The Conscience of EMS
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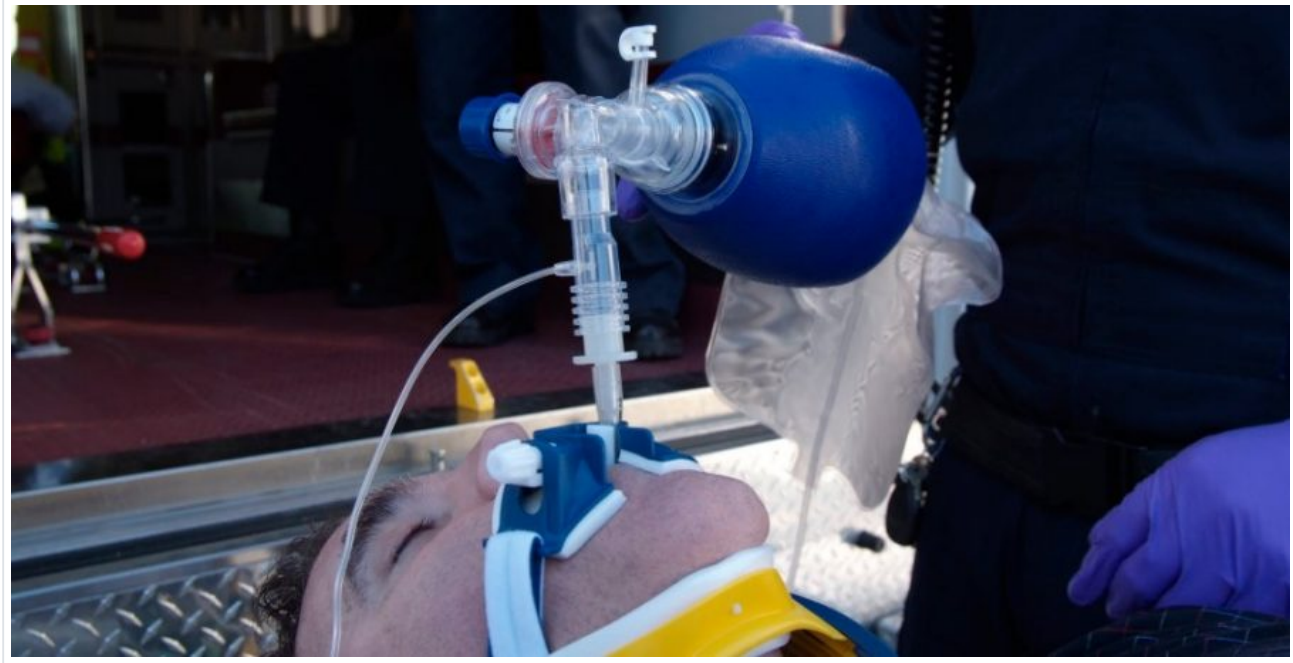
Airway, Breathing or Consequences: Use Your Tools and Trust the Technology

Mon, Oct 1, 2018 | By Scott DeBoer, RN, MSN, CEN, CPEN, CCRN, CFRN, EMT-P , Michelle Webb, RN, MSN, CRNA , John Pisowicz, RN, BSN, NRP, PI , Bob Page, MEd, NRP, CCP, NCEE , Michael Seaver, RN, BA

Part 1 of a 2-part article on successful airway management and the unfortunate legal consequences patient care providers can face



The presence or absence of carbon dioxide in the exhaled breath, referred to as end-tidal carbon dioxide (EtCO2), can provide a very high level of confidence that the airway was properly placed (i.e., presence of CO2) or improperly placed (i.e., absence of CO2). Photo courtesy Medtronic

"An esophageal intubation is no sin, but there is great sin in not recognizing such a placement." — Special Operations Combat Medical Skills Sustainment Course (U.S. Special Operations Command)

How hard is it take to properly intubate the trachea? Actually, it's far more difficult than most people think. Recent anesthesia research shows that at least 75 live adult intubations are needed to achieve a 90% initial competency.[1] Yes, *75!* Not the very limited live number that are experienced in many paramedic schools, and certainly not only practicing with manikins.

And how hard is it to intubate the esophagus? Unfortunately, way too easy.

So, when faced with the need to secure an airway in emergency situations, how likely is it that the tube will end in the proper place?

If you're a pessimist at heart (or possibly a realist), the odds seem pretty good for a misplaced tube. That's not a good thing. After all, having a patent airway is critical to breathing—and life in general.

How do we increase the odds in our favor? Well, certainly practice, practice, practice would be a key. The other thing we need to do is use the tools at our disposal to verify proper tube placement, and we must trust the findings that those tools provide.

And this applies not occasionally, not most of the time, but rather, we need to use the tools and trust the results with *every* tube, *every* time, and with *every* major move.

