

Part 16: Education, Implementation, and Teams

2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care

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Cardiac arrest occurs in a wide variety of settings, from the unanticipated event in the out-of-hospital setting to anticipated arrests in the intensive care unit. Outcome from cardiac arrest is a function of many factors including the willingness of bystanders to perform cardiopulmonary resuscitation (CPR), the ability of rescuers to integrate knowledge and psychomotor skills, the quality of performance delivered by individual rescuers and teams, and the efficiency and effectiveness of post-cardiac arrest care.

The Chain of Survival is a metaphor used to organize and describe the integrated set of time-sensitive, coordinated actions necessary to maximize survival from cardiac arrest. The use of evidence-based education and implementation strategies can optimize the links of that chain.

Strengthening the Chain of Survival in the prehospital setting requires focus on prevention and immediate recognition of cardiac arrest, increasing the likelihood of high-quality bystander CPR and early defibrillation, and improving regional systems of care. In the hospital setting, organized efforts targeting early identification and prevention of deterioration in patients at risk can decrease the incidence of cardiac arrest. The challenge for resuscitation programs is twofold: to ensure that providers acquire and maintain the necessary knowledge, skills, and team behavior to maximize resuscitation outcome; and to assist response systems in developing, implementing, and sustaining an evidence-based Chain of Survival.

Maximizing survival from cardiac arrest requires improvement in resuscitation education and the implementation of systems that support the delivery of high-quality resuscitation and postarrest care, including mechanisms to systematically evaluate resuscitation performance. Well-designed resuscitation education can encourage the delivery of high-quality CPR. In addition continuous quality improvement processes should close the feedback loop and narrow the gap between ideal and actual performance. Community- and hospital-based resuscitation programs should systematically monitor cardiac arrests, the level of resuscitation care provided, and outcomes. The cycle of measurement, benchmarking, feed-

back, and change provides fundamental information necessary to optimize resuscitation care and maximize survival.

This chapter reviews key educational issues that affect the quality of resuscitation performance and describes major implementation and team-related issues shown to improve outcomes. The information is organized into four major categories: willingness to perform CPR, educational design, improving resuscitation quality, and issues related to implementation and outcomes.

While important concepts identified in the 2010 International Liaison Committee on Resuscitation (ILCOR) and American Heart Association (AHA) evidence evaluation process are applied below,^{1,2} this document does not include all education, implementation, and team-related topics contained within the *2010 International Consensus on Cardiopulmonary Resuscitation and Emergency Cardiac Care Science With Treatment Recommendations*.^{1,2}

Willingness to Perform

Without immediate initiation of CPR, most victims of cardiac arrest will die. Bystander CPR can significantly improve survival rates from cardiac arrest,³ but recent evidence indicates that only 15% to 30% of victims of out-of-hospital arrest receive CPR before EMS arrival.⁴ Strategies to increase the incidence of bystander-initiated CPR and the use of automated external defibrillators (AEDs) are addressed in this section.

Barriers to Bystander CPR

Commonly cited reasons for reluctance to perform lifesaving maneuvers include concern for injuring the victim,⁵⁻⁷ fear of performing CPR incorrectly,^{6,8-11} physical limitations,¹² fear of liability,¹² fear of infection,¹⁰ or victim characteristics.¹³⁻¹⁶ Opportunities exist to overcome many of these barriers through education and encouragement to perform when the bystander is faced with a victim in cardiac arrest.

In a study of actual bystanders interviewed following a 911 call in which the EMS dispatcher encouraged performance of CPR, nonresponders most frequently cited panic (37.5%) and

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fear of hurting the patient (9.1%) as the reasons they were unable to perform.⁶ In 2 studies reviewing actual emergencies, bystanders encountered practical and understandable barriers to performance (eg, physical limitations, inability to listen to instructions and perform skills at the same time, and system delays) more often than panic or stress, although both were important factors.^{17,18} Because panic can significantly impair a bystander's ability to perform in an emergency, it may be reasonable for CPR training to address the possibility of panic and encourage learners to consider how they will overcome it (Class IIb LOE C).

