Title
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Journal
Journal of the American College of Emergency Physicians Open, 5(6)

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Publication Date
2024-12-01

DOI
10.1002/emp2.13321

Peer reviewed

Received: 29 February 2024 | Revised: 30 July 2024 | Accepted: 5 August 2024

DOI: 10.1002/emp2.13321

JACEP OPEN WILEY

CLINICAL CONCEPTS

Emergency Medical Services

Rationale and development of a prehospital goal-directed bundle of care to prevent rearrest after return of spontaneous circulation

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Supervising Editor: Juan March, MD

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Funding information
National Heart, Lung, and Blood Institute, Grant/Award Numbers: 1RO1HL117979, K38HL165363

Abstract

In patients with out-of-hospital cardiac arrest (OHCA) who attain return of spontaneous circulation (ROSC), rearrest while in the prehospital setting represents a significant barrier to survival. To date, there are limited data to guide prehospital emergency medical services (EMS) management immediately following successful resuscitation resulting in ROSC and prior to handoff in the emergency department. Post-ROSC care encompasses a multifaceted approach including hemodynamic optimization, airway management, oxygenation, and ventilation. We sought to develop an evidenced-based, goal-directed bundle of care targeting specified vital parameters in the immediate post-ROSC period, with the goal of decreasing the incidence of rearrest and improving survival outcomes. Here, we describe the rationale and development of this goal-directed bundle of care, which will be adopted by several EMS agencies within California. We convened a group of EMS experts, including EMS Medical Directors, quality improvement officers, data managers, educators, EMS clinicians, emergency medicine clinicians, and resuscitation researchers to develop a goal-directed bundle of care to be applied in the field during the period immediately following ROSC. This care bundle includes guidance for prehospital personnel on recognition of impending rearrest, hemodynamic optimization, ventilatory strategies, airway management, and diagnosis of underlying causes prior to the initiation of transport.

KEYWORDS
hemodynamic management, out of hospital cardiac arrest, oxygenation, post resuscitation care, prehospital emergency care, ventilation

1 | INTRODUCTION

Emergency medical services (EMS) management of patients with out-of-hospital cardiac arrest (OHCA) immediately following return of spontaneous circulation (ROSC) is a crucial and under-studied component of early cardiac arrest care. While reported rates of field ROSC are near 40%, survival and neurologically intact survival rates after OHCA remain low at approximately 9% and 7%, respectively.[1] Rearrest in the prehospital setting represents a significant barrier to survival, with up to 40% of patients who achieve ROSC experiencing a rearrest event prior to hospital arrival.[2–6] Prior work has shown that rearrest is independently associated with decreased survival and reduced rates of survival with good neurologic status.[3–6] Thus, optimization of recognition of impending rearrest, hemodynamics, oxygenation, and ventilation in the immediate post-ROSC period is critical to reduce the risk of rearrest and improve chances of survival.[5,6]

Current EMS protocols for post-ROSC care are heterogeneous, with the most common recommended interventions being to obtain a 12-lead electrocardiogram and administer vasopressors; few protocols offer guidance on the timing of post-ROSC stabilization and transport initiation.[7] The American Heart Association (AHA) 2020 Post-Resuscitation Care guidelines recommend prompt initiation of hemodynamic and ventilatory support to mitigate the systemic impacts of ischemia-reperfusion injury, as hypotension, hypoxia, and hyperventilation in the post-ROSC phase have all been found to be independently associated with worse outcomes after OHCA.[8–13] However, timing of these interventions is not specified and there is no direction on whether these should be performed prior to transport; similarly, clearly defined vital sign targets have not been established.[14] Multiple recent studies attempting to evaluate optimal blood pressure and oxygenation targets have yielded inconsistent results.[10,13,15–18] Given that most patients who rearrest do so within the first few minutes after ROSC, it is likely that interventions to prevent rearrest would be most effective if implemented by EMS in the immediate post-ROSC period and not delayed until ambulance transport or hospital arrival.[4]

