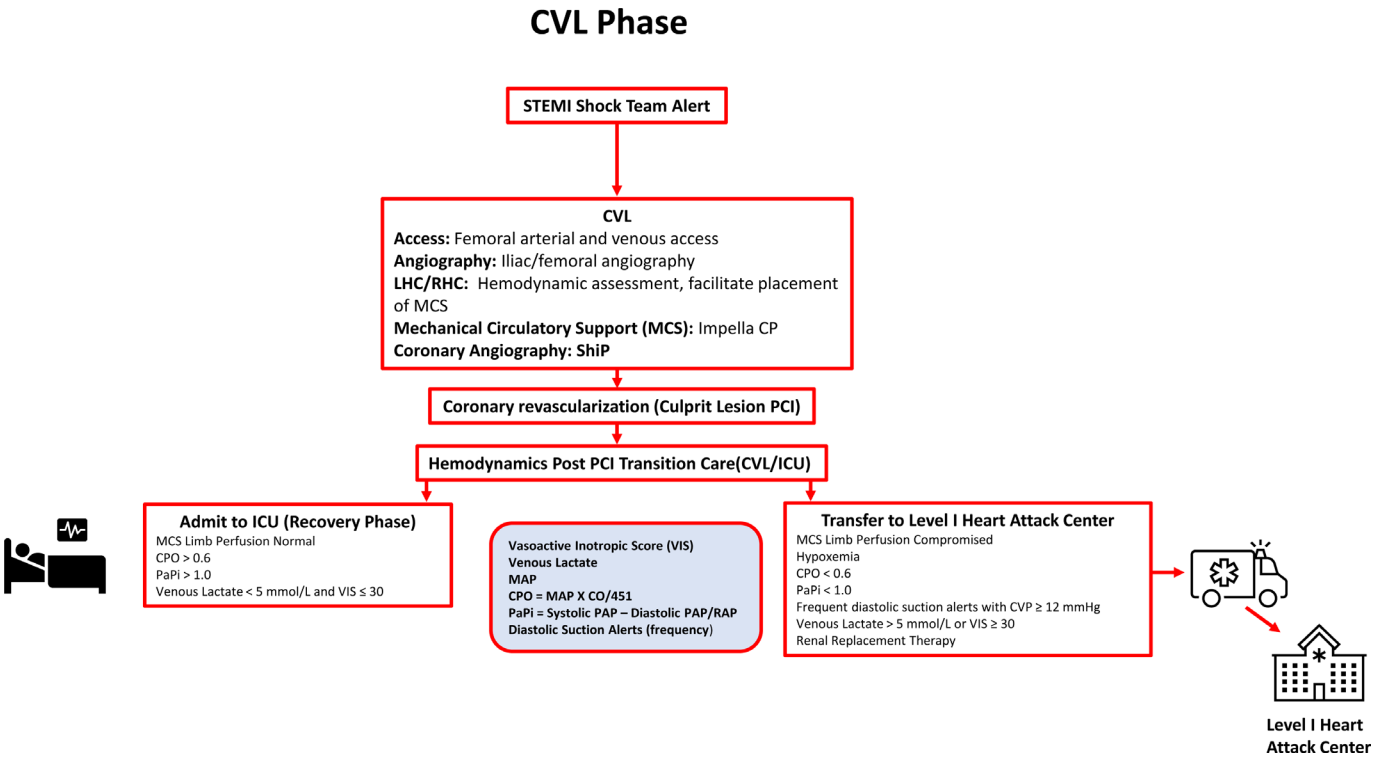

Figure 2 Procedural care and transition phase algorithm highlighting key considerations in the initial and early management of acute ST segment elevation myocardial infarction and CS. CO, cardiac output; CPO, cardiac power output; CS, cardiogenic shock; CVL, cardiovascular laboratory; CVP, central venous pressure; ICU, intensive care unit; LHC, left heart catheterisation; MAP, mean arterial pressure; PAP, pulmonary artery pressure; PaPi, pulmonary artery pulsatility index; PCI, percutaneous coronary intervention; RHC, right heart catheterisation; RAP, mean right atrial pressure; SCAI, Society for Cardiovascular Angiography and Interventions; ShiP, single access for high risk PCI; VIS, Vasoactive Inotropic Score.