Actual bystanders⁶ and surveys of the general public report that people more recently trained in CPR techniques expressed greater willingness to attempt resuscitation than those without recent training.^{16,19–21} Short, self-directed video instruction is an effective and cost-efficient strategy for training rescuers.^{22–33}

Fear of harming the victim or fear of personal injury may reduce willingness to undertake basic life support training or to perform CPR. However infection resulting from CPR performance is extremely rare and limited to a few case reports.^{34–44} Educating the public about the low risks to the rescuer and victim may increase willingness to perform CPR.

Some rescuers, including healthcare providers, may be more likely to initiate CPR if they have access to barrier devices. Despite the low risk of infections, it is reasonable to teach rescuers about the use of barrier devices emphasizing that CPR should not be delayed for their use (Class IIa, LOE C).

Rescuers who are not willing to perform mouth-to-mouth ventilations may be willing to perform Hands-Only (chest compression-only) CPR.^{5,9,10,13,19,21,45–47} CPR training programs should teach compression-only CPR as an alternative to conventional CPR for rescuers when they are unwilling or unable to provide conventional CPR (Class I, LOE B).

Barriers to Recognition of Cardiac Arrest

Victims of out-of-hospital cardiac arrest who are gasping have a higher survival rate compared to victims who are not gasping.⁴⁸ Gasping is commonly misinterpreted as a sign of life that may prevent rescuers from initiating resuscitation. Potential rescuers can be taught to recognize gasping and initiate CPR.⁴⁹ Rescuers should be taught to initiate CPR if the adult victim is unresponsive and is not breathing or not breathing normally (eg, only gasping) (Class I, LOE B).

Dispatcher telephone instructions and support has been shown to increase willingness to perform CPR.^{16,50,51} In order to increase bystander willingness to perform CPR, dispatchers should provide telephone CPR instructions to callers reporting an adult who is unresponsive and not breathing or not breathing normally (ie, only gasping) (Class I, LOE B).

Physical and Psychological Concerns for Rescuers

Correct performance of chest compressions is physically demanding.^{52–54} In the few reports of injuries to CPR providers, most of the injuries are musculoskeletal in nature.^{55–59} Case reports have described occasional complaints of shortness of breath^{60–62}; other isolated events^{63,64}; hand puncture wound from a sternal wire⁶⁵; nerve injury⁶⁶; pneumothorax⁶⁷; and one death due to a myocardial infarction.⁶⁸ It is reason-

able that participants undertaking CPR training be advised of the vigorous physical activity required during the skills portion of the training program (Class IIa, LOE B).

CPR training and performance are positive experiences for most providers.⁶⁹ However, firsthand observation of an actual cardiac arrest and attempting resuscitation can be stressful.^{17,55,56,70} Rescuers who suffer postevent adverse psychological effects may benefit from support or psychological counseling.

Barriers to AED Use

Some rescuers may be intimidated by the idea of delivering a shock, but AEDs are safe,^{71,72} and adverse events are rare.^{55,73–77} Although AEDs can be used effectively with no prior training, even brief training increases the willingness of a bystander to use an AED and improves his or her performance.^{78–80} To maximize willingness to use an AED, public-access defibrillation training should continue to be encouraged for the lay public (Class I, LOE B).

In summary, although the factors influencing willingness to perform CPR are myriad, many obstacles can be overcome with education. Although the precise number of trained volunteers needed to optimize the chance that a specific victim will receive CPR is not known, it is reasonable to assume that maximizing the number of people trained in a community and providing instructions and encouragement at the time an event occurs will improve the odds that a bystander will engage in resuscitation efforts.

Education Design

Evidence-based guidelines for instruction, as well as the development of cost-effective courses, are required to improve training of providers and ultimately improve resuscitation performance and patient outcomes.

