Automated External Defibrillation/Public Access Defibrillation

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INTRODUCTION

The Automated External Defibrillation/Public Access Defibrillation Panel evaluated 5 proposals. The premise that underscored all 5 proposals was that early defibrillation (within 5 minutes of 911 call receipt to shock delivery) is a Class I recommendation. The evidence is well defined that the chance of surviving a cardiac arrest caused by ventricular fibrillation (VF) declines by approximately 10% for each minute without defibrillation. Every community should assess its capability to provide this intervention and institute whatever measures are needed to make early defibrillation a reality. For in-hospital arrest, the time interval from call receipt to shock delivery should be less than 3 minutes.

The first proposal is based on evidence showing that a low-energy (150-J), impedance-compensating, biphasic truncated exponential (BTE) waveform is safe and as effective as or more effective than higher energy, escalating, monophasic waveform shocks for termination of VF. This specific biphasic waveform was evaluated because it was the only biphasic waveform for which out-of-hospital data on efficacy in termination of prolonged VF was available.

The second and third proposals are related in several aspects. The second specifically applies to implementation of public access defibrillation (PAD) programs and stipulates prerequisites that should be fulfilled before implementation of such programs. Fulfillment of these prerequisites should enable rational deployment of automated external defibrillators (AEDs) in a variety of public settings. It is recognized that a large, controlled, randomized multicenter trial is needed to further define

the appropriate disposition of AEDs. The third proposal focuses on the role of health care providers in the provision of early defibrillation. A health care provider is defined as any individual with a duty to perform cardiopulmonary resuscitation (CPR); thus, the term includes a wide spectrum of responders whose role may require a CPR response, such as police officers, firefighters, security guards, lifeguards, and flight attendants. Several studies have demonstrated the ability of such responders to acquire the skills of AED operation and to provide rapid defibrillation resulting in good patient outcomes.

The fourth proposal emphasizes the need for rapid defibrillation in hospitals and other patient care locations. Defibrillation within less than 3 minutes of receipt of the call for help should be the goal in all such settings. Furthermore, it is essential that in-hospital defibrillation programs develop accurate systems for data collection, including synchronized times that will define the actual times from the call for help to shock delivery, as is performed outside the hospital in emergency medical services (EMS) settings. The lack of patient outcome data from in-hospital AED programs is most likely an indication that few hospitals have instituted such programs.

Defibrillation of children is addressed in the fifth proposal. Although it is evident that VF is a relatively uncommon cause of cardiac arrest, some studies indicate that 6% to 22% of arrests in children may be caused by VF, and these children are the ones most likely to survive. Because experience with AEDs in children is very limited, questions remain about the sensitivity and specificity of the algorithm and about which energy dosages are safe and effective for children.

Topic 1: Biphasic Waveform Defibrillation

1992 GUIDELINES

None.

PROPOSED ADDITION OR CHANGE

For out-of-hospital cardiac arrest, biphasic waveform shocks of relatively low energy are safe and as effective for the termination of VF as higher energy, escalating, monophasic waveform shocks. Safety and efficacy data for specific biphasic waveforms must be evaluated on an individual basis in both in-hospital (electrophysiologic studies, implantable cardioverter-defibrillator [ICD] testing) and out-of-hospital settings.

NEW SCIENCE

Most external defibrillators currently use monophasic waveforms, either damped sinusoidal (MDS) or truncated exponential (MTE) monophasic waveforms. Monophasic waveforms are the conventional waveforms used for transthoracic defibrillation with both manual defibrillators and AEDs. The 1992 guidelines recommended an initial 200-J shock with increases in energy levels to either 200 or 300 J and then to 360 J for subsequent shocks (*JAMA*. 1992;268:2211-2).

During the past 2 decades, biphasic waveform defibrillation has been examined in experimental and clinical settings. Biphasic waveforms deliver both a positive and a negative current that together result in successful defibrillation with significantly less delivered energy than monophasic waveforms when VF is of short duration (<60 seconds).[1-4] The advantages of low-energy biphasic defibrillation in the design of ICDs are widely recognized.[5-9] By the early 1990s, all implantable defibrillators were designed to use biphasic waveforms.

