ABSTRACT: The American Heart Association previously recommended implementation of cardiac resuscitation systems of care that consist of interconnected community, emergency medical services, and hospital efforts to measure and improve the process of care and outcome for patients with cardiac arrest. In addition, the American Heart Association proposed a national process to develop and implement evidence-based guidelines for cardiac resuscitation systems of care. Significant experience has been gained with implementing these systems, and new evidence has accumulated. This update describes recent advances in the science of cardiac resuscitation systems and evidence of their effectiveness, as well as recent progress in dissemination and implementation throughout the United States. Emphasis is placed on evidence published since the original recommendations (ie, including and since 2010).

Cardiac arrest is loss of mechanical activity of the heart confirmed by the absence of signs of circulation.1 Approximately 356,461 people are treated for out-of-hospital cardiac arrest (OHCA) annually in the United States.2 One third of cases occur without any prior recognized heart disease; half occur without any prodromal symptoms.3 Despite robust systems of care for patients with trauma and rapidly evolving systems of care for patients with ST-segment-elevation myocardial infarction (STEMI) and stroke, the majority of communities do not achieve optimal survival after OHCA because of large discrepancies in resuscitation-related processes of care.4-6 As a result, survival to hospital discharge varies significantly both across different regions and by presenting rhythm.7,8

Survival increases significantly if the OHCA is quickly recognized and responded to with prompt activation of 9-1-1, bystander-initiated cardiopulmonary resuscitation (CPR), bystander and/or basic first responder application of an automated external defibrillator (AED) before arrival of other emergency medical services (EMS) providers on scene, advanced life support, and postresuscitation care.9

The American Heart Association (AHA) previously recommended implementation of cardiac resuscitation systems of care that consist of interconnected community, EMS, and hospital efforts to measure and improve the process and outcome of care for patients with cardiac arrest.10 Simultaneously, the AHA proposed a national process to develop and implement evidence-based guidelines for the implementation and measurement of such systems. The 2015 AHA guidelines for CPR and emergency cardiovascular care delved deeper into the elements of an effective system of care for both OHCA and in-hospital cardiac arrest.11 This update on OHCA resuscitation systems of care describes recent advances, evidence...
of their effectiveness, and recent progress in their dissemination and implementation throughout the United States. Emphasis is placed on evidence published since the original recommendations (ie, including and since 2010).

**MISSION: LIFELINE RESUSCITATION PROGRAM**

The initial call to implement cardiac resuscitation systems deliberately did not specify how such systems should be implemented. In subsequent deliberations about how to implement and maintain cardiac resuscitation systems of care, experts recognized that many patients resuscitated from OHCA have STEMI or STEMI equivalent and require emergent angiography with primary percutaneous coronary intervention (PCI). Centers providing comprehensive, evidence-based care for cardiac arrest need to be capable of providing PCI 24 hours a day, 7 days a week. Furthermore, experts recognized that insufficient resources are available to support acute cardiovascular care delivery and quality improvement. With this understanding, a strategic decision was made to integrate cardiac resuscitation systems of care with STEMI systems of care under the AHA’s Mission: Lifeline program. Mission: Lifeline is the AHA’s initiative to develop and improve systems of care for high-risk, time-sensitive conditions. The percentage of the United States covered by a Mission: Lifeline—registered cardiac resuscitation system lags significantly behind the STEMI system coverage (Figure).

**DISSEMINATION OF RESUSCITATION SYSTEMS OF CARE**

Since 2010, many municipalities and regions have continued or begun to implement cardiac resuscitation systems modeled on prior experience implementing and maintaining similar interconnected systems for patients with traumatic injury, STEMI, and acute stroke. To assist in the evolution of regional resuscitation systems of care, several national organized efforts have emerged, including Mission: Lifeline, and the HeartRescue Project. Each of these initiatives is intended to facilitate implementation of evidence-based treatments across the continuum of care delivery and to establish an interconnected community, EMS, and hospital response to improve cardiac arrest outcomes. These programs are still early in their implementation, and evaluations of impact and success of these initiatives are ongoing.

