

## Public Access Defibrillation Where Does It Work?

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Sudden cardiac arrest (SCA) is recognized as a serious public health problem, accounting for 250 000 to 300 000 deaths per year; it is now the third-leading cause of death behind cancer and nonsudden cardiovascular deaths.<sup>1,2</sup> Immediate, well-performed cardiopulmonary resuscitation (CPR) and early defibrillation are the only out-of-hospital interventions that improve outcomes.<sup>3</sup> The chain of survival relies on lay responders and emergency medical services (EMS) to initiate the potentially life-saving procedures of CPR and defibrillation.

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### Articles see pp 510 and 518

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In 1994, the American Heart Association (AHA) convened the first conference on public access defibrillation (PAD) to introduce the strategy of placing easy-to-use defibrillators in public places to decrease the death rate from SCA.<sup>4</sup> Specific recommendations encouraged the stakeholders (the AHA, the US Food and Drug Administration, the National Institutes of Health, industry, and communities) to facilitate PAD by developing user-friendly, less-expensive automated external defibrillators (AEDs); testing the concept within large clinical trials; and organizing communities to promote and support effective PAD programs. Widespread CPR and AED training of the public was emphasized. In the ensuing 15 years, many of these recommendations have been heeded, and PAD programs are now commonplace. The National Institutes of Health-sponsored PAD trial demonstrated that survival doubled when events occurred in communities equipped and trained with CPR and AEDs compared with CPR alone.<sup>5</sup> Within the Resuscitations Outcomes Consortium (ROC), out-of-hospital cardiac arrest victims had a markedly increased chance of survival if the first shock was delivered by a bystander using an AED rather than by EMS.<sup>6</sup> PAD programs in airports, airlines, and casinos have also validated the effectiveness of the concept. Out-of-hospital cardiac arrest is treatable, and outcomes can be improved with currently available approaches.

Multiple locations have been recognized as having a higher incidence of cardiac arrest and should be targeted for PAD sites. These include airports and other transportation centers,

prisons, large shopping malls, sports complexes, large industrial sites, golf courses, gyms/health clubs, and community centers.<sup>7</sup> Appropriate locations for a PAD include sites that can expect an arrest every 5 years, sites that cannot provide EMS response within 5 minutes, and facilities that serve high-risk people. Additionally, the AHA has provided guidance on administering a successful PAD program: A planned and practiced response; ongoing training of anticipated rescuers in CPR and AED use; links with local EMS agencies; and ongoing quality improvement.<sup>8</sup> Excitement about the organization of PAD programs was and is infectious. Communities have organized fund-raisers to purchase the devices, and foundations have been established to provide grants and advice to communities seeking to develop PAD programs. Parent-driven groups spearheaded efforts to place AEDs in schools and lobbied state and federal legislatures for statutes to require AEDs in schools.<sup>9</sup>

Two very informative articles in this issue of *Circulation* evaluate these volunteer- or community-initiated programs and demonstrate that the mere presence of an AED in the general area of an arrest does not guarantee success.<sup>10,11</sup> The first, by Folke et al,<sup>10</sup> studied the outcomes of a broad public initiative in Copenhagen, Denmark, to place AEDs in municipal buildings. The authors addressed the appropriate placement of AEDs in public settings compared with the sites of the actual cardiac arrests.<sup>10</sup> The uniqueness of their study was the use of the 100×100-meter grids of the standardized European Grid System. They were able to define the exact locations of high population density (transportation systems, sports centers, public parks, etc) and superimpose sites of all cardiac arrests and the locations of the AEDs. Not surprisingly, grid cells of the highest incidence of SCA contained mass transportation terminals and public gathering sites. Disappointingly, the AEDs had been placed in very low-risk sites with annual cardiac arrest incidences per AED of 0 to 0.09. In these locations, the AEDs covered only 29 arrests during the study period. One third of the arrests occurred within train stations, but the nearest AED, although in the same grid, was in a municipal building. The authors added to their analysis by calculating the number of AEDs needed to comply with the European Resuscitation Council or AHA guidelines, which recommend placing an AED in sites with an expectation of a cardiac arrest every 2 or 5 years, respectively. European Resuscitation Council recommendations provided coverage for 19.5% of arrests and would require 125 AEDs. This coverage increased to 67% of arrests and 1104 AEDs when the AHA recommendations were applied.

