Preemies to Preschoolers: Tubing Tiny Tots and Trauma FAQs, Part 1

This article is the first part of a 3-part series that will be published in the May, June, and September 2014 issues of JEN.

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"No animal is so inexhaustible as an excited infant."—*Amy Leslie*

In the wonderful world of emergency medicine and emergency medical services (EMS), few situations can test our skills and knowledge as much as a newborn or young child in need of ventilatory assistance. Part of the stress we experience is a direct result of not asking certain questions often enough to allow the answers to be readily available to us when we are most in need of them. The goal of this 3-part article is to review some frequently asked questions and provide answers or suggestions that are easily retrievable or obtainable when time is of the essence.

Positioning and Airway Management

BEFORE BAGGING, WHAT'S SO IMPORTANT ABOUT POSITIONING AND AIRWAY MANAGEMENT FOR LITTLE CHILDREN?

In real estate, the 3 most important things to remember are location, location, location. When considering airway management and little children, the 3 important words are positioning, positioning, positioning[1–3] (Figure 1). Newborns and infants have a natural anatomic condition we (the authors) often describe as "Big Head, Little Body Syndrome." Think about a 3-month-old boy with a big head who is flat on a spine board or sedated for a computed tomography scan. What does the child's big head do to his airway? It shoves his chin on his chest, and he does not breathe very well. What is the remedy? Simply putting a diaper or towel under the child's shoulders goes a long way to offset "Big Head, Little Body Syndrome."

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Terminology

WHAT IS THE DIFFERENCE BETWEEN GESTATIONAL TERMS SUCH AS "PRETERM," "FULL TERM," AND "NEONATE"?

Just as children are not simply small adults, newborns and infants are not simply small children. Newborns, from birth to 28 days of age, can be premature, early term, full term, late term, or post term. The American Congress of Obstetricians and Gynecologists provides the following current classifications[4]:

Preterm: Before 37 weeks 0 days
Early Term: Between 37 weeks 0 days and 38 weeks 6 days
Full Term: Between 39 weeks 0 days and 40 weeks 6 days
Late Term: Between 41 weeks 0 days and 41 weeks 6 days
Post Term: Beyond 42 weeks 0 days
Neonate: Birth to 30 days old
Infant: Birth to 1 year old
Toddler: 1 to 3 years old
Preschooler: 3 to 5 years old

Newborns of Known Gestational Age

IF I KNOW THE NEWBORN'S GESTATIONAL AGE, HOW WILL THAT HELP ME?

If the mom is pregnant and not only knows she is pregnant (which is not always the case) but also knows how far along she is (a tremendous benefit, indeed), you can start

FIGURE 1

Pediatric chin on chest positioning. Reprinted with permission from Ossur Americas, (Foothill Ranch, CA), http://www.ossur.com.

off by remembering that 40 weeks is ideal, and ideally a 4.0 endotracheal tube (ETT) is appropriate. Did you spot that relationship? Add a decimal point between the 2 numbers in the gestational age in weeks. If the infant is preterm, you can put in a decimal point between the 2 numbers of the gestational age in weeks and round up or down to the nearest size tube. For example, if you have reason to expect delivery of a preterm baby of 25 weeks gestation, put the decimal point between the 2 and the 5 and you can expect to need a 2.5 ETT. If the baby is 29 weeks along, put the decimal point between the 2 and the 9 and round the 2.9 up to the nearest size tube, a 3.0 ETT. A 32-week gestation newborn would also most likely need a 3.0 ETT (rounding down to the nearest size tube). For a 34-week or 37-week gestation newborn, use a 3.5 ETT. If the baby is 38 weeks or more in gestation, a 4.0 ETT will probably work best.

Reality check: Remember to treat the patient, not the numbers! If the numbers say preterm but you have a big baby, think 3.5 or even 4.0. Conversely, if the numbers say full term but you see a teeny, tiny infant, select a smaller tube. You will see more on this concept later.[5]

Inability to Determine Gestational Age

WHAT SHOULD I DO IF DELIVERY SEEMS IMMINENT AND THE MOTHER EITHER DOES NOT KNOW HOW FAR ALONG SHE IS OR IS UNABLE TO TELL ME?

In the unfortunate situation in which an emergency delivery is needed and the gestational age is unknown, one quick method for estimating tube sizes is simply this: If you can feel the uterus at the belly button (umbilicus) or above, this infant is potentially viable. That being said, it is also very likely that the baby will be very small and very sick, so think "preterm" if no other information is available. With a uterus palpable at the belly button or above, resuscitation is worth a try.