How do we verify tube placements? What evidence are we looking for, and what tools do we have on hand that will provide that evidence and confirm that the tube is actually in the right place?

Let's begin with one basic concept: Carbon dioxide (CO_2) should be present in exhaled air, and only there. So, if we have a method or a tool that enables us to detect CO_2 and attach it to an artificial airway device, the presence or absence of CO_2 in the exhaled breath, referred to as end-tidal carbon dioxide ($EtCO_2$), would provide a very high level of confidence that the airway was properly placed (i.e., presence of CO_2) or improperly placed (i.e., absence of CO_2).

Well, we have tools for verification of endotracheal tube placement with $EtCO_2$ and they come in three categories:

1. Colorimetric devices rely on materials which change colors in the presence (or absence) of CO_2. These devices provide an indication of CO_2 within a range of values, but don't give specific numbers.
2. Capnometric devices measure and display a numerical value for the concentration of CO_2 at end of the exhalation phase of respiration.
3. Capnography devices display a waveform in addition to the numerical values found with capnometry. The real-time waveform provides us with a picture of both respiratory rate and depth as well as ventilatory effectiveness.

Colorimetric Considerations

Whether one remembers that “gold is good” or “yellow is mellow” (indicating that the endotracheal tube is in the right spot), or that “blue is bad” or “purple paper means purple patient” (indicating that the endotracheal tube is in the wrong place, or something worse), colorimetric devices can be useful in evaluating placement.

The colorimetric CO_2 detector has a plastic housing which contains a pH-sensitive chemical indicator that undergoes color changes with each inspiration and exhalation, thus reflecting the change in CO_2 concentration.

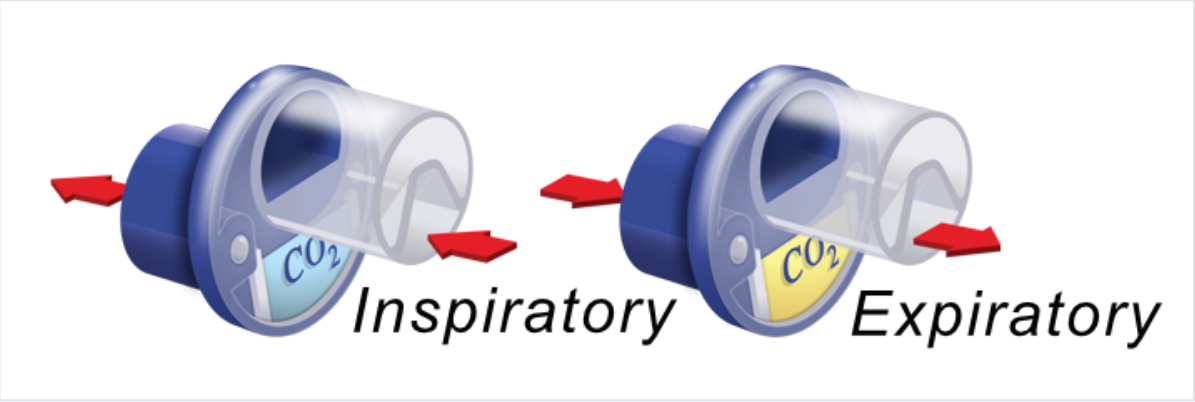
These devices aren’t reliant on any power source and easily fit in a pocket or small jump bag. In the absence of other CO_2 detecting technology, depending on the manufacturer, colorimetric devices can be reliable for from to 2–24 hours of continuous use.

Colorimetric devices should turn yellow when an endotracheal tube or another alternative airway is properly inserted into a patient with intact circulation. These devices start at baseline color when minimal CO_2 is present and undergo gradual color change with increasing CO_2 concentration.

These devices provide semi-quantitative, on-going EtCO2 monitoring by detecting breath to breath color changes through the metacresol purple on filter paper which acts as a pH indicator and changes from purple to yellow in the presence of CO_2.

Figure 1: Colorimetric $EtCO_2$ Device

Image courtesy Mercury Medical



Colorimetric devices have several drawbacks when compared to other forms of $EtCO_2$ monitoring. They provide no numeric or waveform data, no numbers to validate findings, and no alarms for clinicians. In addition, they’re easily contaminated and can be difficult to read in the dark or by color-blind providers.

Colorimetric devices can also give false readings. False positive readings (suggesting a correct placement when the tube is in the esophagus) can occur when the device is contaminated with acidic substances such as gastric acid.

The most common example of this would be vomitus in the airway (natural or otherwise). Contamination can also occur in the rare causes of endotracheal administration of lidocaine or epinephrine.

Furthermore, these devices may not provide an accurate reading if the detector is expired, clogged with secretions, or if the package has been open to air for more than a few minutes prior to use.