However, in addition to the optimal placement of AEDs, an effective PAD program requires continued supervision, maintenance, and training. Over time, it is likely that the supervi-

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sion and maintenance of a PAD site may falter, especially if the site is maintained by volunteers. During the PAD trial, when volunteers were trained at least annually, volunteer or bystander CPR was performed during 70% of the events.<sup>5</sup> A small study from Johnson County, Iowa, evaluated compliance with AHA recommendations after a voluntary task force placed AEDs in schools, businesses, and community facilities.<sup>12</sup> A 25-point scoring system was developed from the 4 components of the AHA recommendations, weighted toward CPR and AED training. Two years after placement, none of the sites had successfully maintained the program as judged by the AHA recommendations, earning only a mean of 57% of the possible points. On-site interviews detected problems with access, unapparent location of the AED, and inoperative equipment such as expired pads or batteries. Only 3 of 32 sites had budgeted more than \$500 annually to provide training, quality assurance, or equipment maintenance. A study of division 1 National Collegiate Athletic Association programs found similar results.<sup>13</sup> Most AEDs had been purchased for concerns of liability, with no determination of local EMS response times, geography of the sports facilities, or budgetary planning. Maintenance checks were more than every 6 months or unknown in 30% of the schools. Thus, placement in high-risk locations alone does not ensure that the AED will be operative or used when needed.

The second article in this issue, by Drezner et al, is a large study reporting the results of a World Wide Web-based registry of AED use in sports.<sup>11</sup> Letters were sent to high schools identified by membership in the National Federation for High Schools, inviting a school representative to complete the survey, which collected comprehensive information on AED purchase, emergency planning, and use. Follow-up interviews were conducted at any site that had experienced a student cardiac arrest within the previous 6 months. The results are extremely impressive and demonstrate that PAD programs can be highly effective and save lives. Of the 2084 respondents, 82% had at least 1 AED on site, and 83% had an emergency response plan for SCA. Thirty-six schools reported an SCA within the previous 6 months, with 64% survival to hospital discharge. Almost all events were witnessed (97%), an astounding 94% received bystander CPR, and 83% received a shock from the AED, which indicates highly successful activation of emergency response plans. As in other reports of cardiac arrests at schools, more than half of the victims were nonstudents. All students who experienced an arrest were athletes, although not all were actively exercising at the time of the arrest. The major shortcoming of this study is that surveys were returned from only 11% of the schools (2084 of 18 974), and of those, 2% had experienced an SCA within the previous 6 months. Other notable features of the respondents were that 60% had developed their emergency plans with assistance from the local EMS. Together, these indicate a probable strong sampling bias of the returned surveys.

The study by Drezner et al<sup>11</sup> can be compared with another study of cardiac arrest in schools within Seattle and King County, Washington.<sup>14</sup> Of 3773 cardiac arrests in public locations during the years 1990 to 2005, 97 events occurred in 641 schools (kindergarten through 12th grade, colleges, and

universities). The majority of the events (almost 90%) occurred in adults. Similar to the study by Drezner et al,<sup>11</sup> most events were witnessed, bystander CPR was performed more frequently than usually reported (74%), and ventricular fibrillation was common (76%).<sup>14</sup> Survival to hospital discharge was high compared with most reports of sudden death, at 38%, but not as high as in the study by Drezner et al.<sup>11</sup> Since the initiation of PAD programs in 1999, 7 of 66 events included lay rescuer use of an AED.<sup>14</sup>

