Boredom Interrupted: 10 Causes of Airway Complications And How to Avoid Them

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Introduction

Anesthesia is one of those professions described as long hours of boredom interrupted by moments of sheer terror. Those moments of sheer terror come when something goes horribly wrong. Often it isn’t preventable, but sometimes it is. Our job is to anticipate what can go wrong and try to prevent it.

Anesthesia providers often cannot imagine themselves causing a major complication in a patient. In an attempt to instill caution, my instructors always used to say, “If you haven’t seen a particular complication, it means you haven’t been practicing long enough.” Indeed, during my 40-year career in anesthesia, I and my colleagues have seen many complications, including some fairly rare and serious ones—enough to make me realize the importance of compulsive attention to detail to avoid their occurrence.

Ironically, my first introduction to the world of anesthesia airway complications was my own intubation! I was a third-year medical student facing intubation for a diagnostic procedure that fortunately turned out to be negative. I was intubated by a first-year anesthesia resident under supervision. When I awoke I had a scrape along the roof of my mouth, a sore throat intense enough to prevent easy swallowing, and severe hoarseness. There was also a tiny nick out of a front tooth, easy to feel but fortunately hard to see. The bad news was that my hoarseness and sore throat lasted four weeks, and ever since, whenever I get a cold, I totally lose my voice for days. The good news was that I was so fascinated by the anesthetic process that I changed career paths and applied for an anesthesia residency.

Incidence of Airway Injuries

The injuries we most often warn our patients about in preoperative interviews are airway injuries. It’s unfortunately easy in the best of times to trap a lip under the laryngoscope blade or laryngeal mask (LM) airway, or use the upper teeth as a fulcrum. Oral injuries occur in one in 20 anesthetic procedures (5%). Dental injuries occur in about 1% of anesthetic procedures, although only about 2% of those are serious enough to warrant treatment.[1,2] That sounds like a small number, but let’s do the math. Of the estimated 90 million anesthetic procedures[3] each year, 5% would yield 4.5 million oral injuries. To be sure, the vast majority of these are tiny lip cuts or slightly chipped teeth, but that’s a sobering number.

A 1999 closed claims analysis against anesthesia providers for 4,460 patients showed 6% of the claims were related to intubation-related airway injuries involving the larynx (33%), pharynx (19%), esophagus (18%), trachea (15%), temporomandibular joint (TMJ) (10%), and nose (5%). Nine of these patients died.[4] Significant airway injuries prolong hospital stay by on average one day and increase hospital costs by 20%.[5] A reported 39% of airway injuries in closed claims are due to difficult intubations.[4,6]

Factors influencing risk for airway injury include the skill of the provider, presence (or absence) of a supervisor, medical condition of the patient, emergent scenarios, out-of-OR settings, and number of intubation attempts.[6-8] Indeed, complications increase sevenfold after the second and third laryngoscopy attempts.[9]

False Sense of Security

We rightfully worry about "can't intubate–can't ventilate" scenarios as catastrophic events. But we often consider the risk for airway injuries to be minor, in the sense that most tend to heal quickly and usually without major sequelae. Indeed, since many of our patients are ambulatory and discharged quickly, we may not even know they developed a complication.

This leads to a false sense of security. Injury prevention is predicated on realizing that *we* can potentially cause harm while administering our anesthetic. If we don't recognize the areas of risk, we can't mitigate that risk. Failure to consider risk tempts us to skip steps, rush, take short cuts or fail to prepare for the unexpected.

In this article, I discuss some airway complications that I, and my colleagues, experienced that were far more serious than cut lips and chipped teeth. Some details have been changed to protect confidentiality.

Patients can die or become disabled from airway injuries. By raising your awareness of risk, you better protect your patients from harm.

1. Video Laryngoscopy: What You Don't See Can Hurt Your Patient

Case

My colleague was struggling with a difficult intubation in the ICU. The patient was profoundly hypotensive and ventilation was difficult. The patient was flat on the bed without head positioning. Direct laryngoscopy was difficult and the intubator switched to the GlideScope (Verathon). Use of the GlideScope Video Laryngoscope (GVL) in our hospital was relatively new at the time, and our providers were still gaining experience. Intubation with the GVL took multiple prolonged attempts, but finally succeeded. Oxygen saturation rose to 94%.

An hour later, as the patient's blood pressure responded to vasopressors and volume, my colleague was called back to the ICU to investigate the source of significant bleeding from the posterior pharynx. Examination revealed that the endotracheal tube had perforated and was passing through the right posterior tonsillar pillar on its path into the trachea.

A head and neck surgeon was consulted and the patient was brought to the operating room for controlled reintubation and repair of the injury.

Discussion

Video laryngoscopy has revolutionized the approach to difficult intubation, but instruments like the GVL are not immune to causing injury. The unique injuries with video laryngoscopy are typically associated with focusing on the beautiful image of the larynx on the monitor rather than looking at the patient.

In this case, the anesthesiologist was using the useful but very rigid GVL stylet. The most likely cause of injury was blind insertion of the styletted endotracheal tube (ETT) into a taut tonsillar pillar. The anesthesiologist was looking at the monitor, not at the patient while

Figure 1.

A stiff GVL stylet can easily cause lacerations. A little more force and this laceration could have become a perforation. Use stylets gently.

All images courtesy of the author unless otherwise noted.

Table 1. Common Causes for Failing to Optimize Position Prior to Intubation

Lack of experience	"I'm still learning how to master that technique."
Crisis situation	"I don't have time to waste in an emergency."
Lack of equipment	"I don't have anything to put under the head."
Time pressure	"I have to hurry up and finish."
Distraction	"I forgot to position the patient."
False sense of security	"I've skipped positioning before and it worked."

inserting the ETT into the pharynx. Injury to the tonsillar pillars and soft palates has previously been reported in the literature.[10-12]

This sounds ironic, but watch what you're doing when intubating with a video laryngoscope.[13] There is a strong temptation to just look at the monitor while you're inserting both the blade and the ETT. Always insert the GVL midline into the mouth while looking at the patient until its tip has passed the palate. You should glance up at the monitor as you're doing this, but this is like glancing in the side view mirror of your car as you're preparing to change lanes. You don't want to take your eyes off the road or you'll crash.