Course Design

The appropriate application of learning theories combined with research into program effectiveness has resulted in substantial changes to the AHA Emergency Cardiovascular Care (ECC) courses over the past quarter century. Since the development of the first ECC Guidelines in 1966,⁸¹ the AHA has established itself as a leader in resuscitation science. However, the AHA's involvement in resuscitation education and training programs predates the development of formal ECC guidelines. In 1973, the AHA first endorsed training of the lay public in CPR.⁸² Subsequently, Advanced Cardiac Life Support (ACLS) was introduced in 1974,^{83,84} followed by Pediatric Advanced Life Support (PALS) in 1988.⁸⁵

In 2004 the AHA established the ECC Education Subcommittee with members including experts in curriculum and instructional design. Over time, the Education Subcommittee endorsed several educational principles as core concepts (see Table 1). Consistent with established methodologies for program evaluation,⁸⁶ the effectiveness of resuscitation courses should be evaluated (Class I, LOE C). Although participant satisfaction is important, program evaluation should extend beyond this end point and assess learners' acquisition and retention of knowledge and skills. Evidence that learners integrate what they learn into actual practice and

Table 1. Core AHA ECC Educational Concepts

- Simplification - Course content should be simplified in both the presentation of the content and the breadth of content in a single course in order to facilitate accomplishment of course objectives.^{22,24,25}
- Consistency - Course content and skill demonstrations should be presented in a consistent manner. Video-mediated, practice-while-watching instruction is the preferred method for basic psychomotor skill training because it reduces instructor variability and potential distractions that deviate from the intended course agenda.^{22-24,27-29,33}
- Objectives-Based - Cognitive,⁸⁷ psychomotor,⁸⁸ and affective objectives⁸⁹ should be included in all courses.
- Hands-on Practice - Substantial hands-on practice is needed to meet psychomotor skill performance objectives.^{22,24,26,28,33,90,91}
- Contextual - Adult learning principles⁹² should be applied to all ECC courses with emphasis on creating relevant training scenarios that can be applied practically to the learners' real-world setting, such as having hospital-based learners practice CPR on a bed instead of the floor.
- Competency-based - Successful course completion should be based on the ability of the learner to demonstrate achievement of course objectives rather than attendance in a course/program for a specific time period.²⁷
- Practice to Mastery - Key skills and course content should be repeated with deliberate practice⁹³ to build toward mastery.^{94,95}
- Assessment - Evaluative strategies should assess competence and promote learning. Learning objectives⁹⁶ must be clear and measurable and serve as the basis of evaluation.

whether that ultimately improves patient outcomes would constitute more robust forms of program evaluation.

Strategies for Basic Life Support (BLS) Courses

Studies have demonstrated that lay rescuer CPR skills can be acquired and retained at least as well (sometimes better) through interactive computer- and video-based synchronous practice instruction when compared with instructor-led courses.²²⁻³³ Short video instruction combined with synchronous hands-on practice is an effective alternative to instructor-led basic life support courses (Class I, LOE A).

AED Training Requirement

Manikin-based studies have demonstrated that AEDs can be correctly operated without prior training.^{79,97} Allowing the use of AEDs by untrained bystanders can be beneficial and may be lifesaving (Class IIa, LOE B). Because even minimal training has been shown to improve performance in simulated cardiac arrests,^{26,78-80,98} training opportunities should be made available and promoted for the lay rescuer (Class I, LOE B).

Strategies for Advanced Life Support (ALS) Courses

Resuscitation and education literature have demonstrated that precourse preparatory strategies including computer-assisted learning tutorials,⁹⁹⁻¹⁰⁴ written self-instructional materials,^{105,106} video reviews,¹⁰⁵ preparatory courses,^{107,108} textbook reading,¹⁰⁹ and pretests^{110,111} enhance knowledge acquisition or reduce classroom time. It is reasonable to include precourse preparatory strategies in advanced life support courses (Class IIa, LOE B).

Teamwork has been reported to impact patient outcomes in a variety of clinical situations.¹¹²⁻¹¹⁷ Teamwork and leader-

ship training have been shown to improve subsequent resuscitation performance in simulation studies¹¹⁸⁻¹²³ and actual clinical performance.¹²⁴ As a result teamwork and leadership skills training should be included in advanced life support courses (Class I, LOE B).

