REVIEW ARTICLE

WHAT DOES THE 2015 UPDATE ON PEDIATRIC BASIC LIFE SUPPORT BRING?

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Abstract

Which sequence is most appropriate for initial resuscitation in children: Airway-Breathing-Circulation (A-B-C) or Circulation-Airway-Breathing (C-A-B)? What is the most appropriate compression-to-ventilation ratio? How many numbers of chest compressions in per minute are enough for the chest massage? Should we ventilate or not ventilate during resuscitation of children? The last guideline which was published in October 2015 is reviewed to answer these and other questions about the new recommendations on pediatric basic life support. One of the new recommendations is, if available, the use of cellular telephones with speakers to activate an emergency response system while beginning resuscitation. The preferred initial resuscitation sequence, as recommended in 2010 The American Heart Association guideline, is the C-A-B sequence (Compressions-Airway-Breathing) to decrease the time to initiate chest compressions and reduce "no blood flow" time.

Keywords: Basic life support, child, guideline, resuscitation, 2015

Introduction

Cardiopulmonary arrest, defined as a complete unresponsiveness characterized by cessation of cardiopulmonary function, has a prevalence of 0.08%-2.0% among hospitalized children and 2.4%-19% in pediatric intensive care units (1-4). Cardiopulmonary arrest is less common in children and its mechanisms of occurrence and outcomes are also different compared to adults (5-8). The primary reasons for this include ongoing growth and a fast-paced metabolism compared to adults, anatomical and physiological differences in respiratory and circulatory systems and distinctive neurological responses. Thus, the statement "children are not little adults" has been recognized for many years. The first guidelines on cardiopulmonary resuscitation (CPR) were published for adults in 1966 and for children in 1987 (9, 10). Regular updates were presented in the following years and in the last 15 years The American Heart Association (AHA) has been publishing guideline updates every 5 years. The most remarkable change in these guidelines was the recommendation in the 2010 AHA guideline for starting resuscitation with chest compressions in children (11).

However, in the 2010 guideline, starting resuscitation with the Compressions-Airway-Breathing (C-A-B) sequence was recommended in children and infants, as in adults, for those whose primary etiology for the cardiopulmoanry arrest is respiratory arrest. The rationale for these recommendations were to emphasize the importance of chest compressions for recovery of spontaneous circulation, confirmed positive effects of more chest compression on survival in addition to the negative effects of hyperventilation and facilitating CPR training by using the same sequence for all age groups (5, 6, 12-15). The main challenge against this conspicuous and unusual recommendation was the limited number of studies supporting the recommended method besides the need for the revolution of the training algorithms. The potential developments regarding this recommendation, which was not supported by The European Resuscitation Council (ERC) up to date, have been the major concern before the publication of the new guidelines (16).

Another major change in the previous guidelines was the number of chest compressions. In the presence of a single rescuer, maintaining CPR cycles of 30 compressions and 2 breaths were recommended as in adults due to the confirmed positive effects of chest compressions and negative effects of interrupting compressions on survival (11, 12). Expectations for potential changes in the new guidelines, for example whether number of compressions would be increased or the 15 compressions-2 breaths cycle with more than one rescuer would be maintained, may raise questions in the minds of rescuers and trainers.

In addition to CPR sequence and number of chest compressions, other major matters of concern regarding pediatric basic life support include possible changes about calling for medical help before beginning resuscitation as in adults, efficiency and sufficiency of chest compressions, efficiency and sufficiency of performing only chest compressions, CPR duration and differences between out-of-hospital and in-hospital arrests. In order to clarify these questions, the contributions of the new guideline was reviewed and summarized under headings including "Are there major differences between outcomes of out-of-hospital and in-hospital pediatric arrest?**"What is optimal resuscitation duration in pediatric cardiopulmonary arrest?" , "Do algorithms differ by number of rescuers?",** "Calling for emergency help before beginning resuscitation",**"Recommendations for effective CPR", , "Number and depth of chest compressions",** and **"Is compression-only CPR effective and sufficient?" Are there major differences between outcomes of out-of-hospital and in-hospital pediatric arrest?** Favorable survival (defined as life-saving, alive at discharge from hospital) rates were between 9% and 47% for in-hospital pediatric arrests and %0-%29 for out-of-hospital arrests (8,17). Outcomes for in-hospital pediatric arrests were shown to improve during the last decade, with hospital discharge rates rising from 24% to 39% from year 2001 to 2009 (1-5, 18). Based on cases recorded in 11 emergency centers from United States and Canada between 2005-2007 by "Resuscitation Outcomes Committee", out-of-hospital cardiac arrest cases had worse prognosis compared to in-hospital cases while hospital discharge rates were 3.3%, 91% and 8.9% in infants (<1 years), children (1-11 years) and adolescents (12-19 years), respectively (6). The committee has recently shown that this rate is 8.3%

for all age groups (19). According to a study conducted in South Korea, outcomes have improved in out-of-hospital pediatric arrests in the last 5 years, survival rates following resuscitation efforts increased from 17.6% to 35.2% and alive discharge rates increased from 4.7% to 12.8% (20, 21).