Only after the tip of the ETT has turned the corner into the pharynx should you look at the monitor. Otherwise you can injure teeth, lips, tongue and pharyngeal structures. Manipulate the tip of the tube through the glottis. Then pause to withdraw the stylet 2 to 3 cm to effectively soften the tip of the ETT. Advance the ETT into the trachea while looking at the monitor.

Remove the GVL looking at the patient, not the monitor.

The GVL stylets are extremely stiff. Intubators like that feature because it will not straighten when redirecting the ETT toward the larynx. But that rigidity makes it more capable of potential harm, such as this pharyngeal laceration in another patient (Figure 1). Be gentle.

Avoid Using Suboptimal Technique

This case is a good example of an injury caused by using suboptimal technique. By "suboptimal technique" I mean failing to take all of the steps that would make that technique safer for the patient. Anesthesia providers do not intentionally use suboptimal technique, but it is not uncommon. For example, it's very common to fail to optimally position a patient for intubation. Table 1 shows common reasons why.

It's easy to fall victim to any of these pitfalls. Practice technique with new or occasionally used devices on routine patients, so that you are ready during emergencies. Be mindful in your actions. If you don't have what you need, then ask someone to bring it to you. If it feels like you're rushing or skipping a step, you probably are.

2. Stylets and Cuffs Can Rupture Tracheas

Case

The first-year resident was intubating with a colleague. The patient was a healthy 30-year-old scheduled for a minor procedure. The ETT came preloaded from the factory with a fairly firm metal stylet that was coated in a thin layer of plastic.

Neither the resident nor his supervisor had noticed that for this particular ETT, the tip of the stylet extended beyond the distal opening of the tube. After what seemed like an uneventful intubation, the patient developed progressively higher peak airway pressures and subcutaneous emphysema. Secretions suctioned from the ETT were blood tinged. A chest x-ray at the end of the procedure showed a left-sided pneumothorax, plus subcutaneous and mediastinal emphysema.

Bronchoscopy showed a laceration in the anterior tracheal wall. The patient required insertion of a tracheal stent, followed by repair. He recovered. Subsequent close inspection of the available preloaded stylets showed that the stylet tip often extended just a bit beyond the end of the ETT.

Case

During a difficult intubation in the ICU, one of my colleagues inserted a bougie to assist with passage of the ETT. As he slowly advanced the tube over the bougie, one of the nurses assisting him suddenly pushed the bougie in deeper in an attempt to help. Unfortunately the tip of the bougie was pushed deep enough and hard enough to penetrate the carina. Both lungs instantly collapsed and the patient went into cardiogenic shock. Emergent placement of Thora-Vents (UreSil) into both chest cavities quickly improved blood pressure and stabilized the patient.

Discussion

Novice intubators are warned from their first days of training about the risk for tracheal injury. We are told to avoid both allowing the stylet to extend beyond the tip of the ETT and overinflating the ETT cuff. Tracheal rupture is rare and usually associated with trauma. However, it has been reported as an intubation complication, with an incidence of 0.005%.[14,15] Doing the math based on an estimated 50 million worldwide intubations[16] would equate to 250 intubation-related tracheal ruptures worldwide per year.

Stylets tend to injure the anterior, cartilaginous wall of the trachea, because the stylet is typically curved anteriorly into a hockey stick shape. Overinflation tends to injure the posterior membranous wall, where the tissue is more vulnerable to stretching and tearing.[14]

Predispositions to tracheal rupture include many potential risk factors (Table 2).[17] Because it's rare, you must have a high index of suspicion to diagnose it. Unexplained dyspnea, hemoptysis, subcutaneous or mediastinal emphysema, pneumothorax or pneumoperitoneum can occur. Controlled ventilation can worsen any of these conditions by increasing the leak.[14,18] Treatment for minor injuries may be supportive but it often requires surgical repair.

Be Careful With Your Stylet!

Preventing tracheal rupture depends on gentle technique and attention to detail. Not every intubation requires a stylet. To curve the ETT without a stylet, insert the tip of the tube into the adapter end of the same tube. Let it sit for a few minutes coiled into a circle. The plastic tends to retain the curve for quite a while once released (Figure 2).

When using a stylet, verify that its tip is fully inside the ETT. Stylets often come out of the package with a preformed bend at the top to help keep the stylet tip inside the tube. Unfortunately, despite this bend, the stylet may be longer than some ETTs (Figure 3). Preloaded ETTs are sometimes shipped with the stylet sticking a few millimeters out the end, which is easy to miss if you don't look. Don't assume. Check!

During intubation, withdraw the stylet 1 to 2 cm once the tip of the ETT is within the glottis, but before you advance the tube fully into the trachea. This maneuver makes the ETT tip flexible and less likely to harm the mucosa.

Don't Overpressurize the ETT Cuff

Only inflate an ETT cuff to minimum seal. This typically means adding 5 to 10 mL of air to the cuff. Inflation pressures above 20 to 25 mm Hg impair capillary blood flow and can injure mucosa.

Overinflating an ETT cuff to an excessive pressure causes sore throats.[6,19] Overinflation can also rupture tracheas.[14,15,17] You can easily inject too much air into a

Table 2. Risk Factors for Tracheal Rupture During Intubation

Female patient	**Use of rigid stylets**
Short stature	**Incorrectly sized ETTs**
Head movement	**ETT overinflation**
Vigorous coughing (while intubated)	**Overinflation of cuff by nitrous oxide absorption**
Steroid use	**Difficult airway**
Underlying connective tissue disease	**Out-of-OR setting**

ETT, endotracheal tube

Figure 2.

Coiling the ETT and inserting the tip into the adapter for a few minutes will curve it into a shape that can be used to intubate without a stylet.

ETT, endotracheal tube

Figure 3.

