Prediction and Prevention of Sudden Cardiac Arrest
Lessons Learned in Schools

N.A. Mark Estes III, MD

Prediction and prevention of sudden cardiac arrest (SCA) remains one of the great challenges of contemporary cardiology. As the most common cause of death in the United States, SCA accounts for an estimated 350,000 deaths annually and represents a leading cause of disability and healthcare costs. Early cardiopulmonary resuscitation and defibrillation are essential steps in resuscitation of individuals with the life-threatening ventricular arrhythmias that most commonly cause SCA. In an effort to improve survival from cardiac arrest, public access to defibrillation (PAD) programs have promoted the chain-of-survival concept with sequential steps in the prehospital phase that result in improved survival. These interventions include rapid access to emergency medical services by calling 911, cardiopulmonary resuscitation (CPR), defibrillation when indicated, and initiation of advanced medical care. Survival depends directly on the time to defibrillation, and early defibrillation has emerged as the most important intervention, with survival decreasing by 10% with each minute of delay in defibrillation.

A confluence of multiple factors over the last several years has resulted in the coming of age of PAD programs. Among these is the recognition that incorporation of the automated external defibrillator (AED) into the chain of survival shortens time to definitive therapy and improves survival. Good Samaritan laws, passed in all 50 states, are supplemented by the federal Cardiac Arrest Survival Act and provide broad-based legal immunity for those purchasing or using an AED. At the same time, there has been a growing recognition that not providing access to an AED as a prudent measure of public protection may subject one to liability in public locations. Finally, a substantial body of robust clinical data, including multiple prospective randomized trials and a meta-analysis, support incorporation of the AED into PAD programs.

Interest in PAD, CPR, and AED training has evolved with a particular focus on school-based programs recently. An early and intriguing study in an elementary school reported that AEDs were safely and successfully operated by sixth graders who performed defibrillation in 90 seconds in a simulated resuscitation. In the same study, trained paramedics performed defibrillation in 67 seconds. Since the publication of this provocative study, the interest in PAD programs with AED and CPR training in schools has been catalyzed by tragic sudden deaths of children and young adults. The movement also has been advanced with recent recommendations from the American Heart Association on AEDs. These include an advisory that AEDs, previously restricted to those ≥8 years of age, are appropriate for use in children as young as 1 year of age.

Another recent recommendation is that AEDs should be placed in all schools with a reasonable probability of a cardiac arrest over the next 5 years, those with any student at high risk for cardiac arrest, or those with an emergency call to shock time >5 minutes. These recommendations were made with consideration of the available data on locations of cardiac arrest and recognition that schools have a lower frequency of cardiac arrest than many other public locations.

Recent initiatives include efforts to have PAD programs with AEDs in every school. Current legislative mandates that either have passed or are pending include AED use in public schools in 13 states. Several of these mandates were initiated in response to student deaths in schools. In addition, a congressional bill promotes public access to defibrillation programs in all schools. The momentum for PAD programs in the schools has grown despite population-based data available for over a decade indicating a low incidence of SCA in schools relative to other locations. However, less information is available on the circumstances, patient characteristics, and outcome of cardiac arrest in schools.

In this issue of Circulation, additional insights into these aspects of SCA are provided by a 15-year retrospective analysis in Seattle. In an effort to improve understanding of the epidemiology of cardiac arrest in schools, the investigators conducted this analysis with a stated "special focus on the role of school-based AEDs." With a total of 23,597 cardiac arrests with emergency medical service responses, 3,773 (16%) had public locations specified. Interestingly, this represents a proportion of public locations identical to that reported previously from the Seattle area for the 4-year period of 1990 to 1994. In the present study, the 97 cardiac arrests that occurred in schools represented 0.4% of all treated cardiac arrests and 2.6% of all public-location cardiac arrests. Of these 97 cases in schools, 12 cardiac arrests were in students, 33 in faculty and staff, and 45 in adults not employed by the school. There also were 7 adults with cardiac arrest who had an indeterminate school association. The investigators report that school-based cardiac arrest occurred on average in 1 of 111 schools annually, with a greater annual incidence among colleges (1 cardiac arrest per

The opinions expressed in this article are not necessarily those of the editors or of the American Heart Association.