What is optimal resuscitation duration in pediatric cardiopulmonary arrest?

Prognosis is generally poor in cases with prolonged resuscitation. Mortality rates in cases with short duration of resuscitation (e.g., < 4 min., < 5 min., < 10 min.) were 56%, 33% and 58% respectively, while mortality rates of 100% and 95% were reported in cases of prolonged res uscitation (>20 min and >30 min., respectively) (8, 22, 23). The rates of spontaneous circulation recovery were 82.4%, 53.2% and 33.3% after ≤ 10 min., 10-30 min. and > 30 min. of CPR, respectively. Survival rates in pediatric in-hospital arrests were 4.8% for prolonged (>30 min.) and 42.2% for short (≤ 10 min.) duration of resuscitation (8). However, prolonged resuscitation was not necessarily associated with fatal outcomes; CPR was performed longer than 35 minutes in 12% of the cases and favorable neurological prognosis was reported in 60% of the survivors (24). In cases with CPR duration between 115 minutes, survival decreased by 2.1% per minute with favorable neurological prognosis in 70% of the survivors while the rate was 60% in those with CPR duration of > 35 minutes (24).

Do algorithms differ by number of rescuers?

Two different CPR algorithms were recommended according to the presence of one or more rescuers from the initial stages of resuscitation: Cardiac arrest algorithm for the single rescuer and cardiac arrest algorithm for two or more rescuers (25).

Calling for emergency help before beginning resuscitation

Etiology for cardiac arrest has differences in children compared with adults and therefore, calling for emergency is at a different order compared to adult CPR algorithms. As recommended in the previous algorithms, in children with a known asphyxial arrest or arrest of unknown etiology CPR should be started before calling for emergency while emergency help should be called before starting CPR, as in adults, if a cardiac etiology is considered. A new recommendation stated that the advanced technology of telephones and availability of speakers could enable a single rescuer begin CPR while calling for help using the speakers of a telephone (25).

Sequence of CPR: C-A-B or A-B-C?

After the update in 2010 by American Heart Association and International Liaison Committee on Resuscitation (AHA-ILCOR), the CPR sequence in children was changed as C-A-B instead of A-B-C (9). The major reason of this change was to begin more faster the chest compressions during CPR thus to decrease the time without blood flow. Additionally, the concordance with the adult CPR guidelines may facilitate the comprehension of the CPR algorithm. The supporting evidences about this major change was reviewed by ILCOR in the last AHA guideline (25). The major barrier against this change was etiologic differantiation between children and adults. Because asphyxia is more common in childhood, ventilation is more important in children than adults (25-28). Both experimental and clinical studies were shown that best outcomes in children with asphyxial arrest were achieved by conventional CPR (combination of ventilation and chest compressions during CPR) (26, 27, 29, 30). There was not clear evidence about initiating the resuscitation with A-B-C or C-A-B sequence. More shorter time to start chest compressions was demonstrated in manikins with C-A-B compared to A-B-C sequence in three manikin studies (31-33). When C-A-B sequence was applied, the time to first ventilation was delayed by 6 seconds compared to A-B-C (31). Although the identification of respiratory arrest was delayed nearly 2 seconds in C-A-B group, cardiac arrest was identified 24 seconds earlier than A-B-C group (33). In another simulation study, A-B-C performers were started to chest compressions 19.8 seconds later than C-A-B performers, however, they were ventilated 15.9 seconds earlier than C-A-B performers (32). If the delaying only 6 seconds in starting ventilation is acknowledged as not harmful for children, C-A-B sequence appears to be advantageous than A-B-C sequence based on the earlier initiation time of resuscitation and first cycle completion (34). Although data were limited in this topic, C-A-B sequence was recommended to begin CPR in the 2015 AHA guideline, as recommended in 2010 (25, 34). Performing the same sequence and using the common algorithm in all ages may simplify and facilitate the CPR training and may enhance active attendance to CPR.