A stylet with a pre-bent end was taken directly from the package and inserted into a #7 ETT without modification. Note that the stylet is protruding from the tip about 2 mm.

ETT, endotracheal tube

A

B

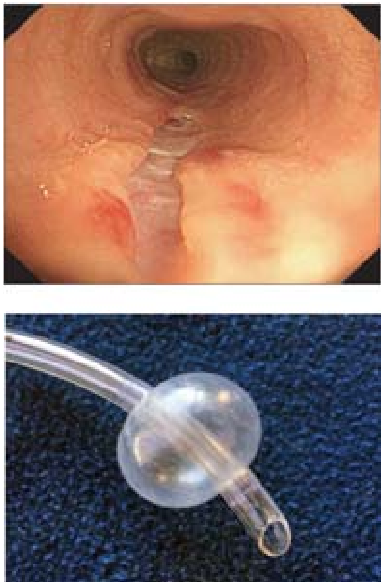

Figure 4.

A. Tracheal laceration in posterior membranous tracheal wall caused by overinflation of an ETT. In this journal case report, the cuff was inflated with 25 mL of air to a pressure over 50 mm Hg.

B. A high-volume, low-pressure cuff overinflated with 25 mL of air. Make sure your helpers know how much air to inject.

ETT, endotracheal tube

Figure 4A is reprinted with permission from *Korean Journal of Anesthesiology* (2012;62[3]:277-280).

standard high-volume low-pressure cuff. Figures 4a and b show a tracheal rupture caused by inflating an ETT cuff with 25 mL of air to a pressure over 50 mm Hg.

In my experience, my intubation helper will commonly inject all the air from the syringe that I attach to my pilot balloon before intubation—especially during an emergency. Make sure that syringe contains a safe volume of air. You can always add more air later if there isn't a good seal.

Most of the time, we don't have manometers in the OR to measure cuff pressures. If the pilot balloon feels tense, release some air. Squeezing the pilot balloon is not a very sensitive test and often underestimates the pressure in the cuff.[20] Instead, attach the barrel of a small syringe (without the plunger) to the pilot balloon (Figure 5). This opens the port on the pilot tubing and allows the pressure inside the cuff to equalize with room air pressure. If this maneuver produces a leak, simply reinject a small amount of air to restore the seal.

Use Bougies With Caution

A bougie is stiff enough to perforate the trachea, bronchi and the esophagus, and must be used with caution. A bougie passed through the bifurcation at the carina can cause a bilateral tension pneumothorax, an event that is particularly difficult to diagnose because the trachea remains midline, the heart is usually not displaced, and the breath sounds, though poor, will often be equal.

To minimize risk, only insert a bougie to mid-trachea (quickly measure the distance against the outside of the patient before you start). When possible, use one in combination with laryngoscopy under direct vision rather than as a blind stent.

Direct your helper to hold the bougie in position when you start to insert the ETT, so that it cannot inadvertently be shoved deeper along with the tube. Always be gentle. Check breath sounds and be alert for hemodynamic changes.

Bougies are not recommended for routine use in exchanging ETTs. To exchange ETTs, use a tube exchanger. It is softer and more flexible, plus the lumen is hollow and will allow insufflation or jetting of oxygen if necessary. The same caution exists for advancing a tube whose cuff is above the cords. If you must use a bougie, then take care that the bougie does not extend beyond mid-trachea.

Figure 5.

Attaching the barrel of a syringe without the plunger to a pilot balloon can quickly reduce ETT cuff pressure to ambient air pressure. Remove the barrel when done.

ETT, endotracheal tube

3. Your Devices Can Perforate the Esophagus

Case

The patient was a 50-year-old man undergoing double-lumen tube placement for thoracotomy. Intubation was difficult, requiring several attempts and resulting in two esophageal intubations. Surgery went well and the patient was extubated uneventfully. On postoperative day 2, the patient developed a fever, a severe sore throat and neck swelling. Exam showed a retropharyngeal abscess. Chest x-ray showed mediastinal widening and air. Endoscopy revealed a 2-cm tear in the posterior part of the pharynx just above the upper esophageal sphincter. The patient underwent surgery but had a complicated course that resulted in sepsis and cardiogenic shock. He died on postoperative day 5.

Discussion

Esophageal perforation has a rate of mortality reported between 6% and 34%.[21] Early diagnosis improves survival as delay in treatment often finds the patient developing mediastinitis, sepsis and cardiogenic shock.

In a series of 11 patients over 12 years, all the patients who were operated on early made an uneventful and prompt recovery.[22] Operative delay of more than 12 hours, however, or nonoperative treatment raised the mortality rate to 56%, and recovery was achieved only after long and difficult treatments.[21,22]

Esophageal perforations are typically associated with difficult intubations. They tend to occur in the regions where the esophagus is most tethered to the surrounding tissue[23]:

- upper third of the esophagus below the opening on the posterior wall,
- in the piriform sinus, and
- inferior esophagus just above the gastroesophageal junction.

Predispositions to Esophageal Perforation[21]:

- Difficult intubation, especially in emergency situations
- Excessive use of force

- Poor muscular relaxation of the patient
- Poor visualization of the appropriate anatomy
- Lack of experience
- Stylet protruding beyond the end of the ETT

Diagnosis Can Be Difficult

You must have a high index of suspicion to diagnose esophageal perforation. Investigate dysphagia with neck pain, fever and subcutaneous emphysema after intubation. Also be suspicious of unexplained sepsis in an unconscious, ventilated patient.[21] Early recognition and treatment is important to improve survival. Laryngoscopy alone may not identify an esophageal lesion. Once you have suspicion, endoscopy should be performed.