In the human electrophysiology laboratory or operating room, impedance-compensating biphasic waveforms with energy levels of 115 or 130 J are as effective as monophasic waveforms with energy levels of 200 to 360 J for induced VF of short duration (≤15 seconds).[3,4,10,11] After prolonged VF (6 to 9 minutes) in out-of-hospital arrest, a nonescalating, 150-J, impedance-compensating BTE waveform defibrillates with greater overall efficacy than a high-energy (200- to 360-J) MDS waveform.[12-15]

In a recent multicenter, randomized clinical study that was published as an abstract at the time of the conference, 150-J biphasic (BTE) waveform and monophasic waveform shock delivery (80% MTE) were compared in victims of out-of-hospital cardiac arrest. Initial success of defibrillation, return of spontaneous circulation (ROSC), survival to hospital admission, and survival to hospital discharge were compared.[16] Biphasic waveform defibrillation with a fixed energy of 150 J significantly improved the efficacy of defibrillation (98% vs 67%, $P<.0001$). This was associated with a significantly greater rate of ROSC (76% vs 55%, $P<.02$). There were no statistical differences in survival-to-hospital admission and survival-to-hospital discharge between the 2 groups. The data from this abstract subsequently were published as a manuscript.[16]

EVALUATION AND DEBATE

The evidence supporting the proposal was from 8 studies with a level of evidence of 1 to 5 that were of excellent quality. There were no studies with either neutral or opposing evidence.

PROPOSED GUIDELINES

A low-energy (150-J), impedance-compensating BTE waveform is safe and as effective as or more effective than higher energy, escalating monophasic waveform shocks for termination of VF (Class IIa).

FINAL GUIDELINE

Biphasic waveform defibrillation with shocks less than 200 J is safe and has equivalent or higher efficacy for termination of VF compared with higher-energy escalating monophasic-waveform shocks (Class IIa).

Topic 2: Public Access Defibrillation

1992 GUIDELINES

"The placement of automated external defibrillators (AEDs) in the hands of large numbers of people trained in their use may be the key intervention to increase the survival chances of out-of-hospital cardiac arrest patients. . . .The widespread effectiveness and demonstrated safety of the AED have made it acceptable for nonprofessionals to effectively operate the device. Such persons must still be trained in CPR and use of defibrillators. In the near future, more creative use of AEDs by nonprofessionals may result in improved survival. . . .Participants in the national conference recommended that (1) AEDs be widely available for appropriately trained people, (2) all fire-fighting units that perform CPR and first aid be equipped with and trained to operate AEDs, (3) AEDs be placed in gathering places of more than 10,000 people, and (4) legislation be enacted to allow all EMS [emergency medical services] personnel to perform early defibrillation." (*JAMA*. 1992;268:2291.)

In its 1997 Statement on Defibrillation, the International Liaison Committee on Resuscitation[17] (ILCOR) defined "a first responder…as a trained individual acting independently with a medically controlled system. In the community this may include police, security officers, lifeguards, airline cabin attendants, railway station personnel, volunteers who render first aid, and those assigned to provide first aid at their workplace or in the community and who are trained in the use of an AED." The following recommendations were made: "(1) Establish acceptance, support, and coordination by responsible community medical and EMS authorities. (2) In some specific situations consider combining training programs for bystander defibrillation with training in BLS [basic life support], with careful monitoring of results. (3) Arrange for review of all clinical applications of an AED by a medically qualified program coordinator or a designated representative. (4) Plan for critical program evaluation at 2 levels: individual clinical uses and overall EMS system effects. (5) Use only AEDs; practical considerations render manual defibrillators inadvisable for lay use. (6) Continue innovations to produce simple, lightweight, economically priced, and highly reliable AEDs."[18]

The 1996 American College of Cardiology (ACC)/American Heart Association (AHA) guidelines[19] state that "Automated external defibrillators (AEDs) have been shown to be effective and safe. They can be used by first responders with a minimum of training to quickly and accurately analyze rhythms and deliver defibrillation shocks to patients in VF. Systems that incorporate AEDs to shorten response times are highly desirable. Prehospital providers trained and capable of providing ACLS [advanced cardiac life support] with drugs, intubation, and other therapy further improve the patient's chances for survival."

