

## EDITORIAL

# Automatic External Defibrillators: the Potential for Widespread Prevention of Sudden Cardiac Death in the Community

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## ABSTRACT

The vast majority of witnessed sudden cardiac death is due to the unpredictable occurrence of ventricular fibrillation, which is almost uniformly reversed by the immediate application of defibrillation. Thus, there is dire need for development of the appropriate conditions for early defibrillation in places where the likelihood of an unexpected sudden death event is deemed probable. In this setting, the automatic external defibrillators (AED) in the hands of even trained lay persons has been considered to have the potential to be the single greatest advance in the treatment of cardiac arrest due to ventricular fibrillation since the development of cardiopulmonary resuscitation. Several studies suggest that the use of publicly accessible AEDs by lay persons is feasible and that organized AED training should also focus on community and on-site responders. The potential for widespread prevention of sudden cardiac death in the community with the use of AEDs is discussed in this brief overview.

**KEY WORDS:** *sudden death, cardiac arrest, ventricular fibrillation, defibrillation, automatic external defibrillators*

## INTRODUCTION

It had been known that ventricular fibrillation (VF) could be effectively terminated with the application of immediate electrical therapy in the animal laboratory since 1850. However, it took more than 55 years before the first human defibrillation was successfully applied within the hospital environment (Cleveland, Ohio, USA, Case Western Reserve University).<sup>1</sup> Since then, thousands of cardiac patients have been saved by ventricular defibrillation within the hospital premises, mostly when VF occurred in the setting of an acute myocardial infarction. The majority of these “lucky” coronary artery disease patients were to continue to live for years after their cardiac arrest, with the invaluable help provided to them by different, still evolving preventive and treatment strategies in the fields of clinical cardiology and cardiovascular surgery. However, over the years, it was realized that the majority of cardiac arrests occur in otherwise “healthy”, mostly middle-aged people, outside the setting of hospital environment. It also became evident that the majority of these cardiac arrest events are reversible if electrical treatment becomes available within the first few minutes

## ABBREVIATIONS

ACLS = advanced cardiac life support  
AED = automatic external defibrillator  
AHA = American Heart Association  
BLS = basic life support  
CPR = cardiopulmonary resuscitation  
EMS = emergency medical services  
ESC = European Society of Cardiology  
SCD = sudden cardiac death  
VF = ventricular fibrillation

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of the unexpected introduction of the sustained ventricular tachyarrhythmia.

Indeed, the vast majority of witnessed sudden cardiac death (SCD) is due to the unpredictable occurrence of VF, a lethal rhythm disturbance which when induced under controlled conditions in the electrophysiology laboratory in high risk cardiac patients, is almost uniformly reversed by the immediate application of defibrillation. Thus, it is well known, for over a century now that lethal electrical accidents such as VF are effectively managed within the very first few minutes in the appropriate environment.

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### DEFIBRILLATORS

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The growing number of implantable defibrillators among high risk cardiac patients has confirmed the efficacy of this life-saving therapy when applied early by prolonging life in patients with advanced cardiac disease at very high risk for sudden cardiac death (SCD).<sup>2</sup> However, the benefits of such prophylactic treatment are limited by the underlying cardiomyopathy, the costs and logistics of such an approach and mostly by the fact that the majority of SCD occur in the community in otherwise “healthy” individuals not known to have an underlying heart disease, with the cardiac arrest being the first and “last” manifestation of such a disease. It was logical to move our efforts towards prevention of SCD in the general population by implementing new management strategies in the community. This is achieved through a still evolving program of early mobilization of Emergency Medical Services (EMS) that involves education, research and development of the appropriate conditions for early defibrillation in places where the likelihood of an unexpected SCD event is judged probable. In this setting, the automatic external defibrillators (AED) in the hands of even trained lay persons has been considered to have the potential to be the single greatest advance in the treatment of cardiac arrest due to VF since the development of cardiopulmonary resuscitation (CPR).<sup>3-9</sup> Indeed, from the early EMS experience in the management of an out-of-hospital witnessed cardiac arrest event, with the proposed chain of survival algorithm of basic life support (BLS), defibrillation and advanced cardiac life support (ACLS) provided by trained professionals within EMS, became evident that the most important factor for a successful result, namely the discharge from the hospital of the cardiac victim, was the early defibrillation (shock delivery within 5 minutes of EMS call receipt). We know the probability of successful defibrillation diminishes rapidly over time with VF converting to asystole within a few minutes, a condition where even the best optimal in-hospital management algorithm available is uncommonly effective.

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### AUTOMATIC EXTERNAL DEFIBRILLATOR (AED) PROGRAMS

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It is estimated that survival rates after VF cardiac arrest decrease approximately 7% to 10% for every minute elapsed with a survival rate as high as 90% when defibrillation is achieved within the first minute of collapse. Thus, it is recommended that an AED and properly trained personnel should be placed in every vehicle that may transport patients at risk for SCD. However, the availability of EMS within the time limitations of a cardiac arrest event in the community is jeopardized by conditions affecting unfavorably the time interval from call to shock responsiveness, especially in large urban centers with heavy traffic problems. It has been suggested by the ESC and AHA Societies to implement AED programs outside the EMS.<sup>5-8</sup> These include community programs, on-site programs and home programs. Community responders outside the EMS such as police officers and fire-fighters using the AED and calling the EMS have increased survival rates even if the time to shock interval was reduced by only one or two minutes. Once again it was realized that best results were observed among those patients in whom defibrillation was delivered within a few minutes and importantly when the restoration of spontaneous circulation was obtained by defibrillation only, without requiring additional ACLS interventions. On site programs advocate deployment of AED, either in hospital or in various community locations, where a significant over time number of expected interventions will justify the cost of training and maintenance of these programs.

