

## [ Primary Care ]

# The Role of Automated External Defibrillators in Athletics

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**Context:** Sudden cardiac arrest is the leading cause of death in young athletes. The purpose of this review is to summarize the role of automated external defibrillators and emergency planning for sudden cardiac arrest in the athletic setting.

**Evidence Acquisition:** Relevant studies on automated external defibrillators, early defibrillation, and public-access defibrillation programs were reviewed. Recommendations from consensus guidelines and position statements applicable to automated external defibrillators in athletics were also considered.

**Results:** Early defibrillation programs involving access to automated external defibrillators by targeted local responders have demonstrated a survival benefit for sudden cardiac arrest in many public and athletic settings.

**Conclusion:** Schools and organizations sponsoring athletic programs should implement automated external defibrillators as part of a comprehensive emergency action plan for sudden cardiac arrest. In a collapsed and unresponsive athlete, sudden cardiac arrest should be suspected and an automated external defibrillator applied as soon as possible, as decreasing the time interval to defibrillation is the most important priority to improve survival in sudden cardiac arrest.

**Keywords:** emergency planning; sudden cardiac arrest; sudden cardiac death; athlete; sports

Sudden cardiac arrest (SCA) is the most common cause of death in the United States resulting in more than 300 000 deaths annually.<sup>32</sup> Sudden cardiac arrest is also the leading cause of sudden death in young athletes<sup>20,35</sup> accounting for approximately 75% of all cases.<sup>21</sup> The death of an athlete is a catastrophic event that has devastating effects on a family, teammates, school/university, and the local community. Athletes are regarded as the healthiest members of society, and their sudden death during practice or competition often sparks debate regarding the adequacy of emergency planning for athletic events.

The placement of automated external defibrillators (AEDs) in public locations has provided a means for early defibrillation for out-of-hospital SCA. Public-access defibrillation in locations such as casinos, airports, and universities has shown a clear survival benefit achieving survival rates of 41% to 74% if bystander cardiopulmonary resuscitation (CPR) is provided and defibrillation occurs within 3 to 5 minutes of arrest.<sup>5</sup> This large-scale success has led many schools, universities, and sporting organizations to accelerate implementation of AEDs at athletic venues in an attempt to prevent sudden cardiac death (SCD) in both athletes and nonathletes attending athletic events.

The purpose of this article is to review the cause and incidence of SCD in athletes, summarize survival rates following SCA and past experience using AEDs in the athletic setting, and emphasize the role of AEDs as an essential component of a comprehensive emergency action plan (EAP) for SCA in the athletic setting.

## Etiology and Incidence of SCD in Athletes

Sudden cardiac death in athletes is usually related to an underlying structural cardiac abnormality. Hypertrophic cardiomyopathy and coronary artery anomalies are the most common causes of SCD in young athletes in the United States, representing 25% and 14%, respectively.<sup>20</sup> Commotio cordis, involving a ventricular arrhythmia caused by a blunt, nonpenetrating chest wall blow in a structurally normal heart, accounts for an additional 20% of SCD in young athletes.<sup>20</sup> The remaining causes of SCD in athletes are a variety of structural and electrical abnormalities of the heart such as myocarditis, arrhythmogenic right ventricular cardiomyopathy, Marfan syndrome, valvular heart disease,

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dilated cardiomyopathy, atherosclerotic coronary artery disease, and ion channel disorders such as long QT syndrome, familial catecholaminergic polymorphic ventricular tachycardia, and Brugada syndrome.<sup>6,20</sup> In approximately 2% of cases, postmortem examination fails to identify a cause of death.<sup>14,20</sup> These cases of so-called autopsy-negative sudden unexplained death likely represent inherited arrhythmia syndromes and ion channel disorders.

Vigorous exercise is thought to be a trigger for ventricular arrhythmias in athletes with underlying heart disease.<sup>6,20</sup> Corrado et al<sup>4</sup> found competitive athletes to have a 2.5 times relative risk for SCA than an age-matched nonathletic population. However, the exact incidence of SCD in young athletes is unknown. Initial reports estimated the incidence of SCD in high school athletes between 1:200 000 and 1:300 000<sup>22,35</sup> and in college-aged athletes between 1:65 000 and 1:70 000.<sup>9,35</sup> However, these reports likely have underestimated the true incidence due to the lack of a mandatory reporting or surveillance system for SCD in athletes. Recently Maron et al<sup>21</sup> reported from the US Sudden Death in Young Athletes Registry more than 100 cases in young competitive athletes per year, or about 1 death every 3 days in the United States. Based on the 5 million high school athletes and 500 000 college athletes participating in organized sports each year, a more current estimate of the incidence of SCD in young athletes is probably closer to 1:50 000. This higher incidence in young athletes is supported by studies using a mandatory reporting system for SCD. Eckart et al<sup>12</sup> documented an incidence of SCD of 1:9000 in US military recruits (mean age 19 years), and Corrado et al<sup>3</sup> reported an incidence of 1:25 000 in young competitive Italian athletes (aged 12-35 years) prior to the implementation of a national screening program.