Another drawback to the use of colorimetric devices is the potential for a false-positive reading when intubation is performed shortly after the patient has consumed a quantity of any carbonated beverage (which contains CO_2).

When providing ventilations to confirm initial tube placement, CO_2 present within the stomach can be expelled from the relaxation of the esophageal sphincter yielding the false-positive reading on the device.

Additionally, the recent ingestion of calcium carbonate products (e.g., Tums, Rolaids, etc.) can result in the same false-positive readings. This occurs when these over-the-counter medications are digested and the breakdown of the calcium carbonate forms calcium oxide and carbon dioxide.

To provide greater reassurance of the accuracy of the color change, it is recommended that *at least 6* breaths be given via the endotracheal tube to "wash out" any CO_2, which may have entered the airway from the belly before confirming the placement of the tube through breath-to-breath color changes on the colorimetric device.

False-negative results (suggesting improper placement when the airway device is actually correctly located) can occur in the event of cardiac arrest, situations involving low pulmonary blood flow due to pulmonary emboli, or in cases of a large alveolar dead space condition.

These erroneous findings can be due to the lack of enough CO_2 in the lungs for detection by the colorimetric device and would result in the clinician not seeing a colorimetric change despite positive clinical assessment findings (e.g., symmetrical chest rise and fall, bilateral breath sounds, good compliance with your bag-valve devices, and changes in skin parameters). It's always important to correlate your clinical assessment findings with the device findings and be aware of their limitations.

One final consideration with the use of any colorimetric devices is the use of one when faced with a pediatric airway emergency. Any patient under the weight of 15 kg (or other specific manufacturer recommendation) requires the use of an infant or pediatric colorimetric device.

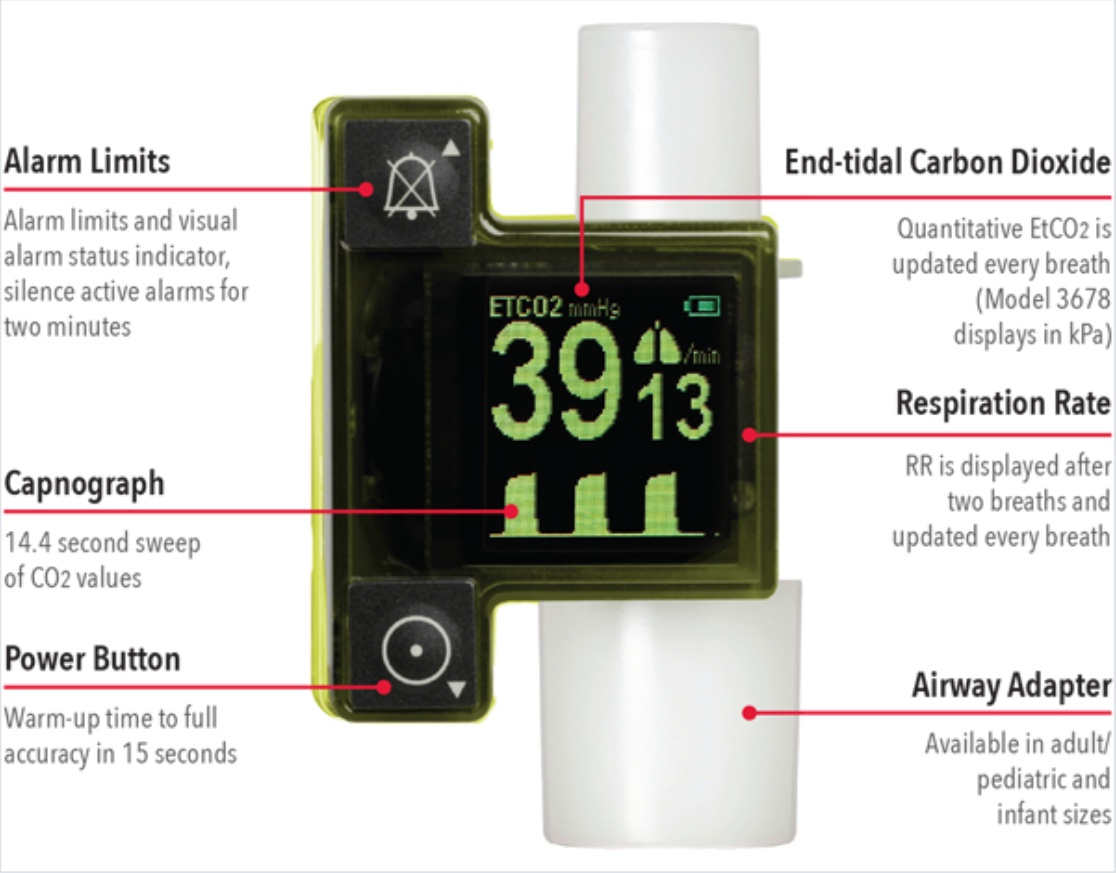
For any patient over 15 kg, the adult colorimetric device may be used. Failure to utilize the correct size device has the potential to result in false results and tragic consequences.

