Editorial

Major Changes in the 2005 AHA Guidelines for CPR and ECC

Reaching the Tipping Point for Change

Mary Fran Hazinski, RN, MSN; Vinay M. Nadkarni, MD; Robert W. Hickey, MD; Robert O'Connor, MD; Lance B. Becker, MD; Arno Zaritsky, MD

The emergency cardiovascular care (ECC) scientists involved in the 2005 evidence evaluation process and the revision of the *2005 AHA Guidelines for CPR and ECC* began and ended the process aware of the limitations of the resuscitation scientific evidence, optimistic about emerging data that documents the benefits of high-quality cardiopulmonary resuscitation (CPR), and determined to make recommendations that would increase survival from cardiac arrest and life-threatening emergencies. This editorial summarizes the factors that contributed to the tipping point, the point at which information and discussion either triggered support for major changes in the guidelines or reaffirmed existing recommendations.

The scientists critically reviewed the sequence and priorities of the steps of CPR to identify those factors with the greatest potential impact on survival. They then developed recommendations to support those interventions that should be performed frequently and well. There was unanimous support for increased emphasis on ensuring that rescuers deliver high-quality CPR: rescuers need to provide an adequate number and depth of compressions, allow complete chest recoil after each compression, and minimize interruptions in chest compressions.

The *2005 AHA Guidelines for CPR and ECC* are based on the most comprehensive review of resuscitation literature ever published.[1] The evidence evaluation process incorporated the input of 281 international resuscitation experts who evaluated research, topics, and hypotheses over a 36-month period before the 2005 Consensus Conference. The process included structured evidence evaluation, analysis, and documentation of the literature.[2] It also included rigorous disclosure and management of potential conflicts of interest, a process summarized in two editorials.[3,4]

The Challenge

Cardiopulmonary resuscitation and emergency cardiovascular care is a relatively new field. The epidemiologic data is incomplete, and high-level evidence is insufficient to support many recommendations. Although sudden cardiac arrest (SCA) is responsible for an estimated 250 000 deaths out of the hospital in the United States each year,[5] it is not yet a reportable cause of death to the National Center for Vital Statistics of the Centers for Disease Control and Prevention. This limits our ability to understand the true incidence of this leading cause of death and determine the impact of interventions.

Despite decades of efforts to promote CPR science and education, the survival rate for out-of-hospital cardiac arrest remains low worldwide, averaging 6% or less.[6–9] The low survival rate makes it difficult to perform clinical trials with sufficient power to demonstrate improved long-term outcomes (ie, neurologically intact survival to hospital discharge). As the experts evaluated current literature, they noted that clinical studies used a wide variety of short-term outcome end points, were underpowered or too small, were not randomized, or had other design factors that limited ability to evaluate the relative effects of many interventions. These difficulties have been compounded by the restrictions on research created by informed consent regulations in North America[10] and Europe.[11] Although researchers continue to try to identify therapies that may improve short-term outcomes, the goal of resuscitation research remains the identification of interventions that improve neurologically intact survival to hospital discharge following cardiac arrest.

Low rates of survival from out-of-hospital SCA are not inevitable. Increased survival rates were reported in a North American study of organized community lay rescuer CPR and automated external defibrillation (AED) programs.[12] In addition, survival rates from witnessed ventricular fibrillation (VF) SCA ranging from 49% to 74% have been reported in lay rescuer CPR and AED programs in airports[13] and casinos[14] and programs involving police officers.[15] These successful programs had several common elements, including the training of rescuers in a planned and practiced response, rapid recognition of SCA, prompt provision of bystander CPR, and defibrillation within 5 minutes of collapse.

A striking finding of the 2005 Consensus Conference was the contrast of data that showed the critical role of early, high-quality CPR in increasing rates of survival from cardiac arrest with data that showed that few victims of cardiac arrest receive CPR[16,17] and even fewer receive high-quality CPR.[18–20]

The Decisions: Factors Influencing the Major Changes in the *2005 AHA Guidelines for CPR and ECC*

Compression-Ventilation Ratio

No human data has identified the optimal compression-ventilation ratio for CPR for victims of all ages. The impetus

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for a change in the recommended ratio was awareness that bystander CPR is performed infrequently and the rate of survival from SCA is low. Scientists agreed with the recommendation of the Utstein Conference on CPR Education to simplify CPR teaching.[21] Those recommendations are supported by evidence that participants often fail to master CPR skills during CPR courses[22] and that the quality of learned CPR skills rapidly declines after course completion.[23] The tipping point for the change in the compression-ventilation ratio came with evaluation and discussion of the cumulative evidence from recent clinical observations, theoretical calculations, and results of manikin and animal studies.