The 1995 AHA statement on public access defibrillation[20] indicates that "early bystander cardiopulmonary resuscitation (CPR) and rapid defibrillation are the 2 major contributors to survival of adult victims of sudden cardiac arrest. The AHA supports efforts to provide prompt defibrillation to victims of cardiac arrest. Automatic external defibrillation is one of the most promising methods for achieving rapid defibrillation. In public access defibrillation, the technology of defibrillation and training in its use are accessible to the community. The AHA believes that this is the next step in strengthening the chain of survival. Public access defibrillation will involve considerable societal change and will succeed only through the strong efforts of the AHA and others with a commitment to improving emergency cardiac care."

"Public access defibrillation will include (1) performance of defibrillation by laypersons at home and by firefighters, police, security personnel, and nonphysician care providers in the community; and (2) exploration of the use of bystander-initiated automatic external defibrillation in rural communities and congested urban areas where resuscitation strategies have had little success."

PROPOSED ADDITION OR CHANGE

Panelists considered addition of a recommendation for PAD to the guidelines.

NEW SCIENCE

The AHA has hosted 2 conferences on PAD, 1 in 1994[21,22] and 1 in 1997.[23] Although there are no randomized clinical trials on PAD, there is unequivocal evidence showing the inverse relationship between time to first defibrillation and survival of out-of-hospital cardiac arrest due to VF. Survival of out-of-hospital VF decreases by approximately 7% to 10% for each minute of delay until defibrillation can be accomplished.

Case series with and without historical control subjects conducted among flight attendants, casino workers, and police officers have documented the ability of properly trained "layperson" first responders to use AEDs appropriately, safely, and effectively.[24-35] But the laypersons who have effectively used these devices are employed in positions that regularly require them to "take command" in an emergency situation. It is not clear whether laypersons who do not function in such a role can safely and effectively use these devices. Finally, mathematical models indicate that the intervention can be cost-effective over a broad range of model assumptions.[36,37]

EVALUATION AND DEBATE

There was some discussion of whether institution of PAD programs should be considered a Class IIa or IIb recommendation. There was clear support of the need for a randomized clinical trial on the use of AEDs by trained laypersons who normally do not have a professional duty to act. In view of the successful implementation of PAD programs in diverse settings such as the airline industry, casinos, and Chicago airports, it was decided that implementation of PAD programs should be recommended in certain locations.

PROPOSED GUIDELINES

Evidence supports implementation of PAD programs (Class IIa) at sites that (1) have a high enough frequency of cardiac arrest events that there is more than a 50% probability of at least 1 clinical AED use within the 5-year expected lifetime of an AED (estimate based on person-years concept, 1 VF arrest per 1000 person-years), (2) cannot reliably achieve a call to 911/appropriate first defibrillation shock interval of less than 5 minutes with the conventional EMS system, and (3) can reliably achieve (in ≥ 90% of cases) a call to 911/appropriate first defibrillation shock interval of less than 5 minutes by training and equipping laypersons to function as first responders in the community's EMS system by recognizing a cardiac arrest, activating 911, initiating CPR, and operating and applying an AED.