We contend that instituting a goal-directed bundle of care in the immediate post-ROSC period, prior to transport, will decrease the incidence of rearrest and thereby improve patient survival outcomes. The recommendations of this bundle of care are limited to the clinical treatment thresholds and protocols outlined in this manuscript, which focus on the post-arrest period. EMS providers will follow their local EMS agency's protocols for cardiac arrest care, and equipment choices are left to the discretion of provider agencies. The California Resuscitation Outcomes Consortium (CAL-ROC) investigators aim to conduct a multicenter clinical trial in EMS systems across California to evaluate the impact of a prehospital goal-directed care bundle for post-ROSC treatment to be initiated on scene. The objective of this paper is to describe the rationale for, and development of, this goal-directed bundle of care

Clinical Research Perspective

- Among patients with out-of-hospital cardiac arrest who attain return of spontaneous circulation (ROSC), rearrest while in the prehospital setting represents a significant barrier to survival. We hypothesized that targeted interventions in the immediate post-ROSC period should be performed in the field to further stabilize patients and prevent rearrest prior to hospital arrival.
- We convened a diverse group of experts including emergency medical services (EMS) Medical Directors, emergency medicine clinicians, and resuscitation researchers to develop a goal-directed bundle of care to be applied in the field during the period immediately following ROSC, with the goal of preventing rearrest prior to hospital arrival.
- This care bundle, based on national and international guidelines, may be considered for adoption by EMS agencies and includes guidance for prehospital personnel on recognition of impending rearrest, hemodynamic optimization, ventilatory strategies, airway management, and diagnosis of underlying causes prior to the initiation of transport.

and to offer it as a protocol that can be adopted by other EMS agencies seeking to implement the most up-to-date evidence.

2 | RATIONALE

Hypotension, hypoxia, and hyperventilation have been strongly associated with decreased survival and worsened neurologic outcomes in patients with OHCA.[3–6] Rearrest is also well established to result in decreased survival and worsened neurologic outcomes.[3–6] Mechanistically, we believe that the prevention of hypotension, hypoxia, and hyperventilation will result in reduced rates of rearrest, and will in turn result in increased survival and increased survival with good neurologic outcomes. Based on current best practices and recommendations, we developed a post-ROSC goal-directed bundle of care that directly addresses each of these physiologic insults, presented in Figure 1 and supported by the evidence below. The recommendations made by the AHA/American College of Cardiology (ACC), European Resuscitation Council and European Society of Intensive Care Medicine, and the International Liaison Committee on Resuscitation (ILCOR) provide the foundation for the development of this bundle of care and are summarized in Table 1. There are many other important and active areas of ongoing research in cardiac arrest management, including the use of cardiopulmonary resuscitation (CPR) assistance devices, targeted temperature management in the field, and post-arrest management after a transfer of care in the ED, among many other areas of active investigation. This bundle does not directly support or reject any of these interventions. This bundle applies to adults (≥18yearold) with OHCA, as the management of pediatric cardiac arrest strategies, including treatment thresholds, differ for pediatric as opposed to adult patients. The evidence for the bundle components is further described in the following sections.

3 | METHODS

The goal of this endeavor was to develop and present a standardized OHCA bundle of care within the CAL-ROC consortium based on currently published national and international guidelines and expert opinion. We used an iterative method during once-weekly CAL-ROC video conference calls (from December 2022 through February 2023) to develop the Stabilize on Scene (SOS)-bundle. Stakeholders from EMS agencies and experts in the pre-hospital treatment of OHCA self-identified from leadership positions within the CAL-ROC consortium, including EMS Medical Directors, quality improvement officers, data managers, educators, EMS clinicians, emergency medicine clinicians, and resuscitation researchers. The same group of stakeholders and experts were present and involved throughout the process of developing this bundle of care. Initial meetings were open-ended and targeted toward identifying potential components of the SOS-bundle that should be standardized. For each component that was identified, the available evidence was then gathered and discussed in working groups until a consensus was reached for the specific action, target, triggers, and interventions to be included in the bundle. These recommendations were then brought back to the larger group and edited in an iterative process until the bundle as a whole was finalized via unanimous support of all authors (Figure 1). Ultimately, there were four components of the bundle: hemodynamic optimization, ventilation and oxygenation, airway management, and ST-elevation myocardial infarction (STEMI) identification. The study was deemed not human subjects research per each institution's Human Research Protection Program.