Other Esophageal Objects Also Carry Risk

Surgeons often ask anesthesia providers to insert objects into the esophagus. Examples of devices that can and have perforated esophagi include nasogastric tubes and styleted Dobhof feeding tubes. Anesthesia providers commonly insert the large, heavy and cumbersome dilating esophageal bougies for Nissen fundoplications, often with little to no training the first time they do so. One of my colleagues was recently asked to insert a DV8 Retractor (Manual Surgical Sciences) into the esophagus of a patient undergoing myocardial ablation. This stiff and curved device deviates the esophagus away from the heart to protect it from heat injury during the ablation. He had not seen the device before and admitted it. The surgeon then successfully talked him through the procedure.

It's important for all providers to know safe insertion techniques for all devices they use, whether they are anesthesia devices or not. If you don't know how to insert the device, ask.

4. Malpositioned Airway Devices Can Cause Ischemia

Case

The patient, an otherwise healthy 41-year-old man, had undergone cervical spine decompression for a tumor two days before. He had been positioned in the prone, head flexed position in tongs during a surgery that had lasted about seven hours. Two liters of crystalloids had been given and blood loss was less than 200 mL. Neurostimulation was used to monitor spinal cord function during the case. Two large, soft bite blocks made of rolled gauze had been placed prior to prone positioning to prevent the patient from chewing the tongue or mouth when stimulated.

Surgery was successful and the patient was extubated at the end of the case neurologically intact. At extubation, the anesthesia team noted that the tongue looked swollen and the ETT had left an imprint over the back of the tongue.

On postoperative day 2, as the anesthesiologist on call, I was asked by ICU staff to evaluate the patient's tongue pain. They had not consulted anesthesia earlier because they assumed it was normal to have a sore mouth after intubation.

On exam, almost the entire right side of the tongue was a pale, grayish brown color. The tongue was very firm, and markedly edematous with an ulceration. The patient had very slurred speech and poor motor control of his tongue. Without ever having seen a case before, I recognized tongue necrosis. This photo of tongue necrosis in Figure 6 is similar to this case.

In retrospect, the ETT had been tightly taped to the right corner of the mouth with the cuff anchoring it securely in the trachea. We speculated that the large bite blocks had forced the tube off-center over the back of the tongue. Flexing the head forward while prone had put the tube under tension. This effectively placed a tourniquet over the base of the tongue and cut off its arterial blood supply. It also blocked the lingual vein, causing edema and increasing ischemic compression of the artery.

Diagnosis, and therefore treatment, came late because the ICU providers assumed that the sore throat and tongue pain were a normal post-intubation discomfort and did not examine the patient closely.

The patient was treated with high-dose steroids and supportive care. During recovery, the patient experienced weight loss, dysarthria, dysphagia, decreased taste and decreased tongue sensation. Although the patient recovered, it unfortunately took more than a year to return to work.

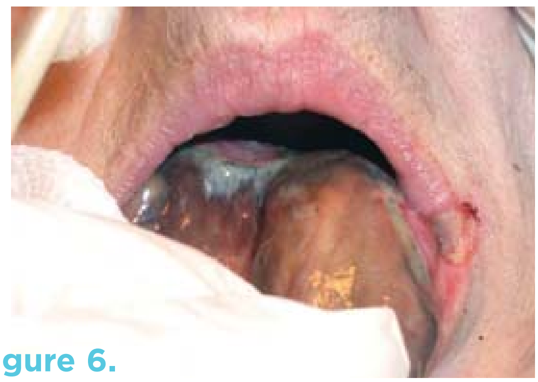

Figure 6.

Tongue showing major tissue damage and ulceration from ischemic episode. Note also the ulcer on left corner of the mouth from pressure from a tightly taped ETT.

ETT, endotracheal tube

Reprinted with permission from *Laryngoscope* (2010;120[7]: 1345-1349).

Discussion

Tongue necrosis is rare and is typically associated with vasculitis or cardiogenic shock.[24] However, any hard device in the mouth compressing the tongue, or other structures, can interrupt blood flow. This is especially true if it is used for a prolonged period of time in a patient who is predisposed to poor blood flow to the tongue.[24-28] Some of the predispositions to this injury include:

- Device-related:
  - Poorly positioned ETT/oral airways/LM airways
  - Surgical manipulations
  - Tongue retractors
  - Arterial and/or venous obstruction
- Patient condition:
  - Giant cell arteritis, coagulopathies, thrombosis
  - Poor blood flow
  - Shock
  - Swollen tongue
  - Trauma, hematoma, burn (heat/chemical)
- Surgery/anesthesia-related:
  - Elective controlled hypotensive anesthesia
  - Neck flexion
  - Prone position
  - Generous volume replacement
  - Overinflation of LM airway devices[29]
  - Use of Guedel (oropharyngeal) airway in combination with an LM airway[27]

Outcomes of Tongue Ischemia

Fortunately tongues and mucous membranes have a high capacity for healing. However, such an injury has the potential for lifelong and severe disability, including:

- tongue scarring and deformity,
- loss of tissue,
- dysphagia, leading to weight loss from impaired ability to eat,
- dysarthria, limiting ability to work and communicate,
- diminished taste, and
- decreased tongue sensation.

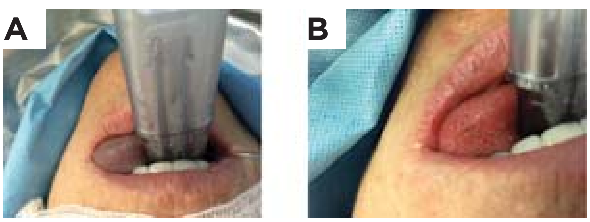

Figure 7.

A. Ischemic tongue caused by arterial compression from a malpositioned LMA Supreme.

B. Repositioning immediately restored perfusion and pink color.

As cyanosis was noted quickly, no injury occurred.

Treatment

Treatment is predominantly supportive, with high-dose steroids and antibiotics if infection develops. Even then, scarring and loss of tissue are common.

Anything that effectively decreases blood flow to the tongue can cause tongue necrosis. After seeing this case, I became somewhat obsessed with checking tongues, a habit that proved important years later with another patient.