Capnometry and Capnography

Capnometry, like capnography, is the continuous analysis and recording of the CO_2 concentration in exhaled respiratory gas. (The name comes from the Greek word *Kapnós*, which translates in English to "smoke.") The technology behind capnometry and capnography provides a breath-to-breath clinical picture of your patient's condition.

Most capnometers are small, battery-powered devices that can easily fit in the palm of your hand. They provide digital read outs of $EtCO_2$ and often display the respiratory rate as well.

Figure 2: Capnometer
Image courtesy Masimo



Although capnometry provides only numerical output, capnography provides both numerical and waveform displays, providing additional information about the patient's condition.

In addition to initial/ongoing verification of correct airway placement, waveform capnography is also commonly used in the assessment of pulmonary circulation, respiratory status and in the optimization of mechanical ventilation.

Figure 3: Normal capnography waveform

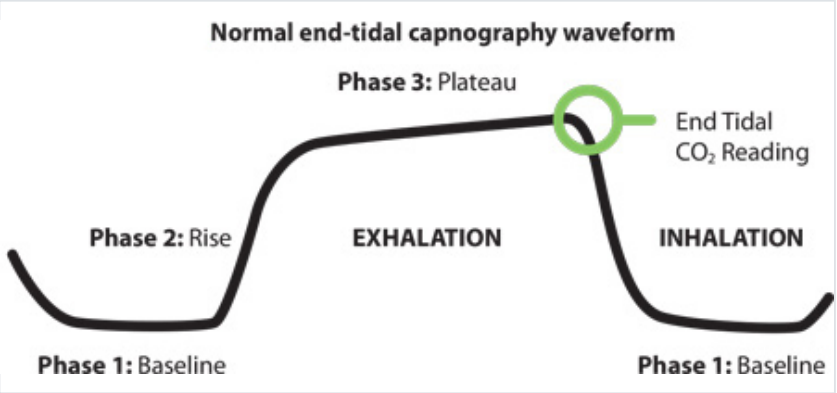


Figure 4: Capnography waveform indicating proper tube placement
Image courtesy Bob Page

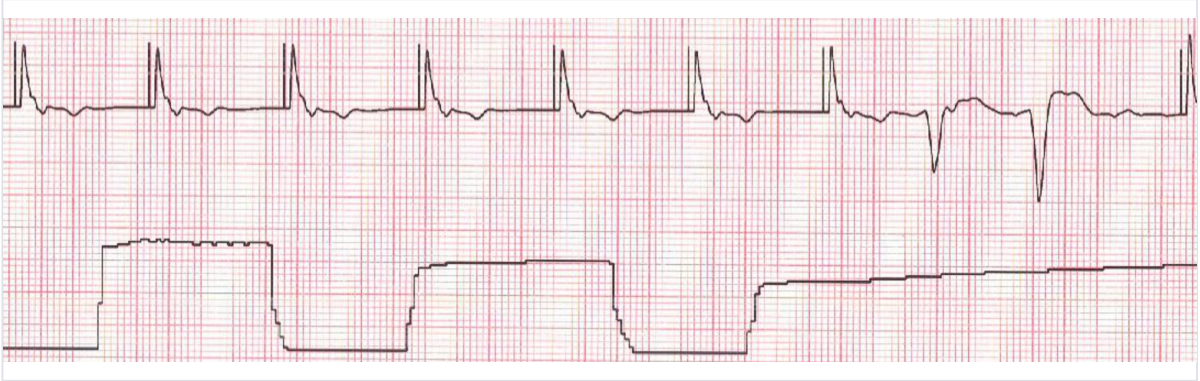
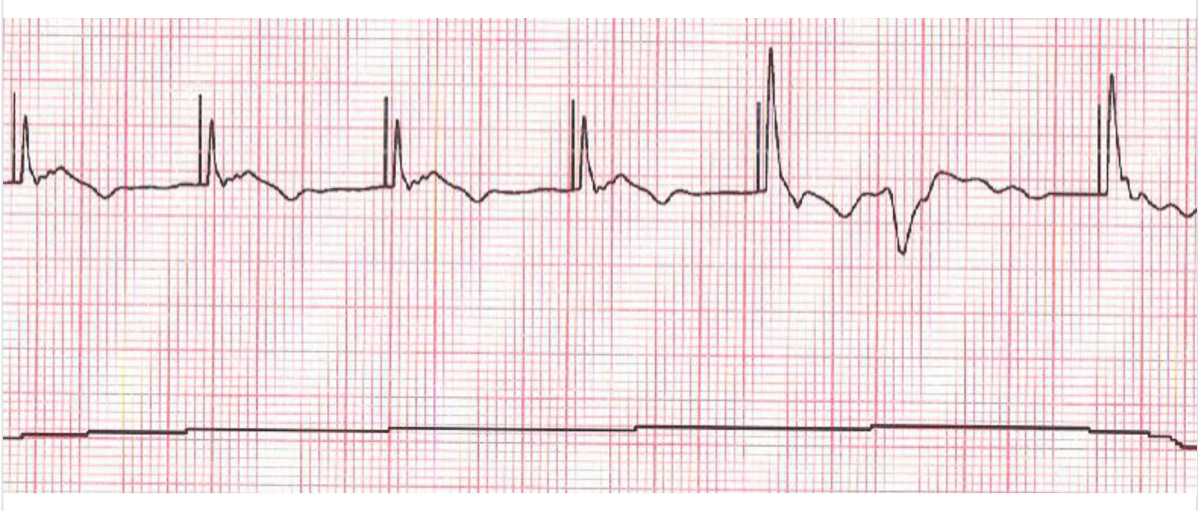


