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Implementation Strategies for Improving Survival After Out-of-Hospital Cardiac Arrest in the United States

Consensus Recommendations From the 2009 American Heart Association Cardiac Arrest Survival Summit

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Endorsed by the Neurocritical Care Society

The goal of the 2009 American Heart Association (AHA) Cardiac Arrest Survival Summit was to develop consensus recommendations for implementation strategies to optimize the care of patients with out-of-hospital sudden cardiac arrest (OHCA). For the purposes of this conference, implementation was broadly defined as the translation of best practices into common practice. The scope was the entire system of care, including recognition and response by laypeople, emergency medical services (EMS) dispatch, EMS care, and hospital-based care. The conference planning committee included representatives from multiple disciplines involved in all stages of cardiac arrest care. Conference participants included stakeholders from the lay public, EMS systems, relevant clinical specialties, health insurance providers, and federal regulatory and funding agencies. Conference speakers were either selected by the conference planning committee on the basis of their content expertise or nominated by the organization they represented.

Before the conference, participants provided written input by responding to a preconference questionnaire. The content of this questionnaire is available in the online-only Data Supplement. The questions were developed by the conference planning committee. All responses were free text. The responses were collated and distributed to the writing group for review. Writing group members drafted preliminary recommendations based on the survey results and the existing literature. These recommendations were refined through conference calls with invited speakers and panelists before the conference. Individual sessions focused on epidemiology, incidence and outcomes monitoring, systems of care, and culture change.

The initial conference sessions consisted of invited speakers who highlighted key issues and presented evidence for best practices. These presentations were followed by panel discussions with audience participation. During the panel discussions, the preconference draft recommendations were further modified. The fourth session consisted of multiple breakout groups that addressed issues of culture change among lay providers, EMS providers, in-hospital providers, policy makers, and payers. These sessions helped integrate the results of the preconference

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survey with the input of conference participants. A final session discussed consensus recommendations. The writing group met immediately after the conference to further refine the recommendations. Writing teams generated drafts of individual sections that were then combined into a single document that was distributed to the entire writing group for final comments, corrections, and revision. The final version of the manuscript was approved by all writing group members before it was submitted for publication.

Monitoring and Reporting Incidence and Outcomes of OHCA

OHCA is a common and usually lethal health condition that affects from 235 000 to 325 000 people in the United States each year.[1] Although overall mortality from coronary heart disease has declined nationwide over the past 40 to 50 years,[2,3] few communities have been able to achieve sustained reductions in mortality after OHCA. There is at least a 5-fold regional variation in survival after OHCA among sites participating in the Resuscitation Outcomes Consortium (ROC).[1] Moreover, large interhospital variations exist in rates of survival to hospital discharge among patients admitted after successful resuscitation from OHCA.[4–6] Such differences in outcome after cardiac arrest do not appear to be fully explained by differences in patient characteristics.[7] Rather, the high rate of survival observed in some communities suggests that OHCA is a treatable condition and that outcomes may depend on the effectiveness of the system of care. Ongoing comprehensive surveillance of OHCA events and outcomes through hospital discharge is necessary to identify opportunities for improvement so that all communities can achieve higher rates of survival.[8] The absence of a national surveillance system is a barrier to such an effort, and available resources are insufficient to support it on an ongoing basis.

National Databases

The National EMS Information System (NEMSIS) is an ongoing effort to standardize the collection of EMS data.[9] NEMSIS is funded by the National Highway Traffic Safety Administration, the Health Resources and Services Administration, and the Centers for Disease Control and Prevention. To date, all states and territories have committed to adopting NEMSIS, which includes all patient encounters regardless of whether the patient is treated for cardiac arrest. The use of standardized data collection terms is a major advantage of NEMSIS. However, events submitted by a given state may not represent all EMS events occurring within that state because the data collected in NEMSIS are based on self-report and the criteria used to determine the types of EMS events submitted to the NEMSIS data set vary by state.[1] Because NEMSIS lacks detailed information about hospital care and has a high rate of missing vital status at discharge, its ability to monitor the effectiveness of interventions throughout the continuum of care is limited.

The National Emergency Department Sample (NEDS) is a large stratified sample of records related to visits to US hospital–based emergency departments (EDs).[10] NEDS, which is supported by the Agency for Healthcare Research and Quality, includes visits that result in hospital admission and those that do not. One advantage of NEDS is that it uses stratification of group EDs into relatively homogeneous subgroups before sampling. But such data sets require collation, verification, and deidentification, and there may be a delay between the time of a visit and the inclusion of that visit in the data set. Because not all patients who are treated by EMS for cardiac arrest are transported, NEDS does not represent a population base. Finally, NEDS excludes data elements that could directly or indirectly identify individuals, hospitals, or states. Therefore, it is currently not feasible to link individual patient data from NEDS with existing EMS databases.

