Cardiac Arrest in Children and Young Adults
We Are Making Progress
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Thirty years ago, sudden cardiac arrest (SCA) in children and young people was called a rare event. Causes were thought to be primarily respiratory, and resuscitation efforts were directed at restoring ventilation or oxygenation. Most studies were limited by incomplete data collection, including in-hospital and out-of-hospital arrest, and small study size. Outcomes were so dismal that resuscitation was considered futile by some. In 1995, Mogayzel et al published a ground-breaking article on ventricular fibrillation in children ages 5 to 18 years of age. They documented that ventricular fibrillation occurred at some time during a resuscitation in 19% of cardiac arrests in children in the Seattle/King County area, and 17% were discharged with good neurological outcomes compared with 2% of those with asystole. This study coincided with the availability of automated external defibrillators in the community and led to a reconsideration of the need for early assessment of rhythm in pediatric cardiac arrest and development of automated external defibrillators with pediatric modifications. Over the last 20 years, there has been increasing documentation of cardiac arrest in children. A major shortcoming in most of these studies is inclusion of all nontraumatic causes of cardiac arrest when incidence is calculated. This has been a major deficiency in pediatric cardiac arrest literature, because most include non-cardiac causes such as suffocation, drowning, and drug overdose. Inclusion of multiple causes in the incidence data rendered them difficult to interpret when attempting to establish the appropriateness of cardiopulmonary resuscitation (CPR) techniques, screening and prevention programs, treatment algorithms, and especially outcomes.

The most important messages of this study are the calculation of incidence of true SCA stratified by age and documentation of improved outcomes in all age groups over the 30-year study period. SCA is more common than expected in this population, with an average incidence of 2.28/100 000 person-years. Incidence increases with age, with the highest in the 25- to 35-year group at 4.40/100 000 person-years. The most encouraging information is that survival has markedly improved over the 30-year period, although incidence, age distribution, cause, and response times were not different. Importantly, this study provides relative frequencies of the cardiac causes. Primary electric disorders and cardiomyopathies, associated with the best survival, are the 2 most common cardiac causes. Additionally, cardiac arrest associated with exercise has better outcomes, although the authors acknowledge that this group is not comparable with studies evaluating competitive athletes.

How do we respond to this new information? The authors suggest that the data promote the development of primary prevention programs for this population. This typically involves a screening program using ECGs or echocardiograms for large populations. The literature is extensive and highly controversial. In Italy, all competitive athletes are required to have ECGs before competition. Although reported to be highly successful at preventing sudden death, other large-scale screening programs have not been effective. Currently the American Heart Association does not recommend screening programs, citing lack of sensitivity, cost, and manpower requirements as major barriers. A National Heart, Lung, and Blood Institute panel concluded that current evidence was insufficient to generate recommendations, but rather outlined the questions which require answers. The first of these is an accurate estimate of the true incidence of cardiac arrest, which this study provides and suggests that the incidence may justify population-based screening. The panel also recommended pilot programs to clarify the best screen-
ing strategies (specific testing methods and selective versus universal screening) and ascertain clinical impact and outcome.

Several recent studies add additional information to fill evidence gaps. Zeltser et al.\(^{18}\) report the results from a state-funded screening program in Texas using health questionnaires, physical examinations, electrocardiography, and limited echocardiograms. Health questionnaires were of limited value. Of 2506 students screened, 11 were identified as being potentially at risk for SCA. Interobserver agreement was 100% for electrocardiography (all ECGs were interpreted by pediatric electrophysiologists), but only 79% for echocardiography. Surprisingly, only 67% of those with abnormal initial screening tests sought follow-up evaluation. Leslie et al.\(^{19}\) published a simulation study and cost–benefit analysis of history, physical examination, and ECG screening. The study was limited to 2 groups considered at higher risk for SCA: competitive athletes 8 or 14 years of age and children initiating stimulant therapy for attention deficit disorder. The algorithms were constructed for children at 8 years of age initiating stimulants for attention deficit hyperactivity disorder and those 14 years of age beginning competitive athletics. Cardiac diagnoses were limited to hypertrophic cardiomyopathy, Wolff-Parkinson-White syndrome, and long QT syndrome. The investigators concluded that cost was high relative to health benefits. The reduction in sudden death was 7.5×10\(^{-5}\), and life expectancy increased by 0.8 to 1.6 days per screened individual. The incremental cost per life-year saved was $91,000 to $204,000. Another small study evaluated the accuracy of 53 experienced pediatric cardiologists to interpret 18 ECGs obtained from normal children or those with known cardiac disease, placing them at risk for SCA. The average number of correct interpretations was 12 (69%).\(^{20}\) Inappropriate exercise (participation or restriction) guidance was given to ~20% of the patients. This demonstrates the difficulty of screening programs for heart disease because the tests do not have a simple yes/no answer, but rather are often dependent on operator skill and experience.

Concern has been voiced about the impact of false-positive screening with overuse of additional testing. However, false-negative tests are also a problem. Several of the at-risk diseases are silent, without ECG or echocardiographic abnormalities, including several electric abnormalities and atherosclerotic coronary artery disease, the most common cause of death in the 25- to 35-year-old group. Others are easily missed or require expert consultation, including long QT and arrhythmogenic right ventricular dysplasia. Although screening programs could be beneficial, we must recognize that we need improved standards, and even the best programs will have considerable limitations.

This study by Meyer et al.\(^{11}\) does demonstrate that we can improve survival from cardiac arrest by enhancing systems that are already in place. The combination of a population motivated to provide bystander CPR and a well-organized, effective EMS system resulted in marked improvement of survival over this 30-year period. This time period, especially since 2005, also coincides with improved scientific basis for CPR and postresuscitation care.\(^{21}\) Survival doubled in the pediatric population in the 5 years after the 2005 CPR guidelines were instituted, compared with the 5 years just before this. But these results are not typical. The Resuscitation Outcomes Consortium recorded overall survival of only 6.4% in a pediatric population.\(^{6}\) Nichol et al.\(^{22}\) described a broad range of survival from 8% to 40% within the multiple EMS agencies participating in the Resuscitation Outcomes Consortium. We can improve cardiac arrest outcomes and communities, and agencies should be accountable for their outcomes and work to achieve results comparable with these.

This investigation by Meyer et al.\(^{11}\) is characteristic of most pediatric resuscitation studies: retrospective analysis of database information. Common methodologies include simulation/mannequin or small cohort studies. There are almost no prospective human trials of pediatric CPR, resuscitation techniques, or postresuscitation care. CPR guidelines, including the changes in 2005 that are associated with the improved outcomes in this study, are primarily developed by extrapolation from adult studies. Yet, virtually every article, including this one, begins with a statement about the devastating nature of SCA in young people. The victims are often thought to be healthy, and the magnitude of years of life lost is substantial, resulting in a shattering effect on the family and community when a young person experiences SCA. However, the presumed rarity of these events, the multifactorial nature of the events, and the need for large multicenter trials has hindered the conduct of studies compared with adult trials. The data presented in this report establish that these events are not rare. As this study demonstrates, high survival rates can be achieved and good neurological outcomes are possible.\(^{23,24}\) The Pediatric Emergency Care Applied Research Network funded by Emergency Medical System for Children (EMSC) of the Maternal Child Health Bureau has developed a successful model to support such studies and is conducting a large trial of postcardiac arrest hypothermia therapy in children.\(^{25}\) The pediatric resuscitation community should be supported to develop well-designed pediatric trials and urge funding agencies to support them. SCA in the young is a public health problem that can be approached in ways that lead to improved outcomes.

Disclosures
None.

References


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