Viability

HOW "VERY SMALL" IS TOO SMALL?

> "*No fetus coming into the world before the seventh month of pregnancy can be saved.*" —Hippocrates, 460 B.C.

Although Hippocrates may be considered the father of modern medicine, this particular quote should no longer be considered good fatherly advice because we keep hearing about the survival of smaller and smaller babies. For EMS/ED caregivers, review and follow your system/hospital policies, protocols, and procedures. If a neonatology and/or pediatric resource person is quickly available, use his or her expertise. If not and the newborn looks and acts like a baby (even a very, very small baby), attempt resuscitation until persons with more experience tell you otherwise. A very wise and experienced neonatologist, Dr. Nancy Lass, summarized the answer to this question with the following statement: "Babies who are born too soon need to be put on a ventilator to live. If someone who can easily find baby vocal cords tries to put the smallest endotracheal tube into the trachea (not the esophagus) and the tube is still too big, that's God's way of saying the baby is just too small."

Equipment for Intubations

REGARDING INTUBATIONS, WHAT IS THE DIFFERENCE BETWEEN ADULTS AND THOSE WHO ARE NOT THE AGE (OR AT LEAST THE SIZE) OF ADULTS?

With regard to equipment, adults (and persons large enough to be adults) are easy to handle. Young or old, the vast majority will get a 7.5 or an 8.0 ETT. Newborns, infants, and even most children and their airways come in various sizes, and thus the equipment needed for intubation needs to come in various sizes. Read on, because it is not quite that easy.

ETT Size

HOW DO I FIGURE OUT WHAT SIZE ETT SHOULD BE PLACED IN A BABY?

Several methods can be used for determining the size of ETT that will most likely be needed for a newborn.

Weight

The American Academy of Pediatrics Neonatal Resuscitation Program teaches that ETT sizes can be calculated based on the weight of the infant.[6] This method works well if you

FIGURE 2

Pedi-Wheel pediatric "cheat sheet." (Photo courtesy of Peds-R-Us Medical Education; www.Peds-R-Us.com.)

resuscitate infants on a regular (daily/weekly) basis and have a scale immediately available. It might also work if you can guess newborn weights with decent accuracy. (This skill might also be useful if you want to pick up extra cash working at an amusement park.) Realistically, we think there has got to be a better way!

Formulas

Many of us remember a formula that would help determine pediatric ETT sizes. That formula might be expressed as [age divided by 4] + 4 or alternatively as [16 + age] divided by 4. Even though this formula works well for pediatric patients, how would it work with a preterm newborn? The age in this formula refers to years, but we are talking about weeks. For example, let's say you have a preterm, 32-week gestation newborn. If you are stressed and try to do the calculation as 32 divided by 4 (using weeks instead of years) plus 4, you would get 8 plus 4. This calculation would have you looking for a 12.0 ETT, which doesn't even exist! Here's a formula we have found that works: stressful situations + mental calculations = mistakes!

Make it Simple (Part 1)—TOTs, BOBs, and Leftovers

There are really only 3 types of babies: preterm, full term, and postterm. Another way we (the authors) look at this issue (and it works when we are not sure about gestational age) is to consider newborns as being either "Tiny Ol' Things" (TOTs), "Big Ol' Babies" (BOBs), or "Leftovers." Nurses can use this concept to assist us determine the size of the ETT needed.

TOTs look like the tiniest baby you have ever seen. These babies get the tiniest tube you can commonly find, which should be a 2.5 ETT. BOBs, who are big and chubby, get a 3.5 or 4.0 ETT. Leftovers—that is, babies between a TOT and a BOB—get the "leftover" tube (between a 2.5 and a 3.5), which is usually a 3.0 ETT.

Make it Simple (Part 2)—Charts

Simply put, GET ONE! A variety of charts are available to assist you during unusual and stressful emergency deliveries (Figure 2). Charts can be found for your smartphone, your pocket, your jump bag, or your cart. These charts, like the Broselow tape, are made by people who are not stressed for use by people who might be stressed (like when a baby just popped out). They will help you determine what size ETT to put in and often have all sorts of other helpful information as well.

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Preemies to Preschoolers: Tubing Tiny Tots and Trauma FAQs, Part 2

This article is the second part of a 3-part series being published in the May, July, and September 2014 issues of JEN

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Use of a Stylet

SHOULD WE USE A STYLET FOR NEWBORN OR PEDIATRIC INTUBATIONS?

