Sudden Cardiac Arrest
A Treatable Public Health Crisis

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Overview

Sudden cardiac arrest (SCA) remains a major unresolved public health problem; each year in the United States alone, sudden cardiac arrest strikes more than 350,000 people—nearly 1,000 per day—making it the single leading cause of death.1,2 Due in part to the unexpectedness with which SCA strikes, most of these victims die before reaching a hospital. Currently, the chances of surviving an SCA in the United States are less than one in 20. Experts agree that many of the deaths due to SCA are preventable and that available technology, if appropriately applied, could reduce them significantly at a relatively low cost.3
The vast majority of sudden cardiac arrests are due to abnormal heart rhythms called arrhythmias, of which ventricular fibrillation is the most common. Ventricular fibrillation is a condition in which the heart's electrical impulses suddenly become chaotic, causing abrupt cessation of the heart's pumping action. Victims collapse and quickly lose consciousness, often without warning.4 Unless a normal heart rhythm is restored, death follows within a matter of minutes.

The underlying cause of sudden cardiac arrest is not well understood. Many victims have no history of heart disease, or if heart disease is present, it has not functionally impaired them. Many people have a perception that sudden cardiac arrest primarily afflicts male senior citizens. The reality is that SCA strikes both men and women; although the average age of victims is 65,4 many of those who experience SCA are much younger—many are in their 30s and 40s.5

Unlike other epidemics of this magnitude, there exists a definitive and proven therapy for ventricular fibrillation. This therapy is defibrillation—the application of an electric shock to the heart—applied to the patient's chest with an instrument called a defibrillator. Defibrillation eliminates ventricular fibrillation and allows a coordinated electrical rhythm and pumping action to resume.

Survival rates from ventricular fibrillation can be remarkably high if defibrillation therapy is administered within the first few minutes of sudden cardiac arrest. In three studies of cardiac arrest occurring in supervised cardiac rehabilitation centers, more than 90% of victims were successfully resuscitated.6-8 For each minute ventricular fibrillation persists, however, the likelihood of successful resuscitation decreases by approximately 10%.9 After as little as 10 minutes, very few resuscitation attempts are successful.

The key to preventing these unnecessary deaths is to provide defibrillation therapy in a timely fashion. The public's investment in an emergency notification system (911 telephone number) and an emergency medical service (EMS) system were the first steps toward achieving the goal of widespread and rapid deployment of defibrillation. For a number of reasons—among them, economic pressures—progress toward achieving this goal has stalled. Only one-quarter of ambulances and only 10% to 15% of fire department vehicles that have emergency "first-response" duties are equipped with portable external defibrillators.10 Considering the number of cardiac-related emergencies handled by such first-responders, this lack of preparedness is unacceptable. According to Dr. Richard O. Cummins, Professor of Medicine at the University of Washington and a leader in the treatment of sudden cardiac arrest:

> *There is now both national and international acceptance of the "principle of early defibrillation," which contends that whoever arrives first at the scene of a cardiac arrest should have a defibrillator.*11

The argument for widespread defibrillator availability is compelling. In cities where defibrillators are more widely available and there is emphasis on timely application, such as in Seattle, Washington, it has been found that the survival rate can be increased to as much as 30%,9 far above the national survival rate of 5% or less.12 If a 30% survival rate could be achieved nationally, it would result in the saving of more than 100,000 lives annually or more than 250 lives per day.

Within the first 10 minutes of sudden cardiac arrest, it has been found that the survival rate improves by approximately 10% for every minute that is saved in getting the defibrillator to the patient.9 Delay in reaching the patient can be due to a number of factors. According to a study of California's emergency response system, obstacles to the rapid provision of emergency care were especially great in public

gathering sites and the work place. The survival rate of those who arrested in locations where there were limited access points, such as concert halls and office buildings, was less than 1%.13 A study of sudden cardiac arrest in New York City found that only one person in 100 who had a sudden cardiac arrest outside of the hospital survived. The poor survival was attributable in part to lengthy elapsed time at every step in the emergency care process.14 The authors recommended wider availability of portable defibrillators to increase the probability that the first responder to an emergency scene would be properly equipped.
Recognizing that rapid emergency response is essential to survival, efforts have been made to improve all stages of the Chain of Survival, which the American Heart Association (AHA) has defined as early access to emergency medical care, early institution of cardiopulmonary resuscitation (CPR), early defibrillation, and early institution of advanced cardiac life support (ACLS).15