In the description of these developing systems, it is important to distinguish between resuscitation referral centers, resuscitation centers, and regional resuscitation systems of care. The first is a hospital that receives patients with cardiac arrest from ≥1 EMS agencies but does not meet the criteria for a resuscitation center. Resuscitation centers provide a designated set of specialized services for patients with cardiac arrest. Regional resuscitation systems of care are interconnected community, EMS, and hospital efforts across an entire region to improve care for patients with cardiac arrest. Complicating the landscape, some institutions have designated themselves as resuscitation centers without necessarily integrating into a local, regional, or statewide system of care. In many cases, the development of specialized resuscitation centers is an important first step in that they have demonstrated improved outcomes with the implementation of evidence-based guidelines and resource allocation. A resuscitation referral hospital will have demonstrated the ability to safely transfer patients with return of spontaneous circulation (ROSC) after cardiac arrest to specialized receiving facilities. The referred patient should demonstrate similar survival with good neurological outcome despite any differences in time from onset of arrest to hospital arrival. Local politics, geography, EMS coverage, and hospital affiliations may complicate the landscape and remain challenges to true regional integration. Although resuscitation referral centers are an important step, the evolution to a regional system of care requires full integration of all community stakeholders, which may include survivors, family members, civic groups, businesses, the 9-1-1 dispatch system, EMS providers, healthcare providers, hospitals, public health entities, rehabilitation centers, payers, and municipal governments.

**LOCAL IMPLEMENTATION**

In selected counties from North Carolina that participated in the HeartRescue program, there were efforts to increase training of laypeople on how to perform bystander CPR, to provide dispatcher/telecommunication instructions for CPR, and to improve layperson and first responder use of AEDs. All of these were done as components of the implementation of a cardiac resuscitation system of care. This significantly improved survival after OHCA compared with a historical control period in those counties. Analysis demonstrated that this improvement was associated with improved rates of bystander CPR and early defibrillation.

In a large metropolitan area in the United States with an already established regional STEMI system of care, an EMS protocol was implemented to transport patients with OHCA with an initial shockable rhythm and with field ROSC to a specialized STEMI receiving center. The center used a protocol to induce therapeutic hypothermia after resuscitation and was associated with a 40% rate of cerebral performance category 1 or 2 at hospital discharge compared with a 6% rate with historical controls (2001) at the same institution. Use
CLINICAL STATEMENTS
AND GUIDELINES

of therapeutic hypothermia was associated with significantly greater favorable neurological status compared with no hypothermia (adjusted odds ratio [OR] for survival with good neurological recovery [cerebral performance category 1 or 2], 2.0; 95% confidence interval [CI], 1.2–3.5; \( P = 0.01 \)).

In the same large metropolitan area, treatment of patients with STEMI complicated by OHCA that included therapeutic hypothermia, early coronary angiography, and PCI was associated with better outcome after an initial shockable rhythm than after a nonshockable rhythm (risk ratio, 2.7; 95% CI, 1.1–6.8).

In a large metropolitan area in the United Kingdom, patients with STEMI complicated by OHCA who were resuscitated and then transported to a specialist STEMI center for angiography and selective PCI had a high rate of survival (66%).

In a secondary analysis of data from a multicenter randomized trial of field interventions in patients with OHCA, use of hospital-based intervention was observed but not mandated or randomly allocated. Rates of early coronary catheterization (19.2%), coronary reperfusion (17.7%), and induced hypothermia (39.3%) varied among hospitals and were higher in hospitals treating more patients per year. Odds of survival to discharge and favorable neurological status at discharge (ie, modified Rankin Scale score <3) increased with hospital volume (per every increase by 5 subjects per year: OR, 1.06; 95% CI, 1.04–1.08; and OR, 1.06; 95% CI, 1.04–1.08, respectively). Survival and favorable outcome were independently associated with early coronary angiography (OR, 1.69; 95% CI, 1.06–2.70; and OR, 1.87; 95% CI, 1.15–3.04), coronary reperfusion (OR, 1.94; 95% CI, 1.34–2.82; and OR, 2.14; 95% CI, 1.46–3.14), and therapeutic hypothermia (OR, 1.36; 95% CI, 1.01–1.83; and OR, 1.42; 95% CI, 1.04–1.94), although these analyses may be limited by survivor bias and unmeasured confounders.

STATEWIDE IMPLEMENTATION

Increasing experience with the development of cardiac arrest centers followed by EMS integration and devel-
opment of regional referral centers continues to result in improved outcomes for patients with OHCA.