Realistic Manikins

Some manikins utilized in resuscitation training have realistic features such as the ability to replicate chest expansion and breath sounds, to provide exhaled carbon dioxide, to generate a pulse and blood pressure, and to speak or make sounds. Two studies reported that training with such manikins improved clinical performance.^{125,126} Thirteen studies showed an improvement in end-of-course skills when realistic manikins were used,^{49,125,127-137} while six studies showed equal performance with lower technology manikins.¹³⁸⁻¹⁴³ Use of more realistic manikins in training may incur substantially higher financial costs.¹⁴⁴

Eight studies showed equal knowledge acquisition with realistic manikins when compared with lower-technology manikins.^{128,130,138,142-146} Three studies indicated that learner satisfaction was greater with realistic manikins.^{130,138,142}

There is insufficient evidence to recommend for or against the routine use of more realistic manikins to improve skills performance in actual resuscitations. Realistic manikins may be useful for integrating the knowledge, skills, and behaviors in ALS training (Class IIa, LOE B). Further research is needed to confirm if such technology improves resuscitation performance in the clinical setting and to determine if it can improve survival from cardiac arrest.

Course Delivery Formats

Course delivery formats other than the standard 2-day ACLS or PALS provider course may achieve equivalent or better knowledge or skills acquisition. These formats include interactive multimedia courses^{99,147,148}; case-based presentations¹⁴⁹; integration of ACLS or PALS content into a larger curriculum such as medical student or resident training^{137,150,151}; noncomputer-based, self-directed learning¹⁵²; problem-based learning^{153,154}; or combination of resuscitation courses with other programs such as Advanced Trauma Life Support (ATLS).¹⁵⁵ It is reasonable to consider alternative course scheduling formats for advanced life support courses (eg, ACLS or PALS), provided acceptable programmatic evaluation is conducted and learners meet course objectives (Class IIa, LOE B).

Post-Course Assessment

Studies have shown poor correlation between written tests used in resuscitation courses and clinical skills evaluations.¹⁵⁶⁻¹⁵⁹ A written test should not be used exclusively to assess learner competence following an advanced life support course (Class I, LOE B).

Assessment used as an instructional tool at the end of resuscitation training has been shown to improve retention of skills at 2 weeks¹⁶⁰ and showed a trend toward improvement at six months.¹⁶¹ End-of-course assessment may be useful in helping learners retain skills (Class IIb, LOE C).

Training Intervals

Training intervals for AHA basic and advanced life support programs have traditionally been time-specific, with a maximum 2-year interval recommended. The *AHA ECC Program Administration Manual*¹⁶² notes that the course completion card “certifies that the individual has successfully completed the objectives and skills evaluations in accordance with the curriculum of the AHA for (*course title*).”

Reflecting the emerging trends supporting continuous maintenance of competence and continuing professional development in the healthcare professions,^{163,164} there is support to move away from a time-related certification standard and toward a more competency-based approach to resuscitation education.

There is substantial evidence that basic and advanced life support skills decay rapidly after initial training. Basic skills have been shown to deteriorate when assessed at 1 to 6 months^{24,27,165–167} or 7 to 12 months^{168,169} following training. Advanced life support providers demonstrated similar decays in knowledge or skills when assessed at 3 to 6 months,^{165,170–178} 7 to 12 months,^{179,180} and more than 12 months.¹⁸¹ These studies were heterogeneous with respect to participant composition, course length, course format, instructor type, and frequency of participant involvement in actual resuscitations. The majority reflected teaching methodologies in use prior to the most recent AHA course design updates in 2005.

In one study a 2-hour class was sufficient for participants to acquire and retain BLS skills for an extended time period, provided a brief re-evaluation was performed after 6 months.¹⁸² Four studies showed minimal or no deterioration of skills or knowledge at 6,⁷⁹ 12,^{183,184} or 17 months¹⁸⁵ after course completion.

While the optimal mechanism for maintenance of competence is not known, the need to move toward more frequent assessment and reinforcement of skills is clear. Skill performance should be assessed during the 2-year certification with reinforcement provided as needed (Class I, LOE B). The optimal timing and method for this assessment and reinforcement are not known.

Further research is needed to determine if modifications to initial training will alter the decay curve of CPR skills. Additional research is also needed to determine what time interval, mechanism of assessment, and method for refresher training will minimize decay in CPR skills. Innovative concepts to reduce the decay of skills and knowledge may include continuous maintenance of competency programs that employ frequent short-duration interactions with content and skills after an initial course, or they may include guided debriefings after real-life events that focus on response improvement.