Stylets (those flexible metal devices that help keep the endotracheal tube [ETT] in the shape desired) can be very helpful when they are properly inserted. Proper insertion means that the tip of the stylet is not past the "Murphy's Eye" near the end of the ETT. We believe that you should at least consider putting a stylet in every ETT. If you need it, you've got it, and the tube goes in the first time. If you do not need it, you are not going to do anything different, and the tube goes in the first time. However, if you need it and the stylet is sitting on the counter, what do you have to do? Take the blade out, bag the baby, put the stylet in the ETT, and try to find the cords again. Why would you want to do that? With experience comes preferences; some practitioners swear by stylets, whereas others do not recommend that they be used routinely. If you have experience intubating newborns and find stylets helpful, don't change what works, but if you find them not to be helpful, don't use them. However, at least consider their use as recommended by many neonatology, pediatric emergency medicine, and anesthesia professionals[1,2].

Cuffed Versus Uncuffed Tubes

WHAT ABOUT CUFFED VERSUS UNCUFFED TUBES?

Young children have airways shaped like tiny funnels; they are big at the top and small at the bottom (Figure 1). The smallest part of that airway—what we could think of as the bottom of the funnel—is the cricoid ring. For *newborns*, using an appropriately sized *uncuffed* tube (Figure 2) allows for the maximum inner diameter (through which the air goes in and out) and potentially less tracheal necrosis. These tubes should just slide on through, with the cricoid ring helping to secure the airway without need for a cuff.

That said, the use of uncuffed tubes in *pediatric* patients is one of the "rules" being reconsidered in some settings. For many years, medical personnel were taught that only uncuffed endotracheal tubes should be used in children. The rationales were 2-fold:

1. Childrens' airways are funnel shaped, and when the right size endotracheal tube just squeaked through the funnel, it created its own natural seal at the cricoid cartilage.
2. Cuffed endotracheal tubes caused tracheal ischemia and necrosis in the fragile airways.

Although both of these rationales were true, as the folk song goes, "the times, they are a changing." First, the

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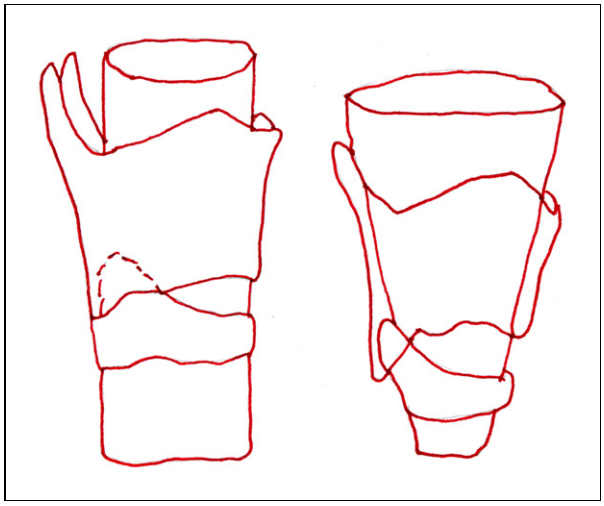

FIGURE 1

Adult "tube-shaped" versus child "funnel-shaped" airways. (Illustration courtesy of Nina DeBoer.)

FIGURE 2

Uncuffed endotracheal tubes, sizes 2.5 to 5.5. (Photo courtesy of Julie L. Bacon, MSN-HCSM, RNC-LRN, CPN, CPEN, C-NPT.)

ETT itself continues to evolve, and tubes are now available with smaller and gentler (meaning much lower pressure) cuffs (Figure 3). As a result, these newer cuffed tubes do not cause the damage we used to see. Second, with the evolution of pediatric ventilators and emergency and critical care, we are now keeping children alive who would not have survived a short time ago. Imagine caring for a child who has nearly drowned, has acute respiratory distress syndrome, and requires incredibly high airway pressures to barely make his chest go up and down. Even with the best possible ETT fit, with those kinds of pressures and an uncuffed ETT, the air will probably leak all over the place. In this sort of case, the critically ill child may need to be extubated and reintubated with a cuffed ETT.

