TECHNICAL REPORT

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Advocating for Life Support Training of Children, Parents, Caregivers, School Personnel, and the Public

Susan M. Fuchs, MD, FAAP, COMMITTEE ON PEDIATRIC EMERGENCY MEDICINE

Pediatric cardiac arrest in the out-of-hospital setting is a traumatic event for family, friends, caregivers, classmates, and school personnel. Immediate bystander cardiopulmonary resuscitation and the use of automatic external defibrillators have been shown to improve survival in adults. There is some evidence to show improved survival in children who receive immediate bystander cardiopulmonary resuscitation. Pediatricians, in their role as advocates to improve the health of all children, are uniquely positioned to strongly encourage the training of children, parents, caregivers, school personnel, and the lay public in the provision of basic life support, including pediatric basic life support, as well as the appropriate use of automated external defibrillators.

INTRODUCTION

Each year, 347 322 adults and 7037 children experience out-of-hospital cardiac arrest (OHCA).[1] Survival in children from nontraumatic OHCA remains dismal at 6.4%, and many survivors have poor neurologic outcomes.[2,3] Although the overall incidence of 8.04 per 100 000 person years of pediatric OHCA is less than that of adults, the incidence in infants younger than 1 year is actually higher (72 per 10 000 person years for infants vs 50–55 per 100 000 person years for adults). According to the Resuscitation Outcomes Consortium, the incidence for children 1 to 12 years of age is 3.73 per 10 000 person years and for adolescents (12–19 years) is 6.37 per 100 000 person years.[2,4] Infants also have the greatest mortality rate, with only 3.3% surviving to hospital discharge.[2] The survival rate of children and adolescents, however, surpasses that of adults (4.5%), with 9.1% of children and 8.9% of adolescents surviving to hospital discharge.[2,4] The most common cause of OHCA in infants includes sudden unexpected infant death (previously called sudden infant death syndrome) and congenital anomalies, whereas the most common cause of OHCA in children was drowning.[2,5] In adolescents, hanging and poisoning

abstract

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Pediatrics, Feinberg School of Medicine, Northwestern University, Evanston, Illinois; and Division of Emergency Medicine, Ann & Robert H Lurie Children's Hospital of Chicago, Chicago, Illinois

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Address correspondence to Susan M. Fuchs, MD, FAAP. E-mail: s-fuchs@northwestern.edu

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were the most common causes of OHCA.[2] The authors of 1 study noted that survival was lower in Canadian children, with only 1.9% of survivors 1 to 19 years of age achieving hospital discharge, but included in this study were traumatic etiologies for OHCA, such as motor vehicle collisions, which had not been part of the data set in the studies referenced previously.[6]

In the Resuscitation Outcomes Consortium Epistry-Cardiac Arrest, emergency medical services (EMS) providers treated approximately 81% of pediatric patients suffering from OHCA; interventions included bag mask ventilation, advanced airway placement, vascular access, and drug therapy.[2] When available, the initial cardiac rhythm was documented as asystole or pulseless electrical activity in 82% of patients, and pulseless ventricular fibrillation or ventricular tachycardia (VF/VT) in 7%.[2,4] Adolescents were more likely than younger children or infants to have an initial VF/VT rhythm (15% vs 5% and 4%, respectively) but in percentages below the 23% of VF/VT seen in adults.[2,4] Predictors of a better outcome included witnessed arrest, bystander cardiopulmonary resuscitation (CPR), and initial rhythm of VF/VT.[2,4] These outcomes were further demonstrated in a literature review by Donoghue et al[3] in which witnessed arrest and submersion injury were also associated with increased survival in children younger than 18 years. A Japanese study of OHCA in children revealed that CPR instruction by dispatchers increased the CPR provision rate (adjusted odds ratio [OR] 7.51), and dispatcher-assisted bystander CPR was associated with improved neurologic outcomes at 1 month (adjusted OR 1.81) when compared with no bystander CPR.[7] The poorer outcomes associated with pediatric OHCA may be attributable to the fact that these events often occur in nonpublic locations, such as a residence (88% of total), and are rarely witnessed (19%). In addition, bystander CPR occurs infrequently (35%), and automated external defibrillator (AED) use is rare.[2]

