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ORIGINAL CONTRIBUTION

Prehospital Pediatric Airway Management

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We are fortunate to live in a time of ongoing research, open discussion and technological advances in prehospital care. EMS providers are dealing with spinal immobilization, "load-and-go" vs. "stay-and-play" situations, medications for rapid sequence airways (RSA) or intubation (RSI), and ways to manage that very first element of patient assessment--the airway.

As Shakespeare's Hamlet pondered his future with the famous words "To be or not to be," he had choices; but only one path seemed correct. In that great tragedy, Hamlet chose a path that led to deception and eventually death. All too often, in the world of prehospital pediatric emergencies, we also face an uncomfortable choice: "to tube or not to tube." Do we attempt a relatively unpracticed procedure that is fraught with danger and potential complications, or do we embrace the future and move forward, toward improved safety for our smallest patients? In this article, we will look at prehospital pediatric airway management, past, present and future. We believe the future of prehospital pediatric airway management for both ALS and BLS providers goes back to basics, back to the past and back to the nonvisualized airways of the future.

"Airway equipment, including one supraglottic alternative for patients of all ages, should be available on every ambulance."[1]

Research shows that, on average, only 13% of prehospital patients are children.[2] We start IV lines on adults every day, and running a full arrest is not an uncommon event. But we don't often experience a need for invasive procedures on kids. A 2001 study of an urban EMS system found that ALS providers only attempted pediatric IV placement 3.7 times a year, and pediatric intubation was only attempted once every 3 years.[3] With such limited actual experience, it is easy to see how real-life proficiency in these procedures is difficult, if not nearly impossible, to maintain.

"Tracheal intubation (ETI) is considered the method of choice for securing the airway and for providing effective ventilation during cardiac arrest. However, ETI requires skills that are difficult to maintain, especially if practiced infrequently."[4]

Intubation with an endotracheal tube properly placed in the trachea, effectively secured, and with placement confirmed and monitored with capnography is the gold standard for airway management. It allows for continuous assisted ventilation, minimizes the risk of aspiration, and, though not a preferred route, provides a means for delivery of certain emergency medications.[5,6] However, intubation is not without risks and potential complications that are generally considered more significant in the uncontrolled and unpredictable prehospital environment. Several studies describe unsuccessful adult intubation rates ranging from 8%-30% and time to intubation ranging from 5-17 minutes.[7-11] For our pediatric patients, data from separate studies reveal successful endotracheal intubations in only 50% of the attempts for children under 1 year of age, 54% in children younger than 18 months, and only 57% in those under 12 years.[12-14]

"...the addition of out-of-hospital ETI to a paramedic scope of practice that already includes BVM (bag-valve mask) did not improve survival or neurological outcome of pediatric patients treated in an urban EMS system."[14]

A study that opened the eyes of many prehospital providers was conducted in the Los Angeles area.[14] The study was developed to evaluate outcome differences between using a bag-valve-mask procedure and intubating children. The methodology used was simple and straightforward. The study population was made up of seriously ill or injured children who were determined to need airway and/or respiratory support. EMS personnel were instructed to intubate children on Mondays, Wednesdays and Fridays, and to use only the bag and mask on other days of the week. Researchers found that pediatric patients who were only bag-mask ventilated did just as well (survival 30%; good neurologic outcome 23%) as those who were intubated (survival 26%; good neurologic outcome 20%).

Do drugs help? Rapid sequence intubation/rapid sequence airway technique has been used in anesthesia and emergency medicine for many years and is an option in some prehospital care systems as well. RSI/RSA involves pre-treating a patient with a combination of sedative and neuromuscular blocking agents or "paralytic" drugs intended to facilitate airway placement. The purpose of medications in RSI/RSA is to completely eliminate the patient's ability to resist intubation, voluntarily or involuntarily. Of course, this also means eliminating the patient's ability to breathe voluntarily or involuntarily. If all goes smoothly, this procedure is very useful. But these techniques are not without their own subset of risks and potential complications, which are increased in the unpredictable EMS setting or in patients with whom we are less comfortable or less familiar (e.g., pediatrics). While research on the use of RSI/RSA techniques in the prehospital setting is ongoing, the subject remains controversial.[15-17]

So, if our attempts at pediatric intubation don't appear to improve patient outcomes, even in a busy urban EMS system, what's the future direction for prehospital pediatric airway management?

