EDITORIAL

2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation: Physiologic and Educational Rationale for Changes

The 2005 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care and the European Resuscitation Council Guidelines for Resuscitation 2005 have prompted a heightened discussion of cardiopulmonary resuscitation (CPR) and emergency cardiovascular care among health care professionals. Compared to the 2000 guidelines, the new guidelines have changed recommendations in many areas primarily because of advances in the science of cardiac resuscitation. The recommended changes are substantial and will influence clinical practice at several levels. The guidelines are the culmination of a rigorous evidence-evaluation process never before undertaken with such a commitment to a thorough review of all available science. The evidence-evaluation deliberations included participation by 281 international experts in resuscitation during a 36-month period. The final session was a week-long International Consensus Conference on Emergency Cardiac Care and CPR Science with Treatment Recommendations held in Dallas, Tex, in January 2005. All interventions were assigned a classification (class I through class III or class indeterminate) in accordance with the level of available evidence (Table 1). The focus throughout the evolution of the guidelines was on those interventions that most likely would have the greatest impact on survival from acute cardiovascular crises, most importantly cardiac arrest. Changes in the practice of CPR and advanced cardiac life support (ACLS) will affect all health care professionals who care for patients experiencing cardiac arrest. This editorial reviews the major recommendations for adult patients experiencing cardiac arrest and the rationale for those recommendations.

Basic Life Support
Compelling evidence was presented that confirmed major deficiencies in the provision of CPR, particularly that provided by trained health care professionals in both out-of-hospital and in-hospital settings. Long pauses without chest compressions and compressions that are suboptimal in both rate and depth are frequent in both settings. Experimental evidence from animal studies has shown that inadequate blood flow during cardiac arrest has a detrimental impact on both restoration of spontaneous circulation and survival.

It is likely that the same adverse effects occur in humans experiencing cardiac arrest. Long pauses without chest compression and therefore with no flow are common during management of patients in ventricular fibrillation (VF) who are receiving defibrillation shocks, as discussed later. At the same time, clinical evidence shows that ventilation during cardiac arrest is frequently excessive and potentially harmful. Experimentally, hyperventilation has been shown to have adverse effects on coronary perfusion pressure and survival, primarily because of impaired venous return secondary to high intrathoracic pressures.

In light of these observations, the major focus in the guidelines emphasizes interventions that will maximize blood flow during CPR by provision of effective and uninterrupted chest compressions for longer periods. Thus, rather than a ratio of 15:2 compressions to ventilation the guidelines call for a 30:2 ratio at a compression rate of 100 per minute and pauses for 2 ventilations limited to 1 second per ventilation. On the basis of experimental observations, this ratio should result in improved sustained blood flow for longer periods during cardiac arrest. Devices that can monitor both rate and depth of chest compressions are becoming available as attachments to monitors and defibrillators. Monitoring end-tidal carbon dioxide tension during chest compression also can be a useful measurement of cardiac output.

Advanced Cardiac Life Support
Defibrillation. Integration With CPR. The advent and widespread availability of automated external defibrillators (AEDs) shifted emphasis from CPR to immediate application of these devices for delivery of shocks if indicated. Two problems have emerged from experience with early defibrillation using AEDs: (1) in many situations a period of blood flow with CPR preceding defibrillation can improve defibrillation success and patient outcome, and (2) excessive no-flow time can be consumed while these devices analyze the cardiac rhythm before and after shock delivery. Regarding the first consideration, several experimental and clinical studies have shown benefit from a period of CPR before defibrillation is attempted in some situations. In clinical studies, this has been observed when...
the time from patient collapse to rescuer’s arrival to the patient exceeds approximately 5 minutes. In such circumstances, a period of 90 to 120 seconds of CPR preceding shock delivery has been reported to improve survival.19,20

The guidelines consider provision of such a period of CPR before attempted defibrillation an option if there is a meaningful delay before the patient can be defibrillated. Of course it is frequently difficult to know how long a patient in an unmonitored setting may have been in cardiac arrest before being attended.