phase is defined as the first 60 min following transfer from the cardiovascular laboratory to the medical intensive care unit (ICU). The recovery phase is defined as the interval of MCS post-transition care to criteria for de-escalation or weaning from the intravascular micro-axial LVAD. The de-escalation/explant phase is defined by invasive haemodynamic and clinical data suitable for weaning and discontinuation of MCS. Patient management will be guided by a clinical decision algorithm (figures 2 and 3) to triage patients for ongoing recovery in facility, transfer to a higher level of care or futility.

Transition phase

The transition phase is focused on optimising MCS, intravenous inotropic therapy, cardiac rhythm management, mechanical ventilation, anticoagulation and early identification of bleeding or vascular access site complications. The first 60 min after transfer from CVL to ICU represents a critical phase in the management of patients following successful PCI in the setting of STEMI-CS. The primary management goals are to document optimal position, performance of MCS, obtain baseline invasive haemodynamic data from pulmonary artery catheter (PAC) to include the calculated haemodynamic parameters (cardiac index (CI), cardiac power output (CPO) and Pulmonary Artery Pulsatility Index (PAPI), confirm adequate mechanical ventilatory support and screen for bleeding or vascular access site complication (limb ischaemia). The early assessment of the clinical response to percutaneous revascularisation and MCS is crucial for decision-making regarding therapeutic strategies, recovery in facility, transfer to a higher level for escalation of support or futility.

The initial ICU patient management will include standard facility-based critical care protocols, invasive haemodynamic monitoring (MAP, CPO and PAPI), implementation of pLVAD orders, assessment for vascular access site bleeding/limb ischaemia and laboratory testing (ABG, arterial lactate).[19–21] The goal is to achieve MAP >60 mm Hg, CPO >0.6 and PAPI >1.0 within the first 60 min of care in the ICU. A bedside echocardiogram will be completed to document the position of the pLVAD. The Impella CP catheter inlet should be positioned 3–4 cm below the aortic valve in the left ventricular cavity and the outlet 1.5–2.0 cm above the sinuses of Valsalva in the aorta. The initial invasive assessment of end-organ perfusion and haemodynamics will include measurement of mean RA pressure, PA SBP and diastolic pressure, mean PCWP, cardiac output, PA saturation and arterial lactate. The vasoactive inotropic score (VIS) will be calculated manually with the recorded infusion rate of vasoactive drugs, including dopamine, dobutamine, epinephrine, milrinone, vasopressin and norepinephrine using the following formula suggested by Gaies *et al*.[12 22] Patients with venous lactate <5 mmol/L, VIS ≤30, CPO