### Survival After SCA in Athletes

Unfortunately, survival following SCA in the young athletic population has been poor. The single greatest determinate of survival following SCA is the time from collapse to defibrillation, with survival rates declining 7% to 10% per minute for every minute defibrillation is delayed. In a small cohort of 9 intercollegiate athletes with SCA, only 1 athlete survived (11%) despite apparent early use of on-site AEDs in 5 cases.<sup>8</sup> Analysis of 128 cases from the US Commotio Cordis Registry also revealed a low overall survival rate of 16%.<sup>23</sup>

Recently, Drezner et al<sup>5</sup> reported a 7-year review of survival trends in exercise-related SCA in youth in the United States. After review of 486 cases of confirmed and suspected SCA, the overall survival rate in young athletes was only 11% (range, 4%-21%) from 2000 to 2006. Females were more likely to survive than males (2% vs 9%). There appeared to be a trend toward increasing survival in the later years of the study, and it was postulated that the increase in survival was related to earlier recognition of SCA and the increasing prevalence of on-site AED programs in schools and at athletic venues.<sup>5</sup>

The poor survival rates found in young athletes with SCA are disturbing given the overall good health and age of the athletes. Factors that may contribute to this poor survival include delayed rescuer recognition of SCA, inaccurate rescuer assessment of pulse or respiration, delayed access to AEDs and early defibrillation, the presence of intrinsic structural cardiac abnormalities such as cardiomyopathies that may be more resistant to defibrillation with increasing delays in resuscitation, and increased catecholamine levels in athletes, which possibly increases the defibrillation threshold.

### Use of AEDs in Athletics

Automated external defibrillators provide a means of early defibrillation and improved survival not only for athletes but also for other persons at athletic events who suffer SCA. Jones et al<sup>19</sup> found a 2.1% annual probability of an SCA occurring on high school grounds and that most cases of SCA were in older school employees, spectators, and visitors on campus. At NCAA Division I universities, Drezner et al<sup>9</sup> found that older nonstudents such as spectators, coaches, and officials accounted for 77% of SCA cases at sporting venues, and that use of AEDs produced a 54% overall immediate resuscitation rate.

Recent findings from the National Registry for AED Use in Sports demonstrate improved survival for both student-athletes and nonstudents with SCA in the high school athletic setting. Upon review of 1710 nationwide high schools with on-site AED programs (at least 1 AED on school grounds; mean 2.8 AEDs per school), 36 (2%) schools reported a case of AED use within a 1-year period from July 2006 to June 2007.<sup>7</sup> Twenty-two of the cases were in older nonstudents, and 14 cases were in high school student-athletes. Thirty cases received defibrillation with use of an on-site AED. The overall survival rate to hospital discharge was 64%, including a 64% survival rate in student-athletes with SCA.<sup>7</sup> These findings strongly support the value of on-site AED programs for the treatment of SCA on school grounds. The favorable survival rate in young athletes who suffer SCA in schools with on-site AEDs sharply contrasts the 11% overall survival rate found in a 7-year review of exercise-related SCA in young individuals in the United States where on-site AED use was rarely reported.<sup>5</sup>

Several national guidelines have also advocated for placement of AEDs in the athletic setting. In a Joint Position Statement issued in 2002 by the American College of Sports Medicine and the American Heart Association (AHA), placement of AEDs at all health/fitness facilities was encouraged, especially in facilities with a membership greater than 2500.<sup>1</sup> The National Athletic Trainers' Association (NATA) released an official statement in 2004 encouraging athletic trainers in every work setting to have access to an AED.<sup>29</sup> In 2004, AHA recommendations for the Medical Emergency Response Plan in Schools stated that every school that cannot achieve an EMS call-to-shock interval of less than 5 minutes should have an AED program.<sup>18</sup> And, most recently, an Inter-Association Task Force provided consensus recommendations for emergency planning for SCA in high school and college athletic programs,

strongly recommending access to AEDs and a target goal of less than 3 to 5 minutes from collapse to first shock.<sup>6</sup>