Highly trained emergency medical personnel and emergency notification systems (i.e., 911) have been developed and deployed. Millions of people have learned the techniques of CPR that can add a few minutes to the time available for successful defibrillation.16 Defibrillation protocols now recommend the immediate application of a defibrillatory shock upon identification of ventricular fibrillation.17 While all of these improvements are important in the rescue process where sudden cardiac arrest is concerned, what may be even more essential for improved survival is the institution of a far wider network of defibrillator-equipped first-responders, including fire department personnel, police officers, lifeguards, flight attendants, and other authorized responders with responsibility for public safety. To make defibrillators more widely available, however, a breakthrough in technology is required to reduce their complexity, size, and cost. This breakthrough is now at hand.

The development of automatic external defibrillators (AEDs) in the 1980s was a major step forward over manual defibrillators. Standard manual defibrillators require that the operator be able to interpret electrocardiogram (ECG) strips and make a "shock" or "no shock" decision. AEDs contain micro-computers to accurately identify the cardiac arrhythmia as ventricular fibrillation so that operator knowledge of ECG wave forms is unnecessary, opening this technology to a much broader group of responders. These devices have proven to be exceptionally safe and effective.18 Early AEDs, however, were expensive, maintenance intensive, required ongoing skills training, and were relatively large and heavy. These factors made them impractical for many groups of emergency responders and limited their widespread deployment.

Recent breakthroughs in AED technology are now removing these barriers, making this life-saving technology practical for broad groups of authorized responders. These new devices are virtually maintenance free, easy to use, small, lightweight, durable, and less expensive. The widespread availability of these new devices will make sudden cardiac arrest a truly treatable disease, preventing literally thousands of unnecessary deaths and allowing a return to full and active lives. Survivors have a good long-term prognosis: 83% of survivors are alive at one year and 57% at five years.19 The potential for lives saved by AEDs makes defibrillation a very cost-effective public investment. Studies of the cost-per-life saved by defibrillator-equipped emergency medical technicians show that it is one of the most cost-effective medical interventions.

Universal deployment of AEDs requires a combination of elements: an effective 911 dispatch system throughout the country; appropriately trained and equipped first-responders including fire department personnel, police officers, and others who respond to 911 calls; and the collective will to ensure that the economic resources are available to purchase equipment and train first-responders. The objective is that AEDs should be widely available so that they can be at the scene of a sudden cardiac arrest within 5 minutes and as easy to use in an emergency as a fire extinguisher.18

With the number of unnecessary deaths that result from the lack of timely defibrillation, the core of the issue is motivation on the part of both professionals and the public to train all first-responders in the community and to equip them with AEDs. This publication is offered as a resource to those responsible for the solution to the problem of preventable deaths from sudden cardiac arrest. It is clearly within the reach of every committed and educated community to implement an early defibrillation program that will prevent unnecessary deaths from this treatable public health crisis.

Part I: Medical Issues

Definition and Incidence of Sudden Cardiac Arrest

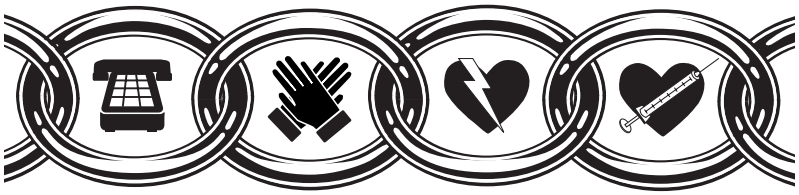
Sudden death that is not due to trauma is most often a consequence of a sudden electrical malfunction of the heart that results in loss of effective pulse and blood pressure. This is called sudden cardiac arrest (SCA).20 There are several electrical abnormalities that result in sudden cardiac arrest, but the most common is ventricular fibrillation21-23—chaotic electrical discharge of the heart that results in ineffective, ventricular "quivering" rather than coordinated contractions. Loss of pulse, blood pressure, and consciousness immediately follow the onset of this arrhythmia. Death of the patient, or sudden cardiac death (SCD), results within minutes if the arrhythmia is not corrected.