The American Heart Association (AHA) pediatric chain of survival includes the following links: (1) prevention of injury or arrest, (2) early and effective CPR, (3) prompt access to EMS, (4) rapid pediatric advanced life support, and (5) integrated postcardiac arrest care.[8] As stated previously, a key component of this chain is early and effective bystander CPR. The pediatric chain of survival varies slightly from the adult version, which includes (1) immediate recognition of cardiac arrest and activation of EMS, (2) early CPR with an emphasis on chest compressions, (3) rapid defibrillation, (4) effective advanced life support, and (5) integrated postcardiac arrest care.[9] The AHA considers victims in puberty and beyond to be adults for the purposes of CPR. Therefore, addressing the needs of adolescent victims would involve the adult algorithm instead of the pediatric approach. Step 3 in the adult algorithm, effective defibrillation, which includes the use of an AED, can be critical in adolescents because they have a higher rate of VF/VT arrests than infants and children.[2,4]

2010 AHA Guidelines

In 2010, the AHA released revised CPR recommendations, which changed the sequence to compressions, airway, breathing/ventilation. The revised recommendations called for 30 chest compressions followed by 2 breaths for adults with either 1 or 2 rescuers, a ratio of 30:2 for children with 1 rescuer, and a ratio of 15:2 for children with 2 rescuers.[9] These changes resulted from the discovery that high-quality chest compressions are needed to restore blood flow during cardiac arrest. The previous sequence had delayed the initiation of crucial chest compressions. Additionally, some potential rescuers had difficulty completing the airway and breathing components, and others were reluctant to initiate CPR at all because of concern about giving mouth-to-mouth breaths.[8]

In infants and children, respiratory arrest is a frequent cause of cardiopulmonary arrest, so the airway and breathing/ventilation components remain important, but the new sequence only delays the first breath by 18 seconds.[10] The authors of a Japanese study demonstrated that traditional CPR (compressions followed by breathing) was associated with increased odds of a favorable neurologic outcome in children 1 month after an OHCA (adjusted OR, 2.30 vs 1.05) compared with chest compression–only CPR.[7] Therefore, although the AHA still recommends traditional CPR compared with chest compression–only CPR for children, if rescuers cannot provide rescue breaths, they should at least perform chest compressions.[10]

Importance of AED Training

The revised AHA guidelines also include a recommendation to extend the use of AEDs to children of any age experiencing an OHCA.[9] A manual defibrillator is preferred to treat infants and children with pulseless VF/VT, and an AED with a pediatric attenuator and pads is preferred for children younger than 8 years, but if neither are available, an AED without a dose attenuator can be used.[8,11] Extending AED training and use to the pediatric population provides a better opportunity to treat those infants and children with presenting heart rhythms that might respond to electrical therapy (eg, pulseless VF/VT). AEDs can also prompt rescuers to continue chest compressions in children with nonshockable rhythms, such as asystole and pulseless electrical activity.

The prevalence of readily available AEDs in public locations (eg, in airports, office buildings, malls, sports facilities, and schools) has been spurred by research literature demonstrating improved survival in adults treated with early defibrillation.[12] In the Public Access Defibrillation trial, survival rates for victims of OHCA doubled when AEDs were available and volunteers were trained in their use, and no inappropriate shocks were given.[12,13] An evaluation of OHCA in the Resuscitation Outcomes Consortium also found a near doubling of survival in those communities where an AED was used before the arrival of EMS.[14]

In 2000, the Cardiac Arrest Survival Act (Public Law 106-505) was signed into federal law. The intent was to reduce barriers to the placement and use of AEDs in public areas.[12] Since then, all 50 states have passed laws promoting lay rescuer programs and providing "Good Samaritan" protection for lay rescuers who use AEDs.[12] Although legal concerns are reduced by Good Samaritan laws, which are designed to encourage volunteers to provide emergency assistance to victims, the protections vary by state.[15] In 2003, the AHA International Liaison Committee on Resuscitation recommended that CPR training be incorporated into the school curriculum and encouraged inclusion of AED skills practice during CPR training.[16,17] The expectation was that over the long-term, training students in CPR would yield more potential responders in the population. Although the number of OHCAs witnessed by students in school is low, students may be able to assist OHCA victims in a nonschool location.

Basic Life Support Training for Parents, Caregivers, and the Public

Parents of high-risk infants often receive CPR training before their infant's discharge from the hospital. The methods used include one-on-one training, classroom training, and self-instruction. In a study in which the effectiveness of a self-instructional DVD to provide CPR training for parents of high-risk infants (eg, preterm infants or those with congenital heart disease) was evaluated, parents who watched the DVD not only were able to perform CPR but also shared the DVD with an additional 3 people in their environment. Parents were also able to review the DVD over the next 12 months; several parents in the study reported performing CPR on their own child in emergency situations, with 75% survival of those children.[18] A separate study in Denmark demonstrated that after laypeople were trained in basic life support and/or AED use, the rates of bystander CPR being performed increased from 22% to 74%.[19] Survival after OHCA in children with all presenting rhythms increased from 0% to 5.4%.[19] The authors of a study from Sweden demonstrated similar results; those who received bystander CPR had a 30-day survival of 10.5% versus only 4.0% when CPR was not performed.[20] Because research has shown improved outcomes with the performance of early bystander CPR, it is prudent for pediatricians to advocate for life support training for parents and caregivers. This training could occur in hospitals, physician offices, other health care facilities, schools, as well as be offered by professional and community groups.

