

Out-of-hospital cardiac arrest due to ventricular fibrillation in children—A call to action



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Cardiac arrest is a leading cause of death worldwide,¹ with an estimated 550,000 combined out-of-hospital and in-hospital arrests yearly in the United States alone.² Overall, survival after cardiac arrest is poor, with only $\approx 10\%$ of out-of-hospital cardiac arrest (OHCA) patients and $\approx 20\%$ of in-hospital cardiac arrest patients surviving to hospital discharge. But, if the initial arrest rhythm is ventricular tachycardia (VT) or ventricular fibrillation (VF), survival rates generally double or triple.² Although children comprise a minority ($\approx 2\%$) of cardiac arrest patients, they have been featured prominently in the history of defibrillation. Potentially, the first reported successful human defibrillation occurred in 1774 when a 3-year-old patient of a fall, with an unknown initial rhythm (as this predated the advent of the electrocardiogram by over a century), was resuscitated with a shock to the chest by an electric generator.^{3,4} In addition, the first documented successful resuscitation using defibrillation for VF in a human was performed by Beck⁵ on a 14-year-old boy undergoing surgery (using electrodes placed directly on the heart). An electrocardiogram diagnosed the initial rhythm as VF, and postshock sinus rhythm was confirmed. Three hours after this successful defibrillation, the boy was cognitively intact and able to respond appropriately to questioning. He was ultimately discharged home without detectable neurological or cardiac damage.

Despite the permeating presence of children in the history of successful defibrillation, for many years pediatric OHCA was assumed to be noncardiac in origin. So strong was this sentiment that some even questioned the rationale for resuscitating children with OHCA given reported poor outcomes and associated costs.^{6,7} An important and often underappreciated point is infant (<1 year of age) data largely skew reports on outcomes of pediatric OHCA. In the Resuscitation Outcomes Consortium Epistry–Cardiac Arrest Database, the incidence of infant OHCA (72 per 100,000 person-years) approaches adult

OHCA incidence (126 per 100,000 person-years) and is ≈ 10 and 20 times higher than adolescent OHCA incidence (12–19 years; 6.37 per 100,000 person-years) and child OHCA incidence (1–11 years; 3.73 per 100,000 person-years), respectively.⁸ Given the complex multifactorial nature of sudden death in infancy,⁹ it is not surprising that survival after infant OHCA is poor. This often overshadows the fact that survival after child and adolescent OHCA is 2–3 times higher than that after infant or adult OHCA. And importantly for prognostication, VT/VF is more commonly the initial rhythm in child and adolescent OHCA, which is not the case in infants.⁸ With the significant advancements in recognition and treatment of cardiac diseases that predispose children and adolescents to VF in the past 2–3 decades, one can expect that current long-term outcomes for the child or adolescent who presents with a witnessed VF arrest would be improved.

In this issue of *HeartRhythm*, Silka et al¹⁰ delve deeper into describing which pediatric patients with OHCA due to VF survive to hospital discharge. This report is a single-center cohort of 45 children who suffered an OHCA with VF as the presenting rhythm from 2004 to 2016. In 40% a cardiac diagnosis was known before the arrest, but in 46% there was no previous diagnosis, no prior symptoms nor any family history. Most patients were ultimately diagnosed with primary electrical disease (15), cardiomyopathy (12), or congenital defects (6), while 7 remained without a known etiology. All survivors were evaluated with a standardized Neurological Impairment Scale. Most noteworthy for an OHCA cohort is the high rate of survival to hospital discharge (89%) and with relatively good neurologic outcomes (38% normal, 32% mild impairment, and 30% moderate to severe impairment). Of note, only 5 patients had support withdrawn before discharge secondary to profound neurological injury. As the authors acknowledge, this is a highly selected group—patients with documented VF as the initial rhythm who were successfully defibrillated with sustained return of spontaneous circulation and survival to transfer to a tertiary center. Most (>90%) were witnessed arrests, and the remaining were found unresponsive within 1–3 minutes of having been last observed alert and responsive.

In addition to demonstrating excellent survival with good neurologic outcomes in pediatric OHCA due to VF, this study

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highlights the need for continued advocacy in promoting layperson cardiopulmonary resuscitation (CPR) training and public access defibrillation (PAD) programs. Although nearly all arrests were witnessed, bystander CPR was known to be performed in only 42%. Bystander CPR has been demonstrated to improve overall and neurologically favorable survival in pediatric OHCA.¹¹ In the present study based at an urban tertiary care center in Southern California, 18 arrests occurred at school but only 2 of these used an automated external defibrillator (AED). California schools are urged, but not required, to implement an AED program. Legislation requiring AEDs in schools has been associated with increased AED deployment as well as increased school implementation of medical emergency response plans.¹² Recent data examining PAD strategies reveal the highest impact on survival when defibrillation is performed by lay responders, with survival rates nearly twice as high when compared to defibrillation by emergency medical service–dispatched professional first responders (firefighters/police).¹³ By examining the patients' demographic characteristics, OHCA details, and resuscitation parameters with the end points of survival and favorable neurologic outcome, Silka et al build growing evidence that OHCA due to VF in children does not necessarily equate with dismal outcomes. With bystander CPR and early rhythm assessment and defibrillation made possible by readily available AEDs, neurologically favorable survival can be attained in most of these children. The vision of the Heart Rhythm Society is to end death and suffering due to heart rhythm disorders. Supporting programs that teach bystanders to recognize cardiac arrest, initiate CPR, and use AEDs in children along with expanding PAD programs will be critical to achieving this vision.

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