Radius of Care in Secondary Schools in the Midwest: Are Automated External Defibrillators Sufficiently Accessible to Enable Optimal Patient Care?

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Context: Sudden cardiac arrest is the leading cause of death among young athletes. According to the American Heart Association, an automated external defibrillator (AED) should be available within a 1-to-1.5-minute brisk walk from the patient for the highest chance of survival. Secondary school personnel have reported a lack of understanding about the proper number and placement of AEDs for optimal patient care.

Objective: To determine whether fixed AEDs were located within a 1-to-1.5-minute timeframe from any location on secondary school property (ie, radius of care).

Design: Cross-sectional study.

Setting: Public and private secondary schools in northwest Ohio and southeast Michigan.

Patients or Other Participants: Thirty schools (24 public, 6 private) volunteered.

Main Outcome Measure(s): Global positioning system coordinates were used to survey the entire school properties and determine AED locations. From each AED location, the radius of care was calculated for 3 retrieval speeds: walking, jogging, and driving a utility vehicle. Data were analyzed to expose any property area that fell outside the radius of care.

Results: Public schools (37.1% ± 11.0%) possessed more property outside the radius of care than did private schools (23.8% ± 8.0%; F₁,₂₈ = 8.35, P = .01). After accounting for retrieval speed, we still observed differences between school types when personnel would need to walk or jog to retrieve an AED (F₁,₄₈,₄₁,₃₅ = 4.99, P = .02). The percentages of school property outside the radius of care for public and private schools were 72.6% and 56.3%, respectively, when walking and 34.4% and 12.2%, respectively, when jogging. Only 4.2% of the public and none of the private schools had property outside the radius of care when driving a utility vehicle.

Conclusion: Schools should strategically place AEDs to decrease the percentage of property area outside the radius of care. In some cases, placement in a centralized location that is publicly accessible may be more important than the overall number of AEDs on site.

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

Key Points
- Secondary schools in northwest Ohio and southeast Michigan lacked emergency preparedness to permit the proper management of patients with sudden cardiac arrest.
- All schools studied had property outside the radius of care, resulting in insufficient access to automated external defibrillators.
- Schools need to strategically locate automated external defibrillators to decrease the percentage of property outside the radius of care and to increase accessibility for all potential caregivers.
- Athletic trainers should focus on why quality emergency-preparedness programs are not being implemented and on improving the understanding of secondary school officials to promote widespread implementation.

Sudden cardiac arrest (SCA) is the leading cause of death in young athletes. An important factor affecting survival is the time between collapse and defibrillation; without the appropriate response, an athlete has only a 1 in 10 chance of survival. Researchers have shown that each passing minute without defibrillation decreases the chance of survival by 7% to 10%. After 10 minutes, the survival rate decreases to 0%. The exact incidence of SCA in secondary schools is unknown, but estimates range from 0.63 to 4.4 per 100 000 high school students. Whereas SCA is considered rare, the devastation from an event of this magnitude greatly affects communities. The effect of a child’s death cannot be overstated, especially when death might have been avoided with early defibrillation. Best practices have been established regarding appropriate access to automated external defibrillators (AEDs). The Inter-Association Task Force recommended that high schools implement onsite AED programs to allow defibrillation within 3 to 5 minutes. Even when following established best practices, not all secondary schools are upholding the standard of care. Authors of research conducted in various regions of the United States have shown that 54% to 81% of secondary schools possess at least 1 AED. A recent survey of Oregon schools revealed that only 56% had an AED that could be accessed within 4 minutes at all sports venues.
Generally, the primary obstacle preventing the implementation of a quality onsite AED program is cost. However, even if schools have AEDs onsite, their personnel lack understanding about where to place them or how to integrate education and use within a comprehensive emergency action plan (EAP). In Vermont, whereas 81% of schools owned an AED, only 16% of those AEDs were located at sports venues. Most often, AEDs were located in the central office or school lobby, which may not be accessible at all times.

For optimal patient care, the American Heart Association (AHA) stated that an AED should always be within a 1- to 1.5-minute brisk walk from any area on a property. Radius of care describes the property zone in which an AED can be accessed within this timeframe (Figure 1). An ideal radius of care allows a rescuer to travel from the patient to an AED within 1 to 1.5 minutes, providing the opportunity for external defibrillation within 3 minutes of SCA. Investigators have established that immediate access to an AED substantially increases survival after SCA. Much of the research on AED placement has been performed in public venues, such as airports and casinos. However, it is unclear whether AEDs in secondary schools are appropriately located to uphold the standard of care.

To enhance the health and safety of everyone at a school, AEDs should be readily accessible at all times. Resuscitation equipment should be centrally located, highly visible, and within the radius of care. Whereas the AHA guidelines for AED accessibility are a good start, clearly understanding whether their AEDs are properly located is still challenging for school officials. We wanted to assist in emergency planning. Therefore, the purpose of our study was to determine whether fixed AEDs in secondary schools were properly located to permit optimal patient care.