3.1 | Circulation: Hemodynamic optimization

Hypotension in the post-ROSC period is common and is associated with poor neurologic outcomes and higher mortality.[6,8,10,11,19–22] Nearly 40% of patients with ROSC experience rearrest, and post-ROSC hypotension is associated with a higher risk of rearrest and decreased survival.[2,4] Hypotension may also be harmful in a dose-dependent mechanism, as longer periods of hypotension and lower blood pressures are both associated with higher mortality.[8]

The association between poor perfusion and worse outcomes among patients with ROSC is well established, and blood pressure management is recommended across multiple guidelines.[23–26] While most of these data are from observational studies, there is emerging evidence that the avoidance or prompt treatment of post-ROSC hypotension may be beneficial.[22,27] Interventions to address hypotension may help reduce the risk of rearrest or otherwise improve patient outcomes.

CAL-ROC SOS BUNDLE

CIRCULATION

HEMODYNAMIC OPTIMIZATION

GOAL = AVOID HYPOTENSION

Actions	Trigger
Assess BP q3min	All
Administer NS Bolus 500mL	All
Prepare push-dose epinephrine	All
Administer push-dose epinephrine	SBP<120mmHg
Repeat NS Bolus 500mL	Persistent SBP<120mmHg
Repeat push-dose epinephrine	Persistent SBP<120mmHg

STEMI IDENTIFICATION

GOAL = IDENTIFY STEMI & DYSRHYTHMIAS

Actions	Trigger
Continuous cardiac rhythm monitoring	Focused assessment q3mins or if clinical deterioration
Obtain and transmit 12-lead ECG	All

AIRWAY

AIRWAY MANAGEMENT

GOAL = SECURE AIRWAY

Actions	Trigger
Place Advanced Airway*	If BVM ineffective or after HD optimized and prior to transport
Confirm airway with $EtCO_2$	All

BREATHING

VENTILATION AND OXYGENATION

GOAL = AVOID HYPER/HYPOVENTILATION

Actions	Trigger
Initiate ventilations at 10 BPM	All
Continuous EtCO2 and SpO2 monitoring	Focused assessment q3mins or if clinical deterioration
Target $EtCO_2$ 35-45mmHg	All
Target SpO_2 94-98%	All

FIGURE 1 The California Resuscitation Outcomes Consortium (CAL-ROC) stabilize on scene (SOS) post-return of spontaneous circulation (post-ROSC) goal-directed bundle of care. Summary of the interventions and events or physiologic thresholds to trigger each intervention.

TABLE 1 Society and California Resuscitation Outcomes Consortium (CAL-ROC) guidelines for post-return of spontaneous circulation (post-ROSC) goals of care.

	American College of Cardiology/American Heart Association	European Resuscitation Council and European Society of Intensive Care Medicine	International Liaison Committee on Resuscitation	CAL-ROC SOS-bundle
Airway	Early placement of endotracheal tube	Intubate unless immediate return of cerebral function[a] Supraglottic airway if no experienced intubator	Insert advanced airway	Intubate or supraglottic airway per local protocol
Oxygenation	100% FiO_2 then titrate to 92%–98% when able	100% FiO_2 until able to measure; then SpO_2 94%–98%	100% oxygen until reliable measurement of oxygen level is possible, then avoid hypoxia and hyperoxia	100% FiO_2; when able to reliably measure, titrate FiO_2 to SpO_2 94%–98%
Ventilation	$PaCO_2$ 35–45 mm Hg	$PaCO_2$ 35–45 mmHg	Normocapnia, possible mild hypercapnia[b]	$EtCO_2$ 35–45 mmHg
Blood pressure	SBP > 90 mmHg MAP > 65 mmHg	MAP ≥ 65 mmHg Fluids, noradrenaline, and/or dobutamine depending on individual patient need for intravascular volume, vasoconstriction or inotropy	SBP > 100 mmHg	SBP ≥ 120 mmHg