Multicenter, Statewide, and Regional Registries

The ROC is a clinical research network focused on prehospital care of patients with cardiopulmonary arrest and severe traumatic injury.[11] It is funded by the National Institutes of Health, the AHA, and other agencies. As part of its research mission, the ROC maintains an ongoing registry of all OHCA events assessed or treated by EMS personnel in 10 participating geographic regions. The sole data coordinating center accepts only deidentified data and regularly monitors the incidence of cardiac arrest in participating communities in an effort to help identify missing episodes. An important consideration is that the sites were selected by competition and may not represent the cardiac arrest experience in all US communities.

The Cardiac Arrest Registry to Enhance Survival (CARES) is a voluntary registry of OHCA of cardiac etiology that was initially funded by the Centers for Disease Control and Prevention. CARES provides communities with a mechanism to identify OHCA, to measure how well EMS personnel perform key elements of emergency cardiac care, and to determine outcomes through hospital discharge.[12,13] After all data on a case are entered into the registry, individual identifiers are stripped from the record. CARES generates standard reports that can be used to characterize the local epidemiology of cardiac arrest and to help managers determine how well EMS systems are delivering OHCA care. An advantage of CARES is its finite data set specific to OHCA. A disadvantage is that voluntary participation may not generate representative samples of the OHCA patient population.

In 2004, the Arizona Department of Health began an initiative to improve resuscitation outcomes from sudden cardiac arrest by implementing a statewide cardiac arrest surveillance system. The Save Hearts in Arizona Registry and Education (SHARE) program began by identifying OHCA as a public health problem. SHARE supports a data collection system and benchmarks system performance. Although participation in SHARE is voluntary, EMS systems receive regular reports to help identify opportunities for improvement. In 2009, 80% of the state population was covered under SHARE. Arizona recently began a voluntary program for hospitals to be recognized as cardiac arrest centers. As a result, resuscitation outcomes have improved under the SHARE program. In 2005, the overall rate of survival from OHCA in Arizona was 4% (11% for witnessed ventricular fibrillation). Survival has tended to increase with the continued implementation of each link in the chain of survival, and in 2009, overall survival was 10% (30% for witnessed ventricular fibrillation).[14,15]

Table 1. Strategies to Continuously Monitor and Report Incidence, Process Variables, and Outcomes at the Local, Statewide, and National Levels

Local OHCA care systems (EMS and receiving hospitals) should continuously monitor and report process and outcomes related to OHCA for the purpose of quality improvement
Local OHCA care systems (EMS and receiving hospitals) should participate in statewide, regional, and national reporting systems for benchmarking
National standards for OHCA data collection should be developed and used by all EMS systems and receiving hospitals and should include a mechanism for monitoring data quality
Funding should be provided for a national OHCA data collection and reporting system
OHCA surveillance should be integrated with other national cardiovascular surveillance systems

OHCA indicates out-of-hospital cardiac arrest; EMS, emergency medical services.

The state of Maryland maintains a statewide cardiac arrest surveillance system. The system is designed to provide complete and accurate reporting of all patients with OHCA who receive care through the 9-1-1 system. Although outcomes include return of spontaneous circulation on ED arrival, data on survival to hospital discharge are lacking. Data are collated and then periodically reported back to hospital and EMS providers. These data are used to compare process and outcomes in Maryland with those of other locations through the use of standardized templates.[16] Minnesota, North Carolina, Pennsylvania, and Washington have similar statewide cardiac arrest surveillance systems, each with varying degrees of participation.

Local Registries

Advantages of local registries include the potential for timely review of individual cases and continuous quality improvement. Disadvantages include the lack of external comparisons with other systems. Several ROC sites maintain local registries in addition to participating in the network registry. The existence of such dual registries allows pooling of resources. Examples of local registries are discussed in Effective Systems of Out-of-Hospital Cardiac Arrest Care.

Consensus Implementation Strategies

The Institute of Medicine has recognized that emergency medicine lacks a standard set of measures to assess the performance of the full emergency and trauma care system in all communities, as well as the ability to benchmark that performance against statewide and national performance metrics.[17] In this respect, cardiac arrest is similar to other acute life-threatening illnesses.

The writing group identified several strategies that are necessary to monitor and report OHCA incidence, process of care, and outcomes (Table 1). Although many factors related to cardiac resuscitation may be of interest, a sustainable system requires adoption of a finite standardized vocabulary. Ongoing data verification and quality assurance are likely to be necessary because prehospital data are collected either while providers deliver time-dependent therapy in the field or afterward as they juggle multiple competing responsibilities. Successful implementation of a surveillance system is likely to require reimbursement to encourage organizations to provide high-quality data in a timely manner and to improve performance.[18]

Effective Systems of OHCA Care

Organization of the system of care appears to have a larger effect on survival than patient factors.[7] The creation and maintenance of an effective system for delivering optimal emergency medical care are complex. Examining either systems with historically good outcomes or systems in which change has improved outcomes provides an opportunity to identify best practices that can be broadly implemented. Key components of some of these systems were described during the conference. A brief summary of this discussion is provided below.