Analysis of the VF waveform is an emerging technology that will predict the likelihood of defibrillation shock success.21-24 An algorithm incorporated into a defibrillator that can determine whether CPR first or a shock first is likely to be beneficial has been developed and is now available for clinical use in AEDs.25 Incorporation of such algorithms into defibrillators of all types will increase the likelihood of correct decision making and impact restoration of spontaneous circulation and survival from cardiac arrest when VF is the presenting rhythm.25

Excessive delays in compression (and therefore blood flow) are common with both AEDs (as they analyze the cardiac rhythm) and manual defibrillators as health care professionals take time to assess postshock rhythms on the monitor and to check for pulses. Delays in the resumption of chest compressions of 29 to 38 seconds after the initial shock have been described.15,16 During treatment of patients in VF, chest compressions have been reported to be performed less than half the time of the resuscitation, obviously with the patient in a no-flow state all this time.14,16

The 2000 guidelines advocated delivery of “stacked” defibrillation shocks to patients in VF if shocks failed to terminate VF. Thus, the recommendation was that up to 3 consecutive shocks be delivered if needed without interruption (and thus with no chest compressions and no blood flow). This resulted in protracted periods when no flow was occurring. Again, the detrimental effects of such no-flow periods have been documented experimentally.7 To obviate such adverse effects, and again to emphasize the compelling need for blood flow in the patient in cardiac arrest, the 2005 guidelines recommend virtually immediate resumption of chest compressions after a shock has been delivered for a period of approximately 2 minutes, which is the equivalent of 5 cycles of 30:2 compression-ventilation. Cardiopulmonary resuscitation is continued until the defibrillator is charged and ready to deliver a shock. An exception to this recommendation would be in a patient whose rhythm and arterial blood pressure are being monitored and a perfusing arterial pressure wave is observed immediately after the shock. In most instances, however, the heart is at least transiently “stunned” by defibrillation shocks and is benefited by a period of coronary blood flow with chest compressions. This is a major change in performance using the new 2005 guidelines, and it emerges from an evidence-based analysis of all available experimental and clinical science.

The recommended sequence of actions to minimize interruptions in CPR during the treatment of pulseless ventricular tachycardia (VT)/VF arrest is shown in Figure 1.

Defibrillation Waveforms and Energy. Monophasic defibrillator waveforms, whether monophasic damped sine or monophasic truncated exponential, are rapidly being phased out of clinical use because of the superiority of biphasic waveforms for termination of VF or pulseless VT. The 2 most widely used biphasic waveforms today are the biphasic truncated exponential (BTE) and the rectangular waveform. Linear bipolar waveform. A low-energy pulsed (chopped) biphasic waveform is in use in Europe and is awaiting approval by the US Food and Drug Administration.26 If a monophasic defibrillator is still being used, it is recommended that the highest energy output of 360 J be used for the first shock. All biphasic waveforms in use today are impedance-compensated and adjust the delivered dose of energy in accordance with the measured impedance with each shock. If a BTE waveform is used, 150 to 200 J can be used for the first shock. With the RB waveform, a selected energy of 120 J is recommended. With this waveform, the delivered energy is typically higher than that
selected because of impedance compensation, and for an 80-ω impedance–patient, approximately 150 J will be delivered. More details on waveforms and energies with various defibrillators have been reported. Biphasic waveforms terminate VF with the first shock in nearly 90% of cases. If VF recurs, the same energy dose should be used. If, however, VF persists, either the same or an escalating dose of energy can be used. There is no evidence that one biphasic waveform is clearly superior to another, nor is there any evidence that escalation of energy during reported shocks is superior to nonescalation in attempted termination of persistent VF. In part this is due to the probabilistic nature of the defibrillation threshold, which is a result of the variations in the amount of myocardium in its vulnerable period at the moment the shock is delivered. The amount of tissue in its vulnerable period will differ compared with another moment in time at the instant of shock delivery. Therefore, the same energy used for an initial unsuccessful shock may succeed in terminating VF with the next shock.

For cardioversion with biphasic waveforms, energy doses have not been well-defined. It is reasonable to begin with 100 to 120 J with either BTE or RB waveforms for both supraventricular tachyarrhythmias and monomorphic VT and use either escalating or nonescalating doses if needed.