Instructors and participants should be aware that successful completion of any AHA ECC course is only the first step toward attaining and maintaining competence. AHA ECC courses should be part of a larger continuing education and continuous quality improvement process that reflects the needs and practices of individuals or systems.

Improving Resuscitation Skills

Checklists/Cognitive Aids

The quality of resuscitation is a major determinant of patient outcome. Simulation studies of basic life support,^{186–190} advanced life support,^{191,192} and anesthetic emergencies^{193,194} demonstrated improved performance when checklists or cognitive aids were used. However, 1 simulation study demonstrated delayed completion of 2 cycles of CPR¹⁹⁵ when individuals not adept at cell phone operation used a cell phone-based cognitive aid. In clinical practice, physicians perceived checklists to be useful.^{196,197} The impact of cognitive aids or checklists on patient outcomes is unknown.

Checklists or cognitive aids, such as the AHA algorithms, may be considered for use during actual resuscitation (Class IIb, LOE C). Specific checklists and cognitive aids should be evaluated to determine if they achieve the desired effect and do not result in negative consequences such as delayed response. Further research on the optimal design is warranted.

CPR Prompt or Feedback Devices

Training in CPR skills using a feedback device improves learning and/or retention.^{167,183,198–203} The use of a CPR feedback device can be effective for training (Class IIa, LOE A).

The use of feedback devices or prompts, such as metronomes, has consistently improved performance of CPR in manikin-based studies.^{204–215} In clinical practice, the use of feedback devices has resulted in improved CPR performance compared to historic or concurrent nonrandomized controls.^{216–220} However, two manikin-based studies demonstrated variable reliability of feedback devices depending on the support surface (eg, floor or mattress) on which CPR is performed.^{221,222} CPR prompt and feedback devices can be useful as part of an overall strategy to improve the quality of CPR during actual resuscitations (Class IIa, LOE B); effect on patient survival has not been demonstrated.

Debriefing

Debriefing is a learner-focused, nonthreatening technique to assist individual rescuers or teams to reflect on, and improve, performance.²²³ In manikin-based studies, debriefing as part of the learning strategy resulted in improved performance in post-debriefing simulated scenarios,^{121,203,224–226} and it improved adherence to resuscitation guidelines in clinical settings.¹²⁶ Debriefing as a technique to facilitate learning should be included in all advanced life support courses (Class I, LOE B).

Debriefing of cardiac arrest events, either in isolation¹²⁴ or as part of an organized response system,²²⁷ improves subsequent CPR performance in-hospital and results in higher rate of return of spontaneous circulation (ROSC). Debriefing of actual resuscitation events can be a useful strategy to improve future performance (Class IIa, LOE C). Additional research on how best to teach and implement postevent debriefing is warranted.

Implementation and Outcomes

Systems Approach and Feedback Loop

Organized, cohesive resuscitation programs can improve survival from cardiac arrest by strengthening the links in the

Table 2. System Components to Prevent or Improve Survival from In-Hospital Cardiac Arrest

System-level components to reduce the incidence of, and improving survival from, in-hospital cardiac arrest may include^{231,260}:

- Systematic education on patient deterioration and its detection.
- Frequent monitoring of vital signs and assessment of at-risk hospitalized patients.
- Consistent use of predefined calling criteria or early warning scores.
- A notification system of calling for assistance.
- Rapid and effective clinical response to calls.
- Administrative support for program initiation and continuous quality improvement.

chain of survival.^{228–230} In this section some of the key systems-based initiatives that may improve patient outcomes are presented.

Rapid Response Teams (RRTs) and Medical Emergency Teams (METs)

RRTs and METs respond to patients who are deteriorating in noncritical-care settings; such teams may represent one piece of a rapid response *system* (RRS). A RRS has several components,²³¹ including an “afferent arm” (ie, event detection and response triggering arm); an “efferent arm” (ie, a planned response arm, such as the RRT); a quality-monitoring arm; and an administrative support arm.