Basic Life Support Training for School Personnel, Children, and Adolescents

In addition to students, who typically attend school 5 days a week, a substantial number of adults, such as teachers, parents, school personnel, and visitors, can be found on school grounds. In the United States, approximately 356 000 people experience OHCA each year; 1 out of every 250 to 600 occurs in a school.[1,21–23] The majority of these incidents occur in adults, often in an athletic setting. Training students and school personnel in CPR and having an accessible AED in higher-risk areas of the school, such as the gymnasium or athletic field, protects both students and adults. A study by Swor et al[23] using data from the Cardiac Arrest Registry to Enhance Survival revealed that of 30 603 cardiac arrests identified in communities studied, 47 (0.15%) occurred in K–12 schools, and 45.7% of those were in high schools. Of those 47 arrests, 66% occurred in adults and 34% occurred in children (younger than 19 years). Eighty-three percent were witnessed arrests. CPR was provided in 76% of cases, and 31.9% of victims survived to hospital discharge. An AED was applied in 58% of cases in which it was available, and victim survival increased to 36%.[23]

With the large numbers of children involved in school sports, having an AED on site can be life-saving. The estimated occurrence of sudden cardiac arrest in young athletes is 1:50 000 athletes[24] or approximately 1 in 70 high schools per year.[25] The Inter-Association Task Force of the National Athletic Trainers Association recommends the following preventive measures: effective communication, training of anticipated responders in performing CPR and using an AED, access to an AED, acquisition of necessary emergency equipment, and coordination and integration with EMS.[26] A study of the National Registry for AED Use in Sports involving 2149 high schools revealed that 87% of schools had AED programs. Over a 2-year period, researchers identified 59 cases of sudden cardiac arrest, of which 44% occurred among students and 66% occurred on an athletic field during training or a competition. Ninety-three percent of victims were given prompt CPR, and 85% had an AED applied. The overall survival to hospital discharge was

71%, including 85% of victims who were students.[25] This should prompt pediatricians to encourage the presence of an AED in high schools, especially at athletic events.

Can Children Be Taught CPR and AED Skills?

In their systematic review, Plant and Taylor[27] reviewed how to best teach CPR to schoolchildren. Children as young as 6 to 7 years can learn to call for an ambulance and how to use an AED.[28] They can also be taught to give basic first aid to an unconscious patient.[29] Older children (aged 11–15 years) performed better than younger children (aged 8–11 years) when assessed for their CPR knowledge and skills.[27,30] However, natural physical factors may have played a role in this variance; for example, a younger child may not have the size or strength to provide effective chest compressions. Children with a weight of >50 kg (approximately 13 years of age or older) and 9- to 18-year-old children and adolescents with a BMI >15 provided adequate compression depth more effectively than those who weighed less or had a lower BMI.[27,31,32] Because of the importance of delivering high-quality chest compressions, it might be reasonable to teach adult and pediatric CPR to those in middle school (13 years and older),[12] but age-appropriate messages (eg, how to recognize an unconsciousness victim and call for help) could be taught earlier.[27] The Basic Emergency Lifesaving Skills framework and curriculum developed by the Maternal and Child Health Bureau of the Health Resources and Services Administration implements this approach by teaching children on the basis of their attainment of developmental milestones.[33] Children in kindergarten (age 6 years) are taught how to recognize an emergency and get help, tell an adult or other responsible person, and stay safe. These skills are reintroduced and reinforced in grades 1 through 12. In grade 3 (ages 9–10 years), skills of airway, breathing, and circulation, including CPR, were taught and acquired and then reinforced in subsequent grades 5 through 12 (ages 11–18 years).[34] The goals of these efforts are to encourage students trained in CPR to continue their refresher training and become adults skilled in CPR.

AED skills, on the other hand, do not require physical strength; research studies have revealed that children 6 to 7 years of age can effectively deliver simulated AED defibrillation.[27,28] Gundry et al[35] demonstrated that 11- to 12-year-old children could properly apply AED pads and use the AED within 90 seconds after receiving verbal instructions.