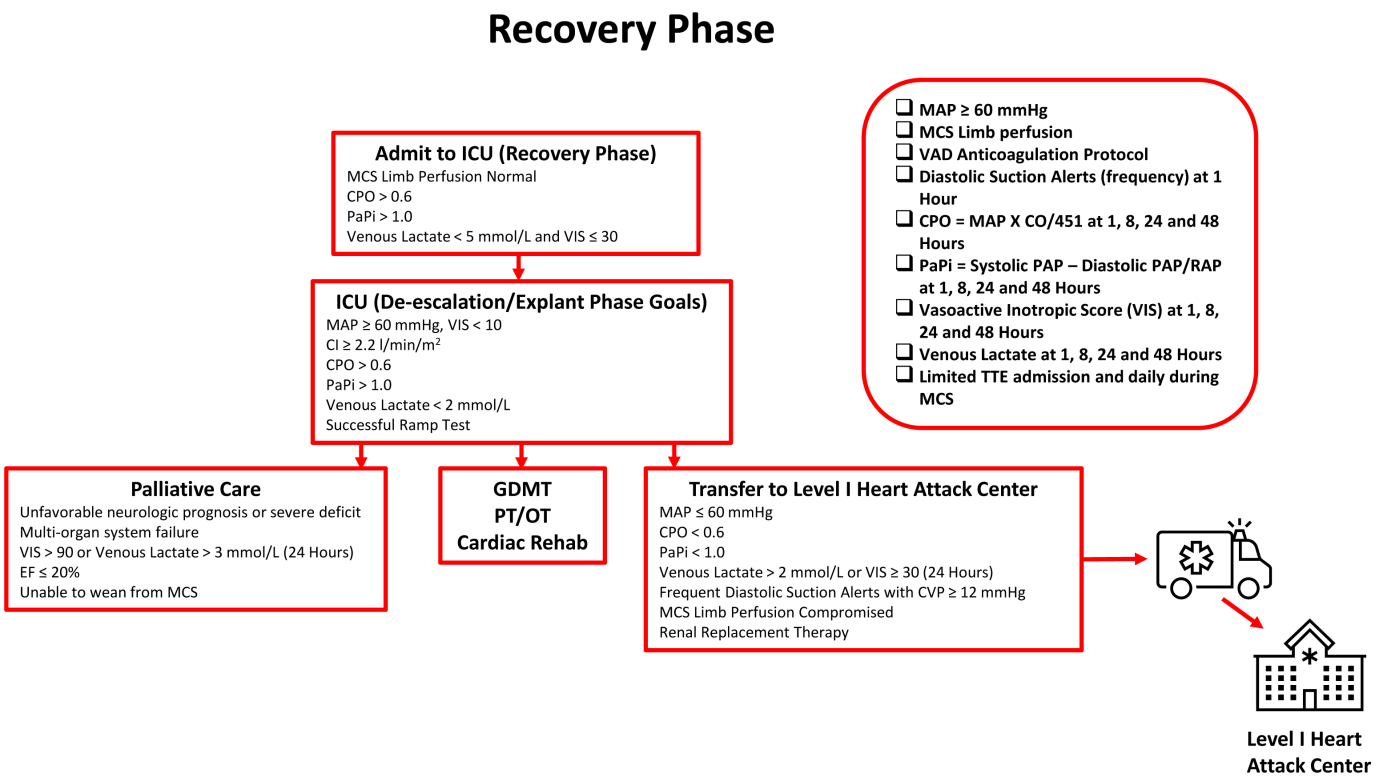

Figure 3 Recovery phase algorithm highlighting key considerations in the management of acute ST segment elevation myocardial infarction and CS. CO, cardiac output; CPO, cardiac power output; CS, cardiogenic shock; CVL, cardiovascular laboratory; CVP, central venous pressure; EF, ejection fraction; GDMT, guideline-directed medical therapy; LHC, left heart catheterisation; MAP, mean arterial pressure; MCS, mechanical circulatory support; PAP, pulmonary artery pressure; PaPi, Pulmonary Artery Pulsatility Index; PCI, percutaneous coronary intervention; PT, physical therapy; OT, occupational therapy; RHC, right heart catheterisation; RAP, mean right atrial pressure; SCAI, Society for Cardiovascular Angiography and Interventions; ShiP, single access for high risk PCI; TTE, transthoracic echocardiogram; VAD, ventricular assist device; VIS, Vasoactive Inotropic Score.

