Journal of Athletic Training 2015;50(10):1054–1058
doi: 10.4085/1062-6050-50.8.01

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original research

Preventing Sudden Cardiac Death: Automated External Defibrillators in Ohio High Schools

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Context: Ohio passed legislation in 2004 for optional public funding of automated external defibrillators (AEDs) in all Ohio high schools.

Objective: To report occurrences of sudden cardiac arrest in which AEDs were used in Ohio high schools and to evaluate the adherence of Ohio high schools with AEDs to state law and published guidelines on AEDs and emergency action plans (EAPs) in schools.

Design: Cross-sectional survey.

Setting: Web-based survey.

Patients or Other Participants: A total of 264 of 827 schools that were members of the Ohio High School Athletic Association.

Main Outcome Measure(s): We surveyed schools on AED use, AED maintenance, and EAPs.

Results: Twenty-five episodes of AED deployment at 22 schools over an 11-year period were reported; 8 (32%) involved students and 17 (68%) involved adults. The reported survival rate was 60% (n = 15). Most events (n = 20, 80%) in both students and adults occurred at or near athletic facilities. The annual use rate of AEDs was 0.7%. Fifty-three percent (n = 140) of schools reported having an EAP in place for episodes of cardiac arrest. Of the schools with EAPs, 57% (n = 80) reported having rehearsed them.

Conclusions: Our data supported the placement of AEDs in high schools given the frequency of use for sudden cardiac arrest and the survival rate reported. They also suggested the need for increased awareness of recommendations for EAPs and the need to formulate and practice EAPs. School EAPs should emphasize planning for events in the vicinity of athletic facilities.

Key Words: sudden cardiac arrest, athletes, emergency action plan

Key Points

- When an automated external defibrillator (AED) was used in Ohio high schools, the survival rate after sudden cardiac arrest appeared to be approximately 60%; more incidents were reported in adults, and most incidents were at or near athletic facilities.
- The AEDs should be situated where large crowds are expected.
- If funds for AEDs are limited and only 1 device is available, it should be placed at or near athletic facilities.
- Emergency preparedness was substantially lacking. Only 16% of responding high schools reported having emergency action plans and rehearsing them at least annually.

Sudden cardiac arrest (SCA) is the leading cause of death in young athletes[1–3] and a major cause of death in the general population.[4] The best way to prevent death from SCA is early defibrillation; survival declines by 7% to 10% for each minute that defibrillation is delayed.[5] Researchers[6] have shown that the placement of automated external defibrillators (AEDs) in public places, such as airports, has increased the survival rate after SCA. Extensive media coverage over the past 20 years of SCA and death in young athletes has spurred discussions about prevention.[7] Investigators[1,8,9] have estimated that the incidence of sudden cardiac death in young athletes ranges from 1 : 50 000 to 1 : 300 000. Drezner and Rogers[10] reported that the survival rate of exercise-related SCA measured during a 7-year period in the United States was only 11% in people aged 5 to 22 years. In a separate study, Drezner et al[3] showed that defibrillation of individuals who had SCA in the high school setting resulted in a 64% survival to hospital discharge; these individuals included 14 student-athletes and 22 adults.

In 2004, the state of Ohio passed legislation to appropriate $2.5 million from the Tobacco Settlement Act to fund AED placement in schools through optional grants.[11] Schools using the grant money to purchase an AED were also required to provide appropriate AED and cardiopulmonary resuscitation (CPR) training to a sufficient number of staff people and to have a physician supervise the AED program. In November 2007, Ohio completed funding, placing, and training staff for AEDs in 4400 public, private, charter, parochial, vocational, and community schools at the kindergarten level through grade 12.[12]

Legislation and public funding of AED programs in all public and private Ohio schools provide a unique opportunity to investigate publicly funded AED programs in schools. Therefore, the purpose of our study was twofold: (1) to report the occurrence of SCA and AED use in Ohio high schools and (2) to evaluate the adherence

Table 1. Survey Responders and Automated External Defibrillators per School

School Characteristic	% (No./Total)
Schools responding	32 (264/827)
Public schools	84 (221/264)
Schools with automated external defibrillator	100 (264/264)
Schools with ≥3 automated external defibrillators on campus	68 (180/264)

of Ohio high schools with AEDs to the recommendations in the state law and to published guidelines on AEDs and emergency action plans (EAPs) in schools.

METHODS

Participants

We e-mailed a Web-based survey link to 827 athletic directors at schools that were members of the Ohio High School Athletic Association. A total of 264 schools (32%) completed the survey. The study was approved by the Institutional Review Board at Akron General Medical Center, which did not require participants to provide written informed consent.