From the Cardiac Arrhythmia Center, Tufts-New England Medical Center, Tufts-University School of Medicine, Boston, Mass.

Correspondence to Dr N.A. Mark Estes III, Director, Cardiac Arrhythmia Center, Tufts-New England Medical Center, Tufts-University School of Medicine, 750 Washington St, Boston, MA 02111. E-mail nestes@tufts-nemc.org

(Circulation. 2007;116:1341-1343.)

© 2007 American Heart Association, Inc.

Circulation is available at http://circ.ahajournals.org
DOI: 10.1161/CIRCULATIONAHA.107.726539
The cardiac arrest rates were significantly lower in high schools (1 per 125 high schools) and lower-level schools (1 per 200 preschools through middle schools). Previously published data on the frequency of cardiac arrests in schools and churches reported an average annual incidence of 0.002 or 1 arrest per 500 sites. Among persons 3 to 18 years of age, school-based cardiac arrests accounted for 13.1% (8 of 61) of public-location cardiac arrests and 4.4% (8 of 183) of all cardiac arrests.26

Overall, the estimated annual incidence of cardiac arrest was 0.18 per 100 000 person-years among students and 4.51 per 100 000 person-years for school faculty and staff. Interestingly, nearly all school cardiac arrests were attributed to cardiac origin, and approximately 3 quarters of the school cardiac arrests were witnessed (79%), received bystander CPR (74%), and presented with an initial cardiac rhythm of ventricular fibrillation or pulseless ventricular tachycardia (78%).26 This represents greater proportions of CPR use and ventricular tachycardia and ventricular fibrillation as initial rhythms than observed in other public-location cardiac arrests. The survival rate to hospital discharge among cardiac arrests was 39% in school settings (46% for initial rhythm of ventricular fibrillation) compared with 27% in other public locations.26 Over the last 7 years of the study (1999 to 2005), 118 schools implemented PAD programs, with the AED used in 7 of 66 school-based cardiac arrests.26 Analyses of outcomes based on initiation of CPR or use of a public-access defibrillator are not provided by the investigators despite their stated focus on the AEDs.26 This study confirms prior epidemiological data that most cardiac arrests occur at home rather than in public locations.2,18–20 Prior studies have shown that outcomes in nonpublic locations are worse than in public locations.2 Because most cardiac arrests occur at home, it is reasonable to hope that widespread training in CPR may increase the incidence of CPR by laypersons and lead to better survival.2,26

In this same issue of Circulation, another group of investigators report on the effect of a school-based mass distribution of CPR instructional materials to students on the frequency of bystander-initiated CPR.27 A 24-minute self-instruction video and manikin were distributed to >35 000 seventh-grade students in 806 Danish primary schools. These students received “first-tier training” in their schools and were expected to then train other relatives and friends during “second-tier” training. This was hoped to result in a “multiplier” effect.27

The investigators optimistically projected a 10% increase in the frequency of bystander-initiated CPR from 25% to 35% as a result of the program. In the 3 months after training, only an estimated 2.3% of the relevant population was trained according to the reporting of the students. The incidence of bystander CPR increased by 3% in the 3 months after the project. This fell short of the projected primary end point and statistical significance compared with the previous year (25.0% versus 27.9%; P=0.16). The 20% of students responding to a questionnaire reported an average of 2.5 additional individuals trained.27 Without a multiplier effect considerably greater than that reported, it would be unrealistic to expect the 10% increase in bystander-initiated CPR projected by the investigators. A more sensitive indicator of the impact of the training would result from assessment of whether first-tier or second-tier trainees actually initiated CPR during cardiac arrests. Detection of the ambitious increase of 10% in frequency of CPR from an instructional program that trained only 2.3% of the population by measuring an outcome in the entire population would not be expected. The 3% increase in CPR reflects an increase proportional to the trained population and may be an indicator of a positive influence of the program.