"Endotracheal intubation is a motor skill that demands practice. EMS providers with limited intubation experience should consider using airway adjuncts other than ETI for respiratory compromise."[18]

PEDIATRIC AIRWAY MANAGEMENT

For all prehospital providers, initial airway management in children includes three key elements: positioning (the patient), placement (of the equipment) and providing (supplemental oxygen). In addition to providing appropriate cervical spine precautions, proper positioning of pediatric patients involves remembering a very important principle: Small children have what we call "big head, little body syndrome." Simply stated, because of their relatively large occiput, infants and small children do not naturally assume a neutral position when supine. Placing a properly sized oral airway is the second key element. Nasal airways are generally too small and are easily clogged with secretions and mucus.[6,19] The third element, providing effective bag-mask ventilation, may be the most difficult of the three. Some anesthesia and emergency medicine practitioners suggest that putting the tube in is often the easy part.[7] Bagging a patient is a true art.

These techniques are essential for not only BLS providers, but emergency professionals at all levels. If pediatric airway management is needed, attention to these concepts will serve you and your patients well. Think about it: If a child is not breathing, what do you do before you tube? Ventilate. What do you do after you tube? Ventilate. What do you really have to do if you can't put the tube in? Ventilate. That's why bag-mask ventilation is so important. But the skill is not as easy to master as many imagine.

"A full stomach is probably the most common problem in pediatric anesthesia. Children can never be trusted to fast."[20]

Does bag-mask ventilation work? Yes and especially when a two-rescuer technique is paired with proper positioning and placement of an appropriately sized airway adjunct and mask.[7] However, there are complications with bag-mask ventilation, the most notable being aspiration of stomach contents. Think of it as "Bellies + Bag-Mask = Barfing." We all know that from the mouth everything goes to either the lungs or the belly. If air, which belongs in the lungs, is introduced to the belly, or if stomach contents that belong in the belly are introduced to the lungs, trouble will surely follow. Ideally, the belly is empty and stays that way, and only air goes into the lungs through a perfectly placed ET tube. But we don't practice in an ideal world. Our patients, especially pediatric patients, are rarely without oral intake for 6 to 12 hours before we see them. So while proper positioning and placement of the oral airway help provide air to the proper area, more often than not, bag-mask ventilation will result in air being forced into the belly, which, unfortunately, is a recipe for aspiration.[21,22]

"We believe the time has come to carefully study the validity of the 'gold standard' assumption (prehospital intubation) and to evaluate the efficacy of alternative airway management."[23]

If we want to avoid the problems of bagging without an ET tube, and we know that prehospital pediatric intubation is not necessarily the answer (due to inconsistent results), is there a better way for BLS and ALS providers to maintain a pediatric airway? Absolutely, through the use of nonvisualized airways. In the prehospital environment, nonvisualized, or blindly inserted, airways had been limited to esophageal obturator airways (EOAs) or, more recently, the Combitube (see *Figure 1*). Combitube insertion has become widely accepted for BLS providers, and for ALS providers who, for whatever reason, determine that an endotracheal tube cannot be placed. The Combitube is blindly inserted into the mouth and usually ends up in the esophagus; however, in a small percentage of cases, blind tracheal placement can occur (see *Figure 2*).[5]

The Combitube comes with two syringes of different sizes, which are used to inflate the two balloons that secure the Combitube in place and block off the upper airway. Ventilations can be provided through two separate tubes, depending on whether the placement was esophageal or tracheal. The process is quite simple. Once the Combitube is inserted to the correct depth using the marker lines as a guide, inflate the blue pilot balloon (pharyngeal), followed by the white balloon (esophageal). Place a resuscitation bag on the end of the longer blue tube (labeled #1) to see if the tube has been placed in the esophagus as expected. If breath sounds are heard, continue using the blue tube. If breath sounds are not heard, or if there are other indications of gastric insufflation, use the shorter, clear tube (#2). It is important to always confirm the presence of breath sounds and absence of gastric sounds. In the event that both chest and belly sounds are absent, it is possible the tube has been advanced too far into the pharynx. If this occurs, deflate both balloons, pull the tube out approximately 2-3cm, reinflate the balloons and start the assessment process again. Combitube insertion can generally be completed in 30 seconds or less.[24-26]