Some studies have demonstrated a reduction in cardiac arrest rates for adult patients after implementation of various components of a RRS,^{232–247} while others have failed to show such a difference.^{248–253}

In pediatric settings the implementation of RRSs has resulted in the prevention of respiratory arrest,²⁵⁴ a decreased total number of arrests,^{255,256} better survival from cardiac arrest,^{256–258} and reduction in hospital-wide mortality.^{256,257,259} Implementation of a pediatric MET/RRT may be beneficial in facilities where children with high-risk illnesses are present on general inpatient units (Class IIa, LOE B).

Although conflicting evidence exists, expert consensus recommends the systematic identification of patients at risk of cardiac arrest, an organized response to such patients, and evaluation of outcomes to foster continuous quality improvement (Class I, LOE C). System components that are potentially important in reducing the incidence of, and improving survival from, in-hospital cardiac arrest are summarized in Table 2.

Regional Systems of (Emergency) Cardiovascular Care

There is wide variability in survival to hospital discharge, one-month survival, and length of critical-care stay among hospitals caring for patients after resuscitation from cardiac arrest.^{261–267} Hospitals with larger patient volumes (>50 ICU cardiac arrest admissions/year) had a better survival to hospital discharge than low-volume centers (<20 ICU-cardiac arrest admissions/yr) for patients treated for either in- or out-of-hospital cardiac arrest.²⁶⁵

Implementation of comprehensive packages of post-cardiac arrest care that included therapeutic hypothermia and

percutaneous coronary intervention^{268–270} has been shown to improve survival from cardiac arrest. Two small studies demonstrated trends toward improved survival that were not statistically significant when comprehensive packages of post-cardiac arrest care were introduced.^{271,272}

Although there is no direct evidence that regional systems of care for cardiac resuscitation improve outcome, extrapolation from research in other time-sensitive conditions, such as acute coronary syndromes,²⁷³ stroke,^{274,275} and trauma,²⁷⁶ suggests there may be a benefit to such a system. In 2010 the AHA published a policy statement calling for the development of regional systems of care as a strategy to reduce the variability in survival for out-of-hospital cardiac arrest.²⁷⁷ It is reasonable that regional systems of care be considered as part of an overall approach to improve survival from cardiac arrest (Class IIa, LOE C).

Resuscitation Training in Limited-Resource Communities

Many AHA instructors are involved in training in limited-resource environments in the United States and throughout the world. The vast majority of participants enjoy training and feel more comfortable after educational programs regardless of the type of training provided.^{278–290}

Improvements in provider performance and patient outcomes following training in resource-limited environments are inconsistent, and important characteristics of students and training environment, as well as outcomes (cognitive, psychomotor skills, operational performance, patient outcome, and cost-effectiveness), are inconsistently measured. Resuscitation training, when appropriately adapted to the local providers’ clinical environment and resources, has significantly reduced mortality in developing countries.^{284,291–294} The evidence from the trauma education is most compelling, and less clear with neonatal^{295,296} and adult cardiac resuscitation training programs.²⁹⁷ Patient outcome studies were often limited by study design, but 1 large, multicenter trial failed to show improvement in neonatal survival after newborn resuscitation training.²⁹⁸

There is no strong evidence to support any specific instruction method as preferable for all clinical environments and training subject experience. There is anecdotal evidence that successful resuscitation training in developing countries requires local adaptation to clinical environments,^{280,299–301} utilizing existing and sustainable resources for both care and training,^{282,300–302} and a dedicated local infrastructure.^{289,299}

Summary

Optimizing the links in the Chain of Survival improves outcomes and saves lives. The use of evidence-based education and implementation strategies will allow organizations and communities to strengthen these links in the most effective and efficient manner.

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Disclosures

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This table represents the relationships of writing group members that may be perceived as actual or reasonably perceived conflicts of interest as reported on the Disclosure Questionnaire, which all members of the writing group are required to complete and submit. A relationship is considered to be “significant” if (a) the person receives \$10 000 or more during any 12-month period, or 5% or more of the person’s gross income; or (b) the person owns 5% or more of the voting stock or share of the entity, or owns \$10 000 or more of the fair market value of the entity. A relationship is considered to be “modest” if it is less than “significant” under the preceding definition.

*Modest.

†Significant.

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