The placement of AEDs in hospital unmonitored wards, lobbies, cafeterias or parking lots with concurrent training of all medical and non-medical personnel working in the hospital to defibrillate and perform CPR will probably improve unacceptable call-to-shock times still observed today in such places with significant number of high risk visitors. On site community places where AEDs have been deployed include airports, airplanes, casinos, high rise office buildings, housing complexes, recreational facilities, shopping malls, etc. Trained lay persons to use an AED in the corresponding site may include flight attendants, security personnel, life guards, police officers, fire fighters, sports marshals and many others. A survival rate as high as 55% was observed in 2 large-scale airline studies involving AEDs in the management of witnessed cardiac arrest, while 74% of SCD victims survived in casinos when the first shock was applied within 3 min from collapse. Home programs are recommended for high risk cardiac patients involving the placement of an AED with appropriate training of close family members. Taking into account that the majority of SCD occur at home (85% of SCD in the Maastricht study)<sup>10</sup> as well as the ability to recognize early those cardiac patients at risk for SCD based on recent developments in the risk stratification approach in coronary

artery disease and various cardiomyopathies, it is desirable to implement such home programs in those cases where an implantable defibrillator will not be available. It is suggested that home programs are still in a preliminary phase of implementation with primary targets for pilot projects on home defibrillation being families with a genetic predisposition to SCD or families with high risk patients not scheduled or unable to receive an implantable device. The concept of public access defibrillation (PAD) with implementation of community programs outside the EMS as previously mentioned, requires training in AED use of volunteers who should be able to recognize a cardiac arrest victim, use effectively the closest available AED and cooperate with the local EMS system appropriately.<sup>8</sup> Objections for defibrillation therapy not to be provided under such community circumstances by lay persons outside the medical profession, still exist in some European countries and should be progressively raised, as suggested by the ESC recent recommendations.

Currently available AEDs are very effective and easy to operate. The introduction of biphasic external defibrillation waveforms requires less energy, less device weight and offers simplicity.<sup>4</sup> Current devices are able to defibrillate the majority of VF events with only 150-Joule shock as opposed to the shock of at least 200 Joules required by older devices with monophasic waveforms. These AEDs can be used by rescuers with minimal or even no previous AED training (both children and adults) although speed, compliance and safety can still be improved.<sup>7</sup> Several studies suggest that the use of publicly accessible AEDs by citizens is feasible and that organized AED training should also focus on community responders and on-site responders. Such training may only last about 6-7 hours, 3-4 hours being devoted to BLS and the rest 3 hours to an AED course. It is still unclear whether the BLS training has a major impact in survival of SCD victims treated by lay persons. However, a number of studies have suggested that VF is becoming more treatable and durable, when the time to shock is delayed, if appropriate BLS has been initiated promptly and sustained until the AED arrival. Thus, it seems reasonable to support the view that combined BLS and AED training should be recommended.<sup>7-9</sup> Skill maintenance of trained volunteers is encouraged at 6 to 12 month intervals. It is also crucial to maintain AEDs properly over time with regular testing, battery replacements, proper storage, pad packaging control and replacement when needed.

The AHA guidelines on use of AEDs by trained individuals require additional actions in 4 special situations. These situations include victims in water, infants or children less than 8 years of age or less than 25 kg, those with transdermal medication patches and those with implanted devices. Water, as a good conductor of electricity, may be associated with a small possibility that rescuers may receive shocks or minor burns if they are within the AED and the wet victim. It is recommended to remove the victim from freestanding

water and dry the victim's chest before using the AED. In infants and children less than 8 years old or less than 25 kg in weight, it is not recommended to proceed with defibrillation to avoid shocking non life threatening tachycardia episodes in this category of pediatric patients, with priority given to the support of the airway, oxygenation and ventilation. In case transdermal patches are present in the victim's chest, these should be removed and the area wiped clean before the AED electrode pad is attached. Thus, in order to avoid block delivery of energy from the electrode pad to the heart as well as small burns to the skin, the electrode pad should be placed at least 2.5 cm away from an implanted pacemaker or defibrillator to maximize effectiveness of defibrillation attempts in victims equipped with such devices.

In *summary*, it is increasingly recognized that the call-to-shock time interval is crucial for the successful resuscitation of the most commonly encountered VF cardiac arrest victim in the community. The goal is to achieve times less than 5 min in duration. This requires not only a well performing EMS system but also the development of on-site community and home programs with the availability of AEDs to appropriately trained rescuers not necessarily confined to the medical and paramedical profession. Further research and planning involving not only the medical community but also supportive government sources are required in order to achieve a cost effective approach with significant impact in the prevention of SCD in the general population.

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