>0.6, PAPI >0.9 and adequate mechanical ventilation without acute limb ischaemia or indication for continuous veno-venous haemofiltration (CVVH) may be candidates for recovery infacility. Patients with acute limb ischaemia, unfavourable initial haemodynamic response (venous lactate >5 mmol/L, VIS ≥30, CPO ≤0.6, frequent diastolic suction alerts with CVP >12 mm Hg and PAPI <0.9) or acute renal failure requiring CVVH are at greatest risk for in-hospital mortality and may benefit from other forms of haemodynamic support (Impella RP, ECMO) or subspecialty care (advanced heart failure, vascular surgery).[18–22] This subset of patients will be evaluated for suitability to transfer to a higher level of care or palliative care due to futility. Patients with successful PCI of infarct-related artery with restoration of TIMI-3 flow, stable intrinsic or ventricular paced cardiac rhythm, adequate oxygenation on mechanical ventilation and favourable neurologic prognosis without severe cerebral deficit will be transferred to a level I heart attack centre. Patients with unsuccessful PCI of the infarct related artery with TIMI flow <3, unstable cardiac rhythm (recurrent ventricular arrhymias, inadequate capture with RV pacing), unfavourable neurologic prognosis or with severe cerebral deficit, declining CPO, VIS ≥90, left ventricular ejection fraction less than 20% with or without other mechanical complications (severe mitral insufficiency, papillary muscle rupture, VSD) despite MCS will be evaluated for palliative care.

Recovery phase

The recovery phase is defined as the period care (1–48 hours) after initial stabilisation of CS with MCS to the point of de-escalation/explant, transfer to a higher level of care due to deterioration in haemodynamic status or palliative care for refractory CS with multiorgan system failure. The primary goals of this phase of care are to identify optimal CVP, dosing of inotropic and/or pressor therapy, maintenance of optimal position and function of Impella CP catheter, effective management of cardiac arrhythmias (VT, atrial fibrillation) and prevention of bleeding/vascular access site complications.

The continuous haemodynamic data (CI, CPO, PAPI), VIS and venous lactate levels will be used to assess myocardial recovery, suitability for de-escalation of MCS. The goal is to aggressively down titrate intravenous inotropic therapy based on invasive haemodynamic parameters. Myocardial recovery is defined as CPO >0.8 without intravenous inotropic or pressor therapy, and venous lactate <2 mmol/L. Patients with CPO >0.8 on low doses of pressor therapy (ie, norepinephrine <5 µg/min or VIS

<10) with venous lactate <2 mmol/L may be considered for de-escalation of MCS. Patients with CPO <0.6, PAPI <0.9, development of RV failure or frequent diastolic suctions with CVP greater than 12, escalating requirement for inotropes/pressures and persistent venous lactate >3 mmol/L at 8 hours after initiation of MCS should be considered for escalation of therapy, transfer to a Level one heart attack centre.

De-escalation and explant phase

The de-escalation phase is identified by signs of improving intrinsic cardiac contractility manifested by increased arterial pulsatility with MAP ≥65 mm Hg, improvement in CI/CPO, echocardiographic parameters of left ventricular systolic function, declining inotrope requirement, adequate ventilation and oxygenation, less than moderate use of vasoactive agents, venous lactate less than 2 mmol/L. These patients are candidates for a ramp test to determine suitability to wean/discontinue MCS. The ramp test can be conducted using 'rapid' or 'slow' weaning protocols for de-escalation of MCS.[23] The Impella CP support can be reduced in a stepwise manner from full to low levels of support (P9–P2) by 2P levels every 1–2 hours (rapid) or by more gradual pump speed reduction by 1–2 P levels every 4 hours (slow) while assessing readiness to explant criteria. Patients who maintain SBP >90 mm Hg, CI >2.2 L/min/m^2 and CPO >0.8 without intravenous inotropic or pressor therapy with a ramp test will likely tolerate termination of MCS. Patients who fail the ramp test should undergo further evaluation, consideration for transfer to a higher level of care for escalation of therapy. Patients who fail to demonstrate recovery in 48 hours should be evaluated for transfer to a higher-level care for VAD/transplant.