Procedures

Data were collected with a cross-sectional anonymous Web-based survey. We elected to survey the members of the Ohio High School Athletic Association to reach both public and private schools that had the opportunity to purchase AEDs with state funding. A letter introducing the study was sent to all 827 athletic directors at schools that were members of the Ohio High School Athletic Association, alerting them to the upcoming Web-based survey. We instructed the person responsible for the school's AED program, whether it was the athletic director or another staff member, to complete the survey. Three follow-up e-mails to the athletic directors at 2-week intervals provided the link to the anonymous Web-based survey, which contained 23 questions. The survey questions were based on the EAP recommendations of the National Athletic Trainers' Association,[13] the American Heart Association,[14] and the Inter-Association Task Force.[2]

The survey questions pertained to the upkeep and use of AEDs, survival of individuals with SCA, and training of staff within each school and covered the period from 2000 to 2010. They also asked about school EAPs and how well the schools adhered to national recommendations. The survey was available for 8 weeks. To maintain respondent anonymity, we did not ask for identifying information, and survey answers were not independently verified.

Statistical Analysis

We calculated the annual use rate for AEDs and calculated the Fisher exact test to evaluate survival differences. All statistical analyses were calculated with the Statistical Package for Social Sciences (version 21.0; IBM Corporation, Armonk, NY) using a type I error rate of .05.

Table 2. Location of Automated External Defibrillators on School Campus (N = 264)

Automated External Defibrillator Location	Schools With Automated External Defibrillators at Site, % (No.)[a]
School lobby	49 (129)
Carried with athletic trainer	32 (85)
Athletic field	34 (90)
Athletic training room	37 (97)
Cafeteria	32 (84)
School nurse's office	28 (75)
Administrator's office	23 (60)
Locker room	13 (33)

[a] Percentage of schools with automated external defibrillators indicates the percentage of all schools with an automated external defibrillator at each site. Each school may be included in each separate location percentage, as some schools had multiple automated external defibrillators.

RESULTS

Use and Survival Data

Of the 264 surveyed schools that completed the questionnaire, 84% (n = 221) were public schools, and 68% (n = 180) had 3 or more AEDs on campus (Table 1). The AEDs appeared to be distributed widely within the schools, but 73% (n = 193) had at least 1 AED at athletic facilities or with the school's athletic trainer (Table 2).

The AEDs had been deployed by 8% (n = 22) of responding schools for a total of 25 occurrences of SCA since 2000. Respondents reported that 15 of 25 individuals (60%) with SCA survived. Seventeen individuals were adults and 8 were students. Four of the students were athletes (Table 3).

Twenty of the reported SCAs (80%) occurred at or near an athletic facility (95% confidence interval = 62%, 95%). Fifteen of the 20 occurrences (75%) were at an athletic facility (eg, football field, gym, weight room), and 5 others (25%) occurred in a hallway or area adjacent to an athletic facility (Table 3).

Reported survival of individuals (number surviving per total events) was not affected by whether the individual was a student (4 of 8, 50%) or an adult (11 of 17, 65%; $P = .67$), by 3 or more AEDs in school (12 of 19, 63%) or 2 or fewer AEDs (3 of 6, 50%; $P = .65$), by occurrence at private (2 of 3, 67%) or public (13 of 22, 59%) school ($P = .80$), or by having an AED present before 2006 (12 of 19, 63%) or after passing and funding of the law in 2006 (3 of 6, 50%; $P = .65$).

Of the 261 schools responding to the question, 24% (n = 63) reported having used state funding to purchase AEDs, 21% (n = 55) reported not having used state funding to purchase AEDs, and 55% (n = 143) were uncertain whether their schools had used state funding. The percentage of responding schools using AEDs annually was 0.7% per school per year.

Preparedness Data

Schools were surveyed on multiple aspects of preparedness and upkeep activity for the AEDs in their schools. These included the presence and rehearsal of EAPs, training of personnel on the use of AEDs and CPR, characteristics of personnel directly charged with mainte-