During a routine interval face check for an orthopedic procedure, I noticed that my patient's tongue was dark blue. The inserted LMA Supreme (Teleflex) was askew and pinning the tongue to the side (Figure 7a). The device had probably slipped out of position when we had moved the patient further down the OR table for surgery 15 minutes before. Repositioning the device restored blood flow and the tongue immediately turned pink (Figure 7b). The patient recovered uneventfully. Had I been content to just watch vital signs, it's quite possible that I never would have noticed the tongue ischemia until the end of the case, after injury had potentially already occurred.

Prevent Ischemia

It's unfortunately easy for airway devices, such as ETTs, LM airways and bite blocks, to cause compression. For example, overdistention of the LM airway cuff, by filling the cuff to the manufacturer's maximum recommended cuff pressures, can generate pharyngeal mucosal pressures that exceed estimated mucosal capillary perfusion pressures.[29-33]

It isn't just the tongue at risk. The patient in Figure 8 developed uvular swelling and ulceration from LM airway compression during a minor procedure.[34-36] LM airways act like tight corks to seal the airway around the larynx.

The nasotracheal tube in the patient in Figure 9 was taped so tightly that it necrosed part of the tip of his nose.

Figure 8.

Uvular swelling and ulceration due to compression from an LM airway.

LM, laryngeal mask

It's especially important to check your devices before draping if patient position or type of surgery will prevent access to them. Perform interval rechecks of the face, eyes and oral structures, if you can:

- Pay careful attention to how your device is positioned.
- Don't let the ETT cross over the back of the tongue.
- Pay careful attention to oral airway positioning/size.

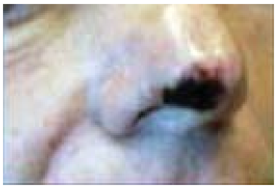

Figure 9.

Nasotracheal tubes can compress and impede blood flow to the tip of the nose if taped too tightly. When taping, make sure the tip of the nose is free from pressure.

- Avoid overinflation of LM airways.
- Avoid pressure over the tongue when prone.
- Use soft bite blocks when the patient is prone. It's too easy for a hard oral airway tip to dig into the back of the tongue. You can always place a conventional oral airway once the patient is supine again prior to extubation.
- Be careful when positioning soft bite blocks: Check what they do to ETT positioning.
- Be mindful of risk factors (e.g., shock, preexisting disease).
- Be mindful of fluid replacement when the head is dependent or when patient is prone.
- If you can see the tongue, check it periodically.
- Don't tape an ETT too tightly against the corner of the mouth or tip of the nose.

Be vigilant. Things frequently change. Unless we look, we won't notice.

5. Your ETT Can Cause Vocal Cord Paralysis

Case

The patient was a 65-year-old, 6 feet 2 inch, 175-lb man, who underwent a 4-hour resection of a maxillary sinus tumor. Oral intubation had been easily performed with a 7.0-mm ETT, taped at 21 cm at the teeth. Breath sounds were verified as equal. He was positioned during surgery with his head tilted into extension. Surgery was uneventful and he was extubated awake and breathing spontaneously.

After extubation, it was noted that he was extremely hoarse with a faint voice. He complained of mild dyspnea, although his breath sounds were clear and equal, and his oxygen saturation was 100% on room air. He had normal strength. Endoscopy was performed when his hoarseness and weak voice continued for several days. Endoscopy showed unilateral, right-sided vocal cord paralysis (Figure 10).

The patient received a course of high-dose steroids, but unfortunately his vocal cord paralysis was permanent.

Discussion

The etiology of this patient's vocal cord paralysis was assumed to be recurrent laryngeal nerve injury due to compression from an ETT cuff. Given the patient's height, an insertion depth of 21 cm would have placed the cuff close to, if not inside, the cricoid ring. In addition, extension of the patient's head during surgery would have caused the tube cuff to rise further in his trachea, possibly compressing the bottom of his vocal cords.

Figure 10.

The right vocal cord is paralyzed and is resting in a paramedian position while the left vocal cord is mobile and abducted.

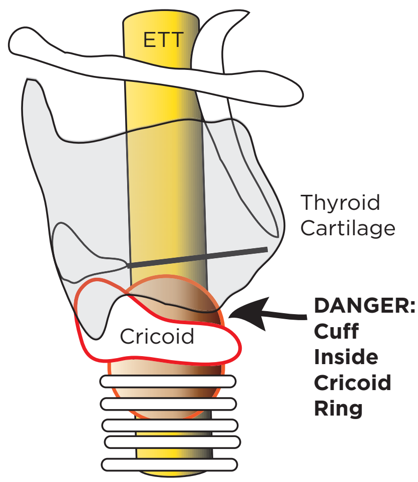

Figure 11.

Inflation of the cuff inside the cricoid ring places the recurrent laryngeal nerves at risk, risking transient or permanent vocal cord paralysis.

ETT, endotracheal tube

Vocal cord paralysis from intubation is rare, with a rate estimated between 0.033% and 0.07% of intubations. Intubation is estimated to cause 4% to 7.5% of unilateral and 9% to 25% of bilateral vocal cord paralysis.[9,37-39] It can be caused by either injury to the laryngeal joints or nerve injury. Joint damage can follow traumatic intubation, with dislocation of the crico-arytenoid or cricothyroid joints.[40]

Prevent Recurrent Laryngeal Nerve Injury

Intubation-related recurrent laryngeal nerve injuries most commonly occur when the cuff sits partially inside the rigid cricoid cartilage, causing transient, possibly permanent, vocal cord paralysis (Figure 11). Anything that places the cuff inside the cricoid ring or against the vocal cords can compress the recurrent laryngeal nerve. For example:

- Failure to insert an ETT to optimal depth (cuff inside cricoid ring)
- Use of an overly large ETT
- Cuff overdistention
- An ETT overlying the tongue on the path to the larynx (raises cuff in trachea)
- Tilting head into extension with a high ETT cuff
- Use of a pediatric tube size for adult surgical access:
  - Pediatric tubes are much shorter, so cuff likely to lie inside cricoid ring

Do not overinflate your ETT cuff. Ensure that your ETT cuff is at an appropriate depth. If a small-sized ETT must be used in an adult, consider a small-bore but longer tube such as a microlaryngoscopy tube. This tube is a longer, standard ETT that comes in smaller sizes and longer lengths.