FINAL GUIDELINES

Evidence supports establishment of PAD programs in the following cases: (1) The frequency of cardiac arrest events is such that there is a reasonable probability of 1 AED use in 5 years (estimated event rate of 1 sudden cardiac arrest per 1000 person-years), (2) An EMS call-to-shock time interval of less than 5 minutes cannot be reliably achieved with conventional EMS services. In many communities, this EMS call-to-shock time interval can be achieved by training and equipping laypersons to: function as first responders in the community; recognize cardiac arrest; activate the EMS system (phoning 911 or another appropriate emergency response number) at appropriate times; provide CPR; and attach/operate an AED safely. (3) For BLS responders such as police, firefighters, security personnel, sports marshals, ski patrol members, ferryboat crews, and airline flight attendants (referred to as level 1 responders in this document), education in CPR and the use of an AED is a Class IIa recommendation. For level 2 targeted responders such as citizens at work sites or in public places, this is a Class Indeterminate recommendation at this time. Likewise, for level 3 responders (family and friends of persons at high risk) this is a Class Indeterminate recommendation.

Topic 3: Defibrillation by Health Care Providers

1992 GUIDELINES

Training of security and other personnel in CPR and use of AEDs was encouraged. Evidence of improvement in survival of VF arrest after institution of emergency medical technician-defibrillation (EMT-D) programs was cited. Conference participants recommended that AEDs be made widely available for appropriately trained persons such as firefighters and that legislation be enacted to permit EMS personnel to defibrillate. The 1992 guidelines strongly supported early defibrillation initiatives to

include all personnel whose occupations require that they perform CPR.

PROPOSED ADDITION OR CHANGE

Evidence supports a national policy that in all communities health care providers with a duty to perform CPR should be trained, equipped, and authorized to perform defibrillation.

NEW SCIENCE

Since 1992, numerous studies have documented that first responders with a duty to perform CPR can acquire and maintain the skills of AED operation and that such AED-equipped responders as police officers can use AEDs successfully.[31,32] Observational studies of AED use by first responders in aircraft and airport terminals and by lifeguards have demonstrated safe and effective use.[34,38,39] The critical relationship between survival and time from collapse to defibrillation is the most compelling evidence of the need to equip first responders with a duty to perform CPR with AEDs. A variety of studies have firmly established this relationship.[23,37,40-42] Observational experience with police defibrillation also has affirmed the close relationship between time to defibrillation and survival.[31,32] Data extrapolated from the studies cited above indicates that there is a 10% decline in chance of survival with every minute that defibrillation is delayed. A 70% to 90% chance of survival would be expected if defibrillation were accomplished within the first minute after collapse. The decline in survival crosses the 50% point at approximately 5 minutes, the 30% point at 7 minutes, and the 10% point at 9 to 11 minutes. Beyond 12 minutes the chance of survival is 2% to 5%. Experience with rapid defibrillation by police first responders is consistent with these extrapolations of survival. Two meta-analyses of survival with early defibrillation by basic EMTs both indicated that this intervention improved survival by 9%.[43,44]

The evidence supporting this proposal consisted of 1 study with level 3 evidence,[32] 1 study with level 4 evidence,[27] and 3 studies with level 5 evidence.[34,38,45] No studies presented either neutral or opposing evidence.

EVALUATION AND DEBATE

There was agreement on the proposal. Because in some settings health care providers might use manual defibrillators, it was recommended that the proposal not be confined to defibrillation with AEDs only, although it was recognized that, in the majority of settings, defibrillation will be provided with AEDs.

PROPOSED GUIDELINES

The evidence available for evaluation coupled with the unequivocal evidence confirming the critical relationship between time to defibrillation and survival suggests that health care providers with a duty to perform CPR should be trained, equipped, and authorized to perform defibrillation (Class IIa).

Topic 4: In-Hospital Resuscitation

1992 GUIDELINES

The 1992 guidelines state that all personnel who have a responsibility to respond to patients in cardiac arrest should be trained and authorized to use a defibrillator, particularly an AED. (*JAMA*. 1992;268;2211-2213.) The Advanced Cardiac Life Support textbook states that all BLS personnel must be trained and equipped to operate a defibrillator if in their professional activities they are expected to respond to people in cardiac arrest.[46]

PROPOSED ADDITION OR CHANGE

The concept of early defibrillation applies not only to out-of-hospital resuscitation but also to in-hospital resuscitation efforts.