Although Combitubes have been used in prehospital, emergency, critical care and anesthesia for several years as backup airway devices for difficult intubations, it is important to remember that they are designed for use with patients who are at least 4 feet tall, which excludes most pediatric patients.[5] Combitubes minimize the risk of pulmonary aspiration, as the device is designed to occlude the esophagus. In addition, if an oral ET tube is to be placed, the Combitube can be moved to the side of the mouth while the ET tube is being placed. However, barring a new, smaller version of the Combitube, this device remains in the prehospital armamentarium for use on only teenage and adult patients.[5,7,24,26,27]

"All prehospital services that perform endotracheal intubation should have alternate airways available."[7]

"The laryngeal mask airway (LMA) has become a standard alternative for airway management during general anesthesia."[19]

THE FUTURE FOR EMS: LARYNGEAL AIRWAYS--NOT ENDOTRACHEAL

"...Oxygenation, not tracheal intubation, is the main goal when treating emergencies."[1]

For many years, anesthesia professionals knew that not every patient needed to be, or could be, intubated. That knowledge led to the development of laryngeal airway devices. First introduced in the U.K. in 1981 and the U.S. in 1991, laryngeal mask airways (LMAs) are now used in hospital emergency and critical care departments, and in ALS and BLS EMS systems[7,28-30] (see *Figure 3*). In parts of the U.K. and Japan, LMAs have become a primary prehospital airway device.[31,32] Several studies suggest that placement of an LMA (generally in 30 seconds or less) is an easier skill at which to become proficient than bag-mask ventilation and certainly endotracheal intubation.[19,28,33,34] Like the Combitube, laryngeal airways are designed for "blind" insertion.

The traditional technique for LMA insertion is to start with the cuff of the device facing the patient's tongue. Advance the LMA along the roof of the mouth to the posterior pharyngeal wall and into the hypopharynx until resistance is felt. At that point, inflate the cuff with the amount of air listed on the pilot balloon until a seal is formed. The rotational or reverse technique has the cuff initially facing the hard palate and then rotated 180° as the LMA is advanced into position.[19,35] When the cuff is inflated, the LMA forms a loose seal around the top of the esophagus and will "pop out" a centimeter or so as the seal is formed. If that outward movement is not observed when the cuff is inflated, it is very likely the LMA is not in the proper position.[19] Once proper placement is confirmed (preferably through continuous capnography), it should be adequately secured, as movement of as little as a centimeter can cause displacement of the airway device.[19,29]

LMAs do a nice job of quickly getting the air to go where we want it to go, i.e., into the lungs. In addition, an LMA delivers increased effective tidal volumes compared with conventional bag-mask ventilation. Of particular importance is that LMAs are made in baby to adult sizes.[36] (The smallest LMA works with a 2.2-lb. baby.) So unless you are doing critical care transport with a neonatal ICU team, there is an LMA for just about every patient we will encounter (see *Table I*).[37] Also available for both adults and children are intubating LMAs through which an endotracheal tube can be placed; however, we strongly recommend waiting until the patient is in a safe and controlled environment (like the ED) before attempting to replace a functional laryngeal airway.

Since the LMA does not pass through the vocal cords, if the patient vomits, the potential for aspiration is certainly a concern (see *Figure 4*).[6,19,36,38] The good news is that research has shown that patients vomit less when ventilated with an LMA in place (2%) than when using a bag and mask (12%).[5,6,21,22,34,39]

Although LMAs allow for effective ventilation for most patients, at inspiratory pressures above 18-20 cm H_20, an LMA can pop off, resulting in an airway leak. This is important to remember in a patient with significant lung disease and/or increased airway pressures, as might be the case with ARDS, near-drowning, severe asthma, etc. In those instances, adequate ventilation may not be possible with just an LMA.[19,40,41]

"We feel the LT (laryngeal tube) is a simple and timely device that should be given consideration for use as a bridge device or primary airway adjunct in the prehospital arena."[18]

KING AIRWAY

"It looks like an endotracheal tube, works like an esophageal tube, reminds you of a Combitube, and allows you to provide positive pressure ventilation."[42]

Like the LMA, learning to use the King airway is easy (see *Figure 5*). Both BLS and ALS providers have been found to have an 85%-100% first-time placement success rate, including inexperienced users. Placement generally takes less than 15-30 seconds.[18,40,43-47] These airways have two cuffs, which are inflated simultaneously with one syringe. One cuff occludes the esophagus and the other occludes the oropharynx. The proximal cuff blocks the oropharynx and nasopharynx (back of the mouth), allowing air to pass through specially designed ventilatory openings into the trachea and lungs (see *Figure 6*).[42]