Each year in the United States, there are nearly one million deaths from cardiovascular disease.24 Sudden, unexpected death from cardiac arrest accounts for more than 350,000 of these fatalities.1,2
Without definitive treatment, sudden cardiac arrest from ventricular fibrillation is almost always fatal. Ventricular fibrillation, however, can be converted to a normal cardiac rhythm with the application of an electric shock to the heart through the chest wall—external defibrillation.25
Little is known about what precipitates sudden ventricular fibrillation.23 While it is a well-recognized complication of acute myocardial infarction, only 30% of sudden cardiac arrests occur in this setting.3,12 Many episodes of sudden cardiac arrest occur in people with no cardiac history.2 Recent well-known victims have included accomplished athletes such as basketball player Hank Gathers of Loyola Marymount University.

Treatment of Sudden Cardiac Arrest

According to the American Heart Association Task Force on the Future of Cardiopulmonary Resuscitation, the availability of automatic external defibrillators is essential to increased survival from cardiac arrest.26 Early CPR appears to benefit patients by slowing the process of dying, but it does not replace defibrillation as definitive therapy and its effectiveness diminishes within minutes.4

Without prompt treatment with a defibrillator, SCA is almost always fatal. Since most sudden cardiac arrests occur in the pre-hospital environment, efforts have focused on providing prompt delivery of emergency care to victims at the location of the arrest. In the late 1960s, Pantridge introduced the concept of the mobile intensive care unit and showed improved survival with pre-hospital treatment of the acute complications of myocardial infarction.27,28 The years since have seen development of 911 emergency notification systems, bystander-initiated CPR, emergency medical service systems, and improvements in external defibrillator technology. Strategies have been developed and refined for implementing these emergency measures as rapidly as possible after sudden cardiac arrest. In 1990, the AHA summarized the accumulated experience of two decades with the recommendations incorporated in the Chain of Survival concept (Figure 1).15,29



This concept enumerates four essential steps in the treatment of sudden cardiac arrest.30,31 The general principles of speed and attention to essential life functions embodied in this formulation apply universally regardless of the cause of the emergency—cardiac arrest, trauma, drowning, foreign-body inhalation, etc. These principles, however, are nowhere more important than in the emergency treatment of sudden cardiac arrest when a treatment delay of as little as a few minutes can mean the difference between death and return to productive life.

The Chain of Survival is as follows:

Early Access to Care. With the sudden loss of an essential life function, rapid treatment is imperative. Beginning with Pantridge in the 1960s, skilled emergency personnel and equipment are now brought to the patient rather than waiting until the patient can be transported to the hospital to receive urgent, emergency care. The universal recognition of the importance of this step has resulted in the development and wide distribution of emergency medical service (EMS) systems throughout the country. Emergency medical technicians (EMTs) and the even more highly trained paramedics now specialize in the delivery of emergency care in the field. To activate the EMS system, the 911 emergency-notification system was developed, and the public was educated in its use for the reporting of emergencies.32,33 Trained dispatchers then complete the link to the EMS system by alerting the appropriate emergency personnel.

Early Cardiopulmonary Resuscitation (CPR). CPR is the procedure by which the basic life-sustaining functions of blood flow and oxygenation can be briefly maintained to support the heart and central nervous system until more definitive treatment can restore normal function. Mouth-to-mouth breathing and chest compression can only partly compensate for normal cardiopulmonary function, but for a short time, tissue oxygenation can be sufficiently maintained to add a few minutes to the time available for definitive treatment—defibrillation. Though CPR expands the window of time for application of defibrillation, it does not replace defibrillation in saving the victim.