6. Nasal Intubation: Never Force Your Tube

Case

The patient was a 25-year-old man scheduled for maxillofacial surgery on his mandible. The surgery required general anesthesia with nasal intubation. After applying a nasal vasoconstrictor, I selected a 7-mm nasal RAE ETT and inserted it into the right nostril. I was not able to pass the ETT on initial attempt. After ventilating I tried again, this time advancing the tube with a reasonable amount of twisting force until I felt a loss of resistance and the ability to thread the tube further.

I performed direct laryngoscopy with my MAC 4 blade and was rewarded with a grade 1 view of the larynx, but there was no ETT in sight. Puzzled, and assuming I simply had not advanced the tube far enough, I slid the tube in further. Immediately I spotted a moving bulge behind the posterior pharyngeal wall. My ETT was dissecting submucosally.

I alerted the surgeon and slowly removed the nasal ETT, expecting a significant nosebleed to follow. Thankfully it did not. However, since surgery would have required the patient's jaw to be wired shut, we felt the risk of continuing in the face of potential epistaxis was too great. We canceled the case. The patient recovered from anesthesia quickly, did not suffer any bleeding or infection from the mishap, and was rescheduled two weeks later.

Case

The oral surgeon had requested a nasal intubation in our 70-year-old patient for excision of the majority of her badly decayed and broken teeth. Her past medical history was positive for hypertension, coronary artery disease and significant bilateral carotid stenosis.

My resident was having trouble passing the nasal ETT. There was a crunching sound and he was rewarded with a spectacular nosebleed that would not quit. We removed the nasal tube and applied pressure, to no avail. Afraid that our patient might aspirate blood, we orally intubated her and called for a stat head and neck surgery consult. The head and neck surgeon found that the left lower turbinate had been avulsed by intubation trauma. After quick surgical intervention, and 1 unit of transfused blood later, we successfully extubated our patient. She remained overnight for observation. Fortunately, despite her multiple cardiovascular risk factors, she suffered no further harm.

Discussion

Nasotracheal intubation is a helpful technique that allows surgeons a clear approach to the oral cavity. But it must be done gently and with attention to nasal anatomy to avoid complications. The incidence of nosebleed in these cases has been reported as 29% to 96% and can occur from soft tissue injury, lacerations and tears. Usually nosebleeds are minor and self-limiting, but occasionally, as in this case, bleeding can potentially be life-threatening.

If a significant injury occurs:

- remove the nasotracheal tube when safe to do so,
- reintubate by an alternate route,
- watch for hemorrhage and consider hematoma formation,
- consult with a head and neck surgeon,
- consider use of steroids and broad-spectrum antibiotics,
- ensure follow-up for long-term complications, and
- insertion of a Foley catheter and inflation of the balloon can be used to tamponade bleeding.

In addition to epistaxis, nasal intubation can cause other serious complications (Table 3).

Understand Anatomy to Prevent Nasal Injury

To perform a nasal intubation, it's important to remember that the passage from the nares to the posterior opening into the pharynx is horizontal. It runs parallel to the hard palate that forms the floor of the nose. It's a novice mistake to think that the passageway follows the septum upward. Attempts to introduce the nasal ETT upward will be met by failure and bleeding (Figure 12).

The medial wall, or septum, is smooth. However, it may be deviated and therefore one nasal passage may be larger than the opposite passage. The patient can often tell you which side they can breathe through the easiest. You can also pinch off each nostril in turn and feel comparative airflow.

It's very important to remember that the lateral wall is not smooth, but is covered by three downward-facing, scroll-shaped shelves covered by thick mucosa called turbinates (or conchae; Figure 13). The inferior turbinate is easily seen on nasal exam. These turbinates fill the nasal passage and act as potential obstructions to passing nasotracheal tubes, nasal airways and nasogastric tubes. Inserting a nasotracheal tube, or any nasal device, requires negotiating the passage between turbinates.

Check Past Medical History

Does the patient have a history of epistaxis? Is there a history of prior cleft lip/palate repair, pharyngoplasty, or nasal trauma or surgery? You will want to avoid any potential areas of bleeding and scar tissue, if possible.

Prepare the Nose

Maximize the size of the nasal passage and minimize the risk for bleeding by using a nasal vasoconstrictor such as oxymetazolone or phenylephrine. If using cocaine, monitor hemodynamic effects.

By gently passing progressively larger, well-lubricated nasal airways you will both lubricate and test the passage for size and obstructions.

Tips for Introducing the Nasal ETT Without Aids

The first place the ETT may encounter resistance is passing the turbinates. Warming the tube in hot water makes it softer and more pliable, although that also tends to straighten out any preformed curve. Coat the outside of the tube tip with water-soluble lubricant. Aim the bevel facing outward. This orientation allows it to slide along the septum and makes it less likely to tear mucosa or damage a turbinate.

If you can't pass the tube easily, and gentle twisting of the tube doesn't solve the problem, then switch to a smaller tube or try the other nostril. Don't force it!

The second place the tube usually hangs up is making the turn into the posterior pharynx. When the head is in a neutral position, the tube exits the back of the nose at right angles to the posterior pharyngeal wall. It tends to dig in and can damage or tear mucosa. Instead, tilt the head back as you advance. The tube tip will now hit the posterior wall at an angle and will tend to slide off (Figure 14).[41]

Table 3. Complications of Nasal Intubation

Hemorrhage	**Septal trauma**
Hematoma/abscess	**Turbinate fracture or avulsion**
Traumatic nasal polypectomy	**Tonsillar trauma**
Mucosal trauma/necrosis	**Otitis/sinusitis**
Bacteremia	**Eustachian tube obstruction**
Airway obstruction	**Retropharyngeal dissection**
Subcutaneous emphysema	**Intracranial placement (basilar skull fracture)**

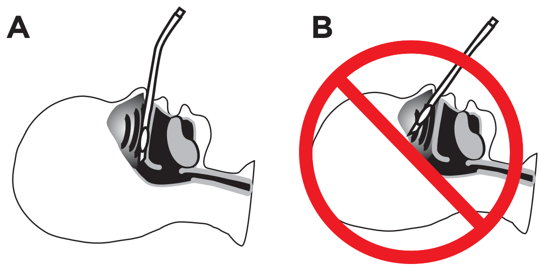

Figure 12.