What Is the Best Way to Teach CPR and AED Training?

There are various ways in which to teach parents, caregivers, school personnel, the public, and students some or all of these skills. The AHA and American Red Cross provide instructional courses and materials. A local children's hospital may have CPR instructors on staff to help provide their personnel and parents CPR education. These courses may be open to local pediatricians and their staff. There are instructor-led courses as well as video and/or computer and self-instruction methods that interested learners can access. Although there are also online courses, the most important aspect of CPR is the practice of the skills of compressions and breathing, which are not part of these courses, unless coupled with an in-person practice session. The instructor-led courses vary in length from 1.25 to 4 hours, whereas self-directed programs range from 22 minutes to 2 hours.[12,36] High school students who received interactive computer-based training and practical training about CPR and AEDs demonstrated greater knowledge and skills initially and at a 2 month follow-up than those who only had computer-based training.[27,37] However, children and adults who used self-instruction kits also showed improvement in performance after training.[38] Not only can a large number of children and adolescents learn CPR skills thorough these programs, but these programs can also facilitate the training of additional family members at home, which has been demonstrated in studies.[27,38,39] Short self-instruction programs in basic life support that include synchronous hands-on practice were demonstrated to be as effective as instructor-led courses.[36,40] Brief video and/or computer self-instruction training of laypeople in AED use that included synchronous hands-on AED practice was shown to be an effective alternative to instructor-led AED courses.[36,41,42]

What Are Barriers and Enablers to Life Support Training and Implementation?

Barriers to training in schools identified included time, funding, equipment, instructor training, and difficulty with class scheduling. Fortunately, researchers have demonstrated that classroom teachers can be as effective as health care instructors, and community volunteer trainers are also effective trainers.[27] Additionally, self-directed learning has been shown to be as successful as instructor-based learning; if instructor training can be reduced or eliminated, both staffing and funding concerns can be mitigated. Tight class time was the barrier cited most often in a study by Reder and Quan.[43] Self-directed video-based learning requiring less than 30 minutes to complete and that is focused on practical skills may reduce the need for extended classroom time commitment.

Costs of training vary depending on the method selected; unfortunately, funding for classes or self-directed

videos remains a barrier for most schools. External sources of donations, such as local foundations, businesses, and civic organizations, may be able to contribute needed resources. Collaboration among schools, local fire departments, and EMS systems has also been productive in this regard.[12] Programs such as project Automated Defibrillators in Adam's Memory (launched in 1999 in Wisconsin) have provided educational programs for high school students and placed AEDs within high schools in the state.[44] This program has resulted in a total of 94 lives saved, of which 49% were children younger than 18 years.[45] In Canada, the Advanced Coronary Treatment (ACT) Foundation (a public-private partnership) helped to deliver training to more than 3.8 million students.[46] Thirty-seven states require CPR training for high school graduation. Unfortunately, only 2 states have passed legislation that addresses funding.[12,47,48] Recently, the Institute of Medicine (now the National Academy of Medicine) recommended CPR training as a requirement for graduation from middle school.[49] In addition, 21 states mandate the placement of AEDs in public schools, only 2 states (OR and NJ) mandate AEDs in all public and private schools, and only 4 states (OR, AL, RI, TX) have state funding.[48,50] Parents, teachers, coaches, and pediatricians can join together to advocate for funded mandates to save lives.

Another potential challenge is the retention of learned skills. Research has shown that CPR skills begin to deteriorate within 3 to 6 months, but AED skills are retained longer.[36,51] However, training children 10 to 13 years of age in CPR twice a year did not improve performance more than annual training.[52] Six-month CPR and AED skill retention in those taught via a self-directed video was slightly better than the retention associated with attendance at a 3- to 4-hour training course.[41] Once trained, skills should be practiced annually.

Infection concerns, especially the provision of breaths, have also been a barrier for effective adult CPR. Although traditional CPR is still recommended in children, if a rescuer is unwilling or unable to provide ventilations, chest compression–only CPR is preferred over no CPR; chest compressions alone do improve outcomes over no CPR.[7,10]

Finally, legal concerns about malpractice or lawsuits should not be a barrier to performing CPR; Good Samaritan laws provide protection to laypeople who provide first aid to victims in the United States. Health care workers are also typically protected as well, except in the case of gross negligence.[15,53,54]

