Pediatric Resuscitation:

Because Children Are Not Just Little Adults

ZOLL MEDICAL CORPORATION

Pediatric resuscitation is a stressful and hectic event, as no one wants to see little ones at such terrible risk. Unfortunately, many defibrillator manufacturers treat children like small adults, with the sole concession to children being smaller defibrillation paddles or electrodes. Inattention to the needs of patients when using "adult" technologies was seventh on the 2013 ECRI Top 10 Health Technology Hazards list.[1] ECRI calls out emergency care and pediatric emergency supplies as key contributors to safety hazards. At ZOLL, we believe that children deserve better and have designed our R Series® Monitor/Defibrillator to meet the needs of children and their caregivers.

CPR

ZOLL is the only manufacturer to offer CPR feedback for children under the age of 8. With our new OneStep™ Pediatric CPR Electrodes, caregivers receive information that shows the actual depth and rate of compressions as they are delivered.

Pediatric Analysis Algorithm

The ZOLL R Series automatically switches to a pediatric AED algorithm when the pediatric electrodes are present, allowing caregivers to use AED analysis effectively and automatically to ensure that compensating rhythms are not terminated unnecessarily.

Optimized Biphasic Defibrillation

Unlike other systems, the ZOLL R Series with pediatric electrodes allows for full impedance compensation to ensure children are dosed effectively and appropriately.[2]

Safer Defibrillation

When the R Series is presented with a pediatric electrode, the energy is automatically lowered to a standard 50 joules (J), or it can be configured to start as low as a single joule in areas like the NICU, where even 50 J may be too much.

The Importance of CPR

There are approximately 16,000 pediatric cardiac arrests annually in the US and at least that many additionally worldwide. The survival-to-discharge rate is approximately 25%, and poor-quality CPR has been cited as a contributing factor to this dismal statistic on outcomes.[3,4,5,6,7]

In children, the cause of the arrest is usually respiratory failure. When a heart fails in this manner, no defibrillation shock is going to be useful. The intervention that is needed is effective, high-quality CPR. CPR becomes a critical intervention. Until now, providing CPR to children was like operating in the dark. Guidelines previously provided caregivers with vague direction to compress approximately one-third the diameter of the chest circumference, or anterior–posterior chest dimension. The 2010 American Heart Association (AHA) guidelines offer more direct instruction: compress 1.5 inches in infants and 2 inches in children. Either way, until now, there has been no way to determine whether the rescuer is delivering adequate CPR.

Furthermore, recent studies have demonstrated that the quality of CPR in children is poor, with compressions too frequently shallow.[8,9] Niles and colleagues showed that clinicians do not compress deep enough; 92.2% of chest compressions delivered to in-hospital cardiac arrest victims 8 to 14 years of age were less than one-third the anterior–posterior chest dimension.[8] In pre-puberty events, 59.8% had a mean corrected chest compression depth of less than 38 millimeters (1.5 inches).

Now there is light. The ZOLL R Series with the CPR Dashboard™ automatically switches to a pediatric display showing actual depth and rate of compression delivery in real time. (Figure 1)

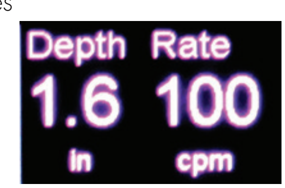


Figure 1. CPR Dashboard Display

In addition, a metronome coaches the correct rate, and an idle timer alerts staff to detrimental pauses in CPR delivery. ZOLL's proprietary See-Thru CPR® feature allows rescuers to visualize an organized underlying rhythm during compressions, reducing the duration of pauses during CPR. (Figure 2)

Figure 2. Display showing filtered and unfiltered waveform. (See-Thru CPR)

The results of the entire case can be easily uploaded to RescueNet® Code Review so that CPR quality during the code can be assessed during debriefing, a tool known to positively influence future behavior and improve CPR performance.[10,11]

The Importance of a Pediatric Analysis Algorithm

Treat the patient, not the device being used to treat the patient, is a common mantra among clinicians. This notion is particularly applicable to pediatric emergencies since cardiac arrest represents only a small subset of all pediatric arrest cases. ZOLL has taken just such a "treat the patient" approach to pediatric defibrillation by providing the only platform that:

- is able to automatically detect whether the patient is a child by the type of electrode used
- automatically decrements the energy to a safer level (50 J first shock)
- is cleared for use in infants <1 year of age
- defaults to an AED analysis algorithm specifically designed for a child's ECG
- uses an optimized biphasic defibrillation waveform, unfiltered by attenuation resistors.

An ECG Analysis Algorithm Designed Specifically for the Pediatric Population

Children differ from adults as to the types and characteristics of shockable and non-shockable ECG rhythms. The lower incidence of ventricular fibrillation (VF) in children indicates that they are more likely to have non-shockable rhythms than are adults.[3] It is important to correctly classify non-shockable high-rate pediatric rhythms such as sinus tachycardia (ST), supraventricular tachycardia (SVT), and accelerated ventricular rhythms when presented to an AED used on a child. Adult-based AED arrhythmia analysis algorithms may have difficulty correctly classifying these high-rate pediatric rhythms as non-shockable since the characteristics of the non-shockable pediatric rhythms overlap the shockable criteria used in the adult-based algorithms.

ZOLL has developed a dedicated pediatric AED arrhythmia analysis algorithm that accurately distinguishes shockable versus non-shockable pediatric rhythms—even the most difficult high-rate, non-shockable rhythms. The analysis algorithm detects the use of either pediatric or adult therapy electrodes and automatically adjusts the arrhythmia analysis processing for the appropriate patient type. This algorithm is available in all ZOLL public access AEDs as well as in the ZOLL R Series. In the presence of pediatric electrodes, the unit automatically switches to pediatric mode, performs a complex rhythm analysis, and requires a heart rate for tachycardia of at least 200 beats per minute (BPM) to be considered shockable.