Abbreviations: FiO_2, fraction of inspired oxygen; MAP, mean arterial pressure; $PaCO_2$, partial pressure of carbon dioxide; SBP, systolic blood pressure; SpO_2, peripheral oxygen saturation; SOS, Stabilize on Scene.

[a]Patients who have had a brief period of cardiac arrest and an immediate return of normal cerebral function and are breathing normally may not require tracheal intubation but should be given oxygen via a facemask if their arterial blood oxygen saturation is less than 94%.

[b]Per ILCOR, "These variations in methodology and in definitions of target ranges prohibit the task force from being able to recommend specific numbers."

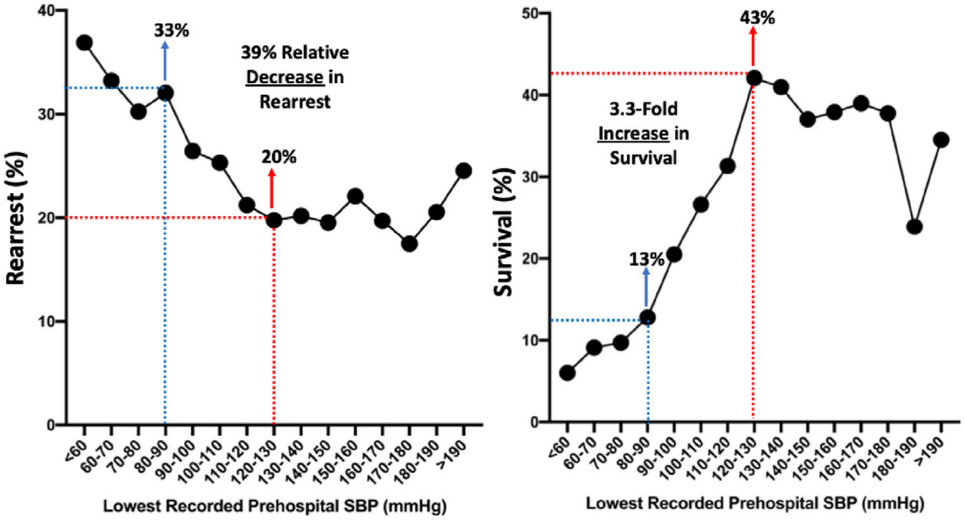

FIGURE 2 Rates of rearrest and survival in out-of hospital cardiac arrest by lowest recorded systolic blood pressure. Blue dotted line correlates with a systolic blood pressure (SBP) of 90 mmHg. Red dotted line correlates with a SBP of 120 mmHg. Adapted with permission from Smida et al.[8]

There remains some uncertainty over which blood pressure thresholds to target, as there are mixed results for different blood pressure targets.[15,25,28,29] The most recent AHA guidelines recommend maintaining systolic blood pressure (SBP) above 90 mmHg and a mean arterial pressure (MAP) above 65 mmHg.[14] Since hypotension is often defined as a SBP < 90 mmHg, this is frequently selected as an arbitrary binary threshold in outcome studies, which inform clinical guidelines, but the optimal threshold remains unknown. To date, randomized trials exploring higher blood pressure targets have not consistently demonstrated significant changes in survival, though higher blood pressure has been associated with better outcomes.[15–18,30,31] One observational study of prehospital data suggested an improved prognosis with an SBP target between 100 and 130 mmHg[10]; a separate study demonstrated that maintaining SBP at 120 mmHg or above compared to a SBP below 90 mmHg as a trigger for action resulted in a 39% relative decrease in the incidence of rearrest and a 3.3-fold increase in survival (Figure 2).[8]