Anticoagulation protocol

A bicarbonate-based purge solution will be used to maintain pump purge performance to simplify the postprocedural systemic anticoagulation regimen and reduce bleeding risk.[24] Postprocedure, heparin anticoagulation will be guided by ACT, sample every hour for 4–6 hours (target ACT ≥180 s) then anti-Xa levels. Heparin anti-Xa assay will be initiated when ACT is <180 s, then every 6 hours after each dosage change, until two consecutive therapeutic levels are achieved at a constant rate of infusion, then once daily. The patients will remain on intravenous heparin infusion to maintain anti-Xa level 0.2–0.4 IU/mL until de-escalation and explant of Impella CP.[25]

RESULTS

The Durango model is a prospective observational registry study intended to implement a facility-based regional strategy for the management of patients with STEMI-CS. This prospective registry includes all patients >18 years of age who presented to or were transferred into MRMC with STEMI with or without CS beginning 1 February 2023. Patient demographic, clinical, laboratory, noninvasive and invasive diagnostic/interventional data will be abstracted from EHR. The de-identified observational data will categorise patients as AMI with or without CS, SCAI shock category, adherence to facility based model for STEMI alert with or without CS, adherence to clinical categorisation of shock status by EMS and in ED, use of any intravenous inotrope or adrenergic vasopressor therapy, use of percutaneous haemodynamic support (pLVAD), indication for percutaneous haemodynamic support (emergent pre-PCI or bailout), culprit only versus culprit and non-culprit lesion PCI, utilisation of PAC, transfer for escalation of haemodynamic support and futility. The primary outcomes are based in-part on the National Cardiogenic Shock Initiative (NCSI) study endpoints.[26]

1. Adherence to model-based documentation of SCAI shock classification prehospital and in the ED with appropriate STEMI shock alert for AMI and stages C, D, E shock with or without cardiac arrest.
2. Use of MCS Pre-PCI (time frame: at index CVL procedure/PCI). Number of patients who receive MCS pre-PCI.
3. DST <90 min (time frame: at index CVL procedure/PCI). Time from patient presentation at MRMC to time that MCS was initiated.
4. Establish TIMI III Flow (time frame: at index CVL procedure/PCI). Establishment of TIMI III coronary blood flow during index PCI in culprit lesions.
5. Utilisation of PAC (time frame: at index CVL procedure in all patients with MCS).
6. Wean off vasopressors and inotropes (time frame: at index PCI in CVL, 1, 8, 24 and 48 hours post-PCI). Ability to wean off vasopressor and inotropic medication use in patients being treated with early MCS during treatment for AMI-CS with in-facility recovery.
7. Maintain CPO ≥0.6 watts (time frame: at index PCI in CVL, 1, 8, 24 and 48 hours post-PCI). Ability to maintain a CPO measurement of ≥0.6 watts.

The secondary outcomes are incidence of in-hospital bleeding and vascular access site complications (Bleeding Academic Research Consortium[27]); acute renal failure with or without need for HD or CVVH, cerebrovascular accident, repeat target lesion revascularisation, need for emergency coronary artery bypass grafting (CABG)[28]; transfer for escalation of haemodynamic support, futility (defined as severe neurological deficit, refractory CS with multiorgan system failure, VIS score ≥90 with CPI <0.6, withdrawal of care) and in-hospital mortality will be reported.

DISCUSSION

The Durango model was designed to enable early identification of patients with STEMI-CS, facilitate primary reperfusion therapy with a shock team management algorithm intended to optimise medical therapy, early utilisation of MCS in a rural level II heart attack centre. The clinical stage, time based, management algorithms are

intended to serve as a guide to identify patients suitable for recovery in-facility or transfer to a level I facility for escalation of haemodynamic support or other specialty care. The model defines critical phases in the care of patients with STEMI-CS: prehospital, initial facility-based care, procedural, transition, recovery and de-escalation/explant.

The feasibility of a shock team approach for the management of AMI-CS is well documented. Data from prospective registries conducted at tertiary care centres suggests improvements in clinical outcomes with a multidisciplinary protocol-based treatment strategy.[20 26 29–31] The introduction of a telephone-activated multidisciplinary shock team, accompanied by an institutional protocol for CS management, was associated with a greater than twofold reduction in 30-day mortality for patients with AMI-CS.[19 29] The implementation of a smartphone-activated shock team at a regional medical centre in Canada was associated with 30% reduction in mortality in patients with AMI-CS.[30] The NCSI recently reported in-hospital outcomes for 300 patients with AMI-CS treated at 72 facilities in the US using a shock team protocol with percutaneous coronary revascularisation and haemodynamic support with an intravascular microaxial LVAD guided by invasive haemodynamic data.[26] The authors of this study reported a reduction of in-hospital mortality from 50% in a historical matched cohort compared with 28% in NCSI registry.[26]