Recommendations for effective CPR (25):

CPR quality is determined by five components:

- Ensuring adequate rate of chest compressions
- Adequate depth of chest compressions
- Full chest retraction between compressions
- Minimum interruption between chest compressions
- Avoiding excessive ventilation

Number and depth of chest compressions

Number and depth of chest compressions are two important points of effective CPR. The number of chest compressions accepted for all age groups was adopted as the target in children based on insufficient data available regarding the depth of chest compressions in children. An observational study has shown that chest compression depth was frequently insufficient during pediatric cardiac arrests (35). Adult data have shown that sufficient chest compression depth had significantly favorable effects on resuscitation outcomes (36), however, limited pediatric data are available. The relation between chest compression depth and blood pressures during resuscitation were investigated and blood pressure was shown to increase as compression depth increased (37). Another study

evaluated 87 pediatric resuscitation cases with the majority over 8 years of age and found that performing over 60% of chest compressions deeper than 51 mm was associated with favorable 24-hour survival (38). Considering the limited data for children and with the aim to simplify CPR training, 100-120 compressions per minute recommended for adults is recommended for infants and children as well (Class IIa) (25, 34). Additionally, feedback devices that provide information about the rate and depth of chest compressions was suggested to be used to measure CPR quality when available (Class IIb). In the pediatric group, chest compression depth should be at least one third the anterior-posterior diameter of the chest from birth to onset of puberty. This corresponds to approximately 4 cm for infants and 5 cm for children (Class IIa). Once signs of puberty are seen, at least 5 cm and maximum 6 cm of compression depth as in adults is recommended (Class I) (25, 34).

Compression-only resuscitation-Is compression-only CPR effective and sufficient?

The ratio of ventilations to chest compressions for resuscitation in adults and children is an ongoing controversy. Higher coronary artery pressures and better neurological prognosis were demonstrated with minimal chest compression interruption for ventilation and the ventilation to chest compression ratio was changed to reduce chest compression interruption in the recent algorithms (9, 25, 34, 39). Experimental ventricular fibrillation induced arrest studies in animals showed the best neurological prognosis at 24 hours was achieved in the 100 chest compressions/2 breaths group; neurological prognosis was better compared to 15 chest compressions/2 ventilations and compression-only groups. Although coronary perfusion pressure was higher in the compression-only group compared to other groups, the ventilation per minute and arterial partial oxygen pressure (PaO2) values were lower than the others (40). The results of this study indicate that minimal interruption of chest compressions and performing ventilation compared to no ventilation were factors affecting favorable outcomes. In order to predict the adequate compression-ventilation ratio in pediatric asphyxial arrest cases, an animal study was conducted using asphyxia induced arrest model. Resuscitation in the two groups was performed either in ventilation-compression-ventilation or compression-ventilation-compression sequences and both groups were intubated for ventilation. In the group resuscitation was started with ventilation, blood pH and PaO2 values were higher while arterial partial carbon dioxide (PaCO2) pressures were lower compared to the other group; there was no difference for cerebral oxygenation between the groups (41). The study also showed that no tidal volume occurred during non-ventilation, end-tidal carbon dioxide pressures were higher in the group resuscitation was started with ventilation. Although there was no difference for cerebral oxygenation between the groups, long-term neurological prognosis may be improved by achieving higher PaO2 pressures in asphyxia arrests. In two observational studies addressing out-of-hospital pediatric arrest outcomes, conventional CPR was associated with favorable neurological status at day 30 compared to compression-only CPR (26, 27). Compression-only CPR can be an alternative for public rescuers performing resuscitation on adults. The results of two observational studies based on The Japanese National Pediatric Out-of-Hospital Arrests Information System showed compression-only CPR was associated with unfavorable neurological survival at day 30 compared with conventional CPR (26, 27).

Despite the small number of cases with non-respiratory etiology (including those of cardiac etiology), evaluation by arrest etiologies revealed that compression-only CPR was as effective as conventional CPR. However, outcomes after compression-only CPR were not any better than conventional CPR outcomes in arrest cases with potentially respiratory etiology (26, 27). Based on these results, the 2015 recommendation by ILCOR was to perform conventional CPR for pediatric cardiac arrests (Class I) (25, 34). The majority of pediatric cardiac arrests are associated with asphyxia, therefore ventilation is required as an essential part of effective CPR. However, in arrests related to primary cardiac etiology, compressiononly CPR is better than none, if the rescuer is unable or unwilling to ventilate, considering the efficiency of compression-only CPR (Class I) (25, 34).

Conclusion

The major new recommendation in the AHA 2015 pediatric resuscitation guideline was to begin CPR while calling for help using the speakers of a telephone if applicable, for a single rescuer. Starting resuscitation with C-A-B sequence is recommended again as in the previous guideline. No new recommendations were stated regarding chest compression depth or compression and ventilation rates. It was emphasized that public rescuers can perform compression-only CPR although CPR consisting of sequential compressions and ventilations is the optimal procedure in children.

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Authors Contribution

SB conceived of the study, wrote and drafted the manuscript. YS and APT participated in writing of the study, and collection of data. All authors read and approved the final manuscript.

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