

THE CROSS POINT OF TWO ALGORITHMS IN THE EMERGENCY PEDIATRIC AIRWAY SITUATION

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DODIRNE TAČKE IZMEĐU DVA ALGORITMA ZA VREME URGENTNOG TRETMANA DISAJNOG PUTA U PEDIJATRIJI

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Summary. The aim of this study was to research the point where two algorithms, the algorithm for pediatric advanced life support and the algorithm for difficult pediatric airway management, cross on the field of airway.

Method. For that purpose we compared the algorithms for resuscitation: American and European algorithms (AHA and ERC algorithm) with the algorithm for unexpected pediatric airway (Marcus Weiss algorithm).

Results. Our clinical practice showed that the first steps in pediatric life support were extremely important. Ventilation and oxygenation were of utmost importance, because the large percentage of asphyxia arrests happened during the transportation without adequate ventilation. When bag-mask ventilation was unsuccessful and endotracheal intubation was not possible, the LMA was acceptable airway for oxygenation and ventilation - we had to switch to the algorithm for difficult airway management for pediatric patient. If the ventilation was not effective, rescuer had to perform endotracheal intubation. Endotracheal intubation in infants and children required special training because the pediatric airway anatomy differs from that of the adult. We had to have a second plan to manage the airway if we could not achieve intubation. We had to switch on the algorithm for unexpected pediatric airway for pediatric patient.

Conclusion. Emergency airway problems in pediatric patients required clear and critical concepts, formulated strategy and plan. Our plan was based on

Sažetak. Cilj ove studije bio je da se istraži tačka u kojoj se algoritmi za napredne mere održavanja života u pedijatriji treba preći na algoritam za tretman otežanog disajnog puta u pedijatriji, u urgentnim situacijama.

Metod. U tu svrhu smo poredili algoritme za reanimaciju: američke i evropske algoritme (AHA i ERC algoritam) sa algoritmom za neočekivano problematičan disajni put u pedijatriji (Marcus Weiss algoritam).

Rezultati. Naša klinička praksa je pokazala da su prvi koraci u održavanje života u pedijatriji bili su izuzetno važni. Ventilacija i oksigenacija su od izuzetne važnosti, jer veliki procenat asfiksije i aresta nastaje u toku transporta bez adekvatne ventilacije. Kada je ventilacija preko maske bila neuspešna i endotrahealna intubacija nije bila moguća, LMA bila prihvatljiva za uspostavljanje disajnog puta i ventilaciju - morali smo da se prebacimo na algoritam tretman otežanog disajnog puta kod pedijatrijskog bolesnika. Ako ventilacija nije bila efikasna, spasilac je morao da izvrši endotrahealnu intubaciju. Endotrahealna intubacija kod odojčadi i dece zahteva specijalnu edukaciju, jer se anatomija disajnih puteva u pedijatriji razlikuje od odraslih. Morali smo da imamo rezervni plan za tretman disajnog puta, ukoliko nismo mogli da intubiramo. Morali smo da pređemo na algoritam za neočekivano problematičan disajni put u pedijatrijskog bolesnika.

Zaključak. Urgentni problematični disajni put u pedijatrijskih bolesnika, zahtevaju jasne i kritične koncepte, formulisane strategiju i plan. Naš plan je bio zasnovan na evropskom algoritmu za napredne

European algorithm for pediatric advanced life support. If we reached the point that we had unexpected difficult airway, we were managing it according to the algorithm that we implemented at national level, the algorithm for unexpected pediatric airway (Weiss and Engelhardt): The rigid bronchoscope with an airway exchange catheter for subsequent tracheal intubation or surgical cricothyroidotomy for emergency access of the airway.