Seattle and King County, WA

Beginning in the late 1960s, Seattle was among the first communities to implement a well-organized EMS system. Physicians associated with the University of Washington School of Medicine worked with other community leaders to create a fire department–based system to deliver care quickly to victims of OHCA. A few years later, others created a similar system in King County outside Seattle.

Today, fire trucks in Seattle and surrounding King County are staffed with firefighters trained as emergency medical technicians–basic and equipped with automated external defibrillators (AEDs) that arrive at the victim's side within a few minutes of the 9-1-1 call being received. Each member of the firefighter team has a predetermined role such as controlling the airway, delivering chest compressions, or deploying an AED. These roles are practiced periodically in drills at the fire station.

In both Seattle and the suburban King County systems, there are ≈15 full-time paramedics dedicated to treating serious emergency conditions for every 100 000 residents.[19] As a result, each paramedic treats an average of ≈9 cardiac arrest patients annually, and most have >10 years of field experience.[19]

A multilevel review of quality of care is also performed for all OHCAs treated by Seattle Fire Department staff. The recording of the 9-1-1 call is reviewed to determine if the cardiac arrest was identified at the time of the initial call and if cardiopulmonary resuscitation (CPR) was delivered to the victim. An experienced nurse reviews the voice and continuous ECG and impedance waveform recordings from the AED to document specific time intervals and to assess the fraction of time in which chest compressions were given during EMS care of the OHCA victim. A physician reviews any deviations from optimal care, and feedback is provided to help firefighters improve their response to the next event. Similarly, the care provided by paramedics is closely reviewed. Should opportunities for improvement be noted during the case review, paramedics meet with a system medical director. Recently, receiving hospitals have been sent reports on the profile of care that they delivered to surviving patients to encourage best practices such as therapeutic hypothermia.

There is also accountability to the wider community, which fosters system excellence. For example, both the Seattle and King County systems report OHCA process and outcomes each year as part of an annual report. This report, reviewed by public officials, is part of the public record.

Finally, among the EMS workforces, there is an expectation of good outcome based on past success. This "peer pressure" can drive improved performance.

Rochester, MN

Rochester is a typical medium-sized city with a population that grew from 75 000 in late 1988 to 100 000 in 2008. In 1988, AEDs were added to Rochester police cars to shorten the time interval from the 9-1-1 call to defibrillation. At that time, although the fire department was not the first responder for cardiac arrest patients, the response interval for police in the field was short at ≈5 minutes. The program was implemented deliberately in plan-do-check-act cycles. On the basis of the success of the program, AEDs were added to fire rescue vehicles in 1998.

An important component of the success of Rochester's program is that it has been led by the same physician since its inception. This individual fostered a culture that paid close attention to detail. Today, when a 9-1-1 call is received, fire, police, and EMS personnel all respond simultaneously. For patients with ventricular fibrillation, the time from the 9-1-1 call to first shock is short, averaging ≈6 minutes. During 2006 to 2008, survival to hospital discharge for bystander-witnessed events in which victims presented with ventricular fibrillation exceeded 50%.[20]

Philadelphia, PA

One potential source of variation in survival rates among different communities is the difference in care that survivors of OHCA receive after they arrive at a hospital. In 2004, a group of physicians and nurses at the Hospital of the University of Pennsylvania sought to optimize post–cardiac arrest care by developing a comprehensive multidisciplinary treatment protocol for patients resuscitated from OHCA. The team met regularly over 18 months to develop a "bundle of care" that could be reliably implemented 24 hours a day, 7 days a week, based on initial success with implementing a resuscitation care bundle elsewhere.[21] Key components of the treatment bundle included therapeutic hypothermia, early percutaneous coronary intervention for ST-segment–elevation myocardial infarction, and early hemodynamic optimization. Multiple strategies were used to implement the protocol, including lectures, case reviews, and distribution of memory aids. Patients were cared for by a small dedicated group of physicians who measured outcomes and compared them with historical controls. Before implementation of the protocol, 22% of OHCA survivors admitted to the hospital with a pulse survived to discharge. After implementation of the protocol, the survival rate more than doubled to 50%.[22]

Richmond, VA

The goal of the Richmond EMS system is to create a high-performance, cost-effective EMS system using technology. As of 2009, patient-centered technology included the use of prehospital 12-lead ECGs, continuous waveform capnography, wireless Internet access, and therapeutic hypothermia. The quality focus has been on EMS advanced life support interventions followed by care in a single receiving hospital. To optimize delivery of postarrest expertise and to improve outcomes, in 2007, a single central hospital was designated as the only receiving center for survivors of OHCA. A small group of experienced attending physicians and nurses deliver therapeutic hypothermia to >50 cardiac arrest survivors annually at that institution. Since the system changed, the overall rate of survival to hospital discharge for EMS-treated OHCA patients improved from 3% in 2001 to 16% in 2009. Of patients achieving return of spontaneous circulation in the field who were treated with therapeutic hypothermia, 52% survived to hospital discharge in 2009 compared with 25% in 2001.[23,24]