To be effective, CPR must restore adequate coronary and cerebral blood flow. Interruptions in chest compressions lower coronary perfusion pressure and decrease rates of survival from cardiac arrest.[24] In the first minutes of VF SCA, ventilation does not appear to be as important as chest compressions, but it does appear to contribute to survival from prolonged and asphyxial arrest.[25] Certainly the ventilation rate needed to maintain a normal ventilation-perfusion ratio during CPR is much smaller than normal because pulmonary blood flow is low.

In 2004 and 2005 several small case series in humans showed that during CPR healthcare providers delivered an inadequate number and depth of compressions, interrupted compressions frequently,[19,20] and provided excessive ventilation, particularly when victims were intubated.[18,20] Delivery of rescue breaths by lay rescuers was also likely to create long interruptions in chest compressions.[26,27] The combination of inadequate and interrupted chest compressions and excessive ventilation rates reduces cardiac output and coronary and cerebral blood flow[18,24] and diminishes the likelihood of a successful resuscitation attempt.

Once the experts agreed that a change in CPR recommendations was needed, the obvious challenge was how to translate that need into a specific recommendation that would be simple and appropriate for both asphyxial arrest and VF SCA and for attempted resuscitation of victims of all ages. Although continuous chest compressions alone could be appropriate in the first minutes of VF SCA, ventilations combined with minimally interrupted chest compressions would be more important for asphyxial arrest (including most pediatric arrests) and all forms of prolonged arrest. The experts also agreed that lay rescuers could not be expected to learn, select, and perform different sequences of CPR for victims with different causes of cardiac arrest.

Mathematical and animal models showed that matching of pulmonary blood flow and ventilation might be more appropriate at compression-ventilation ratios higher than 15:2.[28,29] There was concern, however, particularly among pediatric experts, that inadequate ventilation rates could reduce survival from pediatric and asphyxial (eg, drowning) arrest. To achieve optimal compression rates and reduce the frequency of interruptions in compressions, a universal compression-ventilation ratio of 30:2 for all *lone* rescuers of victims from infancy (excluding newborns) through adulthood is recommended by consensus, based on integration of the best human, animal, manikin, and theoretical data available. The 30:2 ratio is recommended to simplify training in 1-rescuer or 2-rescuer CPR for adults and all lay rescuer resuscitation. A compression-ventilation ratio of 15:2 is recommended for 2-rescuer CPR (a skill taught chiefly to healthcare providers and lifeguards) for infants and children (to the onset of puberty). This recommendation will result in the delivery of more rescue breaths per minute of CPR to victims with a high prevalence of asphyxial arrest.

Rescuers are encouraged to perform effective chest compressions (push hard, push fast), allow complete chest recoil after each compression, and minimize interruptions in chest compressions. Rescuers should take turns providing compressions during CPR because rescuers may tire after performing just a few minutes of compressions, and such fatigue can reduce the quality of compressions and chest recoil.

Compression First Versus Shock First for VF SCA

Recent data challenges the standard practice of providing defibrillation first to every victim with VF, particularly when more than 4 to 5 minutes has elapsed from collapse to rescuer intervention. In 2 studies of out-of-hospital VF arrest, when the interval between the call to the emergency medical services (EMS) system and delivery of the initial shock was 4 to 5 minutes or longer, a period of CPR before attempted defibrillation improved survival rates.[30,31] But one randomized study (LOE 2)[32] showed equivalent survival rates when either CPR or defibrillation was performed first for any EMS-call-to-shock interval.

The consensus was that there was insufficient data to recommend CPR before defibrillation for all victims of VF SCA. When participating in a public defibrillation program, lay rescuers should use the AED as soon as it is available. EMS rescuers may give about 5 cycles (about 2 minutes) of CPR before attempting defibrillation for treatment of out-of-hospital VF or pulseless ventricular tachycardia (VT) when the EMS response (call-to-arrival) interval is greater than 4 to 5 minutes or EMS responders did not witness the arrest. EMS medical directors may create system protocols based on the average response interval of their system. When multiple rescuers are present, one rescuer can perform CPR while the other readies the defibrillator, thereby providing both immediate CPR and early defibrillation.

The data was insufficient to determine (1) whether this recommendation should be applied to in-hospital cardiac arrest, (2) the ideal duration of CPR before attempted defibrillation, or (3) the duration of VF at which rescuers should switch from defibrillation first to CPR first.

1-Shock Versus 3-Shock Sequence for Attempted Defibrillation

The *ECC Guidelines 2000*[33] recommended the use of a so-called "stacked" sequence of up to 3 shocks, without interposed chest compressions, for the treatment of VF/pulseless VT. Although no studies in humans or animals specifically compared the 1-shock defibrillation strategy with the 3-stacked-shock sequence, other evidence created the tipping point for a change from a 3-shock sequence to 1 shock followed immediately by CPR.