The most recent Pediatric Advanced Life Support guidelines (2010) suggest, and our experiences have shown, that more and more pediatric intensive care units (ICUs) are placing cuffed ETTs (usually half a size smaller than an uncuffed tube)[3,4]. Recommendations have emerged that emergency departments should consider using cuffed tubes for their small patients as well. If you do not need to inflate the cuff, great—but if you are having trouble making air go in and out and all you have to do is put a little air into the cuff—even better! Although uncuffed tubes are still most commonly used for children in the emergency department, the change to cuffed ETTs will start to occur in many facilities in the very near future.

Emily Dawson, MD, a pediatric emergency medicine and critical care attending physician, offers the following insights: "Remember, the ETT size formulas are for *uncuffed* tubes. When using a cuffed ETT, most experts suggest using one half a size smaller. For example, if the formula suggests a 4.5 ETT (uncuffed), the appropriate cuffed tube size would be 4.0."

Monitoring of ETT Cuff Pressures

IF I'M USING A CUFFED ETT, DO I NEED TO MONITOR ETT CUFF PRESSURES LIKE WE DO FOR ADULTS?

Current best practice calls for the use of cuff pressure monitors not only in adults but in children as well (Figure 4). Just placing air into the cuff, without regular monitoring of the cuff pressures, is becoming an unacceptable practice, whether it takes place in the operating room, the pediatric ICU, or the emergency department. We should always remember that children are not small adults. The cuff pressure on an endotracheal tube needs to be enough to seal the airway but not so much that it impairs blood flow to the tissue in the trachea. In the adult population, this pressure is usually around 20 to 25 cm H_2O. For smaller patients and smaller tubes, the pressure should be less, hence the need for a cuff pressure monitor.

Recent studies have examined the current practice of placing air into the child's ETT pilot balloon (like we do for adults many times) until it "feels right." After the air was placed, the studies measured how much pressure was actually being exerted on the child's airway. Findings showed that tracheal pressures were between 60 to 120 cm

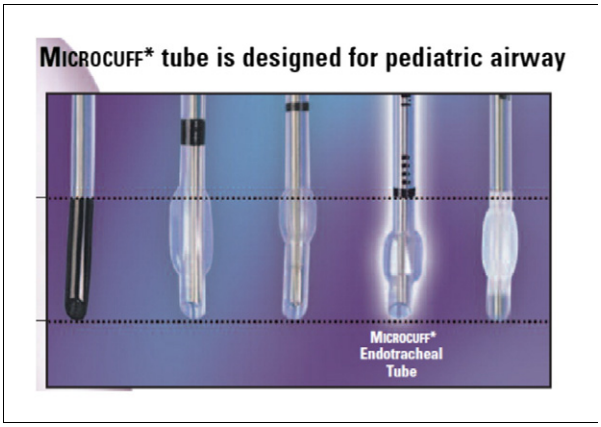

FIGURE 3

Microcuff cuffed pediatric endotracheal tubes. Reprinted with permission from Kimberly-Clark Healthcare (Neenah, WI), http://www.kchealthcare.com.

FIGURE 4

Endotracheal tube cuff pressure monitor. Reprinted with permission from Posey Company (Arcadia, CA), http://www.posey.com.

H_2O! The investigators then looked at how much pressure is really required to seal the cuff in the child. That pressure was found to be ≤10 cm H_2O, which is significantly less than that needed for adults. Obviously, if cuffed tubes are used in small children, much less pressure is required, and it needs to be monitored!

FIGURE 5

Range of masks in infant to adult sizes. Reprinted with permission from King Systems (Noblesville, IN), http://www.kingsystems.com.

Straight Versus Curved Laryngoscope Blades

WHAT ABOUT USE OF STRAIGHT OR CURVED LARYNGOSCOPE BLADES?

As a rule, for newborns and infants, a straight blade should be used. Babies have big tongues, a big, floppy epiglottis, and seemingly no vallecula—the space right before the epiglottis where a curved blade would be placed in older patients. When using a straight blade, gently lift the tongue and epiglottis out of the way and put the ETT in.

For older children, the choice of which blade to use is personal preference. Use a straight blade if you like it and are skilled in using it. If you prefer a curved blade, use a curved blade. If you are not the person putting the tube in, simply ask the person performing the procedure, "Do you want a straight or a curved blade?"

Placement of the ETT Down the Mouth or Nose

SHOULD WE PLACE THE ETT DOWN THE MOUTH OR THE NOSE?