Key words: pediatric advance life support, difficult pediatric airway, algorithms

mere održavanja života u pedijatriji. Ako smo došli do tačke u kojoj smo imali neočekivano problematičan disajni put, upravljali smo se prema algoritmu koji smo implementirali na nacionalnom nivou, algoritmu za neočekivani problematičan disajni put u pedijatriji (Weiss and Engelhardt): rigidni bronhoskop sa kakekerom za razmenu gasova i kasniju intubaciju traheje ili hiruršku krikotiroidotomija za hitno obezbeđivanje disajnog puta.

Ključne reči: napredne mere održavanja disajnog puta u pedijatriji, otežan disajni put, algoritmi

Introduction

The use of the algorithms become usual every day practice in the operating theatre and outside the operating room. The ERC (European Resuscitation Council) every fifth year suggests the algorithms for basic and advanced life support for adults and for pediatric patients.

As ENT anesthesiologist and surgeon, we had the challenge to share emergency situations in which our knowledge and skills for difficult airway management became necessary. For those situations we had to think about and use the algorithm for difficult pediatric airway management.

The identification of the antecedent stages of respiratory failure was a priority, and effective early intervention in pediatric patient was lifesaving.

Assessment of potentially critically ill child started with assessment of the airway and breathing. Congenital abnormalities in the airway structures, trauma, acute inflammation or foreign bodies that make airway obstruction, could lead to respiratory failure.

Signs of respiratory failure include:

- Respiratory rate outside the normal range for the child's age.
- Initially increased work of breathing, which may progress to inadequate or decreased work of breathing as the patient tires or compensatory mechanisms fail, additional noises such as stridor, wheeze, grunting, or the loss of breath sounds.
- Decreased tidal volume marked by shallow breathing, decreased chest expansion or decreased air entry at auscultation.
- Hypoxemia and cyanosis.

In this step of resuscitation we had to be guided by the ERC algorithm for pediatric advanced life support. If the pediatric patient needed the intuba-

tion for establishing the airway, the compromised airway could arise to problematic or difficult airway in the emergency room at ENT departments. In this situation, we had to think about the difficult airway pediatric algorithms and make another plan according to the guidelines.

Aim

The aim of this study was to research the point where two algorithms, the algorithm for pediatric advanced life support and the algorithm for unexpected pediatric airway, cross in the emergency situations.

Methods

For that purpose we used comparative method, so we compared the algorithms for resuscitation: American and European algorithms (American Heart Association - AHA algorithm¹ and European Resuscitation Council - ERC algorithm²) with algorithm for difficult airway management (Marcus Weiss algorithm)¹⁰ to find the point where these algorithms cross on the field of airway.

Why do we need to compare two different algorithms? Because as employed at Ear, Nose and Throat surgery (ENT) Clinic and we had a lot of pediatric patients with obstructive airway problems that need our knowledge and skills, especially in emergency situations. The algorithm that secure pediatric airway in emergency situations, or the combination of both of them, was the best way to use as a guide for the lifesaving situations.

In fact, we were interested in the key point, when we had to switch from the algorithm for resuscitation to the algorithm for difficult pediatric airway management.

Actually, we used the algorithm for pediatric advanced life support for resuscitation in emergency situations, pediatric patients with upper airway respiratory distress syndrome: foreign bodies in the upper airway, inflammation as epiglottitis, croup or pathological substrates that made more than 50% obstruction of the airway flow.

The second algorithm i.e. European pediatric difficult airway management algorithm was used in the situation when the normal airway become difficult airway, defined as the emergency situation when experienced and well trained anesthesiologist could not ventilate the pediatric patient, could not intubate or both.

Results

Our clinical practice showed that the first steps in pediatric life support were extremely important. That means that during the transportation of the pediatrics from another hospital to ours, which is referent center in our country, ventilation and oxygenation were of utmost importance, because the large percentage of asphyxia arrests happened during the transportation without adequate ventilation.