These findings are analogous to the evolving evidence for the prehospital care of patients with traumatic brain injury. The most recent guidelines for prehospital management of traumatic brain injury, which previously recommended a threshold of 90 mmHg, have increased the target SBP to ≥110 mmHg and new research suggests this threshold should be even higher.[32] Patients resuscitated from cardiac arrest have the additional complication that a precipitous drop in blood pressure frequently occurs soon after ROSC as exogenous adrenaline is metabolized.[22] Initiating treatment at a threshold of 90 mmHg will most often result in a period of marked hypotension prior to the patient's response. Therefore, a higher target seems appropriate.

Given the balance of evidence demonstrating potential benefit without data to suggest increased harm, and given the finding that rearrest is often preceded by a dropping blood pressure, the SOS-bundle uses an SBP cutoff of 120 mmHg for the initiation of vasopressor support. The SOS-bundle will standardize the approach to preventing and addressing hypotension through a combination of intravenous fluids and early vasopressor administration. To prevent hypotension, all post-ROSC patients will be given a 500 mL bolus of crystalloid unless they have contraindications (eg., heart failure with signs of volume overload). Early detection will be facilitated by regular and frequent blood pressure checks (every 3 min), and early treatment will be facilitated by the routine (i.e., regardless of post-ROSC blood pressure) preparation of push-dose epinephrine (adrenaline) per local EMS agency protocol for all patients, in parallel with the fluid bolus. Patients with SBP <120 mmHg after the initiation of the fluid bolus will be treated with push-dose epinephrine, with repeat doses titrated to maintain SBP. If the pressure is below the SBP threshold after the initial fluid bolus is complete, a second 500 mL bolus will be given, with a maximum total volume of 1000 mL. Push-dose epinephrine will be continued as needed every 1–5 min as needed until handoff of care in the ED. We note that EMS agencies implementing this bundle may choose to modify specific factors such as the dose and frequency (or even the SBP trigger or vasopressor selection) or may use a vasopressor infusion to achieve the same goals. We maintain that early targeted hemodynamic support is critical to preventing rearrest and improving outcomes and should be included in the post-ROSC bundle of care in some form.

3.2 | Circulation: STEMI identification

Cardiac arrest may be caused by coronary occlusion that would benefit from urgent percutaneous coronary intervention (PCI).[33,34] EMS providers in the United States routinely use 12-lead electrocardiograms (ECGs) to identify patients with ST-segment elevation myocardial infarction in order to direct immediate field management and selection of the appropriate PCI-capable destination facility. In addition to those patients exhibiting STEMI on their ECGs, nearly one-third of patients that achieve ROSC have coronary lesions that would benefit from PCI even when not exhibiting a definitive STEMI.[35]

Post-ROSC patients with ECGs exhibiting ischemia benefit from direct transport to hospitals with emergency PCI capability.[36] In addition to obtaining the 12-lead ECG and paramedic interpretation, the ECG should be transmitted to an appropriate receiving facility EM physician. This has been shown to increase diagnostic accuracy and diminish delays to initiation of interventional treatment and reduction in infarct size, which may result in improved functional recovery upon discharge of post-cardiac arrest patients.[37,38]

The optimal time to obtain the ECG during post-ROSC care is still under investigation.[36] Some research suggests that waiting 8 min after obtaining ROSC before performing a 12-lead ECG will more accurately reflect a true STEMI event due to the possibility of false-positive STEMI patterns that are due to cardiac arrest ischemia rather than coronary artery occlusion.[39] Furthermore, there are data that suggest repeated ECGs and rhythm checks are more likely to pick up STEMIs in chest pain patients than a single ECG (at least 8% in one study), suggesting that serial monitoring may be more useful than a single diagnostic snapshot.[40]

Based on these data, we conclude that obtaining a 12-lead ECG and transmitting it to the appropriate receiving facility emergency medicine physician is an important part of the SOS-bundle. Acknowledging the lack of definitive data for timing of the ECG during post-ROSC care, the SOS-bundle recommends that the ECG is obtained after ROSC while still on scene. In addition to obtaining a 12-lead ECG, patients will be placed on continuous cardiac monitor to monitor for dysrhythmias.[40] Ideally patients post-ROSC would be transported to a PCI-capable facility based on local resources and policies.