These STEMI shock protocols were developed, validated and appear effective in reducing in-hospital mortality at large regional medical centres, level I heart attack centres. There are limited data documenting the feasibility and outcomes of a shock team model in level II heart attack centres. Level II heart attack centres can have vastly different resources to support management of AMI-CS patients and often operate in geographically isolated regions, or areas prone to adverse weather conditions limiting the ability to stabilise and transfer to a higher level of care. The ability to implement MCS in rural level II heart attack centres may provide more timely stabilisation of CS, enable primary PCI with recovery in-facility or when clinically indicated transfer to a higher level of care. The decision to recover in-facility, transfer to a level I centre for escalation of haemodynamic support and other specialty care or referral to palliative care due to futility should be guided by clinical factors, invasive haemodynamic data in a time phased manner based on pre-established protocols.

Prehospital care in the Durango model is focused on early identification of CS and activation of the STEMI-CS team. The SCAI shock classification will be used to facilitate early identification and characterisation of CS in the field by EMS or in the ED at point of FMC. EMS and ED personnel will initiate a STEMI shock alert for all patients with STEMI in SCAI stages C, D or E shock. To our knowledge, this is the first facility-based model to use SCAI shock classification system by EMS at FMC or ED personnel to identify patients at-risk for or in CS. The Durango model will document adherence to protocol-based SCAI shock classification prehospital and in the ED with appropriate STEMI shock alert.

The primary goals of initial facility-based and procedural care are consistent with current evidence-based protocols for management of STEMI-CS, such as the NCSI.[26] The transition and recovery phases of the Durango model are unique and were designed to identify patients suitable for recovery in-facility, transfer to a level I facility or palliative care. The management algorithms (figures 2 and 3) are intended to guide care in a time phased manner based on clinical, laboratory and invasive haemodynamic parameters. The early identification of patients who fail to demonstrate improvement in cardiac performance with venous lactate >5 mmol/L, CPO <0.6, PaPi <1.0, frequent suction alerts or hypoxaemia may benefit from transfer to a higher level of care for escalation of haemodynamic support with ECMO. Patients with venous lactate <5 mmol/L, VIS ≤30, CPO >0.6, PAPI >0.9, and adequate mechanical ventilation without acute limb ischaemia or indication for CVVH may be candidates for transition to recovery in facility. To our knowledge, this is the first rural facility-based model designed to demonstrate feasibility of recovery, escalation of care or futility using a clinical stage, time based, management algorithm for patients with STEMI-CS.

Limitations

The Durango model is a single-centre prospective registry designed to document the feasibility of a shock team approach in the management of STEMI-CS in a rural medical centre with EMS SCAI shock classification and activation from the field. The study is not sufficiently designed to determine a mortality benefit with a STEMI-CS model in a rural medical centre. The observations from this study may generate hypothesis that merits testing in a randomised clinical trial. The observations from this study may not be applicable to tertiary medical centres or some level II heart attack centres.

Summary

The Durango model will demonstrate that the implementation of a STEMI shock team can be feasible in a rural facility through comprehensive education of a diverse group providers with different levels of experience, continuous protocol/device proficiency training and performance feedback guided by patient outcomes.