Table 3. Reported Events of Sudden Cardiac Arrest in Responding High Schools

School	Individual	Event	Location of Sudden Cardiac Arrest	Location of AED	Person Who Deployed AED	Outcome
1	Athlete	Practice	Hallway near athletic facility	Brought to site	Employee with AED training	Died
2	Athlete	Practice	Practice field	Brought to site	Employee with AED training	Survived
3	Athlete (n = 1) Visitor (n = 1)	Practice (n = 1) Game (n = 1)	Basketball facility (n = 2)	At venue (n = 2)	Employee with AED training (n = 2)	Not answered for either individual[a]
4	Athlete	Question not answered	Weight room	Brought to site	Employee with AED training	Died
5	Student (nonathlete)	Unrelated to athletics	Basketball facility	Brought to site	Employee with AED training	Survived
6	Student (nonathlete)	Unrelated to athletics	Question not answered	Brought to site	Question not answered	Survived
7	Student (nonathlete)	Question not answered	Main office	At venue	Employee with AED training	Died
8	Student (nonathlete)	Unrelated to athletics	Classroom building	At venue	Question not answered	Survived
9	Parent	Unrelated to athletics	Hallway near athletic facility	At venue	Emergency medical services	Survived
10	Parent	Game	Basketball facility	Brought to site	Employee with AED training	Survived
11	Visitor (n = 1) Official, coach, or referee (n = 1)	Game (n = 2)	Football field (n = 1) Basketball facility (n = 1)	At venue (n = 1) Brought to site (n = 1)	Employee with AED training (n = 2)	Survived (n = 2)
12	Visitor	Unrelated to athletics	Hallway away from athletic facility	Brought to site	Employee with AED training	Survived
13	Visitor	Game	Football field	At venue	Employee with AED training	Died
14	Visitor (n = 1) Official, coach, or referee (n = 1)	Game (n = 2)	Hallway away from athletic facility (n = 1) Hallway near athletic facility (n = 1)	At venue (n = 1) Brought to site (n = 1)	Employee with AED training (n = 2)	Died (n = 1) Survived (n = 1)
15	Visitor	Unrelated to athletics	Cafeteria	At venue	Employee with AED training	Survived
16	Visitor	Unrelated to athletics	Football field	At venue	Employee with AED training	Died
17	Visitor	Unrelated to athletics	Football field	Brought to site	Employee with AED training	Survived
18	Visitor	Game	Basketball facility	At venue	Employee with AED training	Survived
19	Visitor	Question not answered	Main office	Brought to site	Employee with AED training	Died
20	Visitor	Game	Basketball facility	At venue	Employee with AED training	Survived
21	Visitor	Game	Basketball facility	At venue	Employee with AED training	Survived
22	Other	Unrelated to athletics	Football field	Brought to site	Employee without AED training	Died

Abbreviation: AED, automated external defibrillator.

[a] Both individuals from school 3 were included in deaths because the question of survival was unanswered.

nance and upkeep of AEDs, location of AEDs (Table 2), and presence of a physician medical coordinator for EAPs.

Fifty-three percent (n = 140) of schools had EAPs in place, 17% (n = 45) had no EAP in place, and 30% (n = 79) of respondents did not know if they had an EAP. Of the schools that had an EAP, 31% (n = 43) rehearsed their plans at least annually, 26% (n = 37) rehearsed biannually or less frequently, and 43% (n = 60) had never rehearsed. Forty-five percent (n = 119) of schools reported that local emergency medical services were aware of their EAP; the remaining 55% (n = 145) reported that emergency medical services were unaware or they were uncertain of the answer.

The staff trained in AED use included coaches (88%, n = 232); school nurses (84%, n = 222); athletic trainers (79%, n = 209); athletic directors (77%, n = 203); principal, vice principal, or other administrator (55%, n = 145); and teachers (48%, n = 127). All 264 schools (100%) reported AED training at least biannually, with 251 (95%) requiring CPR training of staff assigned to the AED; this training is consistent with the requirements for AED and CPR training contained in the Ohio law. In addition, 77% (n = 203) reported maintenance on AEDs at least annually, 13% (n = 34) reported biannually, and 10% (n = 26) reported no maintenance.

DISCUSSION

We appear to be the first to study a statewide, publicly funded AED program within high schools. The survival data collected from the survey were consistent with data published from a national survey of SCA and AED use in schools by Drezner et al,[3] who reported survival rates of 64% in both students and adults. Our results also compared favorably with other, more limited studies on AED use in high schools that reported only small numbers of SCA.[15,16] Our data suggested that most individuals at risk of SCA in schools were adults rather than students; 17 of the 25 cases were adults (2 parents, 2 referees or officials at sporting events, 12 visitors, and 1 "other"), and nearly all of them were visiting the school at various times. This observation was also consistent with the data of Drezner et al,[3] who found that 22 of 36 cases of SCA reported in high schools involved adults. A notable difference exists between our data and the data of Drezner et al.[3] Our students with SCA were distributed evenly between student-athletes (n = 4) and nonathletes (n = 4); Drezner et al[3] stated that all students with SCA were student-athletes, but 2 of these events occurred during recreational time or gymnasium class. England et al[15] studied 31 schools in greater Boston that were equipped with donated AEDs. Only 2 SCA events were reported, and both occurred in adults: 1 at an athletic event and 1 in a teacher. In both cases, the individuals were resuscitated successfully. Our reported survival rate compares favorably with a large study of public-access defibrillation at sites other than schools, in which the authors[17] described rates of survival to hospital discharge of approximately 25% in the AED arm of the study.