Since SVT is a prominent pediatric arrhythmia, special efforts were made to gather a significant number of SVT rhythms during development of the ZOLL pediatric ECG algorithm. Adult-based algorithms typically consider high-rate SVT as a shockable rhythm; however, small children can have perfusing rhythms at these same rates but should not be shocked. The non-shockable rhythms in the database used by ZOLL included abnormal ventricular and supraventricular rhythms with rates up to 300 BPM, which are often found in infants and young children. Performance of the ZOLL pediatric arrhythmia algorithm on this database exceeded the performance recommendations the AHA has published for pediatric AED arrhythmia processing algorithms.[12] The use of separate processing algorithms provides the means to retain a high-rate SVT in adults as a shockable rhythm while providing for pediatric SVT to be classified as non-shockable.

Although it is subject to the specifics of a given database, the ZOLL analysis algorithm demonstrated superior performance when compared to the performance reported in other pediatric AED studies that were based on the evaluation of adult-based algorithms on pediatric ECG signals.[13,14] (Figure 3)

Contrary to previous pediatric AED studies,[15,16] shockable and non-shockable VT rhythms were more prominent than VF in our data collection. The database contained 122 records of shockable and non-shockable VT, as compared to 42 records of VF. The ability of the dedicated pediatric algorithm to detect these rhythms and recommend the appropriate therapy is a significant improvement over adult-based algorithms. The increased sensitivity in the detection of shockable ventricular tachyarrhythmia will reduce the time to cardioversion and the return to spontaneous circulation. The increased specificity in the detection of non-shockable VT rhythms will avoid unnecessarily shocking a pediatric patient who does not need defibrillation therapy.

Biphasic Defibrillation Optimized for Children

Contrary to what one might expect based on common sense alone, pediatric patients, while having a smaller thoracic circumference, actually have higher defibrillation impedances. Published work by Atkins has shown that the average impedance of pediatric patients is 90 ohms.[17,18] This is due primarily to the smaller surface area of pediatric electrodes. As a result, impedance compensation methods actually become more important in the pediatric population.

AEDs that use circuits to attenuate the energy delivered to pediatric patients (the bulge that you see on the wires of some pediatric pads) put resistors in between the defibrillator and the patient. This has two negative effects:

1. The unit has no ability to distinguish between the resistors in the wire and the impedance of the patient and, as a result, the ability to compensate for patient impedance—an important part of a biphasic waveform's efficacy—is significantly compromised, or even eliminated.

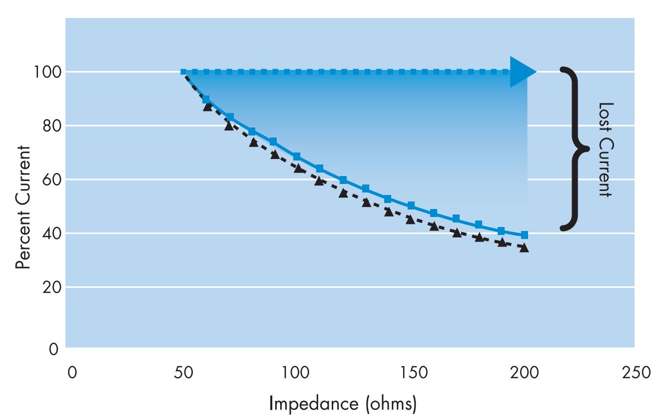
2. In some pediatric systems, a resistor that shunts current away from the child is used to attenuate the energy. However, this method has a negative consequence: as patient impedance increases, proportionally more and more current is steered away from the patient—exactly the opposite of what biphasic defibrillation impedance compensation methods are attempting to accomplish. Figure 4 shows the amount of current delivered to a pediatric arrest patient as a function of the patient's impedance.

The two curves are for commercially available AED pediatric defibrillation systems. As shown in the figure, 40% of the current is lost to the patient, for an impedance of 100 ohms, typical in the pediatric population. And nearly half of the current is not delivered to the patient, for an impedance of 150 ohms for both AEDs.

Figure 3. Comparative Reported Sensitivity of Pediatric Advisory Algorithms

	AHA GOAL	ZOLL	AED A	AED B
Shockable				
Coarse VF	> 90% sensitivity	100% (42/42)	94.3% (50/53)	98.6% (71/72)
Rapid VT	> 75% sensitivity	93.9% (77/82)	70% (21/30)	Insufficient Data
Non-shockable				
NSR	> 99% specificity	100% (208/208)	**100% (374/374)**	99.2% (792/798)
SVT (heart rates 152-302 BPM	> 95% specificity	99.4% (160/161)	Insufficient Data	Insufficient Data

Figure 4. Percent of Current Delivered by a Circuit-based Energy Attenuation System as Patient Impedance Increases



Safer Defibrillation

The ZOLL biphasic waveform when used with ZOLL OneStep Pediatric Electrodes automatically decrements the initial energy to a starting dose of 50 J but allows the device to measure the actual patient impedance and adjust accordingly, delivering sufficient current for effective conversion while not overdosing the patient. In addition, in areas such as the NICU, where one or two joules might be a more appropriate starting dose, the ZOLL R Series can be configured to power up at these low energy settings every time via a simple configuration setting.

Conclusions:

CPR feedback coupled with a pediatric AED algorithm in an ALS defibrillator allows first responders to confidently act, speed the time to first shock, and achieve more efficacious management of these special patients.

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