Essential Elements, Potential Benchmarks, and Quality-Improvement Goals

On the basis of presentations and published literature, conference participants identified a number of key elements commonly found in high-performing systems. Uniformly, the system is led by a medical professional, usually a physician, who is dedicated to improving patient outcomes by paying close attention to the implementation details of the system. The community also contributes by providing high rates of bystander CPR. The professional first response is usually rapid, with the interval from receipt of the 9-1-1 call to EMS arrival at the victim's side of ≈5 to 6 minutes or less in the majority of cases. High-quality CPR is delivered with defibrillation with an AED. Therapeutic hypothermia is initiated—typically in the hospital setting—as the standard of care after restoration of circulation, and many survivors undergo cardiac catheterization shortly after arrival at the hospital. Finally, a mechanism is in place to monitor outcomes and to provide feedback to providers. Table 2 outlines essential elements identified by conference presenters and participants. The writing group also developed preliminary benchmarks that could be used by EMS systems and hospital providers to optimize the overall system of OHCA care.

Strategies for Implementing Optimized Systems of OHCA Care

Conference participants were asked to consider strategies for implementing and sustaining optimized systems of care for patients with OHCA. Overall, changing the cultural perception of professional management of cardiac arrest was thought to be fundamental to optimized implementation; general strategies for cultural change are discussed below. In addition, specific implementation strategies based on the key system components outlined in Table 3 are addressed. Some of these core strategies are described below.

Changing the Culture

Although some reports suggest that outcomes from OHCA have not improved over time,[25,26] others have recently reported improvement after implementation of new methods of resuscitation.[27–29] However, research showing that a given therapy is effective does not guarantee the use of that therapy in practice.[30] Dissemination is the transfer of research results to decision makers to change the behavior of patients or providers to improve health. Implementation consists of identifying barriers to use and actively overcoming them. Dissemination and implementation interventions used to date have had mixed effects at best in various clinical disorders.[31–34]

Table 2. Essential Elements, Benchmarking, and Quality-Improvement Goals for OHCA Care Systems

System Component	Key Element	Possible Benchmarks	Quality-Improvement Goal
Medical leadership: individual or group of individuals who are responsible for overall system of OHCA care	Monitoring and reporting of annual incidence and outcomes Integration of out-of-hospital and in-hospital care Address economic issues	National median for rate of survival to hospital discharge of patients with EMS-treated OHCA Report overall, VF, and non-VF initial rhythm	Improve survival rate within system relative to 3-y rolling average
Community	Bystander CPR	National median for percentage of patients who receive bystander CPR after witnessed cardiac arrest	Improve rate of bystander CPR within system relative to 3-y rolling average
	Public-access defibrillation	National median for percentage of patients for whom an AED is used by bystanders after a witnessed cardiac arrest in a public setting	Improve rate of AED use within system relative to 3-y rolling average
9-1-1/EMS dispatch	Rapid first response	National median for time from 9-1-1 call to first responder on scene of an OHCA	Reduce time from 9-1-1 call to first responder on scene within system relative to 3-y rolling average
	Dispatch-assisted CPR	National median for rate of initiating bystander CPR only after dispatcher instruction	Improve rate of dispatcher-assisted CPR within system relative to 3-y rolling average
EMS	High-quality CPR and early defibrillation	National median for rate of ROSC for EMS-assessed and treated OHCA Report overall, VF, and non-VF initial rhythm	Improve rate of ROSC within system relative to 3-y rolling average
Hospital	Specialized centers for treating post–cardiac arrest patients	National median for rate of survival to hospital discharge after ED arrival with spontaneous circulation	Improve survival to hospital discharge rate relative to 3-y rolling average
	Multidisciplinary post–cardiac arrest care treatment plan	Report overall, VF, and non-VF initial rhythm	
	Early PCI	PCI door-to-balloon time <90 min for post–cardiac arrest STEMI	
	Therapeutic hypothermia	Rate of therapeutic hypothermia provided for qualified patients	
	Early hemodynamic optimization		
	Reliable early prognostication of functional outcome		
	AICD placement		

OHCA indicates out-of-hospital cardiac arrest; EMS, emergency medical services; VF, ventricular fibrillation; CPR, cardiopulmonary resuscitation; AED, automated external defibrillator; ROSC, return of spontaneous circulation; ED, emergency department; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction; and AICD, automated implantable cardioverter-defibrillator.