Many schools and organizations have supported implementation of on-site AED programs. A survey of NCAA Division I universities showed that greater than 90% of institutions already had AEDs placed at selected athletic venues.<sup>9</sup> In Washington State high schools, 54% had at least 1 AED on school grounds.<sup>33</sup> In addition, the riveting nature of SCD in young athletes and the desire to protect student-athletes from a catastrophic event has prompted many states, including New York, Texas, Ohio, and Georgia, to pass legislation mandating that every school have at least 1 working AED unit on-site. It appears the successes of public-access defibrillation and school-based AED programs support an evolving standard in favor of school AED programs.

### Obstacles to Implementing AEDs

The main obstacle to AED implementation is financial resources.<sup>9,15,33</sup> While the average cost of an AED ranges from \$1500 to \$2000 (US dollars), many schools have limited financial resources and competing demands on restricted budgets. In Washington State, 60% of high schools with AEDs received them through donations.<sup>33</sup> While well intentioned, many schools who receive AEDs through donations do not implement the AED in coordination with a comprehensive EAP for SCA. This can result in limited access to or knowledge about the AED on school grounds. Potential financial resources include school districts, local or state legislation, fundraising, and public-private partnerships to generate the needed financial support for schools to implement an AED program.

Human resources are another potential barrier to implementing school AED programs. School administrators may feel overburdened and understaffed and resistant to taking on new responsibilities, such as periodic device maintenance and assessment of device readiness. However, AED programs and emergency planning for SCA can be developed and maintained with a reasonable and acceptable amount of time and effort by a designated program coordinator. If a certified athletic trainer is employed by a school, the athletic trainer is the ideal person to help develop and implement an AED program.

### Emergency Planning for SCA

Any AED program in the athletic setting must be organized as part of a comprehensive EAP for SCA. The core elements of an effective EAP should include the following: (1) establishing an efficient communication system; (2) training of likely first responders in CPR and AED use; (3) acquiring the necessary emergency equipment, including access to early defibrillation; (4) predetermination of transportation routes for EMS; and (5) practice and review of the EAP at least annually.<sup>6</sup> The EAP should be developed by school or institutional personnel in consultation with the local EMS, school safety officials, targeted on-site first responders, athletic trainers, team physicians, and school administrators. It is important to designate an EAP coordinator—usually an athletic trainer, nurse, or administrator.

An effective EAP starts with a rapid communication system that links all athletic venues, practice facilities, and other parts of campus to the EMS system and the local response team. The communication system can be developed through existing telephones, cellular telephones, hand-held 2-way radios, or intercom systems that link the rescuer directly to the EMS as well as alerting the on-site response team. The EAP should target a goal of less than 3 to 5 minutes from time of collapse to first shock.<sup>6,18</sup>

In the athletic setting, the likely first responder to an emergency will vary depending on the setting and may be a coach, teammate, official, athletic trainer, physician, or emergency medical technician. In high schools with AEDs, the most likely first responder to an SCA was found to be a coach or an athletic trainer—emphasizing the importance of training coaches in CPR and AED use.<sup>7</sup> All potential first responders should be familiarized with the EAP to ensure an effective and coordinated response to an emergency situation. The NCAA also recommends that all athletics personnel associated with practices, competitions, skills instruction, and strength and conditioning be certified in first aid, CPR, and AED use.<sup>27</sup>

Resuscitation equipment can be placed at a specific athletic venue, centrally located and highly visible, or brought to the venue by designated personnel (such as an athletic trainer). Typical accessory equipment attached to an AED includes a pocket mask for rescue breathing, a towel to dry the chest, and razor to shave chest hair if needed. An extra set of AED pads should also be considered and can be kept with the AED. All potential responders must be aware of the emergency equipment location and be trained in advance on how to use it properly. In larger venues or schools, duplicate centers for equipment may be needed. Any on-site AED should be registered with the local EMS system so the emergency dispatcher has information on the exact location and specific type of AED.

The EAP should also define venue-specific transportation routes for EMS that allows rapid access to enter and leave the venue.<sup>6</sup> A dedicated staff member should be familiar with the directions and access points for the different athletic facilities on campus.