In 2007, Arizona rolled out a statewide model of regionalizing postarrest care that included state-recognized cardiac receiving centers, implementation of postarrest care focused on therapeutic hypothermia, emergent coronary angiography, and delayed prognostication of neurological status, along with an EMS bypass protocol triaging comatose, postarrest patients with OHCA with ROSC to the closest recognized cardiac arrest center. Arizona reported that implementation of a cardiac receiving center system resulted in a dramatic survival increase from 21.4% (21 of 98) to 39.2% (115 of 293; adjusted OR, 2.96; 95% CI, 1.63–5.38) and that cerebral performance category 1 or 2 on hospital discharge increased from 19.4% (19 of 98) to 29.8% (87 of 292; adjusted OR, 2.12; 95% CI, 1.14–3.93). Collectively, these initial reports of the impact of local and statewide implementation of cardiac resuscitation systems of care suggest that such implementation of systems directing appropriate postarrest patients to specialty centers improves both the process of care and outcomes.

**MEASUREMENT AND FEEDBACK**

A foundation for any quality improvement program is the collection and feedback of data in a way that can be useful to guide implementation and refinement. Currently available systems include the Cardiac Arrest Registry to Enhance Survival, the National EMS Information System registry, the Resuscitation Outcomes Consortium program, statewide programs such as Save Hearts in Arizona Registry and Education, and regional or local databases. These systems provide robust platforms for internal benchmarking and process improvement activities.

**LINKS IN THE CHAIN**

**Bystander CPR and Public-Access Defibrillation**

Broad community-based campaigns have increased the use of CPR and survival after OHCA. In areas where such campaigns have been conducted over a sustained period of time, the majority of citizens in these select communities report that they have been trained in CPR at some point in their life. Furthermore, data from the Cardiac Arrest Registry to Enhance Survival demonstrate that both bystander CPR and AED use have significant direct impacts on improving survival. Currently, bystander AEDs are applied to 4% of patients with OHCA. Predictive modeling suggests that if all OHCA had bystander AED use, survival would increase from 9% to 14%. For witnessed arrest, survival would increase from 16% to 29%. Unfortunately, these improvements are not universal; underserved communities appear to have significantly lower rates of CPR training than their counterparts throughout the United States.

Neighborhoods composed of lower-income black residents, compared with higher-income white residents, are 51% less likely to have someone perform CPR. Rates of bystander CPR also vary significantly by neighborhood characteristics, with observed outcomes ranging from community to community. Furthermore, growing evidence suggests that low-socioeconomic-level communities might be particularly appropriate targets for community-based CPR education and awareness campaigns.

**Telephone CPR**

An integral but sometimes incompletely implemented aspect of emergency first response is delivery of CPR instructions via the 9-1-1 system, which plays a pivotal role in bridging lay rescuers and trained EMS providers. The 9-1-1 system can play a key role if the telecommunication staff are well trained and experienced in identifying suspected cardiac arrest and providing telephone CPR instructions to callers. Simplified protocols and guidelines improve both the rates of bystander CPR and the time to initiation. This novel aspect of the resuscitation system should be measured, compared with benchmarks, and then improved as needed. When these aspects of telephone CPR were combined as part of a statewide public health initiative in Arizona, significant improvements in the percentage of CPR instructions given, time to first chest compression, bystander CPR, and survival were found.

**EMS Response**

A highly-trained and well-equipped team of prehospital providers is a critical component for the ideal resuscitation system of care. Application of an AED by a layperson before the arrival of EMS providers on scene, briefer time from the call for assistance to the arrival of EMS providers on scene (ie, response time interval), and better quality of CPR are associated with improved outcomes.

Simultaneous or “dual dispatch” activation of first responders with AEDs in conjunction with ALS units...
Referring and Receiving Facilities

The AHA model for cardiac resuscitation systems identifies 2 different levels of resuscitation centers: level I and II (Table 1). Although recognition of level I resuscitation centers of expertise makes sense, it is logical for all hospitals in a region to seek and achieve accreditation as a level II resuscitation center even if they are to be bypassed when an ambulance is transporting a patient with OHCA who has achieved ROSC to a level I center. This is important because some patients will experience cardiac arrest in hospital or may arrive at the emergency department by some means other than EMS ambulance. In either case, each hospital should have the ability to initiate advanced post-ROSC care to include induction of targeted temperature management (TTM), cardiopulmonary stabilization, and potential transfer to a level I facility. Such regionalization of resuscitation care is already in place and is serving as a model for the establishment of similar systems throughout the United States. 10,24,31,69–71