Figure 5: Capnography flat line indicating improper tube placement
Image courtesy Bob Page



Capnography is used for respiratory monitoring in the same way that ECGs are used for cardiac monitoring. It is the 12-lead of the lungs. *Waveforms are good … flat lines are bad!*

Much as with colorimetric devices, false-positive results can occur after the recent consumption of carbonated beverages (including beer) or common over-the-counter antacids. However, if the tube is correctly placed in the trachea, after just a few breaths, the waveform should continue indicating true positive results versus the waveform flattening if the tube is misplaced. False-negative results can occur in cardiac arrest states, low pulmonary blood flow states due to pulmonary emboli, or in the case of a large alveolar dead space condition.

To avoid this type of error, in cases where low perfusion is suspected or known, you may need to adjust your machine's $EtCO_2$ scaling down to 0–20 mmHg from the common default setting of 0–50 mmHg. Reducing the scale's range will increase the visibility of changes in the readings, allowing low perfusion (< 10 mmHg) conditions to show a big enough waveform to be easily recognizable.

It's important to note that during cardiac arrest resuscitation efforts, hands-only CPR won't move enough air in and out of the body to facilitate a full gas exchange, where CO_2 is emptied from alveoli and purged from the airways. Therefore, compressions and ventilations are required for endotracheal tube placement verification.

The technology that measures $EtCO_2$ needs to have a minimum sample size to assure an accurate reading and produce a waveform necessary for tube confirmation. So, with a cardiac arrest patient, you must ventilate a normal tidal volume through the tube to assure the volume necessary to read the $EtCO_2$.

Without sufficient quantities of CO_2 available during exhalation, the clinician may not see a waveform despite clinical assessment findings (e.g., symmetrical chest rise and fall, bilateral breath sounds, good compliance with your bag-valve devices, and changes in skin parameters).