A. Thread the nasotracheal tube along the floor of the nose.

B. Never thread it toward the frontal sinus.

Note that the illustration is drawn without the septum to show the tube passing into the left side of the nose. The turbinates are seen on the left lateral wall of the nose behind the tube.

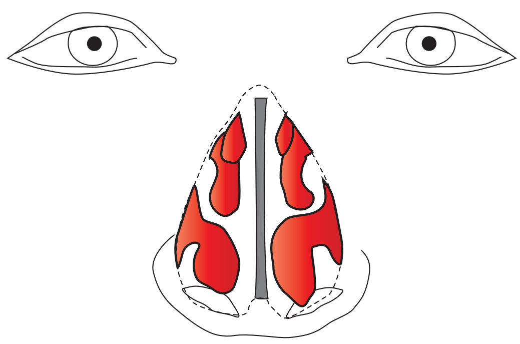

Figure 13.

It is important to remember that the nasal turbinates (red) extend from the lateral nasal walls. Any device passed through the nose must negotiate the twists and turns between them.

Trick: Attach a Red Rubber Robinson Catheter

An even better way to avoid injury is to use a Red Rubber Robinson catheter to shield the tip and act as a guide.[42,43] Insert the beveled tip of the nasotracheal tube into the flange of the red rubber catheter (Figure 15). It must be inserted firmly enough to remain attached while inserting the tube through the nose, but not so tight that you can't detach it. You must remove this catheter before advancing the tube into the trachea.

Lubricate the Robinson catheter and insert it into the nares along the floor of the nose while looking inside the mouth. Grab the catheter with a Magill forceps when you see it. Advance the nasotracheal tube along the floor of the nose until its tip is in the posterior pharynx. Now detach the red rubber catheter, remove it from the mouth, and continue with the intubation.

Nasotracheal Intubation Using Video Laryngoscopy Made Easier

Sometimes a patient with a known challenging airway also needs a nasal intubation. Routine nasotracheal intubation depends on visualizing the ETT in the posterior pharynx, and then directing it into the trachea using a Magill forceps to guide the tip into the larynx. Routine nasal intubation is difficult when intubating using a device like the GlideScope for two reasons:

1. You are no longer working with a direct line of sight, but a curved passage.
2. There may not be room to maneuver the GlideScope, the ETT and the Magill forceps.

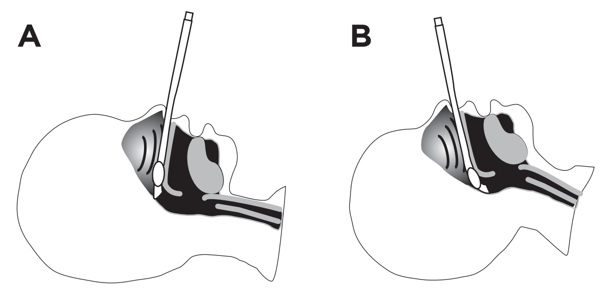

Figure 14.

A. When the head is neutral during nasal intubation, the ETT bevel hits the posterior pharyngeal wall at 90 degrees, possibly preventing its turn toward the trachea.

B. Tilting the head into extension decreases the angle of impact and may allow it to slide downward more easily.

ETT, endotracheal tube

You can use a nasal airway and a pediatric bougie to make this a lot easier. After vasodilating the nose, insert a nasal airway.

Visualize the larynx with your GlideScope. Then advance a pediatric bougie through the nasal airway and into the pharynx while watching. The pediatric bougie is smaller bore and therefore more flexible and able to make the curve. As soon as the bougie enters the pharynx, you will usually be able to manipulate it into the glottis. Advance it halfway down the trachea and stop.

Now remove the nasal airway and thread your well-lubricated nasotracheal tube over the bougie and through the nose. The ETT will follow the path of the bougie. Be gentle as you pass the turbinates. Watch as the ETT enters the larynx. Slowly back out the bougie. As discussed earlier, bougies carry the potential risk for tracheal perforation, so be gentle.

Make Sure the ETT Cuff Is Below the Cricoid Ring

A nasal tube has to travel a longer distance from nares to mid-trachea than the path from the mouth. We often use smaller gauge tubes for nasal intubation in an attempt to minimize trauma and ensure we have chosen a tube that will pass through the nose. The problem is those smaller gauge tubes are often significantly shorter than their larger counterparts. Too short a tube can place the cuff inside or above the cricoid ring.

True nasotracheal tubes are longer than standard ETTs of the same size. There are also the microlaryngoscopy tubes that come in smaller sizes and longer lengths. If you must use a standard tube, be mindful of where your cuff sits in the trachea, as well as the pressure inside the cuff.

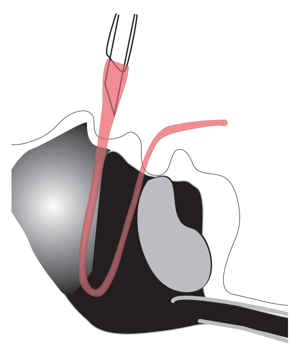

Figure 15.

Bevel of an ETT inserted into the flange of a Red Rubber Robinson catheter in preparation for nasal intubation. The catheter shields the bevel and helps protect the turbinates from trauma as the ETT is inserted into the nose. Pull the tip of the catheter out of the mouth and remove it from the ETT before completing the intubation.