A PCI center is an ideal candidate to become a level I resuscitation center because it can provide comprehensive cardiovascular care, including primary PCI, for the ≈25% of patients who experience their OHCA in the setting of an acute STEMI. However, although STEMI and stroke centers provide a solid initial framework, both involve a single-organ system, not the multisystem insult experienced by most patients with OHCA. Therefore, such hospitals may lack the multidisciplinary team and resources required to provide optimal care to the postarrest patient. For a hospital seeking accreditation as a level I resuscitation center, an important prerequisite should be to first demonstrate the need for an additional resuscitation center and the impact that it would have on the community’s regional plan for patients with OHCA. For most urban and suburban areas where ambulance transport times from the scene to hospital are not unduly long, it is reasonable to bypass the closest hospital and bring the patient directly to a level I center because survival is not significantly affected by transport interval. 72,73

Table 1. Resuscitation Center Criteria

<table>
<thead>
<tr>
<th>Level I</th>
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<tbody>
<tr>
<td>Must meet all requirements of an STEMI receiving center</td>
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<tr>
<td>Is a designated hospital champion for cardiac resuscitation</td>
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<tr>
<td>Actively participates in multidisciplinary group to monitor, provide feedback, and improve cardiac resuscitation process and outcome</td>
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<tr>
<td>Implements and maintains standard triage and treatment protocols for patient who received cardiac resuscitation consistent with AHA guidelines</td>
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<tr>
<td>Works with EMS medical direction and cardiac resuscitation referral centers to develop cardiac resuscitation treatment plan</td>
</tr>
<tr>
<td>Initiates hypothermia as soon as possible when indicated</td>
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<tr>
<td>Initiates cardiology consult as soon as possible</td>
</tr>
<tr>
<td>Universal 24 h/d, 7 d/wk acceptance of cardiac resuscitation patients regardless of diversion status of ED</td>
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<tr>
<td>Has plan to treat simultaneous cardiac resuscitation patients</td>
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<tr>
<td>Has plan for and ability to treat nearest, including mechanical CPR or pharmacological support</td>
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<tr>
<td>Is capable of assessing need for ICD placement and providing appropriate follow-up</td>
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<tr>
<td>Defers assessment of prognostication and withdrawal of care for at least 72 h after cardiac resuscitation</td>
</tr>
<tr>
<td>Participates in regional or national quality improvement program to monitor and improve cardiac resuscitation care processes and outcome</td>
</tr>
<tr>
<td>Integrates plans for return of the patient to the local community for follow-up care after discharge from the cardiac resuscitation receiving hospital on a routine basis</td>
</tr>
<tr>
<td>Provides CPR training for community with the goal of achieving bystander CPR rates &gt;50%</td>
</tr>
<tr>
<td>Provides CPR, ACLS, and PALS training for appropriate staff</td>
</tr>
<tr>
<td>Has external certification, not self-designation, as part of cardiac resuscitation system of care</td>
</tr>
<tr>
<td>Should include at least compression-only CPR training for all employees (The AHA hands-only campaign produces short, easy-to-understand videos to help the general public learn compression-only CPR [<a href="http://cpr.heart.org/AHAEC/CPAndECC/Programs/HandsOnlyCPR/UCM_475516_CPR-Demos-and-Videos.jsp">http://cpr.heart.org/AHAEC/CPAndECC/Programs/HandsOnlyCPR/UCM_475516_CPR-Demos-and-Videos.jsp</a>])</td>
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<table>
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<tr>
<th>Level II</th>
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<tbody>
<tr>
<td>Must meet criteria for ideal STEMI referral center</td>
</tr>
<tr>
<td>Is designated hospital champion for cardiac resuscitation</td>
</tr>
<tr>
<td>Actively participates in multidisciplinary team meetings to monitor, provide feedback, and improve cardiac resuscitation care process and outcome</td>
</tr>
<tr>
<td>Implements and maintains standard triage and treatment protocols for patient who received cardiac resuscitation consistent with ACC/AHA guidelines</td>
</tr>
<tr>
<td>Implements and maintains a plan with EMS to ensure that interhospital transfers receive priority response</td>
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<tr>
<td>Initiates hypothermia as soon as possible when indicated</td>
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<tr>
<td>Is not capable of PCI</td>
</tr>
<tr>
<td>Transports early patients resuscitated from OHCA to cardiac resuscitation receiving center to allow angiography of catheterization-eligible/ appropriate patients as soon as possible to achieve the goal of first door-to-device time within 120 min</td>
</tr>
<tr>
<td>Implements and maintains the ability to treat nearest, including mechanical CPR or pharmacological support if indicated</td>
</tr>
<tr>
<td>Provides CPR training for community with the goal of achieving bystander CPR rates &gt;50%</td>
</tr>
</tbody>
</table>