METHODS

A convenience sample of 30 secondary public (n = 24) and private (n = 6) schools located in northwest Ohio and southeast Michigan participated in this investigation. The average number of fixed AEDs owned by each public school was 2.58 ± 1.21 (range = 1–5) and by each private school was 2.83 ± 0.41 (range = 2–5). We did not include portable AEDs in our data because availability in a fixed location cannot be guaranteed.

Instrumentation

We used the application Measure Map Pro (Global DPI, LLC, Wilmington, DE) for the iPad (Apple Inc, Cupertino, CA) to gather data. Measure Map Pro is an interactive map available in both standard and satellite views. With this application, global positioning system points were used to determine the total square footage of school properties (Figure 2) and the specific locations of the AEDs on each campus.

Procedures

The principal investigator (M.O.) consulted with school staff members who were familiar with each school’s property and the locations of AEDs. First, the perimeter
of the school property, including offsite athletic venues, was surveyed and calculated using Measure Map Pro.

Second, the exact location of each AED within the school property was determined using global positioning system coordinates (Figure 2).

**Radius of Care.** The radius of care was defined as the distance a rescuer could travel from an individual with SCA to an AED in 1 to 1.5 minutes. In a perfect scenario, this allows an AED to be accessed and applied within 3 minutes of collapse. For our investigation, we used 75 seconds as the appropriate timeframe to travel 1 way to retrieve an AED. We did not account for barriers to AED retrieval, such as locked doors, school security measures, or building layout. Only straight-line measurements were used.

Depending on the rescuer and resources available, the speed of travel from a patient to an AED varies. Therefore, to determine the appropriate radius of care of each AED on each campus, 3 modes or speeds of travel were used: walking, jogging, and driving a utility vehicle.

**Walking.** According to Bohannon and Williams Andrews, \(^{18}\) the average walking speed for men and women aged 20 to 59 years is 3.09 mi/h (1.38 m/s). This equates to 103.5 m in 75 seconds (Table 1). If the nearest AED was more than 103.5 m from any campus location, that area was considered outside of the radius of care when walking (Figure 3).

**Jogging.** Realistically, the rescuer likely will not be walking but moving more quickly to retrieve an AED. Jogging has been defined as running slower than an 8-minute mile \(^{19}\) or 7.0 mi/h (3.13 m/s). \(^{20}\) This rate of locomotion calculates to a radius of 234.7 m (Table 1). Therefore, if an AED was beyond 234.7 m from any campus location, that area was considered outside the radius of care when jogging (Figure 4).

**Utility Vehicle.** Utility vehicles are commonly used by athletic trainers (ATs) and other school staff and may be available at a venue when an SCA occurs. They may travel at speeds of 15 to 20 mi/h (6.71 to 8.94 m/s), with an average speed of 17.5 mi/h (7.82 m/s). \(^{21}\) This more than doubles the size of the jogging radius of care (586.7 m; Table 1). Therefore, any property area farther than 586.7 m from the nearest AED was considered outside the radius of care when driving a utility vehicle (Figure 5).

**Data Analysis**

The percentage of total school property outside the radius of care was used for analysis. We performed a factorial analysis of variance and conducted a post hoc Tukey test to determine the main effects of school type (public, private) and speed (walking, jogging, driving a utility vehicle) and the interaction between school type and speed on the radius of care. The \(\alpha\) level was set at .05. We used SPSS (version 22; IBM Corp, Armonk, NY) for statistical analysis.

**RESULTS**

The average campus size of public schools was 218 229 m² and of private schools was 110 930 m². The average number of onsite AEDs was 2.58 at public schools and 2.83 at private schools.

We observed a main effect for school type \((F_{1,28} = 8.35, P = .01)\), indicating that public schools (37.1% ± 11.0%) possessed more property outside the radius of care than did private schools (23.8% ± 8.0%). We also noted a main effect for speed \((F_{1,48,41.35} = 263.78, P < .001)\), which showed that walking (69.4% ± 14.4%) resulted in more area outside the radius of care than did jogging (30.0% ± 18.6%) and that jogging resulted in more area outside the radius than did driving a utility vehicle (3.4% ± 8.6%).

The percentage of school property outside the radius of care for each speed condition is reported in Table 2. We demonstrated an interaction \((F_{1,48,41.35} = 4.99, P = .02)\) indicating that public schools had a greater percentage of property outside the radius of care for both walking (72.6% ± 13.0%) and jogging (34.4% ± 17.3%).

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Table 1. The Predicted Radius of Care Calculated From Average Velocities for Walking, Jogging, and Driving a Utility Vehicle (Velocity × 75 s)

| Mode of Travel          | Average Velocity, m/s | Radius of Care, m |
|-------------------------|-----------------------|-------------------|
| Walking                 | 1.38\(^{18}\)         | 103.5             |
| Jogging                 | 3.13\(^{19}\)         | 234.7             |
| Driving a utility vehicle | 7.82\(^{20}\)        | 586.7             |
DISCUSSION

We found that secondary schools in northwest Ohio and southeast Michigan lacked the emergency preparedness to properly manage patients with SCA. All public and private schools possessed property outside the radius of care, resulting in insufficient AED access. Researchers have reported that SCA is the leading cause of death among young athletes\(^1,2\) and early defibrillation is critical for survival.\(^3,5,9\) Investigators\(^22,23\) have also shown that survival rates were remarkably higher for patients at schools with AED access. Nevertheless, our results provide evidence that secondary schools are still not implementing effective onsite AED programs. Given the publically available best-practice recommendations, obstacles must be inhibiting the schools’ commitments to properly manage SCA.