NEW SCIENCE

No published studies have documented improved outcome when hospital first responders are trained and equipped to provide early defibrillation using an AED. Times to defibrillation for in-hospital resuscitation are often inaccurate and prolonged in non–critical care areas. Several hospitals have shown that nurses can be trained to operate an AED and that they retain these skills over time.

EVALUATION AND DEBATE

The development of early defibrillation programs for in-hospital responders was discussed. It was thought that all hospital staff who may need to respond to a sudden cardiopulmonary emergency should be trained and equipped to provide early defibrillation. Ideally, this should be accomplished by placing AEDs in strategically located

areas throughout a facility.[22,47] Hospitals should critically evaluate the process by which they perform resuscitation, the type of equipment and location used to deliver early defibrillation, the accuracy of documentation during resuscitation, and the methods used for data collection and reporting.[47]

PROPOSED GUIDELINES

In-hospital nurses and other first responders should be trained, equipped, authorized, and encouraged to perform early defibrillation before the arrival of other health care professionals. Hospital outpatient areas should be staffed and equipped to provide early CPR and early defibrillation. Early defibrillation by manual or automated methods is a Class I recommendation.

FINAL GUIDELINES

For in-hospital defibrillation: (1) Early defibrillation capability, which is defined as having appropriate equipment and trained first responders, should be available throughout hospitals and affiliated outpatient facilities (Class IIa); (2) the goal of early defibrillation by first responders is a collapse-to-shock interval, when appropriate, of less than 3 minutes in all areas of the hospital and ambulatory care facilities (Class I); and (3) response time intervals for in-hospital resuscitation events are often inaccurate and must be corrected before documented times to defibrillation can be considered reliable (Class IIa).

Topic 5: Use of AEDs in Infants and Children

1992 GUIDELINES

AEDs are currently recommended for use in children older than 8 years, but the priority within the cardiac arrest algorithm is unclear. AEDs are not recommended for children younger than 8 years.

PROPOSED ADDITION OR CHANGE

AEDs should be used on pulseless, unresponsive children older than 8 years in the out-of-hospital setting. The use of an AED may be considered for children younger than 8 years. Limited data indicate that the VF detection algorithms currently in use are both sensitive and specific for use in children.[48-50] High sensitivity and specificity also support the use of AEDs for rhythm diagnosis in young children. The pediatric advanced life support cardiac arrest algorithm should reflect this recommendation.

NEW SCIENCE

During the literature review, 23 articles and abstracts were reviewed (3 level 3, 15 level 5, 1 level 6, and 5 level 8). Not all the articles were directly related to the use of AEDs in children.

EVALUATION AND DEBATE

The following points and issues were brought out in the discussions:

The most common (>50% of cases) causes of cardiac arrest in children are respiratory events in those younger than 5 years and accidents in children older than 5 years. The prevalence of ventricular arrhythmias as the initial rhythm during pediatric cardiac arrest varies from 10% to 25% and increases with age.

The rate of successful resuscitation in children is less than 10% for those with asystole and 5% to 25% for those with VF.

It is difficult to determine with certainty what level of energy is safe and effective for children, especially now with the widespread use of low-energy biphasic waveforms. Data on safe energy levels in children are limited. Energy levels that cause serious myocardial toxicity are probably much greater than those currently recommended (2 to 4 J/kg).[51] Biphasic waveforms appear to cause less myocardial toxicity than damped monophasic waveforms.[11,52] A broad range of safe energy levels would support the use of a single pediatric AED energy dose. A single dose of either 75 or 100 J would deliver a reasonable dosage of energy to children who weigh more than 10 kg.

PROPOSED GUIDELINES

AEDs are recommended for use in children older than 8 years (Class IIb). It is unclear at this time whether AEDs should be used in children younger than 8 years (Class Indeterminate).

FINAL GUIDELINES

The use of AEDs in children older than 8 years of age (approximately >25 kg body weight) is a Class IIb recommendation. The use of AEDs in infants and children

younger than 8 years of age is not recommended (Class Indeterminate).

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