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Pediatric defibrillation: Concerns and opportunities

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In 1947, after completing thoracic surgery, Dr. Charles Beck noted that his patient was experiencing what appeared to be a ventricular fibrillation cardiac arrest. Fortunately for the patient, Dr. Beck had in his laboratory what would turn out to be the first defibrillator used on a human patient. The defibrillator was rolled into the operating room, and after several shocks, the patient's heart returned to a normal sinus rhythm, and the patient went on to a make a full recovery. What is truly amazing is that the Dr. Beck's patient was a child (1, 2).

There is no doubt that the pediatric heart in ventricular fibrillation, like the heart of an adult, must be defibrillated. The problem arises with the availability of the appropriate equipment and personnel needed to provide safe and effective energy through pediatric pads or paddles. The standard dose of energy for pediatric monophasic manual defibrillation is 2 J/kg followed by 4 J/kg (3, 4). Operating instructions for manual defibrillators with biphasic waveform technology also include indications for pediatric use. The concern begins when the automated external defibrillator (AED) is used. Standard AEDs are approved for use on pediatric patients over the age of 8 years. Most of the current models of AEDs begin with a biphasic energy output of 150 to 200 J. It is important to note that the biphasic waveform technology can utilize less energy and thereby provides a "gentler" shock, with the same or equal efficacy of monophasic defibrillation (5). In a 10-kg infant, these defibrillations would still deliver 15 to 20 J/kg, a dose considered too high by current standards.

Although the American Heart Association (AHA) does not take a definitive position on which is the best waveform or the most efficacious (6), most manufacturers are currently utilizing biphasic waveform technology with both AEDs and manual defibrillators. According to the AHA, biphasic waveforms under 200 J are currently considered to be a class IIA intervention (standard of care, considered to be the intervention of choice by majority of experts, based on good/very good evidence) (6, 7). Although only swine models have been used to research and simulate biphasic defibrillation in children, the results of these studies appear quite promising in regard to the efficacy and safety of biphasic defibrillation in children (8). "Outside of the context of pediatrics, there are numerous studies demonstrating that . . . low-energy biphasic waveform defibrillation may be as effective as, or superior to, high-energy monophasic waveform therapy and with less energy of dysfunction. It is therefore possible, although not demonstrated, that with a biphasic waveform, lower energies than currently practiced with monophasic devices may be effective for children" (4).

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AUTOMATED EXTERNAL DEFIBRILLATORS AND CHILDREN

Automated external defibrillators can be found in shopping malls and casinos, airports and airplanes, schools and factories, and just about anywhere you might expect to find large groups of people. AEDs are found in police squad cars and many first response fire department vehicles. With a physician's order, you can even purchase one for home use through selected pharmacies (eg, http://www.cvs.com). Some researchers suggest that in the future, AEDs may actually be a common household item for persons at high risk for sudden cardiac arrest, noting that most cardiac arrests do not occur where public AEDs are placed. In addition to placing AEDs in strategic locations in the community, some authors also recommend that AEDs should be placed throughout hospitals as well (2). The reasoning is simple: the longer ventricular fibrillation persists, the lower the chance of survival. The chance of survival decreases 7 to 10% each minute that ventricular fibrillation continues (7, 9).

Think about hearing "Code Blue: Pediatrics" over the hospital speaker system. By the time the emergency room/critical care resuscitation team arrives on the pediatric floor, finds the resuscitation equipment, determines the need for defibrillation, and actually defibrillates the child, precious time and heart and brain function can be lost. Now think about what might happen if there was an appropriate AED available for use? Even if ventricular fibrillation or pulseless ventricular tachycardia only occurs in less than 20% of the cases of pediatric cardiac arrest (10–12), what a difference it could make for those children and their families.

Currently, the AHA recommendation regarding the use of AEDs on children is that the child be at least 8 years old or weigh more than 55 lb (13). A formal AHA statement in support of a guidelines change would be issued only when AHA expert review panels agree that the evidence is sufficient to support the safety and efficacy of AED use in younger or smaller patients (14). Despite the position of the AHA on pediatric AEDs, other researchers in this field summarize their opposing opinion by stating, "the current prohibition of the use of AEDs in the young pediatric patient essentially means that (pediatric) patients . . . do not receive the equivalent level of care for older children and adults" (15).