Persons in controlled settings who often intubate babies or children can place the ETT either through the mouth or the nose. In uncontrolled settings (such as in the back of an ambulance or in the emergency department) or when the

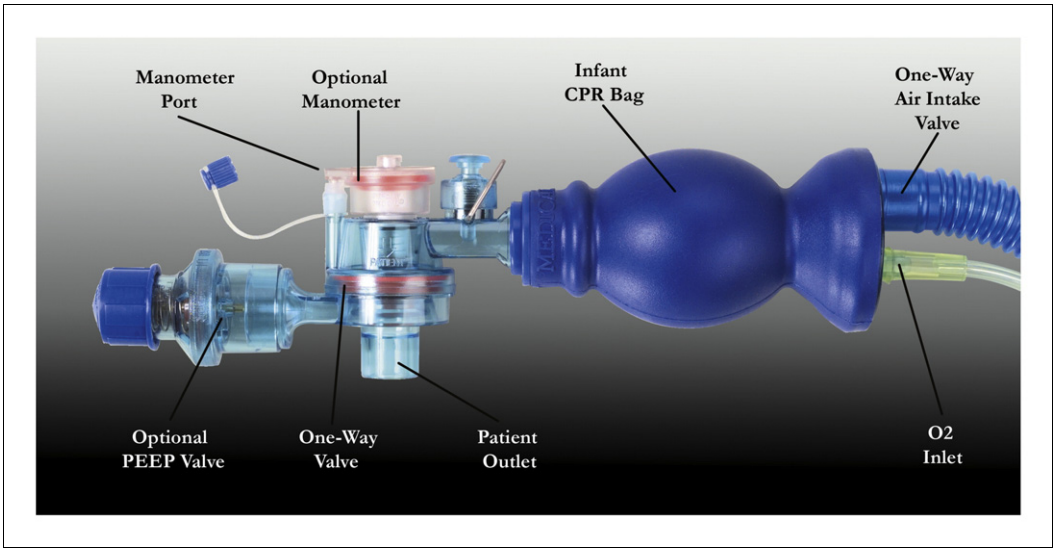

FIGURE 6

Infant cardiopulmonary resuscitation bag. Reprinted with permission from Mercury Medical (Clearwater, FL), http://www.mercurymed.com.

staff is not highly experienced, we suggest placing the ETT down the mouth for several reasons:

1. The mouth hole is bigger than the nose hole.
2. When you put the ETT down the mouth, you actually see where the ETT is going, and therefore the chances of placing it in the trachea are much better.
3. The tonsils in the back of children's throats are amazingly vascular structures. If an ETT starts bouncing off the tonsils, they can bleed quite profusely.
4. The vocal cords in children (including newborns and infants) are very anterior (ie, toward the front of the neck) compared with older patients. If you blindly put an ETT down the nose of a newborn or infants and hope that it will go where you want it to go (the trachea), it is more likely to take the easier pathway, resulting in an esophageal placement. (And yes, this is a bad thing!)

Thus when you need a tube right here, right now, your best bet is to put it down the mouth. Also, during difficult intubations of newborns and young children, you may be asked to provide *gentle* external cricoid pressure (ie, on the front and middle of the neck) to help lower the vocal cords into view.

Length of an Intubation Attempt

HOW LONG SHOULD AN INTUBATION ATTEMPT LAST?

In most cases, the patient will let you know when you have taken too long. The Neonatal Resuscitation Program recommends a maximum of 20 seconds per attempt, but remember to watch the patient as well as the clock. You should closely monitor the patient's heart rate and oxygen saturation; if any significant decrease occurs, abandon the intubation attempt. Provide ventilation with 100% oxygen with an appropriate size bag and mask, which should always immediately available (Figures 5, 6, and 7). If you are using a blade and handle that have a conventional, heat-producing light source, it is highly recommended that the blade be closed between attempts, which will prevent the laryngoscope blade from overheating and possibly burning the mouth or the airway.

FIGURE 7

Range of resuscitation bags in infant to adult sizes. Reprinted with permission from Ambu, Inc. (Glen Burnie, MD) http://www.ambuusa.com.

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Plan B

IF THE INTUBATION DOESN'T WORK, WHAT'S MY "PLAN B?"