Previously identified barriers include cost\(^14\) and a lack of education and emergency preparedness.\(^10,13,15\) Emergency planning for SCA is an important concern not only for the safety of athletes but for all students, school employees, and the community. Emergency preparation must include 3 basic components: a detailed response plan, access to AEDs and other lifesaving equipment, and trained personnel.\(^13\) Unfortunately, some secondary schools lack such preparation. Johnson et al\(^13\) reported that only 11% of secondary schools surveyed in Oregon met all 3 standards. Merely 38% had venue-specific EAPs, and only 56% had AEDs that could be accessed within 4 minutes at all sports venues. Schools with trained personnel, specifically ATs, were more likely to have implemented best practices.\(^13\) All of the schools in our study employed or contracted with an AT (full or part time). Nonetheless, as noted, all schools had property outside the radius of care. This raises questions regarding an AT’s role and authority in making decisions concerning AED access across an entire school campus.

Public schools had a greater percentage of property outside the radius of care than did private schools (Table 2). The average public school campus (218,229 m\(^2\)) was nearly twice the size of the average private school campus (110,930 m\(^2\)). Others\(^10,24\) have noted that, given their campus sizes, public schools may need to consider providing access to a greater number of AEDs. In our study, the average number of AEDs was similar between public (mean = 2.58) and private (mean = 2.83) schools. We agree that schools with larger campuses may need a greater number of onsite AEDs. However, regardless of the number of AEDs or campus size, all of the public and private schools we investigated were deficient.

A limitation of our study was that we calculated the radius of care “as the crow flies” (ie, in a straight line from the location of the AED). We did not account for the time it may take to navigate through or around buildings or to open

| School Type | Walking (Mean ± SD) | Jogging (Mean ± SD) | Utility Vehicle (Mean ± SD) |
|-------------|---------------------|---------------------|-----------------------------|
| Public (n = 24) | 72.6 ± 13.0\(^a\) | 34.4 ± 17.3\(^a\) | 4.2 ± 9.4 |
| Private (n = 6) | 56.3 ± 12.8 | 12.2 ± 12.6 | 0.0 ± 0.0 |

\(^a\) Public schools possessed a higher percentage of school property outside the radius of care (\(P = .02\)).
locked located inside school buildings and central offices, often leaving outdoor venues outside the radius of care. Whereas we did not quantify whether AEDs could actually be accessed, buildings and central offices may be securely locked at any time of day, rendering an AED inaccessible to a potential rescuer. Sports, community events, and classroom activities commonly occur outdoors, highlighting the importance of anyone being able to access an AED anywhere and at any time. Schools should consider mounting AEDs on the outside of structures for continual and uninterrupted access.

At an individual’s average walking velocity, access at 100% of schools studied was unsatisfactory, with an average of 72.6% ± 13.0% of public and 56.3% ± 12.8% of private school property outside the radius of care (Table 2). The AHA standard is based on walking speed. However, many would argue that walking during an emergency is unrealistic; most will run to help rescue an individual with SCA. Whereas most rescuers will probably be able to walk a distance to retrieve an AED, a smaller percentage of rescuers will be able to jog 234.7 m at a sustained pace of 7 mi/h (3.13 m/s) or faster (Table 1). Nevertheless, even when a staff member jogged to retrieve an AED, up to one-third of schools had property beyond the radius of care (Table 2). When using the fastest retrieval option (driving a utility vehicle), more than 96% of secondary schools had all property within the radius of care (Table 2). However, again, these calculations did not account for the need to navigate inside buildings on foot or around buildings or other barriers. Consequently, it is likely that a higher percentage of school properties was beyond the radius of care. To corroborate these results, researchers should test human rescuers in actual secondary school environments to determine whether the schools have the appropriate number of AEDs in the best locations for optimal prehospital care of individuals with SCA.

Overall, our findings highlight the complicated nature of emergency preparedness and the coderependence of critical emergency planning components. The simple existence of a detailed EAP, trained personnel, and an AED does not ensure quality care. The execution of each element of an EAP must be deliberately grounded in the available evidence. The need for an effective onsite AED program is well established in the literature. Further, the standards of practice recommended by the Inter-Association Task Force have been in place since 2007. However, quality emergency preparedness programs still do not exist in all secondary schools. We must identify the reasons for sustained resistance to implementing best-practice recommendations for patients with SCA. Perhaps the lack of state regulation is a contributing factor. Interestingly, all 50 states have implemented laws governing the use and placement of AEDs in public venues. However, more states require AEDs in fitness centers than in secondary schools. In the absence of state regulation, ATs may be left to educate about and advocate for an AED program. With a dearth of resources, it appears that programs often fall short. Given the clear needs and recommendations regarding AED access in secondary schools, we must focus on why programs are not being implemented and how to improve communication and understanding for their widespread implementation.

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