3.3 | Airway: Airway management

Effective airway management to support oxygenation and ventilation in patients with OHCA is critical to post-ROSC stabilization and survival.[41–44] How this is accomplished, including by what technique and device, remains controversial.[44–48] Classic teaching regarded intubation as the gold standard for cardiac arrest; however, recent studies and guidelines emphasize the importance of provider experience over specific modalities for best outcomes.[49] When comparing bag-valve-mask (BVM) use, supraglottic insertion, or endotracheal intervention, studies show conflicting data for which approach is most successful, and this difference is generally linked to provider experience, training, and preference rather than to the intervention itself.[50,49]

Importantly, relying on BVM alone presents significant challenges to maintaining effective oxygenation, which is made even more difficult during patient movement and ambulance transport.[51] Further, an advanced airway facilitates more consistent and accurate measures of $EtCO_2$ to apply the ventilation target. Thus, the SOS-bundle recommends placement of a supraglottic device or endotracheal tube prior to transport, according to local guidelines and EMS provider experience. Additionally, the SOS-bundle follows current best practices, stating that patients should be preoxygenated and every effort made to allow for best first past success, with concurrent use of passive oxygenation with nasal cannula when possible.[52] Advanced airway placement will be confirmed by $EtCO_2$ and continuous capnography monitoring will take place to ensure early detection of displacement.

3.4 | Breathing: Oxygenation

Hypoxia is both a symptom of and a cause of cardiac arrest; if not reversed quickly it contributes to decreased survival and poor neurological outcomes.[53–55] Because of this clear association, guidelines recommend 100% oxygen for post-ROSC patients until SpO_2 can be measured, at which time oxygen delivery should be titrated down to avoid the incidence of hyperoxia and its associated harms.[5,50,56,57]

Current guidelines for post-resuscitation care advocate the targeting of normoxia for post-ROSC oxygenation.[56] Normoxia range is defined as 94%–98% as per the European Resuscitation Council (ERC) and 92%–98% as per the AHA.[24,25,56] Evidence in favor of these ranges is still evolving. The recently published Reduction of Oxygen After Cardiac Arrest (EXACT) trial is the first trial conducted in the prehospital setting comparing the standard oxygen saturation target of 98%–100% measured by colorimetric pulse oximetry to a treatment strategy targeting 90%–94%.[13] This study showed a higher likelihood of survival for patients with the higher oxygen goal. Importantly, use of a lower pulse oximetry target has potential to perpetuate disparities in survival from OHCA due to overestimation of arterial oxygenation in dark complexion patients because pulse oximetry can read falsely high in patients with darker skin.[58]

While further studies are warranted, the current evidence supports titrating oxygen in post-ROSC patients in the prehospital setting to avoid both hypoxia and hyperoxia.[54,55,50] Acknowledging a lack of definitive evidence on target SpO_2 range, the SOS-bundle adopts the ILCOR range of 94%–98%, rather than the lower AHA range, because this threshold could (i) help buffer against brief periods of hypoxia that may be more common when using 92% as a lower threshold and (ii) protect against hypoxia in patients with darker skin with falsely high pulse oximetry measurements. In patients with unreliable SpO_2 measures or other deteriorating vital signs, a 100% FiO_2 will be administered, with titration per the SOS-bundle protocol if monitoring is adequate or patient clinical condition subsequently improves.