The writing group believes that OHCA care provider organizations, including EMS agencies and hospitals, can learn from business organizations about how to implement and maintain a culture of change to achieve broad and sustained improvement in outcomes. There are 4 barriers to implementing change in an organization.[35] The first barrier is lack of understanding that change is needed. For EMS agencies and hospitals that treat patients with cardiac arrest, this need for change is driven by the large regional and interhospital disparity in outcomes. The second barrier is resource limitations, which force organizations to change resource allocations. The third barrier is a lack of desire among individuals to make changes. The final barrier is institutional politics.

A tipping-point approach to implementing change should be considered.[35] Initial efforts to change should focus on local opinion leaders who have a disproportionate influence in the organization. For EMS agencies, such a leader could be the medical director, shift supervisor, or person responsible for training or quality assurance. Once such an individual is committed to change, then that person's achievements should be highlighted to encourage others to change also. In the unlikely event that individuals are not committed to change, then consideration can be given to reassigning their duties. Lecturing on the need for change is unlikely to succeed, so the organization should seek to continuously experience the realities that make change necessary. For resuscitation organizations, this includes monitoring survival to discharge after EMS-treated cardiac arrest. Resources can be redistributed from activities that are high effort and low yield to those that are low effort and high yield. For resuscitation organizations, this might include shifting away from training and equipping providers to obtain intravenous access to training providers

Table 3. Implementation Strategies to Optimize OHCA Care Systems

System Component	System Parameter	Strategy
Medical leadership: Individual or group of individuals who are responsible for overall system of OHCA care	Monitoring and reporting of annual incidence and outcomes	Engage lay leaders in community
		Integrate out-of-hospital and in-hospital care
		Maintain continuous quality-improvement program
		Create performance incentives
		Create accountability by public reporting system outcomes
		Celebrate saves
Community	Bystander CPR	CPR training in schools
		CPR training in the workplace
		Public service messages
		Just-in-time smartphone training
		Performance incentives
		EMS dispatcher–assisted CPR
	Public-access defibrillation	AED deployment at all public buildings where ≥1 cardiac arrests occur per year
		AED mapping
		Cell phone localization
9-1-1/EMS dispatch	Rapid first response	Training in rapidly and accurately identifying cardiac arrest
	Dispatch-assisted CPR	First-responder use (police and firefighters)
		Automated systems to detect unwitnessed cardiac arrest and to activate EMS
		Dispatcher training
EMS	High-quality CPR	Real-time monitoring and feedback of CPR quality, including compression rate, depth, relaxation, and pauses
	Improved team performance	Team structure simulation training
		Case review and outcomes feedback
Hospital	Multidisciplinary post–cardiac arrest care treatment plan	Established multidisciplinary diagnostic and treatment protocols
	Early PCI	Regionalization of postarrest care to specialized hospitals
	Therapeutic hypothermia	
	Early hemodynamic optimization	
	Reliable early prognostication of functional outcome	
	AICD placement	

OHCA indicates out-of-hospital cardiac arrest; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; AED, automated external defibrillator; PCI, percutaneous coronary intervention; and AICD, automated implantable cardioverter-defibrillator.

and the public to deliver effective chest compressions. Each organization will have different activities that require redistribution of resources. Finally, a resuscitation organization should appoint a mentor who is highly respected, knowledgeable about who supports change and who resists it, and able to devise strategies and build the coalitions necessary for change. The mentor can advise the change leader of what is happening at lower levels of the organization.

Medical Leadership

Identify a Leader or Leadership Group Who Will Assume Overall Accountability for the System

In each of the systems highlighted at the conference, ≥1 champions spearheaded efforts to prioritize OHCA care in the community. Although such a champion could, in theory, be any stakeholder in OHCA resuscitation, frequently someone in the medical field can mobilize the talent and resources needed for the effort. A fundamental quality of such leaders is their ability to build alliances and coalitions. In addition, successful leaders have fostered accountability. The medical leadership is also responsible for integration of community response, 9-1-1 dispatch, EMS care, ED care, and inpatient care. In many of the systems highlighted during the conference, there was a strong emphasis on integrating delivery of care. In terms of developing medical leadership, the implementation strategies described in this document should become an integral part of EMS fellowship programs and/or EMS medical director courses. It is essential that our new leaders have a clear understanding of the issues and be engaged in the solutions.

Define the System and Obtain Buy-In and Resources From All Stakeholders

Every effort should be made to define the system in a way that engages all relevant stakeholders. In most cases, the system of care should include local government officials, community representatives, 9-1-1/EMS dispatch, EMS providers, and hospital providers. A major challenge is defining the borders of the system. In the case of a large municipal EMS system, the borders can be defined by the response area of the EMS system and the hospitals to which patients are delivered. In more rural regions, multiple small EMS systems and their corresponding hospitals may benefit from forming coalitions.