A backup, nonvisualized, supraglottic airway can be used in place of, or until, an endotracheal tube (ETT) is accurately and securely inserted. In our experience, 2 types of these airways, the King airway (King Systems, Noblesville, IN) (Figures 1 and 2) and laryngeal mask airway (LMA) (Figures 3 and 4), are most commonly used for crashing or coding children. For EMS providers and personnel at urgent care/episodic care locations and smaller or critical access hospitals where child intubations are rare, the supraglottic airways are the perfect fit. The smallest King airway (King Systems) currently available in the United States is a size 2, which conveniently is appropriate for a 2-year-old child. In addition, it has been reported that King airways (King Systems) for infants and 1-year-old children will be available in the United States in the near future because they have been successfully used in Europe for several years. The smallest LMA currently available in the United States is a size 1, which conveniently is appropriate for a baby as small as 1 kg (2 lb). These airways are easily and quickly inserted in the vast majority of patients and do a great job of maintaining the airway until an ETT or surgical airway can be placed. King airways (King Systems) and LMAs can be left in place for several hours and even can be hooked up to a ventilator.[1-5]

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Placement of the Airway

HOW DO I KNOW IF THE AIRWAY IS IN THE RIGHT PLACE?

Correct placement (Figures 5 and 6), both initially and on an ongoing basis, can be verified with colorimetric (Figure 7) or, preferably, waveform capnography (Figure 8), just as with an ETT. Many fine articles and references are available that deal with verification of airway placement.

Tips for Tubes

NOW THAT WE'VE GOT THE ETT PROCEDURE FIGURED OUT, DO YOU HAVE ANY "TIPS FOR TUBES" YOU CAN SHARE?

Imagine this scenario: An Advanced Life Support ambulance is en route to the emergency department with a hemodynamically unstable child who is approximately 4 years of age. The child is the only survivor of a head-on motor vehicle crash. The ED nurse anticipates that the following equipment

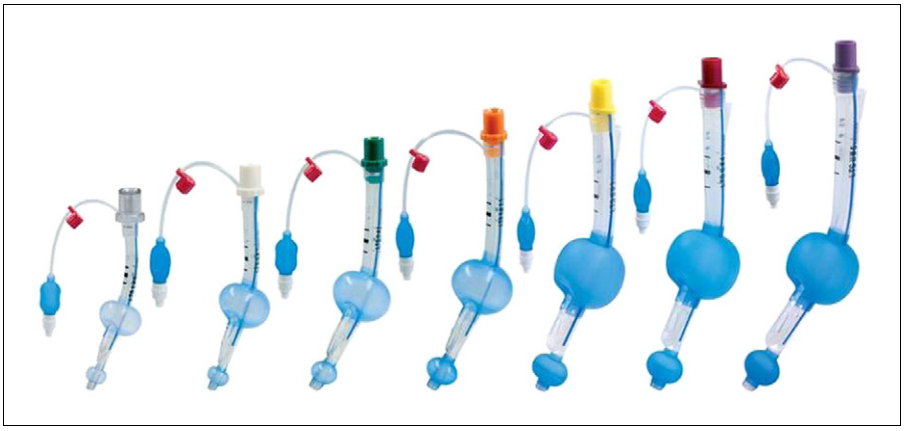

FIGURE 1

Infant to adult King airways. Reprinted with permission from King Systems (Noblesville, IN), http://www.kingsystems.com.

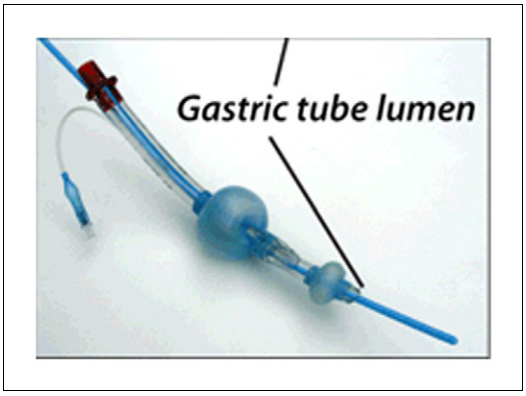

FIGURE 2

A King airway with a gastric decompression port. Reprinted with permission from King Systems (Noblesville, IN), http://www.kingsystems.com.