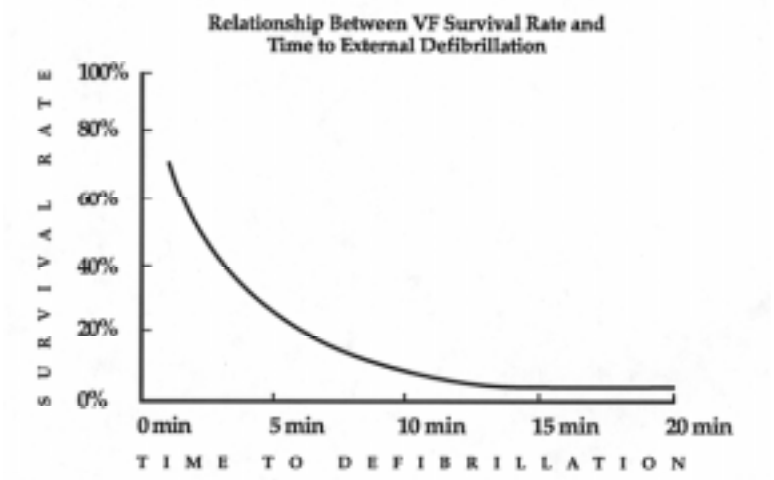


Figure 2. Illustration of sudden cardiac arrest survival curve. (From info. in reference 37)

Early Defibrillation. It is widely accepted that early defibrillation is the single most important factor in survival from SCA caused by ventricular fibrillation. The sooner the defibrillatory shock is administered, the more likely is the restoration of normal cardiac rhythm. Defibrillation administered less than three minutes after collapse in cardiac arrest is most likely to be successful.34-36 For each minute in duration of SCA, the likelihood of successful conversion decreases by approximately 10% (Figure 2).9,37 The potential for success is clearly seen in arrests that have occurred in supervised cardiac rehabilitation programs. In these settings, where cardiac arrests actually occur during cardiac monitoring and are defibrillated in less than one minute, success rates are about 90%.6-8 Thus, much of the focus of attention in treatment of SCA is on providing rapid defibrillation. Patients who survive cardiac arrest have an excellent prognosis: 83% are alive at one year and 57% at five years.19 This compares favorably with the survival rates for people of the same age who have not experienced a sudden cardiac arrest.13

Early Institution of Advanced Life Support. When sudden cardiac arrest is the result of ventricular fibrillation, electrical countershock is the definitive treatment and may be the only emergency treatment necessary. In general, survival is unlikely if successful defibrillation is not accomplished at the site of the arrest.38 The patient is then monitored carefully on the way to the hospital for more definitive diagnostic evaluation. On other occasions, more advanced treatment measures such as intubation or intravenous drugs may be indicated prior to arrival at the hospital emergency department, but defibrillation must be

successfully accomplished first if transport, monitoring, and advanced treatment and diagnostic measures are to be worthwhile.

The Evolution of Rapid Emergency Defibrillation

As the concept of on-site emergency care began to emerge, it was apparent that a physician could not always be present. Therefore, new ancillary medical professions were developed specifically to provide expert emergency care. Paramedics receive from 800 to 2000 hours of intensive instruction in emergency diagnosis and treatment in the field, including advanced cardiac life support (ACLS).39,40,41 These professionals are trained to interpret ECG strips and use manual portable defibrillators.

Because of the expense associated with training and maintaining teams of paramedics, the concept of a two-tiered emergency response system has developed, adding emergency medical technicians (EMTs) to the emergency medical system. EMTs initially receive approximately 110 hours of training to provide basic life support including CPR.42 In many communities, authorized fire department personnel, police officers, and even private citizens serve as EMTs. Because of their lower cost, a community can typically maintain a greater number and geographical distribution of EMTs who can therefore reach patients more quickly than paramedics and begin basic life-support procedures prior to arrival of an ACLS-trained paramedic team. There are approximately 600,000 EMTs nationwide.43 Many of the 15,000 basic life support (BLS) ambulances and 75,000 fire department-based vehicles are staffed with EMTs.44 Less than 25% of BLS ambulances and 10% to 15% of fire department-based vehicles presently, however, are reported to be equipped with AEDs.10