A valuable technique for gaining cooperation from competing hospitals and EMS systems is to use an interested but unaffiliated group as an honest broker. Several options have been shown to work effectively. In Arizona, the state health department serves as a data repository and reporting system for EMS agencies and hospitals participating in the OHCA system of care.[15] The North Carolina chapter of the American College of Cardiology and the Duke Clinical Research Institute host the Reperfusion of Acute Myocardial Infarction in Carolina Emergency Departments (RACE) program with financial support from all PCI hospitals in the state and private foundations.[36] Other areas have used the regional EMS agency,[37] the county medical society, or a regional hospital council as the honest broker.

System Integration

A well-integrated system of care is needed to identify and resolve any barriers to communication during patient care and to collect data describing care, processes, and outcomes. In terms of patient care, this could be written and verbal communication between EMS providers and the receiving ED and between the ED and inpatient unit. This is particularly important when time-sensitive interventions such as percutaneous coronary intervention are indicated. In terms of monitoring process and outcome variables, accurate data recording requires the use of well-defined parameters that are uniformly interpreted by all providers (eg, EMS and hospital staff).

Another strategy to improve communication is to integrate participants in the training process. For example, physicians train EMS providers in resuscitation techniques, and EMS providers train community members. It should be emphasized that each person who interacts with the patient has an impact on the patient's outcome.

Collect, Analyze, and Report Data on Incidence, Outcomes, and Key Process Variables

Continuous evaluation of each component of the OHCA chain of survival[38–40] is fundamental to accountability with the goal of improving OHCA outcomes. This is best achieved by a process of continuous data collection, analysis, and reporting. In some communities, annual reports of OHCA care are made public to all stakeholders. The medical leader is held accountable for significant gaps in quality of OHCA care and serves as a point person for partnerships, strategic alliances, and even blame when results are poor or kudos when results are good. Funding is often a challenge to implementing continuous monitoring and reporting of incidence, outcomes, and process variables for a local system of OHCA care. The primary cost is for personnel to collect data, to perform data quality assurance and analysis, and to generate reports. Much of this cost could be reduced if an EMS agency could participate in a regional, statewide, or national system for monitoring and reporting incidence and outcomes. The Health Insurance Portability and Accountability Act (HIPAA) does not preclude sharing data between entities as part of a quality-improvement program for a system of care. CARES uses a series of business use agreements that spell out how the data are used. Health departments are exempt from HIPAA, and Arizona uses the state health department to collect data on OHCA. However, if the data will be used for research, then HIPAA issues must be addressed as part of the institutional review board approval process. In contrast, the ROC registry is a research project conducted with institutional review board approval using waiver of documented consent under minimal risk criteria and confidentiality agreements to maintain compliance with HIPAA.

Identify the Weakest Links in the System

Benchmarks serve as useful metrics for resuscitation systems to identify areas of weakness and to direct efforts toward improvement. Ideally, these would be benchmarks derived specifically for the setting, resources, and baseline performance of the system (Table 2). In the absence of adequate data to generate such benchmarks, consensus targets should be developed and used. If performance falls below a specific benchmark, stakeholders should examine process variables related to that benchmark.

Implement Strategies to Improve the Weakest Links in the System

There may be numerous weak links in an OHCA system of care. Although it might seem appropriate to try to fix

everything at once, an approach that is more likely to be successful is to prioritize and concentrate on 1 or 2 weak links at a time. Specifically, the feasibility and resources available to address any one specific process variable should be taken into consideration. For 1 community, the weakest link could be low rates of bystander CPR. For another it could be long delays (>10 minutes) in delivery of initial defibrillation. Specific implementation strategies that optimize individual process variables are described below.

Measure and Report Impact on Process Variables and Outcomes

System improvements are unlikely to be sustained without evidence that outcomes are also improved. This is especially true when financial resources are involved. The duration of the measurement period will vary with the process variable. A reasonable approach is periodic examination of process data (eg, quarterly) and outcomes data (eg, annually).

During the measurement period, relevant providers should be given timely feedback on both process variables and outcomes. If process variables were not affected by the intervention, efforts should be made to determine why, and alternative approaches should be identified and implemented. If the intervention was successful and benchmarks were achieved, then the next weakest link should be addressed.

Economic Issues

Although few will argue that improving the care and outcomes for OHCA is a good thing, the resources required (data measurement, infrastructure, and staff) can seem daunting. Given competing demands for limited quality-improvement resources in hospitals, EMS systems, and communities, establishing a viable economic model for improving care would provide a template for other communities interested in improving survival from OHCA. However, the solutions are unlikely to be the same for different communities, counties, and states. Successful models include basing the infrastructure in a municipal fire department (Seattle), county health department (King County), state health department (Arizona), hospital foundation (St. Cloud, MN), countywide EMS agency (Austin–Travis County, TX), local or state medical society, or local nonprofit organization.