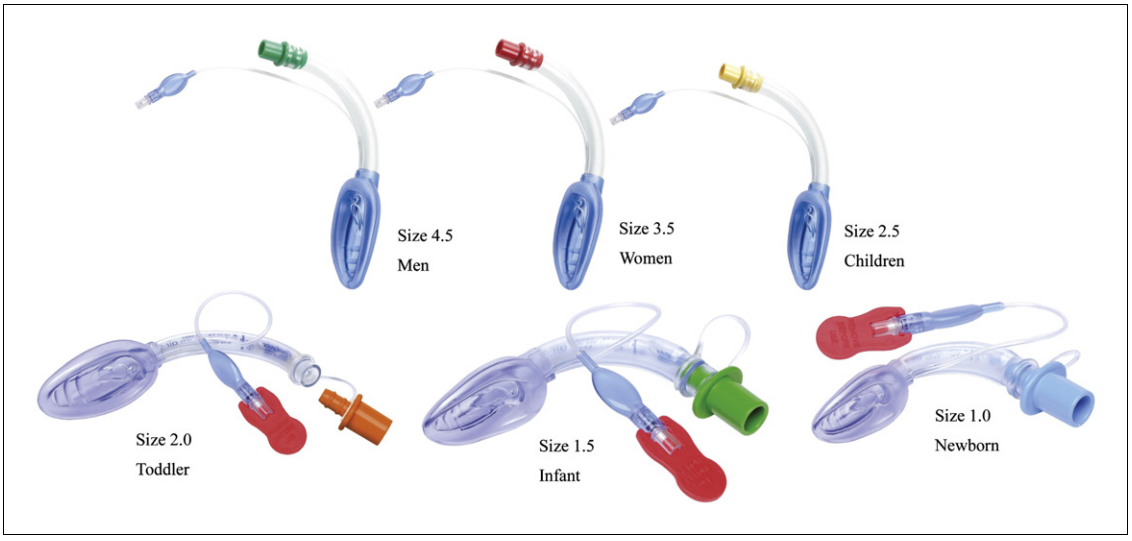

FIGURE 3

Infant to adult laryngeal mask airways. Reprinted with permission from Mercury Medical (Clearwater, FL), http://www.mercurymed.com.

FIGURE 4

A laryngeal mask airway with a gastric decompression port. Reprinted with permission from Teleflex Medical (Research Triangle Park, NC), http://www.teleflex.com.

- 2× the size of the ETT is the suggested size of the suction catheter, nasogastric/OG tube, and Foley urinary catheters (Covidien, Mansfield, MA).
- 3× the size of the ETT is approximately where the oral ETT should be taped at the lip
- 4× the size of the ETT is the suggested size of the chest tube to be placed for evacuation of a pneumothorax (air in the chest)
- 5× the size of the ETT is the suggested size of a chest tube to be placed for evacuation of a hemothorax (blood in the chest)

Thus based on the 5.0 ETT, the nurse can prepare by obtaining a 10 French OG tube, 10 French suction catheters, and a 10 French urinary catheter (Covidien;

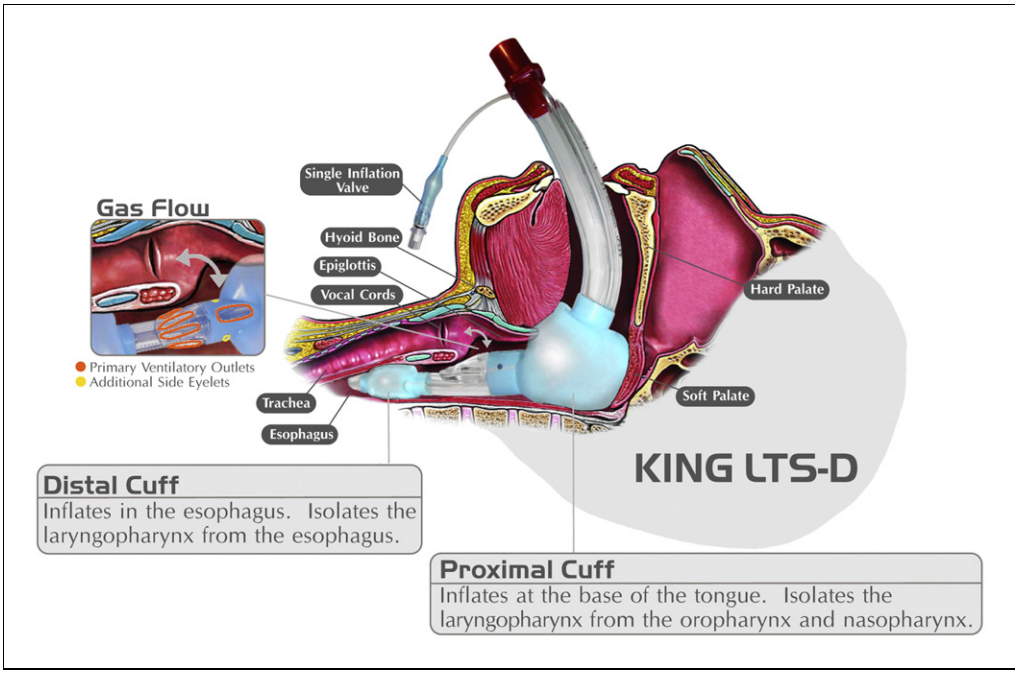

FIGURE 5

A correctly placed King airway. Reprinted with permission from King Systems (Noblesville, IN), http://www.kingsystems.com.

will be needed: an ETT, an orogastric (OG) tube, suction catheters, a urinary catheter, and a chest tube.