In 1994, the United States Department of Transportation incorporated defibrillation into their EMT-Basic National Standard Training Curriculum. For the first time, the curriculum includes a section requiring all EMTs to be trained in the use of AEDs.42 Since timely application of defibrillation is the key factor in reversing sudden cardiac arrest, increasing the number of appropriately equipped responders is the direction of the future if unnecessary deaths from SCA are to be prevented.11

The best results have been achieved in cities where a combination of aggressive public education programs in CPR, 911 service, two-tiered emergency response systems, and policies to allow early defibrillation by EMTs result in rates of successful resuscitation of approximately 30%.9 In Seattle, Washington, and surrounding King County, 60% of the lay community has participated in CPR instruction.19 A two-tiered emergency response system has been established and first-responder defibrillation has been extended to EMTs and fire department personnel. Improvement in each layer of emergency response has been shown to contribute to improvement in overall survival rates.25, 36, 41, 45-56

Part II: Economic Issues

The cost to society of life-saving defibrillation is far less than for other important medical diseases. In one study, the cost-per-life saved from sudden cardiac arrest by emergency medical systems staffed by EMTs certified to provide external defibrillation or paramedics is estimated at from $2,100-$2,300.40 This is compared with an expenditure of $35,000-$45,000 for renal dialysis per year of useful life, $50,000 per year of life saved for primary prevention of coronary heart disease by cholesterol reduction treatment with lovastatin (except in very high-risk patients), and $15,000-$30,000 per year of life saved for screening and generic drug treatment of high blood pressure.57

Of note is that the above estimate of defibrillation cost includes a $7,000 defibrillator and a $40,000 ambulance.40 The addition of less expensive AEDs to the emergency vehicles already in operation but not yet defibrillator-equipped will further decrease the cost-per-life saved by both decreasing the cost and increasing the number of victims who will be treated in time to be saved.

A similar study analyzed 190 out-of-hospital cardiac arrests in Tucson, Arizona.58 The cost-per-year of life saved for care of sudden cardiac arrest by paramedics, including training, personnel, equipment, and response time maintenance, was found to be $8,000. This is much less than the cost-per-year of life saved for the several other procedures noted by the authors: heart transplantation ($27,200), liver transplantation ($44,000), bone marrow transplantation for acute nonlymphocytic leukemia ($62,500), and chemotherapy for acute nonlymphocytic leukemia ($64,000).

A further reduction in cost-per-life saved would come from wider availability of AEDs to a broader range of first-responders. Dr. Richard O. Cummins has stated:

> *Anyone who can learn CPR can learn to use AEDs.*18

Considering that more than 90% of the 350,000 annual cardiac arrests occur out-of-hospital,4 and that nationwide no more than 5% of SCA victims currently survive,12 the cost-per-life saved by making inexpensive, reliable AEDs available to a wider range of first-responders figures to be well below that of addressing any other major cause of death.

Americans have long since recognized the value of skilled mobile emergency care and have invested heavily in this area. Sophisticated emergency medical systems have been developed, along with the skilled professionals to staff them. The public has been given the means to rapidly access the emergency system via the 911 emergency telephone number. Millions of citizens have gone further, learning the techniques of CPR. Yet, only one-quarter of ambulances and 10% to 15% of first-response fire department vehicles are equipped with defibrillators.10

With such a large investment already in place to respond to out-of-hospital medical emergencies, the incremental investment required to properly equip first-responders to treat victims of sudden cardiac arrest is likely to be a worthy investment for a community, given the significant life-saving potential of early defibrillation.

Part III: Technology Issues

Early defibrillation is widely accepted as the critical determining factor in survival from SCA. Advances in defibrillator technology, enabling a much broader group of responders to deliver defibrillation therapy, has the potential to significantly impact patient outcome. Progress toward this objective was made with the advent of the automatic external defibrillator (AED).