The reliability of seventh graders reporting second-tier training, as noted by the authors, has not been established. Furthermore, potential reporting bias exists, with only 20% of participants responding. Although the investigators note that both the immediate and lasting skill retention of the CPR Anytime Program have been documented to be at least as good as traditional CPR training, the effectiveness of such training in this age group remains uncertain. Furthermore, there is a paucity of data on the effectiveness of second-tier training by seventh graders with relatives and friends.33–37

This investigation brings to the forefront many relevant issues related to CPR training. Although the utility of video-based self-instruction has been evaluated in other age groups, further validation in this and other age groups is needed. Video-based training needs to be assessed in this age group and those trained by them through the use of the end points of effective initiation of CPR and assessment of competency, skill acquisition, and retention of video-based self-instruction when facilitated by a seventh grader with a family member or friend.

These 2 studies in Circulation represent useful information that advances the efforts to predict and prevent SCA. The lessons should be carefully considered when strategies for optimal CPR training and PAD programs are formulated. Schools have a relatively low frequency of cardiac arrest compared with other public locations.18–20,26 However, schools have a higher frequency of witnessed arrests, cardiac causes, ventricular fibrillation, bystander CPR, and better survival to hospital discharge compared with other public locations.26

Although the inference might be that schools represent a lower priority than other public locations for PAD programs, multiple other factors are appropriately considered in the calculus of resource allocation in a given community. These include the profound emotional and psychological considerations that frequently dominate prioritization of resources to ensure the safety and well-being of youth. The indirect effects of AED placement and CPR training in schools remain unknown. The issue of whether PAD programs and CPR training in schools, as centers of both education and influence, affect outcomes by promoting similar programs in a given community merits further research. Many communities and organizations have reasonably elected to advance PAD and training programs in schools with the knowledge that they do not represent the most common location of public cardiac arrests. Commonly, this represents a considered decision to provide a special measure of protection of youth. The resources for these school initiatives frequently are uniquely available to schools and are not available for allocation to alternative public locations where SCA is known to occur more frequently. With these considerations in mind, such school programs should serve to underscore the need for prudent protection with PAD programs in all public locations.
These 2 studies bring to the forefront several additional areas in which more complete information is needed regarding the prediction and prevention of SCA. With knowledge of the frequency of cardiac SCA by locations, additional research is necessary to ensure enduring proficiency in CPR and AED for those individuals most likely to be at the site. Continued research also is needed to identify age-appropriate training techniques that achieve competency and sufficient retention of skills to improve outcomes. The issue of whether training focused on reducing the psychological barriers to initiating CPR in an emergency can result in improved outcomes needs further investigation. In many respects, the most important lesson about the prediction and prevention of SCA from the studies in this issue of Circulation is one commonly learned in schools: Despite continued advances in knowledge, much remains unknown.

Disclosures
Dr Estes is on the speakers’ bureau for Medtronic, St Jude Medical, and Boston Scientific.

References
Prediction and Prevention of Sudden Cardiac Arrest: Lessons Learned in Schools
N.A. Mark Estes III

_Circulation_. 2007;116:1341-1343
doi: 10.1161/CIRCULATIONAHA.107.726539
_Circulation_ is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
Copyright © 2007 American Heart Association, Inc. All rights reserved.
Print ISSN: 0009-7322. Online ISSN: 1524-4539

The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://circ.ahajournals.org/content/116/12/1341

Permissions: Requests for permissions to reproduce figures, tables, or portions of articles originally published in _Circulation_ can be obtained via RightsLink, a service of the Copyright Clearance Center, not the Editorial Office. Once the online version of the published article for which permission is being requested is located, click Request Permissions in the middle column of the Web page under Services. Further information about this process is available in the Permissions and Rights Question and Answer document.

Reprints: Information about reprints can be found online at:
http://www.lww.com/reprints

Subscriptions: Information about subscribing to _Circulation_ is online at:
http://circ.ahajournals.org//subscriptions/