The 3-shock recommendation was based on the low first-shock efficacy of monophasic damped sinusoidal waveforms and efforts to decrease transthoracic impedance with delivery of shocks in rapid succession. Modern biphasic defibrillators have a high first-shock efficacy (defined as termination of VF for at least 5 seconds after the shock), averaging more than 90%,[34,35] so that VF is likely to be eliminated with 1 shock. If 1 shock fails to eliminate VF, the VF may be of low amplitude and the incremental benefit of another shock is low. In such patients, immediate resumption of CPR, particularly effective chest compressions, is likely to confer a greater value than an immediate second shock.

After VF is terminated,[36–38] most victims demonstrate a nonperfusing rhythm (pulseless electrical activity or asystole) for several minutes; the appropriate treatment for such rhythms is immediate CPR. Yet in 2005 the rhythm analysis for a 3-shock sequence performed by commercially available AEDs resulted in delays of 29 to 37 seconds or more between delivery of the first shock and the beginning of the first post-shock compression.[38,39] This prolonged interruption in chest compressions cannot be justified for analysis of a rhythm that is unlikely to require a shock.

Experts recommend that rescuers resume CPR, beginning with chest compressions, *immediately after attempted defibrillation.* Rescuers should not interrupt chest compressions to check circulation (eg, evaluate rhythm or pulse) until after about 5 cycles or approximately 2 minutes of CPR. In specific settings (eg, in-hospital units with continuous monitoring in place), this sequence may be modified at the physician's discretion.

The recommendation for a 1-shock strategy creates a new challenge: to define the optimal energy for the initial shock. The consensus is that it is reasonable to use 150 J to 200 J for the initial shock with a biphasic truncated exponential waveform or 120 J with a rectilinear biphasic waveform. In recognition that many EMS systems may still be using monophasic defibrillators, the consensus recommendation for initial and subsequent monophasic waveform doses is 360 J. The goal of this recommendation is to simplify attempted defibrillation. For children, the consensus recommendation is an initial dose of 2 J/kg (monophasic or biphasic); for second and subsequent biphasic shocks, it is advisable to use the same or higher energy (2 to 4 J/kg). Manufacturers of defibrillators should ensure that each of their products clearly displays the range of energy levels at which each specific defibrillator waveform was shown to be effective at terminating VF. Healthcare providers should be aware of the range of energy levels of the specific device they are authorized to operate.

Vasopressors, Antiarrhythmics, and Sequence of Actions During Treatment of Cardiac Arrest

Despite the widespread use of epinephrine and several studies of vasopressin, no placebo-controlled study has shown that any medication or vasopressor given routinely at any stage during human cardiac arrest increases rate of survival to hospital discharge. Most out-of-hospital studies, however, are hampered by heterogeneous populations with prolonged arrest times, making it difficult to identify potentially successful therapies.

A meta-analysis of 5 randomized out-of-hospital trials showed no significant differences between vasopressin and epinephrine for return of spontaneous circulation, death within 24 hours, or death before hospital discharge.[40] A proposal to remove all recommendations for vasopressors was considered but not approved in the absence of a placebo versus vasopressor trial and the presence of laboratory evidence documenting the beneficial physiologic effects of vasopressors on hemodynamics and short-term survival.

There was no evidence that routine administration of any antiarrhythmic drug during human cardiac arrest increased rate of survival to hospital discharge. One antiarrhythmic, amiodarone, improved short-term outcome (ie, survival to hospital admission) but did not improve survival to hospital discharge when compared with placebo[41] and lidocaine.[42]

Given this lack of documented effect of drug therapy in improving long-term outcome from cardiac arrest, the sequence for CPR deemphasizes drug administration and reemphasizes basic life support. In the *ECC Guidelines 2000,*[43] pulse and rhythm checks were recommended after each shock. These recommendations contributed to prolonged interruptions in chest compressions. To minimize these interruptions in chest compressions, the *2005 AHA Guidelines for CPR and ECC* recommend that rescuers resume CPR beginning with chest compressions *immediately* after a shock, without an intervening rhythm (or pulse) check. Vasopressors or antiarrhythmics should be administered during CPR, as soon as possible after a rhythm check. The drug will be circulated by the CPR performed while the defibrillator charges or by the CPR that follows the shock. The most important part of the sequence is high-quality chest compressions with minimal interruptions. Providers should not interrupt compressions to check the rhythm after a shock is delivered until about 5 cycles or 2 minutes of CPR are provided. If an organized rhythm is present, the healthcare provider should check for a pulse.