The Automatic External Defibrillator (AED)

Improvements in solid-state circuitry and micro-computers in the 1980s facilitated the development of a sophisticated defibrillator that can identify ventricular fibrillation, advise the operator that a shock is indicated, and deliver the defibrillatory shock-the automatic external defibrillator. Many studies have demonstrated the ability of AEDs to correctly identify ventricular fibrillation and provide successful defibrillation in the field.11 The safety record for patient and operator is excellent.18

Because AEDs can perform the crucial diagnostic step, many more first-responders now have the capability to provide definitive treatment. Successful experience has been reported for AED use by EMTs,25,59,60 fire department personnel,25 police officers,61,62 and other citizens.63 For example, in Rochester, Minnesota, all police cars are equipped with AEDs, as the police tend to be the first emergency responders on the scene of a sudden cardiac arrest. With minimal training, the police officers are able to provide defibrillation without waiting the extra minutes for paramedics to arrive. Through this innovative program, survival rates from ventricular fibrillation in excess of 45% have been achieved.64

Most communities already have extensive networks of fire, police, and ambulance personnel. As noted previously, however, most ambulances and fire departments with first-responder duties are currently unequipped with defibrillators. With only a few additional hours of training, these professionals can perform defibrillation with AEDs. Adding their numbers to existing EMT and paramedic services would dramatically increase the number and distribution of sudden cardiac arrest first-responders.

In addition, the AHA strongly endorses the use of AEDs by all first-responders:

> *...all personnel whose jobs require that they perform basic CPR [should] be trained to operate and permitted to use defibrillators, particularly automated external defibrillators (AEDs)....The AHA considers early defibrillation the standard of care in the community. Failure of emergency personnel to have a defibrillator available during a cardiac arrest is difficult to defend.*17

This position is further endorsed by the International Association of Fire Chiefs, which calls for all fire suppression vehicles in the United States to be equipped with AEDs and for all fire personnel to be trained in their operation.65

The general public has also demonstrated the ability to master and use AEDs.63 Distribution of "public access" AEDs for use by trained employees in the workplace, such as corporations, office buildings, and industrial settings, as well as in public gathering places, such as stadiums, theaters, airports, and on public transportation, adds additional potential for significant life saving. The AHA has recognized the enormous potential for rapid defibrillation of out-of-hospital SCA by public access defibrillators and has recommended that communities:

> *...should authorize and implement more widespread use of automated external defibrillation by community responders...*15

The AHA Task Force on Automatic External Defibrillation is pursuing the feasibility of broad community use of public access AEDs. Use of AEDs by family members of high-risk patients (such as in the first months after a heart attack) also has great potential to improve SCA survival.

A quantitative expansion of defibrillator distribution of this magnitude, however, requires a qualitative advance in AED technology.

Breakthrough AED Technology: Key Criteria

Automatic external defibrillators are safe, reliable, tested, and commercially available. To date, however, these products have only received limited acceptance, primarily by fire departments. This is largely the result of limitations in AED technology because until recently, AEDs were expensive and maintenance intensive, required ongoing skills training, and were relatively large and heavy. Recent breakthroughs in AED technology finally address these barriers to make them an appropriate tool for a broad group of responders.

Maintenance-Free. AEDs must be highly reliable with minimal maintenance. Early AEDs used rechargeable batteries that were maintenance intensive. Due to the inherent uncertainties of rechargeable batteries, these AEDs required hands-on testing at each shift change to insure a state of readiness. Maintenance logs had to be kept and a battery recharge schedule and rotation plan implemented. The inconvenience of battery recharging and testing led to poor user vigilance and improper maintenance, which resulted in numerous instances in which defibrillators failed to function properly. In a five-state survey, the Defibrillator Working Group of the Food and Drug Administration found that only 8% of survey responders followed manufacturers' recommendations for defibrillator battery maintenance and replacement.66

New AEDs address these shortcomings with a lithium-based battery system that is reliable, compact, powerful, long-lasting and virtually maintenance-free. This new battery technology completely eliminates recharging and enables AEDs to be placed in service much like a fire extinguisher. New AEDs also incorporate self-test and status indicator features that monitor the batteries and internal electronics and alert the owner if service is required.