Contributors All authors have reviewed and contributed to the design, development of the study, review and approval of the manuscript. AJC, DO and FACC: design, development and implementation of model; draft manuscript; JR and MD: design, development and implementation of model; critical thought content; review of manuscript; LLane, CVRN and MSN-Ed: design, development and implementation of model; critical thought content; review of manuscript: LLeSage, CVRN and MSN-Ed: design, development and implementation of model; critical thought content; review of manuscript: SL, CVRN and DNP: design, development and implementation of model, critical thought content, review of manuscript MD: implementation of model, review of manuscript: DH: design, development and implementation of model; critical thought content; review of manuscript: MG and DO: implementation of model, review of manuscript. SW and MD: implementation

of model, review of manuscript MS and MD: implementation of model, review of manuscript; WDA and MD: implementation of model, review of manuscript.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Disclaimer All authors have disclosed that they are members of the Authors' Submission Toolkit Working Group. LLeSage CVRN, MSN-Ed is a per diem clinical educator for Abiomed, Danvers, MA. The following authors have no conflicts of interest to report with this study: AJC DO, FACC; JR MD, MRS MD, FACC; LLane, CVRN, MSN-Ed; SL, CVRN, DNP; MD, MD; DH MD, MG, DO; SW, MD; WDA, MD.

Competing interests None declared.

Patient consent for publication Not applicable.

Ethics approval The Common Spirit Health Research Institute IRB approved this study (IRBNet ID 2060146-1), performed under a waiver of informed consent.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available on reasonable request. No data are available.