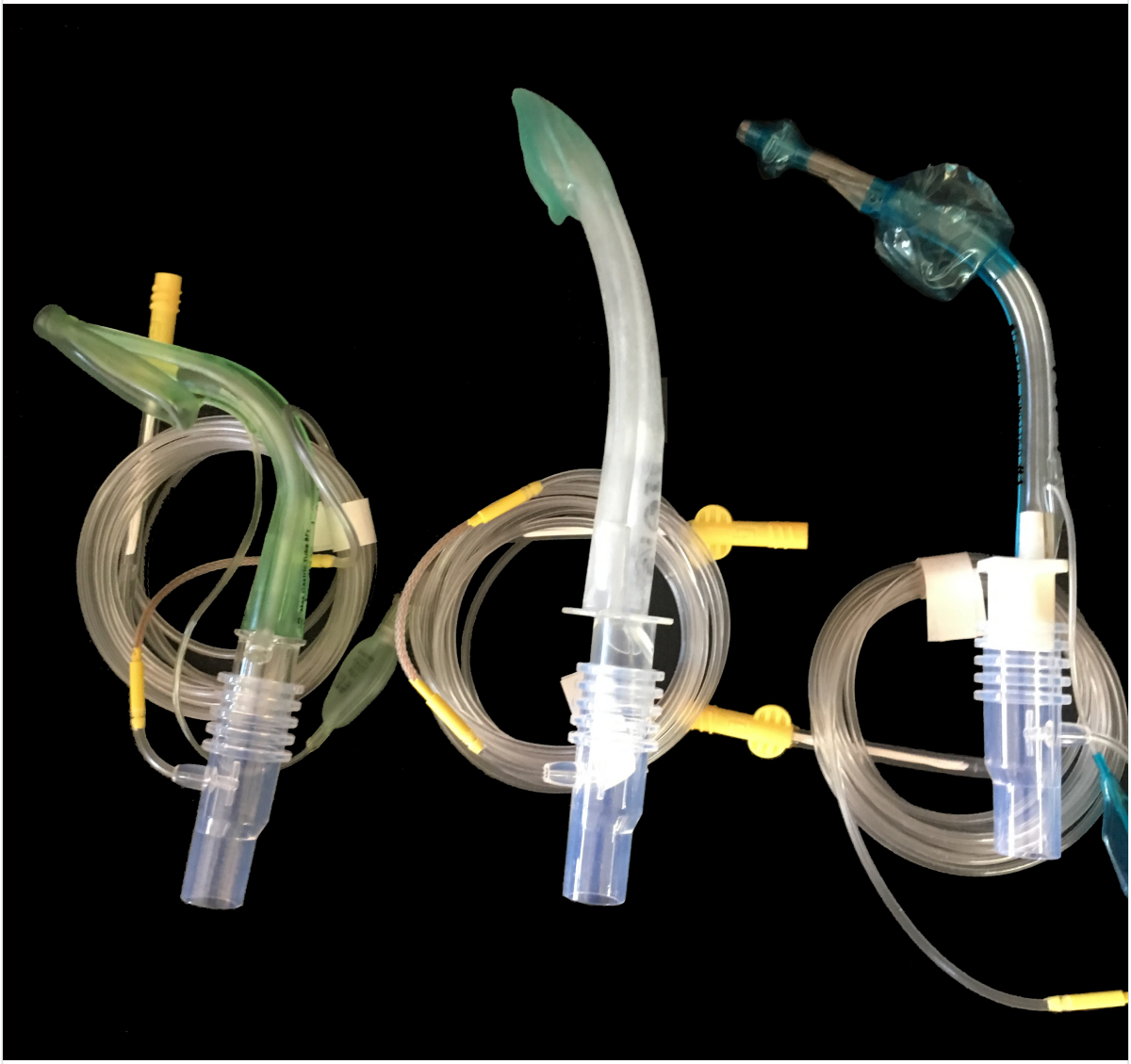
Always correlate your clinical assessment findings to the device findings and be aware of their limitations.

One final consideration is that the CO_2 detection device must match the size of the endotracheal tube or alternate airway used. Pediatric patients with endotracheal tube sizes or alternate airway devices of 4.5 mm or smaller require the use of a special neonatal-infant capnometry or capnography adaptor (or per specific manufacturer recommendations). For patients with endotracheal tubes 5.0 mm or larger, the pediatric-adult capnography device should be used.

Failure to utilize the correct size device has the potential to result in false results and tragic consequences. If you have a teeny tiny patient with a teeny tiny tube, use a teeny tiny adaptor.

Figure 6: Capnographic $EtCO_2$ adapters with backup/alternate airways

Photo courtesy Pedi-Ed-Trics



Conclusion

Ongoing confirmation of proper placement of an airway device is critical. Whether by a colorimetric device, capnometry, or, ideally, capnography, the tools should always be available and always be used. Note that there's no mention of when this confirmation should take place. That's because it's essential to ensure that the tube is in the right spot and stays in the right spot. Each time, every time, all the time!

As a healthcare provider, it's essential to know your equipment, its uses and its limitations. You're responsible for understanding not only how and why these tools work, but also how and why they might *not* work. You'll use that knowledge to guide your actions when unexpected results or situations occur. In other words, you must use your tools and trust the technology!

In part 2 of this article, we explore some real-life situations which demonstrate the medical-legal consequences when airway confirmation tools were either not used, or the technology wasn't trusted.

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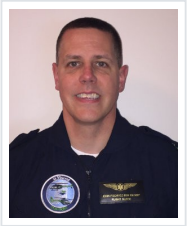

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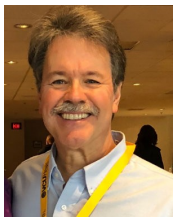

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Airway, Breathing or Consequences: Medical-Legal Consequences of Airway Mismanagement

Thu, Oct 4, 2018 | By Scott DeBoer, RN, MSN, CEN, CPEN, CCRN, CFRN, EMT-P , Michelle Webb, RN, MSN, CRNA , John Pisowicz, RN, BSN, NRP, PI , Bob Page, MEd, NRP, CCP, NCEE , Michael Seaver, RN, BA

Part 2 of a 2-part article on successful airway management and the unfortunate legal consequences patient care providers can face

In the first part of this two-part article, we reviewed the tools and technology available to help ensure proper endotracheal tube placement through the detection and evaluation of end-tidal carbon dioxide ($EtCO_2$).