Unfortunately, ventilation was sometimes delayed because the equipment: bag, mask and oxygen were not mobilized on time. Chest compressions in a pediatric patient without any sign of breathing, required only the hands of a willing rescuer. AHA suggested to start CPR with chest compressions immediately, and ventilation starts after that.^{1,2}

The effectiveness of pediatric advanced life support (PALS) depended on high-quality CPR that requires:

- adequate compression rate (100 compressions/min),
- adequate compression depth (at least one third of the AP diameter of the chest or approximately 1 ½ inches (4 cm) in infants and approximately 2 inches (5 cm) in children,
- complete recoil of the chest after each compression, minimizing interruptions in compressions,
- adequate ventilation.

The compression-to-ventilation ratio differed (newly born and newborns – 3:1; infant two rescuer - 15:2) provided ventilations in the presence of an advanced airway differed (newly born and

newborns – pause after 3 compressions; infants – no pauses for ventilations).^{3,4}

If the ventilation was not effective, rescuer had to perform endotracheal intubation, cuffed tracheal tubes could be used safely in infants and young children. The size should be selected by applying a validated formula^{5,6}.

The safety and value of using cricoid pressure, according the ERC algorithm, during tracheal intubation was not clear. They suggest modified or discontinued cricoid pressure which we were not using at all.

We used exhaled carbon dioxide (CO₂), by capnography, to confirm correct tracheal tube position as a mandatory monitoring. The capnography was recommended by all algorithms for airway management.

Discussion

The cross point between two algorithms based on our clinical experience could be defined in two points:

1. Airway problems solved in PALS according to ERC

Assessment of a potentially critically ill child started with assessment of airway (A) and breathing (B). Abnormalities in airway patency or gas exchange in the lungs could lead to respiratory failure.

Signs of respiratory failure might be associated with the signs of the other organs or systems that were either affected by inadequate ventilation and oxygenation or act to compensate the respiratory problem. These were detectable in step C (circulation) of the assessment and include: increased tachycardia (compensatory mechanism in an attempt to increase oxygen delivery), pallor, bradycardia (ominous indicator of the loss of compensatory mechanisms) and alteration in the level of consciousness (a sign that compensatory mechanisms were overwhelmed).

The guidelines for these problems according to ERC were:

- To open the airway and ensure adequate ventilation and oxygenation with high-flow oxygen.
- To establish respiratory monitoring (first line – pulse oximetry/SpO₂).
- To achieve adequate ventilation and oxygenation that might require use of airway adjuncts, bag-mask ventilation (BMV), use of a

laryngeal mask airway (LMA), securing a definitive airway by tracheal intubation and positive pressure ventilation.

If a surgical airway is required **we had to switch to the algorithm for difficult airway management for pediatric patient.**

2. Airway problems solving in PALS according to AHA

Oropharyngeal and nasopharyngeal airways helped maintain an open airway by displacing the tongue or soft palate from the pharyngeal air passages.

Oropharyngeal airways were used in unresponsive pediatric victims who did not have a gag reflex. The rescuer had to select the correct size, because an oropharyngeal airway that is too small might push the base of the tongue further into the airway.

Nasopharyngeal airways could be used in children who had a gag reflex, but we had to pay attention to proper diameter and length. A nasopharyngeal airway that is too short might not maintain an open airway, while one that is too long might obstruct it. A small-diameter nasopharyngeal airway might be obstructed easily by secretions that require frequent suctioning.

100% oxygenation was reasonable during CPR because there was insufficient information on the optimal inspired oxygen concentration. Once the circulation was restored, we had to monitor systemic oxygen saturation and titrate the oxygen administration to maintain oxyhemoglobin saturation $\geq 94\%$.

If the patient had a perfusing rhythm, we had to monitor oxyhemoglobin saturation continuously with a pulse oximeter because clinical recognition of hypoxemia was not reliable.

Bag-mask ventilation could be as effective, and might be safer, than endotracheal tube ventilation for short periods during out-of-hospital resuscitation.