3.5 | Breathing: Ventilation

Hyperventilation has been recognized as an important cause of poor outcomes in cardiac arrest patients for almost two decades.[59,60] The potential harms of hyperventilation include overinflation of the lungs resulting in barotrauma, air trapping, increased intra-thoracic pressure, decreased central venous return, and decreased cardiac output, as well as risk of coronary artery constriction, cerebral artery constriction, and gastric insufflation.[60–64] These complications can be caused by either excessive volume and/or and excessive rate of assisted ventilations.

TABLE 2 Mitigation of hyperventilation with control of ventilation rate and volume.

Intervention	Helps control rate	Helps control tidal volume delivered
Strategy		
Education and training (i.e., "Squeeze, release, release", simulation-based training with feedback)	X	X
Synchronous compression to ventilation ratio	X	
Guiding ventilation to compression count	X	
Devices		
Auditory and visual prompt devices (e.g., metronomes and rate timing lights)	X	
Using smaller resuscitator volume bag-mask devices (e.g., pediatric vs. adult bag device)		X
Capnography	X	
Thoracic impedance waveform	X	
Ventilation feedback flowmeters	X	X
Mechanical ventilation	X	X

Source: Adapted from tab. 1 (Carlson et al.[61,p.57]).

This harm can occur in the initial cardiac arrest management and/or in post-arrest care.

Until recently, the importance of adult cardiac arrest ventilation and its potential benefits and risks have not been emphasized in training of EMS personnel.[60,61] In practice, assisted ventilation during resuscitation—both intra-arrest and post-ROSC—often exceeds these parameters.[24,60,62,65–67] Current strategies to avoid intra-arrest hyperventilation emphasize using synchronous compression-to-ventilation ratios.[14,26,68] Several supplemental approaches to optimizing ventilation have also been evaluated, with provider education and training strategies having been shown to assist in appropriate patient ventilation (Table 2).[61] For example, CPR metronome training has shown benefit in avoiding over-ventilation, while simulation training shows promise in minimizing deviance from AHA guidelines and training EMS clinicians to state "squeeze" just until chest rise is initiated and then state "release, release" to allow time for exhalation may control both rate and volume.[69–71] Equipment-based strategies to limit excessive tidal volumes have also been examined, including volume-restricted bags (e.g., using pediatric-sized BVMs in adult patients) and BVM flowmeters.[61,72] While conceptually promising, evidence of benefit of such devices at this time is mostly limited to simulation settings.[72] Relatedly, guidelines do not offer instruction on post-ROSC ventilation mechanism, and manual or mechanical ventilation will be used according to local practice.

As with intra-arrest care, training and equipment-based strategies to minimize hyperventilation in the post-ROSC period are conceptually appealing but not well studied in field settlings. Real-time monitoring of ventilation quality in cardiac arrest resuscitation is usually assessed using end-tidal carbon dioxide ($EtCO_2$) measurement, with a standard post-ROSC target of normocapnia ($EtCO_2$ between 35 and 45 mmHg).[14] $EtCO_2$ is also frequently used to evaluate correct advanced airway.[14] Despite the common use of $EtCO_2$, it is not universally available and, when available, several challenges in using $EtCO_2$ to guide ventilation strategies remain.[61,65] Varied etiologies of cardiac arrest, resuscitation duration, use of vasoactive medications and sodium bicarbonate, and oscillations caused by chest compressions may result in changes in the pattern and values of $EtCO_2$, which make any single value or waveform difficult to determine the quality of the ventilation.[73] Newer strategies to mitigate these factors include use of waveform algorithms to better detect the presence of ventilation; however, these programs are not currently widely used.[74,75] Despite its shortcomings, $EtCO_2$ is still used as the reference standard for ventilation monitoring in the field during cardiac arrest and post-ROSC care.