(Continued)
Table 1. Continued

| Provides CPR and ACLS training for appropriate staff |
| Has external certification, not self-designation, as part of cardiac resuscitation system of care |
| Should include at least compression-only CPR training for all employees |
| The AHA hands-only campaign produces short, easy-to-understand videos to help the general public learn compression-only CPR [http://cpr.heart.org/AHAEC/CPRAHandECC/Programs/HandsOnlyCPR/UCM_475516_CPR-Demos-and-Videos.jsp] |

ACC indicates American College of Cardiology; ACLS, advanced cardiac life support; AHA, American Heart Association; CPR, cardiopulmonary resuscitation; ED, emergency department; EMS, emergency medical services; ICD, implantable cardioverter-defibrillator; OHCA, out-of-hospital cardiac arrest; PALS, pediatric advanced life support; PPCI, primary percutaneous coronary intervention; and STEMI, ST-segment-elevation myocardial infarction.

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Post-ROSC Care

Targeted Temperature Management

On the basis of the results of randomized trials,74,75 the International Liaison Committee on Resuscitation and the AHA recommended in 2010 the use of mild therapeutic hypothermia for comatose hospitalized victims of OHCA with ROSC.76 Recently, a large randomized77 trial comparing rigorous temperature control at 33°C versus 36°C in unconscious survivors of OHCA found that neither temperature was superior for the outcomes of survival and functional status. Another recent trial has suggested that there was no large significant difference in long-term neurological outcome among children unconscious after OHCA who received TTM to 33°C compared with those who received TTM to 36°C.78 The first 2 trials that suggested that hypothermia was beneficial achieved their intended target temperature much faster than the later 2 trials. With these considerations and as part of a broader TTM strategy, the AHA and International Liaison Committee on Resuscitation now recommend selecting and maintaining a constant temperature between 32°C and 36°C for at least 24 hours for comatose patients with ROSC after cardiac arrest.79,80

Access to PCI

Up to 70% of patients with OHCA have coronary artery disease. Although 50% have acute coronary occlusion,81–91 only a minority of patients with OHCA with ROSC who were transported to hospital have an ST-segment elevation on a 12-lead ECG.92,93 Mortality after emergent angiography for STEMI patients in the setting of post-ROSC OHCA is greater than that in the setting of STEMI alone.94,95 A barrier to the use of emergent angiography in post-ROSC patients with OHCA is that multiple registries track the mortality of patients with STEMI. Third-party payer reimbursement and individual- and hospital-level incentive programs are linked to public reporting of outcomes after STEMI. Because patients who have OHCA associated with STEMI have a higher mortality than those with STEMI alone, individual providers and hospitals have disincentives to provide potentially efficacious care to the newly resuscitated.96 Recognizing the absence of accurate symptoms or signs to assess neurological prognosis in the emergency department,76,97 AHA guidelines have argued that case selection for emergent angiography after resuscitation should be independent of neurological assessment. This conflicts with hospital and physician concerns about reportable outcomes data related to postprocedure, specifically mortality, and the public perception of publicly reported numbers.96 As a consequence, the proportion of patients who undergo emergent angiography may not include all of those who the data suggest may benefit from it.30,98 Experts have recommended disaggregating patients with OHCA from public reporting of outcomes after STEMI to reduce unintended consequences.96 Ongoing efforts are warranted to understand and disseminate appropriate use of emergent angiography in patients resuscitated from OHCA.

Prognostication and Neurological Intensive Care

AHA guidelines state that after cardiac arrest, prognostication should be reserved until at least 72 hours after return to normothermia if the patient is treated with TTM and until at least 72 hours after ROSC if the patient is not treated with TTM.79 Evidence-based approaches to discontinue life support after this time have been well described.99

The electroencephalogram and loss of the N20 component on testing median nerve somatosensory evoked potentials in experienced hands are helpful for prognostication.100–103 Premature declaration that the patient has a poor prognosis by an inexperienced clinician or consultant may contribute to early decisions to withdraw care as a “self-fulfilling prophecy.”104 In general, it is not possible to determine the patient’s prognosis accurately until at least 72 hours after resuscitation in the era of TTM.105,106