Referring to the chart, cheat sheet, or formula that the well-prepared nurse has on hand, it is determined that the ETT size needed will most likely be a 5.0, and that's a really good start. The following trick might help you remember the most likely sizes of the remainder of the tubes (Table). Based on the ETT size:

Mansfield, MA). In addition, the nurse should obtain 20 French and 24 French chest tubes in case of a pneumothorax or hemothorax, respectively (they don't make 25 French tubes). The nurse can anticipate that the oral ETT will be taped at 15 cm at the lip.

Most importantly, remember that an intubation attempt means that the patient is not being ventilated for that period of time. Most babies (and children) have

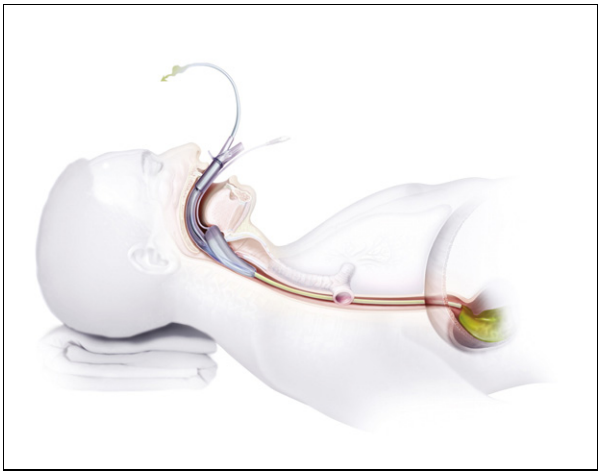

FIGURE 6

A correctly placed laryngeal mask airway. Reprinted with permission from Teleflex Medical (Research Triangle Park, NC), http://www.teleflex.com.

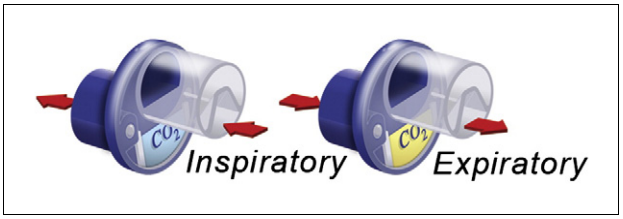

FIGURE 7

Pediatric colorimetric end-tidal CO_2 detectors. Reprinted with permission from Mercury Medical (Clearwater, FL), http://www.mercurymed.com.

airways that can be maintained with bag-mask ventilation using the correct size bag and mask. Intubation is great, but *ventilation* is even better, whether it comes from an ETT, a bag/mask, or a backup airway. If the tube cannot go in for whatever reason, go back to the basics: bag, baby, bag!

"*A person is a person, no matter how small.*"
—Dr. Seuss

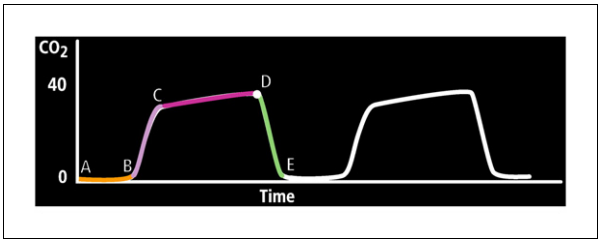

FIGURE 8

Capnography verification of proper endotracheal tube, King airway, or laryngeal mask airway placement. Reprinted with permission from Covidien (Mansfield, MA), http://www.covidien.com.

TABLE
Tips for determining tube sizes

Size based on the endotracheal tube	Type of tube or centimeter mark
2×	Suction catheter
2×	Nasogastric tube
2×	Foley urinary catheter
3×	Centimeter mark to secure the tube at the lip
4×	Chest tube for a pneumothorax
5×	Chest tube for a hemothorax

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Submissions to this column are encouraged and may be sent to **Joyce Foresman-Capuzzi, BSN, RN, CEN, CTRN, CPN, CCRN, SANE-A, EMT-P**
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