The key takeaway from part one is that we need to understand, use and trust the equipment available and the information we are given. *Each time; every time; all the time*. When we lose track of that key principle, bad things happen.

As healthcare professionals, whether we work outside of hospitals, inside hospitals or between hospitals, our experience often leads us beyond direct patient care. For some, that means focusing on management responsibilities. For others, it leads to rewarding career paths in education and training. And for a few, opportunities arise to bridge professional interests and engage in the challenging work of providing expertise in medical-legal situations.

Among the more common medical-legal situations for which expert witnesses are needed are cases where airway management (or the lack thereof) has led to significant negative outcomes. As expert witnesses, we may work for the plaintiff team (representing the person harmed) or the defense team (representing the medical professionals and organizations being sued).

Avoidable or Correctable?

When dealing with airway-related medical malpractice suits, one of the first questions that must be asked is simply, was the situation avoidable or correctable? We all know that mistakes happen. (After all, we're all human.) But was the training and preparation adequate for the level of responsibility? Were all precautions taken? Was the appropriate level of monitoring (e.g., human and mechanical) applied? Was the need for corrective action recognized and taken?

Unfortunately, in many cases, the harm was preventable (as would be the subsequent lawsuit). And avoiding that harm by preventing that disastrous outcome is actually quite simple. If people used the tools available and trusted their findings, catastrophic results *could have* been avoided.

An endotracheal tube, whether starting in the nose, mouth or neck, ends up in one of two places: the esophagus or the trachea. What makes matters more challenging is that where an endotracheal tube ends up initially may not be where it remains, especially through transports and transfers.

And when good airways go bad and the situation ends up in court, the root issues tend to revolve around one of two situations: 1) not using the available tools; or 2) not trusting the technology.

This usually means that the individual or team responsible for securing and maintaining the patient's airway didn't use an $EtCO_2$ device, or they didn't believe the findings.

In the cases where the appropriate tools weren't used, this is simply unacceptable, both in practice and in court. For many years, in countries around the world**,** verification of tracheal tube placement (oral, nasal or cric) with $EtCO_2$ has been the standard of care. This applies whether the location is a hospital procedure or operating room, during an inter- or intra-facility transfer, or on prehospital calls.

And this applies not only to adults, but to children and babies as well. Failure to follow the standard of care jeopardizes patient safety and professional careers.

The other major category of airway management mishaps involve situations where the CO_2 detection devices were used, but the results weren't trusted. Although no piece of technology is absolutely accurate 100% of the time, the failure rate of $EtCO_2$ devices is remarkably low, especially when we understand the relative limitations discussed in part one of this article.

Use Your Tools

Case 1: A transport team was called for a premature infant in respiratory distress. Shortly after arrival, the team orally intubated the baby, but the baby continued to deteriorate. As just about everything bad that happens with babies starts with a respiratory problem, the deteriorating condition shouldn't have continued once the endotracheal tube was placed.

A chest X-ray was done, and documentation of breath sounds, skin color, etc., was made in the chart (after the transport, of course). However, there was no documentation of the use of any sort of $EtCO_2$ detection device.

It was determined that the transport team had colorimetric devices available to them and even had capnography available at the bedside. The nursery also had colorimetric devices available on their crash cart. The story was further complicated when the radiologist called the nursery 30 minutes later to report that the endotracheal tube was in the esophagus.

That's a report no one ever wants to hear. The baby continued to deteriorate, and despite extensive resuscitation measures, expired in the nursery. What was the core issue? Tube placement wasn't verified immediately after intubation. The team didn't use the tools available.

Case 2: An ALS EMS crew was caring for a critically ill multi-trauma patient. They elected to perform a rapid sequence intubation (RSI) on the scene. Documentation of breath sounds, vitals, skin color, etc. was made in the chart. However, what was not documented? $EtCO_2$. The patient continued to deteriorate in route and shortly after arrival in the ED, was found to be in full arrest.

The emergency physician performed video laryngoscopy to confirm the endotracheal tube placement and found the tube to be in the esophagus. It was discovered that the ALS crew had colorimetric devices available in their jump bag, but apparently didn't use an available device to verify proper initial and ongoing placement of the endotracheal tube. What was the core issue? Not using the tools.

Case 3: While on the scene of an EMS incident, a flight team performed a RSI on a critically ill, head injured patient. Immediately after intubation, the tube position was verified not only by breath sounds, skin color and vital signs, but also with a colorimetric device.

That's the good news. The patient was then manually bagged as the team made their way across a field en route to the awaiting aircraft. Upon securing the patient in the aircraft, the crew

documented breath sounds, skin color, and vital signs, and removed the EMS $EtCO_2$ detector. Shortly after liftoff, the patient deteriorated into traumatic arrest.