Care guidelines recommend that an electroencephalogram should be performed with prompt interpretation as soon as possible and should be monitored frequently or continuously in comatose patients after ROSC because nonconvulsive status epilepticus occurs frequently after resuscitation from cardiac arrest.76,107–111 In such patients, the brain has suffered a prolonged episode of global ischemia, is hypothermic, and often is under the influence of sedatives and paralytics. Electroencephalographic tracings in this setting present a challenge even for experienced interpreters of electroencephalograms unless they have managed a significant number of these patients and have had the opportunity to correlate their findings with the patient’s clinical course. A subset of patients may benefit from access to experienced neurocritical care services.
The strong relationship between the volume of patients received at a trauma center and their subsequent outcome implies that there is a need for ongoing assessment of the relationship between the volume of patients with cardiac arrest received at hospital and their outcome.

Interfacility Transport
Further discussion is warranted about whether and how patients who have in-hospital cardiac arrest at a facility that does not have expertise in resuscitation should be transferred after ROSC to a facility with such expertise. The intent of transfer would be to provide care that is not available at the primary hospital. However, this may affect the ability of the primary hospital to initiate appropriate postresuscitation care before transfer.

Extracorporeal CPR
Extracorporeal CPR (ECPR) is the rapid initiation of cardiopulmonary support and extracorporeal maintenance of circulation until restoration of an effective cardiac output. ECPR has been proposed as a rescue therapy in patients with cardiac arrest refractory to standard therapy. Case-control studies suggest that ECPR is associated with better outcomes compared with no ECPR in cardiac resuscitation systems of care with a low overall survival. ECPR may be considered for select patients for whom the suspected cause of the cardiac arrest is potentially reversible during a limited period of mechanical cardiorespiratory support. Such specialized care is promising, but more research is needed to support implementation in standard practice.

Neurocritical Care
The evolution of neurocritical care as a subspecialty discipline over the past 25 years has led to the development of neurocritical care as a distinct medical specialty, bridging neurosurgery, neurology, and critical care and neurocritical care intensive care units from theoretical constructs to focused closed units that provide comprehensive care to the neurologically injured patient. Although many have logically advocated that closed specialty intensive care units managed by critical care physicians should improve care and outcomes, debate about the broad efficacy remains. The ideal staffing and unit model has yet to be defined. Across the spectrum of neurological emergencies, care delivery in neurocritical care specialty units by neurointensivists improves outcomes in patients with traumatic brain injury, intracerebral hemorrhage, cerebrovascular accident, and subarachnoid hemorrhage. How this specialty could be integrated into the continuum of care?
care delivery for survivors of OHCA represents an important area of future inquiry.

Implementation and Operationalizing

Operationalizing the comprehensive components of an optimal resuscitation system of care may face challenges at each level of implementation, from overall community leadership, bystander engagement with CPR, EMS provider and emergency telecommunications, and roles of the referring and receiving hospitals to the infrastructure of data and quality management. With each challenge, specific opportunities for improvement can be identified. It is incumbent on the medical community to lead in the improvement of our local and regional resuscitation system of care. However, it is mandatory that the entire cross section of stakeholders become engaged in the process of building and continually improving such a system if any sustainable improvements are to be realized. The medical community, along with other local stakeholders, can advocate for dedicating appropriate resources to advance bystander engagement and education and EMS operations and for appropriate resuscitation and postresuscitation systems to be put into place. Successful systems are usually led by a champion who could, in theory, be any stakeholder in OHCA resuscitation but is frequently someone in the medical field who can mobilize the talent and resources needed for the effort. A fundamental quality of such leaders is their ability to build alliances and coalitions. Multiple barriers may exist to implementing or maintaining a cardiac resuscitation system of care in a community (Table 2). Borrowing techniques for implementing change in business, the first key barrier to address is lack of understanding that change is needed. For communities, EMS agencies, and hospitals that treat patients with cardiac arrest, this need for change is driven by the large regional disparities in the process and outcome of care. The second is resource limitations, which force organizations to change allocations of resources. The third is a lack of desire among individuals to make changes. The final key barrier is institutional politics. Use of local opinion leaders, mentors, and a tipping point approach was previously recommended to implement change in resuscitation organizations. Regional consortia such as those organized for Mission: Lifeline in STEMI care may provide a logical starting place for extending those consortia to other high-risk, time-sensitive conditions, including resuscitation and stroke.