In most communities, the resources required are not large. Typically, 1 full-time employee can manage the data and relationships for a population of 250 000 to 500 000. In King County, a local tax levy supports EMS service delivery. In St. Cloud, the St. Cloud Hospital Foundation funds a coordinator to help with data management and community outreach. Hospital leaders support this position because it improves the health of the community. They have also measured the funding stream, which has shown an increase in hospital revenue with increasing survival.[41]

Key Players in Implementing Strategies to Optimize OHCA Care

Community

Bystander CPR is the most important contribution from the lay community to the OHCA system of care. To improve survival after OHCA, the AHA and its affiliates have developed community programs to raise public awareness of the signs of cardiac arrest and the importance of bystander CPR.[42–44] However, even trained bystanders sometimes encounter intellectual and volitional barriers when it comes to performing CPR. The traditional strategy has been to train as many community members as possible. This approach of periodic CPR training addresses the intellectual barrier by teaching people how to perform CPR. Volitional barriers may reflect a lack of confidence in performing CPR for fear of doing it incorrectly or causing harm or reluctance to provide mouth-to-mouth ventilation.[45,46] Simplified pre-event[47] or "just-in-time" instruction[48] is associated with good CPR process. Interactive video instruction might also improve dispatcher-assisted chest compressions.[49,50]

Another barrier to CPR is that people often forget their training. Possible solutions include strategies to simplify what needs to be remembered and to increase frequency of practice. For example, mandatory CPR training in schools and at the workplace could be conducted like fire drills. Then CPR becomes instinctive (ie, "It is my job/duty to do this") and is practiced routinely in a less stressful way to keep lay providers ready for an acute event. Furthermore, frequent training of large groups can be facilitated by the use of video self-instruction.[47] The potential effectiveness and public health impact of these measures are likely to vary among communities because of available resources or program incentives.

Public outreach via the media (eg, public service announcements) could be used to better educate community members that bystander CPR is a key component in the chain of survival and saves lives. Lay providers must understand that they are part of a "team" aligned with EMS with hospitals serving as their backup. To enhance outreach efforts, public service announcements should be sought from CPR champions such as cardiac arrest survivors.

Public-access defibrillation is the second key component in community response. Community standards should be developed for strategic placement of AEDs in public settings where cardiac arrest is common. Other strategies include Global Positioning System–based localization of the nearest AED that can be accessed by 9-1-1 operators or via smartphones. Global Positioning System mapping of AED deployment within a community enables the medical leadership to investigate ways to optimize deployment and to maximize the rate and timeliness of AED use for cardiac arrest in public settings.

Ultimately, the sustainability of any CPR or AED program is contingent on resource allocation and maintenance of close collaborations between local EMS agencies, hospitals, and key community stakeholders.[51]

9-1-1/Emergency Medical Systems Dispatch

When a call for unscheduled medical assistance is received at a public safety answering point, emergency medical dispatchers seek to identify cardiac arrest rapidly and accurately.[52] Formal dispatch protocols and an ongoing quality-improvement process, including the use of audits and feedback, should be used to minimize response times for EMS providers. Accurate determination of "time 0" is essential; the first record is the time that the telephone system identifies a 9-1-1 call, called trunk seizure time. Providing telephone instructions on delivery of chest

compressions and AED use to the caller is also vital because, with encouragement, most bystanders can provide chest compressions and use an AED, thus decreasing the time to treatment and thereby improving survival.[7,53]

Emergency Medical Systems Providers

It has long been recognized that EMS providers improve rates of survival from OHCA by providing CPR for the majority of the duration of the resuscitation attempt,[54] timely provision of first-responder defibrillation,[27] and timely provision of advanced cardiovascular life support by paramedics.[55] Other components associated with greater survival rates after OHCA are greater provider experience,[56–58] ongoing quality assurance of EMS care,[7] and transport to hospitals that receive a high volume of patients resuscitated from cardiac arrest or that have particular technical capabilities.[59] Moreover, prearrival notification of receiving hospitals is recommended to reduce time to reperfusion for patients who have ST-segment elevation on a prehospital ECG after resuscitation from cardiac arrest.[60]

Hospital Providers

The delivery of care to patients who achieve return of spontaneous circulation after OHCA is dependent on well-integrated and complementary out-of-hospital and in-hospital care. The AHA scientific statement on post–cardiac arrest syndrome describes the complexity of both the cardiac arrest condition and the care required to optimize outcomes.[61] Therapeutic hypothermia has provided the proof of concept that interventions initiated after return of spontaneous circulation can improve outcomes.[62–64] However, optimized post–cardiac arrest care involves much more than therapeutic hypothermia. Comprehensive post–cardiac arrest care requires multidisciplinary medical teams that include providers from emergency medicine, cardiology, critical care, neurology, and rehabilitation. It also requires a multiprofessional approach involving physicians, nurses, emergency medical technicians, respiratory therapists, pharmacists, and rehabilitation therapists. These organizational challenges contribute to the limited translation of advances in post–cardiac arrest care to routine clinical practice.