In the prehospital setting it was reasonable to ventilate and oxygenate infants and children with a bag-mask device, especially if transport time was short. Bag-mask ventilation required training in selecting a correct mask size, maintaining an open airway, providing a tight seal between mask and face, providing ventilation, and assessing effectiveness of ventilation.

We had to use only the force and tidal volume needed to just make the chest rise visible; to avoid

delivering excessive ventilation. Excessive ventilation might cause air trapping and barotrauma in patients with small airway obstruction. It also increased the risk of stomach inflation, regurgitation, and aspiration.

If the infant or child was not intubated, we had to pause after 30 chest compressions (1 rescuer) or after 15 chest compressions (2 rescuers) to give 2 ventilations (mouth-to-mouth, mouth-to-mask, or bag-mask). Each breath had to be delivered with an inspiratory time of approximately 1 second. If the infant or child was intubated, we had to ventilate at a rate of about 1 breath every 6 to 8 seconds (8 to 10 times per minute) without interrupting chest compressions. It might be reasonable to do the same if an LMA is in place.

It was possible in the victim with a perfusing rhythm to see absent or inadequate respiratory effort. In that situation we had to give 1 breath every 3 to 5 seconds (12 to 20 breaths per minute), using the higher rate for the younger child.

A two-person ventilation technique might be preferable when personnel were available and might be more effective than ventilation by a single rescuer if the patient had significant airway obstruction, poor lung compliance, or the rescuer had difficulty in creating a tight mask-to-face seal.

Although several supraglottic devices had been used in children, clinical studies for these devices were limited, except LMA. When bag-mask ventilation was unsuccessful and endotracheal intubation was not possible, the LMA was acceptable airway for oxygenation and ventilation - we had to switch to the algorithm for difficult airway management for pediatric patient.

Endotracheal intubation in infants and children required special training because the pediatric airway anatomy differs from that of the adult. We had to have a second plan to manage the airway if we could not achieve intubation. We had to switch on the algorithm for unexpected difficult airway for pediatric patient. For verification of endotracheal tube placement, we could use the following steps:

- To look for bilateral chest movement and listen for equal breath sounds over both lung fields, especially over the axillae.
- To listen for gastric insufflation sounds over the stomach - they should not be present if the tube is in the trachea
- To check for exhaled CO_2 (End-Tidal CO_2)

Monitoring).

- If there was a perfusing rhythm, to check oxhemoglobin saturation with a pulse oximeter.

After securing the tube, we had to maintain the patient's head in a neutral position; neck flexion may push the tube further into the airway, and extension may pull the tube out of the airway

If an intubated patient's condition deteriorates, we had to consider the following possibilities (mnemonic DOPE):

- Displacement of the tube
- Obstruction of the tube
- Pneumothorax
- Equipment failure

Exhaled CO₂ detection (capnography) is recommended as confirmation of tracheal tube position for neonates, infants, and children with a perfusing cardiac rhythm in all settings (prehospital, emergency department, ICU, and operating room) and during intrahospital or interhospital transport.

Trans tracheal oxygenation and ventilation might be considered for patients with severe airway obstruction above the level of the cricoid cartilage if standard methods for managing the airway were unsuccessful. Trans tracheal ventilation primarily supported oxygenation as tidal volumes, but they were usually too small to effectively remove carbon dioxide. This technique was intended to be for temporary use while a more effective airway was obtained.^{7,8}

Difficulties with airway management in healthy children with compromised airway were very frequent in our country and presented a major reason for pediatric related cardiac arrest, death, and brain injury. We had the same problems: rapid hypoxemia and respiratory acidosis that influenced on children's consciousness. Our conclusion was that emergency airway problems in pediatric patients requires clear and critical concepts, formulated strategy and plan. Our plan was based on European algorithm for pediatric advanced life support. If we reached the point that we have unexpected difficult airway, we were managing it according to the other algorithm, the algorithm that we implemented at the national level, the algorithm for unexpected pediatric airway (Weiss and Engelhardt algorithm).⁹

ASA published the closed claims analysis and made the perioperative cardiac arrest registry at anesthetized children with unanticipated difficult airways with the same recommendations for unex-

pected difficulties in airway management.¹⁰

Conclusion

The unexpected "can't intubate, can't ventilate" situation in children is the worst case scenario. This scenario is potentially relevant for the child with a known or obvious acute severely compromised airway.