Intuitive to Use. An AED must be easy to operate if it is to be used by a first-responder who will likely only use it in an emergency situation on an infrequent basis. New AEDs make extensive use of audible prompting and icons to provide operators with clear and concise instruction, making their use uncomplicated and intuitive. This simplification results in reduced training requirements and improved skills retention. Safeguards are built in to protect both operator and victim and to ensure that the AED will only deliver a shock if the victim is in ventricular fibrillation.

Highly Portable. AEDs must be small enough to fit easily into cramped spaces on fire trucks, police cars, ambulances, and the first-aid kits of emergency responders working and moving through crowds in large public gatherings such as theaters or sports arenas. They must be lightweight for easy transport through crowds, up stairs, and into poorly accessible places. Early AEDs weighed between 8 and 20 pounds and were about the size of a portable typewriter. Technological advances in new AEDs have resulted in devices that are significantly smaller—about the size of a hardcover book and weighing as little as 4 pounds.
Durable. In addition to being small and light, AEDs must be durable in order to remain dependable in the abusive field environment. Early AEDs incorporated electromechanical components that were subject to damage, resulting in frequent maintenance and expensive service contracts. New AED technology addresses these issues with rugged and durable designs that can withstand the chronic hard use that is common in the pre-hospital emergency environment.

Low Cost. To increase nationwide SCA survival, AEDs must be available to many more first-responders, both emergency medical personnel and authorized responders in public and private facilities. The high cost of early AEDs with prices ranging from $5,000-$10,000 posed a significant barrier to widespread deployment. Technological advances in defibrillator design, circuitry, and battery technology have reduced the cost of new AEDs to the $3,000-$4,000 range, making them more affordable to communities around the country.

Breakthroughs in technology have addressed the barriers to widespread deployment of AEDs. These advances in defibrillator technology have set the stage for a major progression in the treatment of sudden cardiac arrest in the community.

Part IV: The Ultimate Goal—Rapid And Effective Response

To improve survival from sudden cardiac arrest, it is necessary either to identify those at high risk prior to an attack and prevent it from occurring, or to improve post-arrest treatment. Though research is under way to improve identification of those at risk, there is no current basis for useful stratification of the population as a whole. In the foreseeable future, therefore, most of the 350,000 occurrences of sudden cardiac arrest each year are likely to remain unpredicted. For these victims, rapid response and defibrillation are the difference between life and death.

To improve rates of successful resuscitation and make the improvement more widespread, efforts must continue to involve the public in emergency notification and CPR. Emergency medical services must continue to develop and become more widely available. Ultimately, however, improved outcome from sudden ventricular fibrillation depends specifically on more rapid access to defibrillation. To make significant improvement in this area, the capacity to defibrillate must be in the hands of more first-responders in every community. It will never be possible for every victim of sudden cardiac arrest to be treated immediately by a physician, nurse, or paramedic. After family members or other lay persons, the first responders to an arrest are usually emergency medical technicians, fire department personnel, police officers, or ambulance personnel. The availability of an automatic external defibrillator to all first-responders greatly increases the potential for early defibrillation and saved lives. The American Heart Association estimates that 20,000-100,000 unnecessary deaths could be prevented each year if AEDs were more widely available to first-line responders, who often are the first to arrive on the scene.

Hence, the issue for communities is how to provide rapid-access defibrillation most effectively within realistic logistical and financial constraints. It is estimated that nearly 5 million years of potential life are lost annually owing to cardiovascular disease.67 This represents an enormous financial and emotional cost. With only a few hours of additional training, many more first-responders can qualify to provide life-saving defibrillation for SCA. AEDs designed to overcome the barriers to widespread deployment are the tools to make this goal fiscally and logistically feasible.