CONCLUSIONS

The overall rate of survival after pediatric OHCA is poor. Improved survival rates in adults attributable to the implementation of early bystander CPR and the use of AEDs have been documented in adults. There is some evidence showing improved survival in children who receive immediate bystander CPR. Early and effective CPR is essential for survival after pediatric OHCA. Additionally, although the majority of pediatric OHCAs are not the result of primary cardiac causes, as many as 15% of adolescents and 5% of children experiencing OHCA may present with an initial cardiac rhythm, as identified by an AED, that may be responsive to electrical treatment.[2,4]

Pediatricians should advocate for the institution of age-appropriate basic life support training in schools (eg, teaching young children how to seek help for victims of OHCA, teaching CPR to older children, and CPR and AED use to adolescents) and assist in the process by suggesting avenues for funding of CPR training, by becoming certified AHA or American Red Cross instructors themselves to be able to teach target groups, and by minimizing barriers to learning and implementing CPR training. Pediatricians can encourage their staff to become providers or instructors, hold training classes in their office, provide literature to parents, play CPR videos in the waiting room, and have an AED in their office. Pediatricians should also advocate for the presence of AEDS in high schools, especially near gyms and athletic facilities and at athletic events. Many children can effectively learn how to perform CPR and use an AED and could subsequently provide care or assist in the care of a victim of OHCA, including teachers, coaches, parents, siblings, or classmates. Educating and certifying children in these skills and providing periodic refresher training will result in a more informed and effective population. Basic life support training, including the performance of CPR should be in the skills toolkit for children, with the additional skill of the use of an AED for adolescents, parents, caregivers, school personnel, and the general public.

LEAD AUTHOR

Susan M. Fuchs, MD, FAAP

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APPENDIX 1: AHA GUIDELINES

The AHA now encourages the compressions, airway, and breathing approach. Although pediatric cardiac arrests tend to be asphyxial in nature, the delay in providing breaths by starting with compressions should be only 18 seconds for a solo rescuer and less with 2 rescuers.[10] There are also key differences in the ratio of compressions to ventilations (breaths) in child victims based on their age and the number of rescuers.

In their CPR guidelines, the AHA defines a neonate as a new born (ie, an infant at the time of delivery, an infant as being a baby <1 year of age, and a child as being age 1 until puberty [breast development in girls, axillary hair in boys]). Victims beyond puberty (eg, adolescents) are considered adults.[8,55]

AHA basic life support guidelines for infants and children set the compression ratio 30 compressions to 2 breaths for a single rescuer, whereas the ratio becomes 15 compressions to 2 breaths if 2 rescuers are present. In the CPR sequence for lay providers, the AHA recommends a quick check for responsiveness and a check for breathing. If the victim is not responsive and not breathing or only gasping, chest compression should be initiated and no pulse check needed. (For health care providers, there is a 10-second pulse check before chest compressions are started.) Chest compressions should be performed at a rate of 100 to 120 compressions per minute.[10] Compression depth should be at least one-third of the anterior-posterior diameter of the chest or ~1.5 inches (4 cm) in infants and 2 inches (5 cm) in children. Once the child has reached puberty, the depth is at least 2 in (5 cm) but no more than 2.4 in (6 cm).[10] Complete chest recoil should occur after each compression (do not leave pressure on the chest). After 30 compressions, the single rescuer should open the airway and give 2 breaths, with each breath taking 1 second and making the chest rise. If the chest does not rise, the rescuer should reposition the head and try 2 breaths again, then resume chest compressions. This cycle of 30:2 should continue for 5 cycles or ~2 minutes before leaving the child to activate the emergency response system and obtain an AED if one is nearby. EMS is typically activated by calling 911. On returning with an AED, a single rescuer should use the AED (preferably with pediatric pads, if available) and follow its prompts (shock or resume CPR) until emergency responders arrive or the child begins breathing. If a rescuer is not trained in providing ventilations, or cannot perform them, the rescuer should continue with compression-only CPR until additional help arrives.[10]

If 2 rescuers are available, 1 rescuer should start chest compressions immediately while the other rescuer activates the emergency response system (call 911 or local EMS number) and gets an AED if one is available. Use the AED as soon as it is available and follow its prompts (shock or resume CPR).[10] When resuming CPR with 2 rescuers, the ratio should be 15 compressions to 2 breaths for 5 cycles (2 minutes). The chest compressor role should be rotated every 2 minutes to minimize rescuer fatigue.[8,10] CPR should be continued until the child begins to breathe or emergency responders arrive.

ABBREVIATIONS

AED: automated external defibrillator
AHA: American Heart Association
CPR: cardiopulmonary resuscitation
EMS: emergency medical services
OHCA: out-of-hospital cardiac arrest
OR: odds ratio
VF/VT: ventricular fibrillation or ventricular tachycardia

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