To successfully undertake cultural change to improve post–cardiac arrest care among hospital providers, we can learn from the experiences of other groups.[65–67] For OHCA, it requires investment in and organization of in-hospital resources (equipment, personnel, and triage systems) to care for survivors and a change in culture to allow such programs to develop and complement existing care for what are most often medically complicated individuals. Tables 2 and 3 outline proposed key elements and strategies for improving care and changing the culture at the level of in-hospital care for OHCA survivors.

Efforts must also be made to integrate in-hospital care of patients with OHCA. This involves ensuring that patients are considered, when appropriate, for cardiac catheterization and coronary reperfusion, therapeutic hypothermia, and hemodynamic optimization. In some centers, post–cardiac arrest care is provided by resuscitation or post–cardiac arrest teams, which are composed of a select group of experienced medical and nursing staff skilled in the management of post–cardiac arrest survivors. For many hospitals, however, such a program is either not feasible or not cost-effective because the number of post–cardiac arrest patients treated is limited. A potential solution supported by the AHA is the identification and certification of specialized cardiac resuscitation centers to treat patients who achieve return of spontaneous circulation after OHCA.[18] Conference participants also proposed that The Joint Commission or another independent body certify such centers rather than permit them to designate themselves as specialized cardiac resuscitation centers.

Summary and Next Steps

Overall, optimizing implementation is the action most likely to result in widespread improvement in survival after OHCA. The communities discussed in this statement have succeeded in improving OHCA survival rates because they were able to change systems of care. Without exception, this has required a dedicated champion who has marshaled human and financial resources and deftly built alliances among stakeholders. Each community has found ways of integrating processes of care in resuscitation management, as well as EMS and hospital staff, to improve efficiencies in delivery of care. Widespread expansion of these efforts will be limited unless significant barriers are removed. The most important barrier is the absence of a national system to continuously monitor and report OHCA incidence, process variables, and outcomes. Such a system would provide a mechanism to benchmark process variables and outcomes and to evaluate the effectiveness of quality-improvement measures. This information is also essential to foster accountability and to drive change among the medical leadership, community, EMS providers, and hospital providers. One solution proposed by the AHA is to make OHCA a reportable disease.[8]

The second major barrier is greater involvement of the lay public in the chain of survival. Culture change and novel training strategies are needed so that it becomes unacceptable for a patient with a witnessed cardiac arrest not to receive bystander CPR. For EMS providers, modification of training to prioritize the most effective interventions and case-by-case feedback on process and outcome variables are likely to be most effective. Finally, optimization of post–cardiac arrest care will require the commitment of hospital providers to develop and implement comprehensive multidisciplinary treatment protocols that can be executed 24 hours a day, 7 days a week. Optimized post–cardiac arrest care is resource intensive and not feasible in every hospital that receives EMS patients. A solution proposed by the AHA is the development and certification of specialized cardiac resuscitation centers.[18]

A number of questions remain. The model systems cited in this statement largely reflect the experiences of urban centers. It is unclear whether this paradigm also applies to rural areas. Half of all OHCAs are unwitnessed, and this number may be higher in rural communities, which would compound the difficulties in demonstrating improvements in OHCA survival in these regions. There also may be reporting bias; that is, we have learned much from communities that have improved OHCA survival rates, but we know little about those that failed. A nationwide system for monitoring and reporting incidence and outcomes would allow investigators to identify high- and low-performing

communities and to perform more systematic studies of factors that distinguish high from low performance.

Appendix

Participants in the 2009 American Heart Association Cardiac Arrest Survival Summit were Dianne L. Atkins, Janice M. Barnhart, Robert R. Bass, Lance Becker, Sean M. Berenholtz, Robert A. Berg, Jill Birnbaum, T.J. Bishop, Bentley J. Bobrow, Brendan G. Carr, Paul S. Chan, Chris Chiames, Ted Delbridge, Anne Elixhauser, John Freese, David F. Gaieski, Romergryko G. Geocadin, Louis Gonzales, Darryl Gray, Colleen C. Halverson, Michael T. Handrigan, Yuling Hong, Jerod Loeb, Russell V. Luepker, Keith Lurie, Mary E. Mancini, Clay Mann, Alice Mascette, Susan D. McHenry, Bryan McNally, Greg Mears, Venu Menon, Robert K. Merritt, Vinay M. Nadkarni, Robert W. Neumar, L. Kristin Newby, Mary Newman, Graham Nichol, James E. Niskanen, Robert A. Niskanen, Robert E. O'Connor, Joseph P. Ornato, Brett Patterson, Jeffrey Ranous, Thomas Rea, Eddie Rinehart, David L. Rodgers, Joe Sabato, Marcel E. Salive, Michael R. Sayre, George Sopko, Larry Starr, Richard Summers, and Roger D. White.

Disclosures

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Michael R. Sayre	Ohio State University, Associate Professor	Medtronic Foundation: Steering Committee Chair for the HeartRescue multistate program†	None	None	None	None	Expert witness*

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*Modest.

†Significant.

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†Significant.

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