AMERICAN HEART ASSOCIATION PEDIATRIC AUTOMATED EXTERNAL DEFIBRILLATOR CONCERNS

The AHA has several concerns regarding pediatric AED usage. AEDs were initially created and intended for adult use, and therefore the shock/no shock algorithms were developed with adult cardiac rhythms in mind. Children, especially younger ones, naturally have and tolerate much faster heart rates, and if the AED interprets a tachyarrhythmia as "shockable" based on rate alone, this is a definite problem (16, 17). Because there are several makers of defibrillators, one must remember that each AED has a different shock/no shock algorithm, and each type of defibrillator must be tested for its ability to accurately analyze and be utilized with pediatric arrhythmias (16, 17). Through extensive testing, the Heart Start AED (Philips Medical Systems, Andover, MA) has been shown to not only appropriately identify infant/pediatric cardiac rhythms for shock/no shock determination (overall sensitivity to ventricular fibrillation/rapid ventricular tachycardia exceeding the AHA's 1997 performance standards for AEDs) but also to function as well or better than a conventional monophasic manual defibrillator in pediatric swine models (8, 12, 16, 18–20).

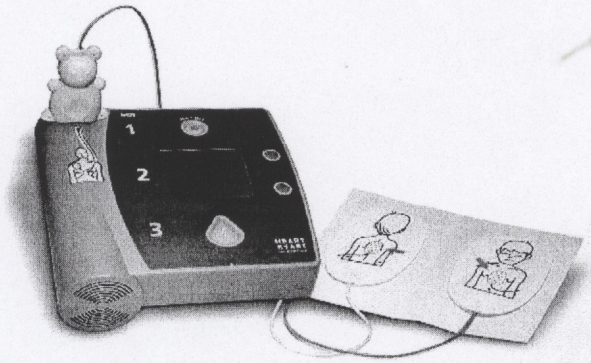

FIG. 1. Pediatric adapter for adult Heart Start Automated External Defibrillator. Published courtesy of Philips Medical Systems, Andover, Massachusetts.

A second AHA concern is that of the safe "dosage" of energy delivered. Adult AEDs currently come in two forms. There are those that provide nonescalating 150-J biphasic defibrillation and those that escalate or increase the energy delivered on subsequent shock attempts. Clearly, it is not appropriate to shock an infant at an adult dose of energy. The pediatric adapter for the Philips adult Heart Start AED (Fig. 1) downgrades the 150-J adult dose to 50 J. According to current Pediatric Advanced Life Support/Advanced Cardiac Life Support recommendations, an 8-year-old child weighing 25 kg can be shocked with a maximum of 360 J or 14 J/kg with an escalating energy AED (13, 21, 22). This maximum amount of 14 J/kg could then be extrapolated to infants and children, with a 50-J dose administered to a 3.5-kg infant being a 14-J/kg shock. Although there are few human studies specifically addressing pediatric defibrillation, swine model studies appear quite promising (8).

A third AHA concern is that of the ease of use. We must fit the energy level and pad size to the pediatric patient in a quick and easy way, making it as foolproof as possible. Once again, the pediatric adapter for the Philips Heart Start AED has addressed this issue with appropriately sized pads, clear pictorial instructions for pad placement, and an adapter that can be clearly identified as being for pediatric use.

CONCLUSIONS

What is the future of pediatric defibrillation? Further research is needed to answer questions such as whether the use of pediatric AEDs actually results in better outcomes, whether specific diagnoses are more likely to result in ventricular fibrillation in children, whether "phone first" or "phone fast" (23, 24) is the best approach to pediatric cardiac arrests, and whether the actual frequency of ventricular fibrillation in infants and children will better define the future. Hopefully in the near future, many more basic and advanced life support emergency medical service providers, medical centers, and eventually even lay people will have access to safe and effective pediatric defibrillation.

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