Of note, several trials of hypercapnia during the post-ROSC phase of cardiac arrest (PCO_2 50–55 mmHg) have showed some promise in adult patients admitted to the intensive care unit.[76,77] However, in a systematic review by Holmberg et al., of seven trials and 36 observational studies evaluating oxygenation and ventilation targets after cardiac arrest, point estimates from these trials favored normocapnia, and a more recent randomized trial found no benefit to mild hypercapnia.[77,41,42]

The SOS-bundle incorporates current post-ROSC guidelines of starting with a minimum of 10 ventilations per minute and titrating the rate to a target $EtCO_2$ of normocapnia (35–45 mmHg). While acknowledging ongoing research regarding the accuracy of $EtCO_2$ in providing real-time feedback on adequate ventilation during post-ROSC care and evolving evidence regarding $EtCO_2$ targets, we have chosen to include normocapnic $EtCO_2$ targets in the SOS-bundle as it is the current reference standard method for assessing patient response to ventilation in the field.

4 | CONCLUSION

The goal-directed bundle of care presented here was developed by iterative consensus by the CAL-ROC, with the intended therapeutic goals of preventing hypotension, hypoxia, and hyperventilation in patients with ROSC following out-of-hospital cardiac arrest, and the intended outcome goals of reducing rearrest and improving survival and good neurologic outcomes. Although post-arrest management of these parameters is an evolving field, with ongoing evaluations of association and causality, our protocol incorporates the most up-to-date evidence and guidelines and is refined by expert opinion. While details regarding optimal management remain to be determined, our focus herein is to establish early goal-directed management to stabilize patients and prevent further physiologic insults. We believe that this bundle should be initiated in the immediate post-ROSC period and prior to transport in order to maximize the chances of preventing decompensation and rearrest. Our future work will implement this bundle across multiple sites to measure feasibility of implementation, success in bundle targets, and—most importantly—improvements in patient outcomes.

AUTHOR CONTRIBUTIONS

Conceptualization: Nichole Bosson, Joelle Donofrio-Odmann, Marianne Gausche-Hill, Juan Carlos C. Montoy, and James J. Menegazzi. *Investigation*: All authors. *Methodology*: Nichole Bosson, Joelle Donofrio-Odmann, Marianne Gausche-Hill, Juan Carlos C. Montoy, and James J. Menegazzi. *Roles/writing—original draft*: all authors. *Writing—review and editing*: All authors. All authors contributed to the conception and design of the study, drafted portions of the article and provided it critical revisions for important intellectual content, give final approval of the version to be submitted, and agree to be accountable for all aspects of the work.

ACKNOWLEDGMENTS

We would like to thank the following CAL-ROC members for their support of this project: Joanny All, Peter Benson, Christian Bey, Lily Choi, Rosie Christ, Chris Coyne, Leslie Duke, Anthony Fabio, Catherine Farrokhi, Erica Garcia, Hernando Garzon, Gagandeep Grewal, Antonio Gumucio, Loreen Gutierrez, Caroline Jack, Chris Kahn, Kristi Koenig, Lisa Madrid, Tammi McConnell, Kenneth Miller, Daniel Nishijima, Sara Rasnake, John Rose, David Salicido, Daniel Shepherd, Pranav Shetty, Joshua Smith, Carl Schultz, and Reza Vaezazizi. The authors declare that all methods are available within the article; all supporting data are available in the cited references.

CONFLICT OF INTEREST STATEMENT

James J. Menegazzi was supported in part by a grant from the National Heart, Lung, and Blood Institute, National Institutes of Health (NHLBI 1RO1HL117979-01) and David G Dillon was supported in this work by NHLBI grant K38HL165363. They have three patents issued and has been loaned equipment for use in his lab. These are described in more detail in his conflicts of interest form. The other authors declare no conflicts of interest.

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How to cite this article: Dillon DG, Montoy JCC, Bosson N, et al. Rationale and development of a prehospital goal-directed bundle of care to prevent rearrest after return of spontaneous circulation. *JACEP Open*. 2024;5:e13321.
https://doi.org/10.1002/emp2.13321