Lastly, the EAP should be reviewed and practiced at least annually with all potential responders to an emergency, including athletic trainers, school nurses, safety personnel, administrators, coaches, and any other identified members of the local response team.<sup>6</sup> A mock SCA scenario is recommended as a practice method for the EAP and to review AED access and application. The existing EAP should be modified based on feedback from the EAP rehearsal as needed.

### Management of the Collapsed and Unresponsive Athlete

Prompt recognition of SCA is essential to prevent critical delays in CPR and defibrillation. When a young athlete collapses,

SCA can be confused for other less serious causes of collapse. Barriers to recognizing SCA include the presence of brief seizure-like activity and inaccurate rescuer assessment of pulse or respirations. In a series of student-athletes with SCA, greater than half were reported to have brief seizure-like activity immediately following collapse.<sup>31</sup> Mistaking SCA for a seizure can prevent initiation of life-saving medical care. Thus, any unresponsive collapsed athlete should be assumed to be in SCA until proven otherwise, and an AED retrieved and applied for rhythm analysis and defibrillation (if indicated) as soon as possible.<sup>6</sup> Automated external defibrillators are extremely accurate and will not recommend a shock in an athlete who is not in ventricular fibrillation or ventricular tachycardia, so applying the AED to an athlete who is not in SCA has minimal potential for harm.

Management of a collapsed athlete begins with an initial assessment of responsiveness (ie, “Are you all right?”). If the athlete is unresponsive, one or more rescuers should begin CPR while another activates the EMS system by calling 911 or the local emergency number and then retrieves the AED if available. When contacting EMS, the rescuer should be prepared to provide the exact location of the emergency, a brief account of what happened, and a summary of the initial care given. In the case of a lone rescuer, he/she should first activate the EMS system, obtain an AED if readily available, and then return to the victim and initiate CPR and AED use. An AED should be applied to the victim as soon as possible and turned on for rhythm analysis and defibrillation if indicated.

In 2005, the AHA released updated CPR guidelines, placing a stronger emphasis on chest compressions and reducing interruptions in CPR.<sup>10,11</sup> If a shock is deployed, the rescuer

should immediately resume CPR beginning with chest compressions. Cardiopulmonary resuscitation is continued for 5 cycles (or about 2 minutes) before rhythm reanalysis or until the patient becomes responsive.

## CONCLUSION

Sudden cardiac arrest in athletes is a catastrophic event that can be effectively treated through a prompt and coordinated emergency response, early CPR, and early defibrillation. The most important factor in SCA survival is decreasing the time to defibrillation through the presence of a trained rescuer who can initiate CPR and has direct access to early defibrillation through the use of an on-site AED. The athletic community is in a unique situation having trained targeted responders such as athletic trainers and coaches present at practices and competitions. The presence of on-site AED programs in the school and athletic setting is strongly recommended as a means for early defibrillation in both athletes and nonathletes who suffer SCA.

High suspicion for SCA should be maintained in any collapsed and unresponsive athlete, and the EAP initiated without delay. An AED should be applied immediately for rhythm analysis and defibrillation if indicated, and CPR provided until a defibrillator is available. Automated external defibrillator programs should be part of a comprehensive EAP for SCA that includes an effective communication system, training of potential first responders in CPR and AED use, acquisition of appropriate emergency equipment, and routine practice and review of the response plan. By decreasing response times and increasing access to early defibrillation, survival from SCA in athletics will be optimized.



## Clinical Recommendations

### SORT: Strength of Recommendation Taxonomy

**A:** consistent, good-quality patient-oriented evidence

**B:** inconsistent or limited-quality patient-oriented evidence

**C:** consensus, disease-oriented evidence, usual practice, expert opinion, or case series

Clinical Recommendation	SORT Evidence Rating
The presence of on-site AED programs in the school and athletic setting is strongly recommended as a means for early defibrillation in both athletes and nonathletes who suffer SCA. <sup>7,9</sup>	<b>B</b>
In any collapsed and unresponsive athlete, an AED should be applied immediately for rhythm analysis and defibrillation if indicated, and CPR provided until a defibrillator is available. <sup>6</sup>	<b>C</b>
Access to early defibrillation and on-site AED programs should be part of a comprehensive emergency action plan for SCA. <sup>6</sup>	<b>C</b>

For more information about the SORT evidence rating system, see [www.aafp.org/afpsort.xml](http://www.aafp.org/afpsort.xml) and Ebell MH, Siwek J, Weiss BD, et al. Strength of Recommendation Taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. *Am Fam Physician*. 2004;69:549-557.

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