The crew, per their protocols, elected to extubate and reintubate in flight. Upon arrival to the trauma center, the new endotracheal tube was confirmed to be in correct position. Unfortunately, the patient expired despite extensive resuscitation efforts.

We know that endotracheal tube verification—and documentation—by way of $EtCO_2$ detection is the standard of care not only immediately after intubation, but after any major move.

Those moves might be as unusual and complex as going across a field, as involved as transferring and securing a patient into a helicopter or other transport vehicle, or as common and basic as transferring a patient from an EMS stretcher to hospital stretcher.

Most colorimetric devices are identified as being reliable for between two and 24 hours of continuous use, so the answer to the question of why the crew removed the $EtCO_2$ detector upon arrival to the aircraft is unknown; but this question definitely came into play as the case progressed.

Upon further review, it was found that the crew not only had the $EtCO_2$ detector that was used as they moved across the field, but also additional replacement colorimetric devices available in their flight jump bag.

So, what was the core issue? Not using the tools with the consistency expected.

Trust the Technology

Case 1: A team arrived at a community hospital ED to transport an intubated young child with pneumonia to a facility with a pediatric ICU. In the ED, the tube position was verified not only by breath sounds, skin color and vital signs, but also with a colorimetric device.

However, after loading the patient into the ambulance that was to drive to the helipad, the patient began to quickly deteriorate.

It was documented that the colorimetric device was no longer changing from purple to yellow, and at that point remained purple with bagging. Shortly thereafter, the patient went into full arrest.

The team then administered epinephrine, began CPR, followed PALS protocols, and continued bagging through the endotracheal tube. Since the patient clearly wasn't stable enough for transport, the transport team decided to return to the hospital ED.

Using direct visualization, the emergency department physician determined that the tube was in the esophagus and immediately replaced the endotracheal tube.

After several minutes, spontaneous circulation was obtained, but the child sustained significant hypoxic brain damage. What was the core issue? Not trusting the technology that indicated that the was no longer in place.

Case 2: A team was flying a seriously ill, intubated child, to a pediatric ICU. The team had a capnograph in use. Mid-flight, the child began to deteriorate and the capnography waveform became flat. The child then quickly deteriorated into full arrest.

For several minutes, the medical team continued to bag through the endotracheal tube, which was displaying a flat capnography reading. The team administered epinephrine, began CPR, and followed PALS protocols, but made no changes in terms of their airway management.

Eventually the flight crew notified the pilots that they need to land as soon as possible so the child could be reintubated.

After landing in a field, the team quickly replaced the endotracheal tube and, shortly thereafter, spontaneous circulation was obtained. But after being in full arrest for over 15 minutes, the child sustained significant hypoxic brain damage. What was the core issue? Not trusting the technology and reacting in a timely fashion.

Case 3: An adult patient suffered head and neck injuries as a result of a fall. There was progressive neck swelling and concerns about the patient's ability to maintain a patent airway, so intubation was attempted on scene by an ALS ground crew and flight crew.

Attempts at oral intubation were unsuccessful and a surgical cricothyroidotomy was performed prior to flight. A 6.5 mm endotracheal tube was placed in the patient. Immediately after placement, documentation of breath sounds, skin color and vital signs were documented. The capnography waveform, however, was flat. The team then changed the $EtCO_2$ adapter, but the waveform remained flat.

As the patient continued to rapidly deteriorate, the team then tried another capnography monitor.

That second capnography monitor still displayed the flat waveform. Finally, the team replaced the second monitor's $EtCO_2$ adapter, but the waveform continued to show a flat line. As the patient had now progressed into full arrest, the flight team opted to fly the patient to the nearest hospital.

Despite aggressive resuscitation measures, the patient was pronounced dead upon arrival to the ED. Autopsy findings revealed that the endotracheal tube placed via the surgical cricothyroidotomy ended up in the esophagus, and not in the trachea.

The cause of death was listed as esophageal intubation. What was the core issue? Not trusting the technology—multiple times.

Conclusion

Although practice may not make perfect, it certainly can make proficiency. And when it comes to airway management, for every tube, every time, every age, everywhere … capnographic (or at least capnometric or colorimetric) verification of proper initial and ongoing placement is the standard of care.

If being the subject of a serious medical malpractice lawsuit is among the things you strive to avoid, get in habit of using your tools and trusting the technology.

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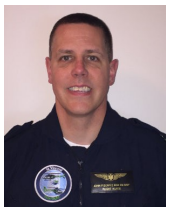

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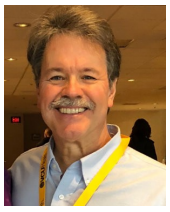

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