In 3 cases, details were provided for athletes with SCA, and the SCA occurred during practices rather than games. These occurrences away from games are in contrast to the adults in our survey who had SCA at the high schools surveyed. Ten of the 17 adults (59%) experienced their SCAs during a game at the high school (Table 3). These consisted of 1 parent, 7 visitors, and 2 adult participants in the game (eg, coach, referee, official). Our data were comparable with national data, in which researchers reported that 64% of adults experienced their SCAs during a high school athletic event.[3]

Our results suggested that the location of AEDs in the high schools varied, but approximately 72% were at or near an athletic facility (with the athletic trainer, in the athletic training room, at the athletic facility). To improve the chances for survival, the American Heart Association[18] has recommended placing an AED within a 3-minute walk of locations where the incidence of SCA is higher. Given that a large majority of SCA events occurred around athletic facilities in our study, ensuring that AED placement allows quick and easy access from athletic facilities appears prudent.

Unfortunately, we also observed a surprising lack of preparedness by those responding. Just over half (53%) reported having EAPs, as suggested by the Inter-Association Task Force.[2] Whereas only 17% reported not having EAPs, it seems that not knowing whether one exists is tantamount to not having one. This finding compared less favorably with previously published data in which 83% of surveyed schools were reported to have EAPs.[3] We also observed that only 57% of the schools with EAPs reported ever having practiced the plans. It is unclear what would lead to such low numbers; perhaps these are related to the availability of resources at the schools without plans. Although we requested that the survey respondent be the person responsible for the school's AED program, it is also possible that the respondent was not fully aware of the school's AED program.

The information about the training of staff on AED use was encouraging. All responding schools reported training staff at least every 2 years. Cardiopulmonary resuscitation training was required in 95% of schools. Maintenance of AEDs occurred in 90% of schools at least every 2 years. Both the CPR and AED training and the maintenance of the AED were mandated as part of the law's passage, which may partly explain the high rates of compliance, even though EAPs are based on national recommendations that schools are not mandated to follow.

From previously published data, we recognize the value in having AEDs present at scholastic and intercollegiate athletic events.[3,10] Whereas we have seen success with the presence of these devices, we scrutinized a state in which the legislature passed a law providing public funds for the purchase of AEDs in every school. The use of AEDs and the survival data reported are very encouraging, but we are concerned about the lack of planning for SCA at the schools. It appears from our data that the EAPs should include emergencies not only affecting individuals participating in games and school activities but also affecting individuals attending these activities, because they may be more likely than students to experience SCA. This point suggests that scholastic medical staff need to be aware that they may be called on to assist individuals in the stands or audience in the case of an emergency. It also emphasizes the need for an EAP so everyone is prepared to address this possibility.

Our study was limited by several factors. Our response rate was only 32%, which is far from optimal but is similar

to that for previously published data.[3] In addition, our overall occurrence rate and annual rate were possibly skewed by the likelihood that schools that experienced SCA events might have been more likely to respond to the survey. All of the respondents to the survey reported having AEDs present on campus; given that we were asking for AED deployment in the event of SCA, this may have decreased the likelihood of responses by schools without AEDs or might have led schools without AEDs to not respond to the survey. The results of the survey are also likely skewed by recall bias, as well as by staff turnover at the schools, because the period surveyed was more than 10 years. Perhaps the most limiting element was the lack of independent verification of the survival reports from the schools. We asked only for self-report of survival after the SCAs that the respondents were detailing and did not seek independent verification of these details. Our intention was to increase the response rate.

CONCLUSIONS

Given the concordance with previously published data, the survival rate when an AED was deployed in a high school appeared to be at or near 60%. In our study, most (approximately two-thirds) of these SCA incidents occurred in adults. Even when they did not involve student-athletes, most of these incidents occurred at or near athletic facilities. This observation indicated that schools would be best served to include adult visitors and staff in their EAPs. It also suggested that if funds for defibrillators are limited and only 1 is available, it should be placed at or near athletic facilities. Similarly, moving the AED to a site at which large crowds are expected, such as an athletic event or concert, would be prudent. Lastly, emergency preparedness appeared to be substantially lacking, given that only 16% of responding high schools had an EAP and rehearsed it at least annually per national recommendations.[2] This observation showed an ongoing need for medical personnel (eg, nurses, certified athletic trainers, physicians) to be advocates and encourage schools to prepare for emergency situations. We believe including trained medical personnel in EAP would be the best way to ensure an efficient and structured response to SCA in our high schools.

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