Financial Impact

The variation among EMS system designs may create challenges to operationalizing regional resuscitation systems of care. These challenges may be both financial and operational in nature. EMS systems with limited

<table>
<thead>
<tr>
<th>Table 2. Potential Barriers to Improvements in Cardiac Outcomes</th>
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<tbody>
<tr>
<td>Community</td>
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<tr>
<td>Lack of bystander CPR</td>
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<tr>
<td>Lack of recognition of cardiac arrest</td>
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<td>Lack of knowledge of basic first aid emergency care/CPR</td>
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<td>Apprehension about performing CPR correctly</td>
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<tr>
<td>Apprehension about liability issues and needing a current certification</td>
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<tr>
<td>Lack of public access to defibrillators</td>
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<td>Lack of education on need</td>
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<td>Lack of education on how to use an AED</td>
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<td>Lack of funding to purchase AEDs and train the public</td>
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<td>Lack of knowledge of AED location</td>
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<tr>
<td>No system for maintaining AEDs</td>
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<tr>
<td>Need for local and state government support and commitment for sustainability</td>
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<tr>
<td>Discrepancy of who owns AEDs for access, maintenance, and repair</td>
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<tr>
<td>Emergency dispatch</td>
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<tr>
<td>Delayed identification of patient with cardiac arrest</td>
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<tr>
<td>Lack of formal dispatch protocols</td>
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<tr>
<td>Lack of training needed to recognize the need for CPR</td>
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<tr>
<td>Lack of telecommunicator-assisted CPR</td>
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<tr>
<td>Lack of formal telecommunicator-assisted CPR protocols</td>
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<tr>
<td>Difficulty instructing bystanders to perform CPR</td>
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<tr>
<td>Lack of real-time data on the location of AEDs so callers can be directed to them by telecommunicators</td>
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<tr>
<td>EMS</td>
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<tr>
<td>Lack of resources to implement cardiac resuscitation systems of care</td>
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<tr>
<td>Lack of understanding why change is needed</td>
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<td>Lack of reallocation of resources (high-effort, low-yield activities)</td>
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<tr>
<td>Insufficient integration of first responder training</td>
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<tr>
<td>Insufficient quality review or quality improvement programs for cardiac resuscitation at a systems level</td>
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<tr>
<td>Providing high-quality CPR</td>
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<tr>
<td>Compressions are interrupted for performing various interventions such as intubation and intravenous insertion</td>
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<tr>
<td>Compression interruption to move the patient</td>
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<tr>
<td>Insufficient quality review or quality improvement programs for chest compression and ventilation quality</td>
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<tr>
<td>Lack of destination protocols</td>
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<tr>
<td>Lack of cardiac resuscitation designation for hospitals</td>
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<tr>
<td>No national certification process to identify destination hospitals</td>
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<tr>
<td>Need early alert to hospitals of arrival of patient with cardiac arrest</td>
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<tr>
<td>Referral center</td>
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<tr>
<td>Lack of comprehensive postarrest care</td>
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<tr>
<td>Lack of active engagement from multidisciplinary team</td>
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<td>Lack of multiprofessional engagement</td>
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<tr>
<td>Lack of organization of in-hospital resources to care for patients who received cardiac resuscitation</td>
</tr>
<tr>
<td>Lack of established treatment protocols for cardiac resuscitation</td>
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(Continued)
resources, particularly those with a limited number of response units, may find it difficult to bypass a closer hospital in favor of a designated receiving center if this bypass removes a unit from service for a longer period of time. This difficulty compounds as transportation distances increase. EMS systems may find transporting to a referring resuscitation center followed later by transferring to a receiving center to be a more practical/realistic option.

Regional systems of care may require equipment and devices when supported by appropriate evidence. Many EMS systems have implemented relatively simple therapies involving equipment or devices such as therapeutic hypothermia and compression/ventilation rate control. Metronomes and other devices have been used to improve compression and ventilation rates during manual CPR. Multiple randomized trials have shown that mechanical chest compression devices are not demonstrably better than optimized manual CPR. However, these devices may have a role in reducing risks to EMS providers associated with performing manual compressions in a moving vehicle or in facilitating emergent coronary angiography in a patient with ongoing cardiac arrest and a high likelihood of acute coronary occlusion.