ORCID iD

Andrew Joseph Carter http://orcid.org/0000-0003-4727-4642

REFERENCES

1 Shah RU, Henry TD, Rutten-Ramos S, *et al*. Increasing percutaneous coronary interventions for ST-segment elevation myocardial infarction in the United States: progress and opportunity. *JACC Cardiovasc Interv* 2015;8:139–46.
2 Miller L. Cardiogenic shock in acute myocardial infarction: the era of mechanical support. *J Am Coll Cardiol* 2016;67:1881–4.
3 Rab T, Ratanapo S, Kern KB, *et al*. Cardiac shock care centers: JACC review topic of the week. J Am Coll Cardiol 2018;72:1972–80.
4 Tehrani BN, Truesdell AG, Psotka MA, *et al*. A standardized and comprehensive approach to the management of cardiogenic shock. *JACC Heart Fail* 2020;8:879–91.
5 Henry TD, Tomey MI, Tamis-Holland JE, *et al*. Invasive management of acute myocardial infarction complicated by cardiogenic shock: a scientific statement from the American heart Association. *Circulation* 2021;143:e815–29.
6 Jacobs AK, Ali MJ, Best PJ, *et al*. Systems of care for ST-segment-elevation myocardial infarction: a policy statement from the American heart Association. *Circulation* 2021;144:e310–27.
7 Naidu SS, Baran DA, Jentzer JC, *et al*. SCAI SHOCK stage classification expert consensus update: a review and incorporation of validation studies. JSCAI 2022;1:100008.
8 O'Gara PT, Kushner FG, Ascheim DD, *et al*. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: a report of the American college of cardiology foundation/American heart Association task force on practice guidelines. *J Am Coll Cardiol* 2013;61:e78–140.
9 Lawton JS, Tamis-Holland JE, Bangalore S, *et al*. 2021 ACC/AHA/SCAI guideline for coronary artery revascularization: a report of the American college of cardiology/American heart Association joint committee on clinical practice guidelines. *Circulation* 2022;145:e4–17.
10 Perez P, Kimmoun A, Blime V, *et al*. Increasing mean arterial pressure in cardiogenic shock secondary to myocardial infarction: effects on hemodynamics and tissue oxygenation. *Shock* 2014;41:269–74.
11 Levy B, Clere-JehlR, LegrasA, *et al*. Epinephrine versus norepinephrine for cardiogenic shock after acute myocardial infarction. *J Am Coll Cardiol* 2018;72:2413.
12 Choi KH, Yang JH, Park TK, *et al*. Differential prognostic implications of vasoactive inotropic score for patients with acute myocardial infarction complicated by cardiogenic shock according to use of mechanical circulatory support. *Crit Care Med* 2021;49:770–80.
13 Wollmuth J, Korngold E, Croce K, *et al*. The Single-access for hi-risk PCI (ShiP) technique. *Catheter Cardiovasc Interv* 2020;96:114–6.
14 Thiele H, Akin I, Sandri M, *et al*. PCI strategies in patients with acute myocardial infarction and cardiogenic shock. *N Engl J Med* 2017;377:2419–32.
15 Thiele H, Akin I, Sandri M, *et al*. One-year outcomes after PCI strategies in cardiogenic shock. *N Engl J Med* 2018;379:1699–710.
16 Kolte D, Sardar P, Khera S, *et al*. Culprit vessel-only versus multivessel percutaneous coronary intervention in patients with cardiogenic shock complicating ST-segment-elevation myocardial infarction: a collaborative meta-analysis. *Circ Cardiovasc Interv* 2017;10:e005582.
17 Bates ER, Tamis-Holland JE, Bittl JA, *et al*. PCI strategies in patients with ST-segment elevation myocardial infarction and multivessel coronary artery disease. *J Am Coll Cardiol* 2016;68:1066–81.
18 Wood DA, Cairns JA, Wang J, *et al*. Timing of staged nonculprit artery revascularization in patients with ST-segment elevation myocardial infarction: COMPLETE trial. *J Am Coll Cardiol* 2019;74:2713–23.
19 Fuernau G, Desch S, de Waha-Thiele S, *et al*. Arterial lactate in cardiogenic shock: prognostic value of clearance versus single values. *JACC Cardiovasc Interv* 2020;13:2208–16.
20 Tehrani BN, Truesdell AG, Sherwood MW, *et al*. Standardized team-based care for cardiogenic shock. *J Am Coll Cardiol* 2019;73:1659–69.
21 Garan AR, Kanwar M, Thayer KL, *et al*. Complete hemodynamic profiling with pulmonary artery catheters in cardiogenic shock is associated with lower in-hospital mortality. *JACC Heart Fail* 2020;8:903–13.
22 Gaies MG, Gurney JG, Yen AH, *et al*. Vasoactive-inotropic score as a predictor of morbidity and mortality in infants after cardiopulmonary bypass. *Pediatr Crit Care Med* 2010;11:234–8.
23 Randhawa VK, Al-Fares A, Tong MZY, *et al*. A pragmatic approach to weaning temporary mechanical circulatory support: a state-of-the-art review. *JACC Heart Fail* 2021;9:664–73.
24 Beavers CJ, Dunn SP, DiDomenico RJ, *et al*. Bicarbonate-based purge solution during Impella support: a growing alternative. J Am Coll Cardiol2022;79:633.
25 Beavers CJ, DiDomenico RJ, Dunn SP, *et al*. Optimizing anticoagulation for patients receiving Impella support. *Pharmacotherapy* 2021;41:932–42.
26 Basir MB, Kapur NK, Patel K, *et al*. Improved outcomes associated with the use of shock protocols: updates from the national cardiogenic shock initiative. *Catheter Cardiovasc Interv* 2019;93:1173–83.
27 Mehran R, Rao SV, Bhatt DL, *et al*. Standardized bleeding definitions for cardiovascular clinical trials: a consensus report from the bleeding academic research consortium. *Circulation* 2011;123:2736–47.
28 Dehmer GJ, Badhwar V, Bermudez EA, *et al*. 2020 AHA/ACC key data elements and definitions for coronary revascularization: a report of the American college of cardiology/American heart Association task force on clinical data standards (writing committee to develop clinical data standards for coronary revascularization). *Circ Cardiovasc Qual Outcomes* 2020;13:e000059.
29 Truesdell AG, Tehrani B, Singh R, *et al*. 'Combat' approach to cardiogenic shock. *Interv Cardiol* 2018;13:81–6.
30 Lee F, Hutson JH, Boodhwani M, *et al*. Multidisciplinary code shock team in cardiogenic shock: a Canadian centre experience. *CJC Open* 2020;2:249–57.
31 Taleb I, Koliopoulou AG, Tandar A, *et al*. Shock team approach in refractory cardiogenic shock requiring short-term mechanical circulatory support: a proof of concept. *Circulation* 2019;140:98–100.