Summary and Conclusions

The key element in averting death from sudden cardiac arrest is rapid defibrillation, because ventricular fibrillation is fatal if not corrected within minutes. Bystander-initiated CPR, speedy access to basic and advanced emergency care, and access to defibrillation have improved survival rates. Delayed defibrillation, however, remains the most important impediment to successful resuscitation in thousands of victims. Improved survival will require that many more first-responders be able to perform defibrillation. These first-responders should include not only all emergency medical personnel but also those of other first-response emergency services such as fire department personnel, police officers, and ambulance attendants. Automatic external defibrillators should be available to authorized persons in the workplace and in large public gathering places such as stadiums, as well as to family members of high-risk patients. Widespread availability of defibrillators is practical because of advances in AED technology. An AED that requires minimal maintenance and training and is easy-to-use, durable, compact, and inexpensive can exponentially increase the number of responders able to give treatment for SCA and thereby save lives that are currently lost.

The economics of survival clearly support investment in the appropriate equipment and training of an expanded first-responder force. AEDs that meet the key criteria for widespread deployment will play an essential role in ending sudden cardiac arrest as a public health crisis that claims the lives of over 350,000 Americans each year. What is needed is the public will within each community to make the investment in new technology and training for a broad range of responders. Given the tens of thousands of victims struck down each year, often in the most productive phases of their lives, this situation is ripe for change.

Glossary

Advanced cardiac life support (ACLS)—The knowledge and skills necessary to treat cardiopulmonary arrest. Includes basic life support (see BLS below) plus techniques for patient monitoring, arrhythmia interpretation, defibrillation, intubation, and administration of intravenous drugs.

Arrhythmia—Abnormal electrical activity of the heart resulting in irregular, intermittent, or absent pulse.

Automatic external defibrillator (AED)—See defibrillator.

Basic life support (BLS)—Emergency care that prevents respiratory or circulatory arrest or insufficiency through recognition and intervention, or supports respiration and/or circulation through the techniques of cardiopulmonary resuscitation and defibrillation with an AED .

Cardiopulmonary resuscitation (CPR)—Techniques that briefly maintain essential organ perfusion with oxygenated blood until definitive intervention can be instituted. Includes: emergency notification, airway opening, mouth-to-mouth or mask ventilation, and external chest compression.

Defibrillation—The treatment of cardiac arrhythmias, especially ventricular fibrillation, by delivering an electrical current to the heart.

Defibrillator—A device that can deliver electrical current to the heart to treat arrhythmias. Many are portable and have electrocardiographic monitoring capacity.
Manual defibrillators require that the operator read and interpret the ECG tracing, and may require specific steps to program and administer the electric shock.
Automatic external defibrillators (AEDs) contain sophisticated electronics to monitor and identify the cardiac rhythm. The AED will only permit the operator to deliver a shock if ventricular fibrillation is occurring.

Emergency medical service (EMS)—The standing organization of a community to provide emergency medical care to its citizens. May include: 911 notification system, paramedics, emergency medical technicians, and fire, police, or ambulance personnel.
Emergency medical technician (EMT)—A professional trained in basic emergency medical care. Typically receives about 110 hours of initial training. Provides basic life support with techniques including cardiopulmonary resuscitation and defibrillation with an AED.

External defibrillation—Defibrillation energy delivered to the heart by means of electrodes applied to the chest (as opposed to defibrillation via a catheter inside or directly on the heart).

Paramedic—A professional trained to evaluate and provide treatment for a wide variety of emergencies. Initially receives 800-2000 hours of training. Qualified in arrhythmia interpretation and to treat sudden cardiac arrest with defibrillation and advanced cardiac life support.

Sudden cardiac arrest (SCA)—Precipitous loss of effective pulse and blood pressure. Usually due to cardiac arrhythmia, primarily ventricular fibrillation.

Sudden cardiac death (SCD)—Death occurring within one hour of an acute cardiac event.

Ventricular fibrillation—A chaotic arrhythmia that causes the heart to quiver rather than contract in a coordinated fashion. No effective pulse or blood pressure is generated, unconsciousness is immediate, and death follows within minutes if the arrhythmia is not halted.

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