Although the acceptance of regionalized approaches to systems of care and designated centers has increased, some EMS systems remain challenged by local concerns related to bypassing closer hospitals and the resultant loss in patient volume and case-mix index. Concerns about loss of complex patients and subsequent revenue remain an important challenge in many competitive marketplaces. EMS systems and resuscitation centers should work together to inform the lay community and medical community of the benefits of resuscitation centers and the evidence supporting EMS transport to such centers.

The increased use of electronic patient records within EMS systems has created remarkable improvement opportunities for systems of care. EMS systems may have difficulty obtaining useful results from an analysis of these data without simple, effective data analysis and reporting tools. Data solutions used by EMS systems should incorporate analytical and reporting methods that allow the EMS systems and the systems of care to use the data to improve performance and outcomes. Essential to this approach is the need for effective data sharing processes between EMS and resuscitation centers. These processes may include processes that provide bidirectional data exchange or data sharing within a single data repository.

Hospitals seeking to be a level I resuscitation center for patients with OHCA require significant infrastructure investment and bear the incremental cost of supporting interventional cardiology, critical care, and the myriad other providers and equipment required for the comprehensive care of the postarrest patient. Smaller-volume facilities or those in financially disadvantaged areas face challenges in establishing or maintaining these comprehensive services.

**Reportable Hospital Mortality**

There are some challenges to operationalizing the creation of resuscitation centers. One potential barrier is in the public reporting of disease-specific hospital mortality. If a hospital chooses to become a resuscitation center, the number of cardiac arrest victims who are transported to the hospital will increase. The mortality rate of the hospital across time is likely to increase because ≈11% of patients who sustain an OHCA survive to hospital discharge. A potential way to mitigate this increase in hospital mortality is to exclude all patients with OHCA from the calculation of hospital mortality rates or to report mortality for patients with cardiac arrest separately, as is currently being done for other conditions (myocardial infarction, pneumonia, heart failure, etc). It is also possible that cardiac arrest–specific rates could be calculated for each of the participating resuscitation centers and systems of care, which would allow both local and national benchmarking for similar types of hospitals.

**CONCLUSIONS**

OHCA remains a major public health challenge in the United States. Over the past decade, significant scientific advancements in 9-1-1 telephone CPR instructions, by-

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<td><strong>Limited resources</strong></td>
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<td><strong>Rural geography</strong></td>
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<td><strong>Receiving center</strong></td>
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<td><strong>Lack of comprehensive postarrest care</strong></td>
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<td><strong>Lack of active engagement from multidisciplinary team</strong></td>
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<td><strong>Lack of organization of in-hospital resources to care for survivors</strong></td>
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<td><strong>Lack of established treatment protocols for postarrest survivors</strong></td>
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<td><strong>Effect of increases in postarrest survivors requiring PCI on nationally reported hospital data and outcomes</strong></td>
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<td><strong>Lack of resources</strong></td>
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<td><strong>Conflicting interests</strong></td>
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<td><strong>Lack of reporting system</strong></td>
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AED indicates automatic external defibrillator; CPR, cardiopulmonary bypass; and PCI, percutaneous coronary intervention. Adapted from Mission: Lifeline Program. Copyright © 2017, American Heart Association, Inc.
stander CPR, optimal CPR technique, public AED availability, and postresuscitation care have been shown to improve outcome in the patient with OHCA. Despite these advancements, widespread implementation lags reveal large regional variation in outcome with opportunities for improvement.

Lessons from the implementation of local, regional, and statewide systems center and the maturation of STEMI, stroke, and trauma systems of care provide important road maps for developing OHCA systems of care. Many of these lessons have been distilled and disseminated by the AHA Mission: Lifeline program. Early examples of cardiac arrest centers and regionalization have revealed promising results, but much work remains to be done to further understand regional differences and to optimize care for the patient with OHCA.

**ARTICLE INFORMATION**

The American Heart Association makes every effort to avoid any actual or potential conflicts of interest that may arise as a result of an outside relationship or a personal, professional, or business interest of a member of the writing panel.

Specifically, all members of the writing group are required to complete and submit a Disclosure Questionnaire showing all such relationships that might be perceived as real or potential conflicts of interest.

This statement was approved by the American Heart Association Advisory and Coordinating Committee on October 13, 2017, and the American Heart Association Executive Committee on December 11, 2017. A copy of the document is available at http://professional.heart.org/statements by using either “Search for Guidelines & Statements” or the “Browse by Topic” area. To purchase additional reprints, call 843-216-2533 or e-mail kelle.ramsay@wolterskluwer.com.


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*Modest.
†Significant.

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