Caution should be used when interpreting the SCA incidence of 4.4/100 000 per year presented by Drezner et al.<sup>11</sup> This calculation is not population based but rather derived from data supplied voluntarily by a select group of respondents. It is most surely not a representative sample of US high schools. Another calculation of the incidence of cardiac arrest of high-school aged children is provided by Lotfi et al,<sup>14</sup> who found the incidence within the Seattle/King County area over a 16-year period to be 0.15/100 000 per year. The authors also indicate that the incidence of 4.4/100 000 compares favorably with that reported from the ROC of 3.75/100 000 per year<sup>15</sup>; however, the 2 populations are very different. The ROC data were population based and derived from all cardiac arrests to which EMS responded and provided CPR or defibrillation from 11 sites in the United States and Canada. Although trauma deaths were excluded, drownings and hangings, as well as patients with known preexisting conditions and drug exposure, were included in the ROC study. The estimate in the study by Drezner et al<sup>11</sup> that 2 of 50 high schools can expect a cardiac arrest per year is 5 times the estimate derived from the Seattle/King County study, and it far exceeds the number estimated by Maron et al,<sup>16</sup> who have maintained a registry of sudden death within athletes for 27 years. Even though the reported frequency is increasing annually, they estimate only 100 deaths per year in this population. Despite these large differences, any estimate of cardiac arrest is imprecise because of inadequate data collection, and regional variation is poorly understood.<sup>1,17</sup>

An important evaluation of community PAD programs is cost-effectiveness. Multiple cost-effectiveness studies have been published, and all provide data that PAD programs are cost-effective.<sup>9,18,19</sup> The cost per quality-adjusted life-year has typically been calculated to range from \$30 000 to \$100 000, figures that are within the acceptable range for many medical therapies; however, these estimates are highly dependent on assumptions made in the analysis. Effectiveness of the therapy, estimated frequency of use, location of cardiac arrest, costs of program maintenance and training, and duration and cost of follow-up therapy can dramatically affect these figures. The 2 reports published this week provide guidance on location and cost-effectiveness. Folke et al<sup>10</sup> analyzed the cost-effectiveness of the European Resuscitation Council recommendations (\$33 100 per quality-adjusted life-year) versus the AHA recommendation (\$40 900). Both are reasonable, but the AHA recommendation provides reasonable coverage of an urban area. Although Drezner et al<sup>11</sup> did not include a cost-effective analysis, the study does demonstrate that even locations considered very low risk with a high quality-adjusted life-year can be effective. A simple dollar evaluation may not be the only consideration of PAD pro-

grams at low-risk locations. The tragic death of an adolescent has a profound effect on the community, and the desire to protect this population may outweigh financial considerations. A striking example of wasted resources is the analysis by Folke et al,<sup>10</sup> who calculated a cost of \$181 700 per quality-adjusted life-year when AEDs were placed by unguided or nonstrategic initiatives. In such locations, which may include many schools, a well-executed emergency plan along with well-performed CPR and close proximity to EMS may be sufficient.

What is next for our understanding and treatment of out-of-hospital SCA? These 2 reports starkly illustrate the success and shortcomings of PAD programs and can direct our ongoing efforts to decrease the unacceptable mortality of SCA. Clearly, many of the goals from the 1994 conference have been achieved. Public awareness of SCA is markedly greater, and the lay public recognizes their involvement in rapid response and treatment. But much remains to be done to optimize the effectiveness of PAD programs. First, recognition that CPR is as important as AED availability needs further emphasis. CPR is easily taught in health classes and should become a requirement for completion of both middle and high school. Improved approaches to teach and refresh CPR inexpensively with nominal time commitments are now readily available. New CPR techniques, such as hands-only CPR, have demonstrated effectiveness and will likely increase the number of lay responders willing to perform CPR. Second, the nonequipment components of a PAD site are essential. The need for ongoing CPR training, fully developed and executed emergency plans, and links to EMS are vital to the immediate and long-term outcomes of shock delivery. Supervision is critical, and therefore, the funds and personnel to perform these functions should be identified at site initiation. Finally, consistent and high-quality data collection for all out-of-hospital cardiac arrests is warranted to combat this public health scourge, which is eminently treatable.

### Disclosures

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