Emergency resuscitation strategy is that not forced ventilation and oxygenation can maintained oxygen blood saturation, to make a conditions for ENT surgeon to find out the reason for the respiratory compromised airway. Severe respiratory distress could be prevent with endotracheal intubation. If we enter into can not ventilate, can not intubate scenario, a surgical tracheostomy should be performed by a trained ENT surgeon. However, it is important to underline that this requires plan and the presence of a skilled anesthesiologists and surgeon.

Alternatively, if suitable equipment and local expertise are immediately available, rigid bronchoscopy may be successful to manage the unexpected difficult pediatric airway. The rigid bronchoscope once in place can be used to place an airway exchange catheter for subsequent tracheal intubation. Cannula cricothyroidotomy in infants and children has an unacceptable high incidence of complications and should therefore not be used in patients below 5–6 years as an emergency adjunct. Surgical cricothyroidotomy in children is the procedure of choice for emergency access of the airway.

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Figure 1. ERC Pediatric advanced Life support

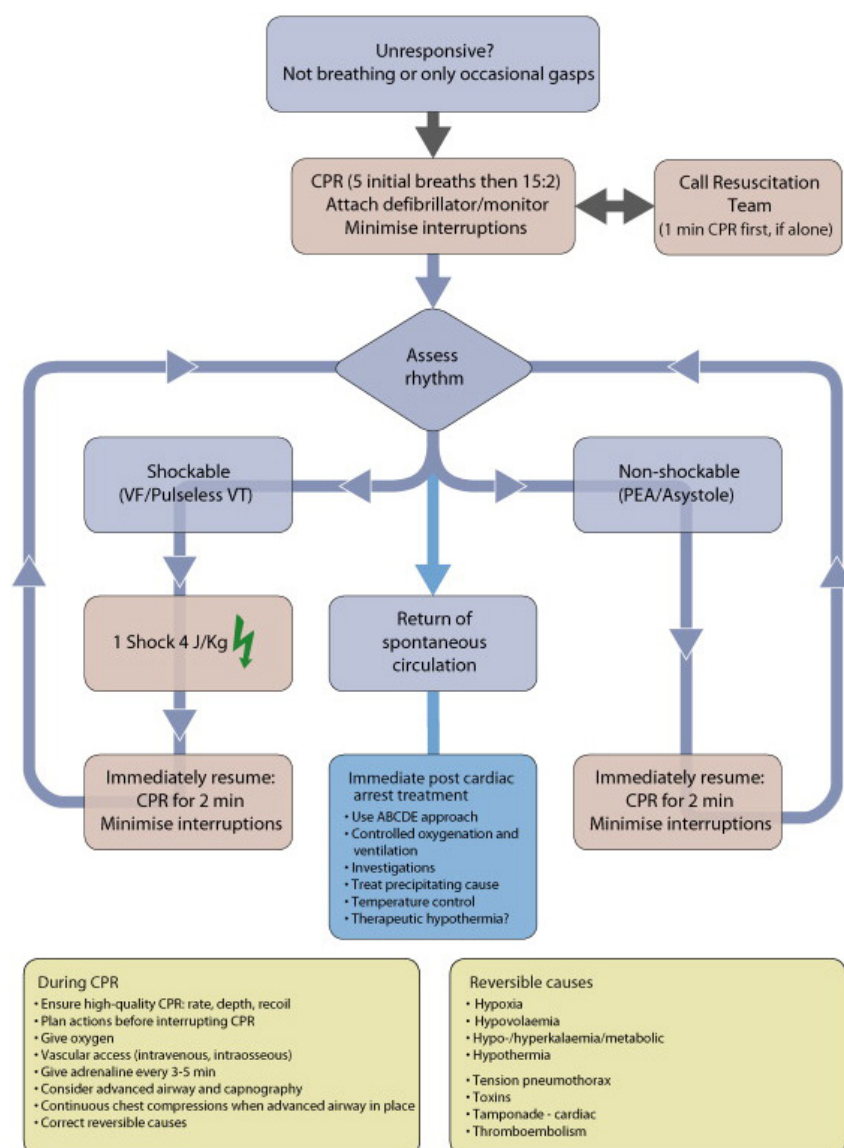


Figure 2. ERC Pediatric foreign body airway obstruction treatment

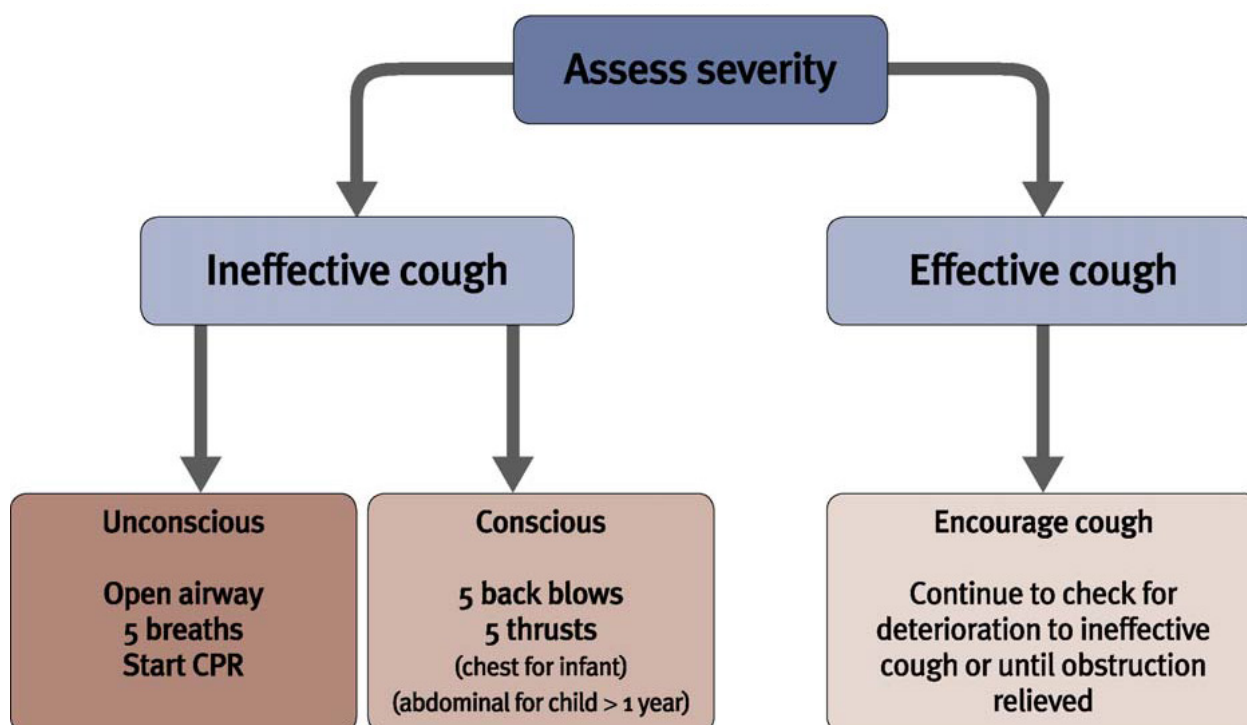


Figure 3. Weiss and Engelhardt algorithm (with the authors permission)