The King laryngeal airway is designed to be inserted without direct visualization. It is initially placed laterally into the mouth and rotated back to midline after passing under the tongue (this is important). Once it passes the corner in the posterior pharynx under the base of the tongue, the tube is advanced until resistance is felt or the base of the connector is aligned with the teeth or gums, at which point the tube is in the upper esophagus.[48] While King airways are ideally inserted in the "sniffing" position, the angle, shortness and size of the tube allow it to be placed with the patient in a neutral position (i.e., in a cervical collar) with minimal mouth opening or with severe facial trauma.[40,47,49] Once it's placed to maximum depth with the balloons inflated, slowly withdraw the tube until ventilation is easy with equal bilateral breath sounds. During ventilation, air passes into the pharynx, over the epiglottis and into the trachea, because the mouth, nose and esophagus are blocked by the balloons.[46] When properly inserted and secured, the King airway almost always goes to the esophagus.[18] Though tracheal placement is possible, in studies involving direct laryngoscopic visualization, tracheal placement of the King airway was attempted but not achieved.[45,50] Only one published study details tracheal placement in 10% of insertions, but it is important to note that the insertion techniques were different than those recommended by the manufacturer, and the airways used were different from those available in the United States.[51,52]

King airways allow for ventilation in most patients, but, like the LMA, they can pop off when airway pressures are significantly elevated. The "pop-off" point for King airways has been listed at pressures above 25-35 cm strong0, significantly higher than with LMA.[34,40,46] As previously described, the potential for the airway to lose its seal and leak is an important consideration if the patient has significant lung disease or any other condition that would result in increased airway pressures. Like the LMA, correct placement of the King airway is best confirmed and monitored with continuous capnography, keeping in mind the limitations of CO_2 monitoring in cardiac arrest. You should also be able to see appropriate chest rise and auscultate equal breath sounds.

Though possible, gastric insufflation with potential pulmonary aspiration of stomach contents is minimized, as this device occludes the esophagus.[40,48] In addition, newer models like the King LTS-D have an extra port that can be utilized to decompress the stomach. If intubation with an oral endotracheal tube is desired after a King airway has been secured, an intubation catheter or bougie can be passed through the airway's ventilatory inlet and used as a stylet during removal of the King airway and subsequent replacement with an ET tube using an over-the-catheter technique.[42] As mentioned earlier, this substitution should be done in a controlled environment.

Like LMAs, King airways must be well secured at all times, as displacement in a transport environment can occur with even minimal movement.[21] Of note for prehospital pediatric patients, the smallest King airway is currently recommended for children over 12 kg (25lbs) or 35" in length. Finally, laryngeal tubes are much simpler than Combitubes, as they have only one syringe with which to inflate the cuff(s) and only one tube to ventilate the patient.[25] Guesswork and the concomitant potential for error are eliminated.

KEEPING THE AIRWAY IN PLACE

Following are some simple suggestions to help avoid potential airway management complications. First, we highly recommend that prehospital and hospital providers remove the bag from the airway device when the patient is being moved. The ventilation bag is a significant weight if not completely supported or removed. Imagine trying to keep your neck straight with a brick hanging from it. Not easy to do, especially if you don't weigh much more than the brick.

Second, an airway device that is not carefully secured to the patient can easily become displaced or dislodged, especially in an infant or child. Movement of 1cm in an adult ET tube may be insignificant, but that same 1 cm movement in an infant's 3.0 ET tube may pull it completely out of the trachea.

Third, if you are transporting a pediatric patient with an airway in place, make sure the patient is also secured. Many airway disasters occur after a successful intubation. Critical care transport teams routinely place intubated patients (with or without a history of trauma) in hard cervical collars to minimize head and neck movement and the subsequent effect on the airway.

Fourth, it is critical to monitor the airway, ideally through continuous capnography. The difference between an unexpected airway event and a disaster is often simply the amount of time between recognition and remedy.

You may not be able to control all eventualities, so be prepared. If something happens to the airway device, you will need a mask for your patient. We suggest taping the mask onto something that will always be with the patient, such as the head blocks, monitor or even the patient's forehead, so you always know where it is. It's also a good idea to have a back-up airway device on hand in case something happens.

In the world of prehospital pediatric emergencies, managing your patient's airway will present certain challenges and opportunities. Non-visualized laryngeal airways and other new modalities make it possible to treat children more effectively while minimizing adverse events. With increased knowledge, proper planning, preparation and practice, we can enhance our comfort level and competence and continue to improve patient care and outcomes.

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