Healthcare providers should practice coordination of CPR and shock delivery so that when a shock is indicated, it can be delivered as soon as possible after chest compressions are stopped and rescuers are "cleared" from contact with the victim. Studies have shown that a reduction in the interval between compression and shock delivery by as little as 15 seconds can increase the predicted shock success.[44,45] Defibrillator manufacturers are encouraged to develop AEDs that are capable of analyzing the heart rhythm during uninterrupted chest compressions.

Postresuscitation Care

Postresuscitation treatment is now receiving greater emphasis in emergency cardiovascular care, but there is little evidence to support specific therapies, and treatment is not standardized across healthcare communities.[46] After initial resuscitation, providers must be prepared to support myocardial and organ function. Support of blood pressure, control of temperature (particularly prevention or treatment of hyperthermia) and glucose concentration, and avoidance of routine hyperventilation are now recommended.

Therapeutic hypothermia has been shown to improve neurologic outcome among initially comatose survivors from out-of-hospital adult VF cardiac arrest.[47,48] Studies of newborns with asphyxia at birth suggest that brain cooling for selected patients may improve survival rates and neurologic outcomes.[49] But the role of this therapy after in-hospital cardiac arrest, across all age groups and arrest etiologies, requires further definition. Because of challenges in the practical application of therapeutic hypothermia, further research is needed to identify optimal methods of cooling and optimal timing, duration, and intensity of cooling that is likely to be effective.

Highlights of the *2005 AHA Guidelines for CPR and ECC* Recommendations

For further information about the evidence evaluated and treatment recommendations noted in this section, the reader is referred to relevant sections of this supplement. In many cases, as summarized below, there was insufficient evidence to create a tipping point toward a change in the guidelines; in others, accumulating data actually reaffirmed existing practices.

In pediatric resuscitation, emphasis is placed on provision of effective compressions and ventilations. A prospective randomized controlled trial confirmed that routine use of high-dose epinephrine was not beneficial and may actually increase rates of morbidity and mortality.[50]

In newborn resuscitation, a recent randomized controlled trial[51] showed no benefit for suctioning of the vigorous meconium-stained infant. This result reaffirmed the recommendations of the *ECC Guidelines 2000*.[52] There was inadequate data to indicate the superiority of room air to 100% oxygen for resuscitation. Evidence evaluation reaffirmed a focus on establishment of effective ventilation as the most important intervention in newborn resuscitation.

The Acute Coronary Syndromes Task Force confirmed the fundamental role of risk stratification involving the use of ECGs for classification and management of patients with acute coronary syndromes.[53] The task force reaffirmed the recommendation for out-of-hospital performance and prearrival transmission of either 12-lead ECGs or their interpretation to the receiving hospital to reduce time to reperfusion in acute myocardial infarction.[54] The recommendations for acute coronary syndromes have been simplified to focus on the first hours of therapy.

The Stroke Task Force reaffirmed the 2000 recommendation for use of tissue plasminogen activator (tPA) therapy for acute ischemic stroke[55] when administered by physicians in hospitals with stroke protocols that rigorously adhere to the eligibility criteria and therapeutic regimen of the National Institute of Neurological Disorders and Stroke (NINDS) protocol. Hospital commitment to stroke care can improve outcomes. A dedicated stroke unit with care provided by a multidisciplinary team experienced in managing stroke can improve survival rates, functional outcomes, and quality of life for patients with acute stroke.[56]

The First Aid Task Force evaluated the evidence supporting a number of first aid therapies, including the use of direct pressure versus tourniquets[57] for control of hemorrhage and treatment of ingestion and environmental emergencies. The recommendations of the task force form the basis of expanded guidelines for first aid.

Summary

This editorial summarizes several key changes in resuscitation skills and sequences recommended in the *2005 AHA Guidelines for CPR and ECC*. Simply put: rescuers should push hard, push fast, allow full chest recoil, minimize interruptions in compressions, and defibrillate promptly when appropriate. Many of these changes were not supported by level 1 evidence but were made by consensus, tipped by a combination of laboratory, clinical, and educational research and outcome data. Throughout the evidence evaluation document,[1] critical gaps in resuscitation knowledge were identified. Research in these issues has the potential to further improve CPR.

Further research is required in nearly all aspects of CPR and ECC. What is becoming clear is the need to focus on CPR performance and to integrate the performance of advanced cardiovascular life support skills into the continuous chest compression-ventilation sequence. There is no question that high-quality advanced cardiovascular life support depends on high-quality basic life support.

In the final analysis, the most important determinant of survival from sudden cardiac arrest is the presence of a rescuer who is trained, willing, able, and equipped to act in an emergency. Our greatest challenge and highest priority is the training of lay rescuers and healthcare providers in simple, high-quality CPR skills that can be easily taught, remembered, and implemented to save lives.

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