**Drug Therapy in Cardiac Arrest.** Epinephrine remains the drug of choice in cardiac arrest, although vasopressin is an option if the arrest persists after the first dose of epinephrine. These are the only 2 vasoactive drugs recommended during cardiac arrest, and both are used to induce vasoconstriction and thereby improve coronary and cerebral blood flow. Despite earlier evidence that vasopressin might have advantages over epinephrine, subsequent evidence has not supported that position, and thus 1 dose of vasopressin is considered an option to epinephrine.

Despite years of use in cardiac arrest, lidocaine has not been shown in an evidence-based evaluation to have any demonstrable short-term or long-term efficacy in VF or pulseless VT cardiac arrest. Therefore, amiodarone has surfaced as the antiarrhythmic drug of choice in this circumstance and is the preferred antiarrhythmic agent. In randomized trials that compared amiodarone and lidocaine, amiodarone was accompanied by higher rates of restoration of spontaneous circulation and survival to hospital admission. However, amiodarone is not without adverse effects and can produce vasodilation and thus a decline in perfusion pressure, certainly an undesirable effect in cardiac arrest. This adverse effect may be secondary to the polysorbate 80 and benzyl alcohol solvents. An aqueous formulation that does not contain these solvents may produce less vasodilation. To attenuate the hypotensive effects of amiodarone during cardiac arrest, administration should always be preceded by at least 1 dose of epinephrine. Currently, there is no evidence that amiodarone im-

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**FIGURE 1. Treatment sequence for ventricular fibrillation (VF)/pulseless ventricular tachycardia (VT).** CPR = cardiopulmonary resuscitation. Reproduced with permission from *Handbook of Emergency Cardiovascular Care* ©2006, American Heart Association.
proves discharge survival after a VF or pulseless VT arrest and thus for this end point has no advantage over lidocaine.

**Postresuscitation Interventions.** The major new recommendation in this area is therapeutic hypothermia for patients who have experienced an out-of-hospital cardiac arrest in VF, have been resuscitated, and are hemodynamically stable but unresponsive on hospital admission.\(^{33,34}\) Therapeutic cooling for 24 hours to 32°C to −33°C has been shown in several studies to result in improved neurologic recovery compared with patients after a similar arrest who have not been cooled.\(^{35}\) For this specific group of patients, a class IIa recommendation was assigned; for patients with non-VF arrests or for in-hospital arrests, a class IIb recommendation was given, primarily because no data are available for these patients. More studies are needed to define more precisely the neurologic benefit of therapeutic hypothermia, but at this time it appears to hold promise.

**Educational Initiatives.** Retention of acquired resuscitation skills is well established as a challenge yet to be resolved. Educational methodology was reviewed in detail and is discussed in the guidelines section on educational methods. It is evident that frequent retraining in both theory and practice is mandatory for maintenance of both basic life support (BLS) and ACLS skills, but the optimal interval for such retraining has yet to be defined. Novel approaches to education in BLS and ACLS are being assessed, but at this time no one method has been clearly established to be superior in knowledge and skills retention. Sophisticated simulators are being assessed, among other approaches. Health care professionals would be well-advised to avail themselves of opportunities for training and retraining in accordance with currently recommended American Heart Association intervals. Retraining in both BLS and ACLS should be undertaken by all health care professionals who care for patients at risk of cardiac arrest.

The 2005 guidelines emerged from an intensive and rigorous evidence-evaluation process culminating in recommendations for substantial changes in provision of emergency care by health care professionals. Although the recommendations are based on the science available today, many areas are in need of further definition and substantiation. A major refocus is on the performance of prompt, effective, and uninterrupted chest compressions to enhance blood flow during cardiac arrest. Thus, the compression-ventilation ratio has been increased to minimize interruptions, and the pause for ventilation has been limited to 2 seconds. In selected instances in which cardiac arrest may be longer than approximately 5 minutes, a period of 90 to 120 seconds of CPR preceding defibrillation has the potential for improving survival. When defibrillation is used, chest compressions should be resumed immediately after shock delivery, without delay to assess the postshock cardiac rhythm or to check for pulses. Vasopressin is considered an option to epinephrine for 1 dose only. Amiodarone has displaced lidocaine as the antiarrhythmic drug of choice in VF/VT arrest. Finally, therapeutic hypothermia is a recommended postresuscitation intervention in patients who survive an out-of-hospital VF arrest but who remain unresponsive.

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