ETT, endotracheal tube

7. Preexisting Medical Conditions Can Cause Unexpected Airway Abnormalities

Case

The patient was a 50-year-old man with a history of Waldenstrom macroglobulinemia who was scheduled for an urgent endoscopic retrograde cholangiopancreatography (ERCP) in the GI suite. During laryngoscopy, the anesthesiologist noted that the epiglottis was distorted, with its structure curled across the anterior portion. Since ventilation was easy, the provider called for the GlideScope for a better view. The GlideScope confirmed the epiglottis was completely disfigured and covered by a scarred mass, almost occluding the right side of the cords. Intubation was successful and the ERCP was performed.

At this point, the head and neck surgeon was called to consult regarding how to manage extubation, as well as further workup. Although the patient had been breathing asymptomatically prior to the procedure, the head and neck surgeon felt that edema from both intubation and the ERCP might compromise the airway. The patient was awakened but kept intubated. The team, after discussion with the recovered patient and the family, made the decision to transfer the patient to the OR where they performed a tracheotomy and biopsied the mass.

The mass was determined to be a neoplastic proliferation of lymphatic tissue. Chemotherapeutic management of his Waldenstrom's shrank the laryngeal lymphatic tissue and ultimately the tracheotomy was removed. The patient did well.

Case

The patient was a 55-year-old woman with a body mass index of 40 kg/m^2 scheduled for an elective gynecologic procedure. Her past medical history was remarkable for chronic relapsing polychondritis, manifested by polyarthropathy. She had poor exercise tolerance attributed to her morbid obesity and moderate asthma. The patient was induced and paralyzed for intubation. Her larynx and vocal cords were easily visible, but the anesthesia team was unable to pass the 7.0 mm ETT through the visibly small glottic opening. Multiple attempts with smaller tubes were made and they would not pass. At this point, manual ventilation with both a mask and an LM airway was attempted and failed.

An attempt at cricothyrotomy failed, as the team was unable to penetrate the tracheal wall with the cricothyrotomy kit. Severe oxygen desaturation and persistent inability to ventilate prompted the surgeon to perform a median sternotomy to cannulate the lower mainstem bronchus with an ETT. Ventilation was established.

Subsequent evaluation of the patient's airway showed that the cartilage of her tracheal rings was overgrown and thickened. Her tracheal lumen was barely several millimeters in width. This narrowed airway no doubt contributed to her diagnosis of bronchospasm and poor exercise tolerance. It was postulated that she required the negative pressure of spontaneous ventilation to maintain an open airway. Once apneic and paralyzed, her airway collapsed. Her tracheal cartilage was so thickened that it was not easily penetrable with routine rescue devices.

Unfortunately, the patient suffered hypoxic brain injury and ultimately died.

Table 4. Rare Medical Conditions With Potential Airway Abnormalities

	Disease Characteristics	Airway Manifestations
Amyloidosis	Chronic deposition of amyloid protein in various target organs of the body. This ultimately leads to organ malfunction and failure	• 0.2% to 1.2% of benign tumors of the larynx • Deposition of amyloid may occur either diffusely or in a single tumor nodule
Relapsing polychondritits	Episodic inflammation of cartilaginous structures	• 14% airway symptoms but 55% eventually have them • Mortality 10-50% if tracheobronchial tree involved • Respiratory distress by 2 mechanisms: - Airway collapse/tracheal erosion - Airway narrowing from scarring
Sarcoidosis	Chronic granulomatous disease that can effect any organ of the body	• 9% airway manifestations • 1%-5% laryngeal involvement • "Turban-like" thickening of epiglottis • Subglottic stenosis • Granulomas elsewhere in airway possible
Wegener's granulomatosis	Necrotizing granulomatosis and necrotizing vasculitis of small arteries, arterioles, capillaries, and venules	• Airway involvement: upper and lower respiratory tracts, including the larynx and trachea

Discussion

Anesthesia providers care for patients with rare chronic medical conditions all the time. However, many of us are unaware that some of those conditions can have undiagnosed airway abnormalities. Any of the conditions that involve invasion of tissues by cells, substance or inflammation, such as multiple myeloma, amyloidosis, sarcoidosis, Waldenstrom macroglobulinemia and Wegener's granulomatosis, can involve the larynx or pharynx.[44-47] The laryngeal and tracheal symptoms of systemic disorders vary from mild to severe. They include hoarseness, cough, stridor and airway compromise. The conditions can also be asymptomatic.[45,46] Several examples are shown in Table 4.

In addition, some very common medical conditions predispose the patient to increased risk for airway complications for reasons that are not well understood. Patients with diabetes, hypertension, hypotension, heart disease, kidney or liver failure, and malnutrition are much more likely to develop airway injury. It's possible that poor tissue perfusion may increase the risks for poor wound healing, necrosis or ulceration.[6,48-50] Gastroesophageal reflux, perhaps by bathing intubation trauma with pepsin, can also increase the risk for short and long-term airway complications.[51]

Being prepared for unexpected airway problems requires a high index of suspicion. If your patient has an uncommon medical condition, then check your reference sources for possible laryngeal or tracheal involvement. Consider consultation or a more extensive exam if your patient has significant unexplained voice changes or breathing problems.

Always be prepared for a difficult intubation. Also, know when to stop.

8. Oxygen Burns

Case

My colleague was anesthetizing a 55-year-old woman having a breast biopsy, using local plus deep propofol sedation. Although breathing spontaneously, the patient was essentially unresponsive. She received 6-L flows of supplemental oxygen through a green mask.

Although she was covered by a surgical drape, oxygen was able to leak onto the surgical field through gaps in the drape where it crossed her neck.

A spark from the surgeon's cautery lit the paper surgical drape on fire. The alert surgical tech immediately pulled the drape off the patient and extinguished the drape fire. What no one noticed in the resulting chaos was that the ChloraPrep (BD), which had dripped off the patient's shoulder and breast onto the sheets underneath her—and was still wet—had caught fire. Alcohol flames are nearly invisible, especially in the very bright lighting of the OR. By the time they noticed this second fire, the patient's shoulder and back had suffered third-degree burns. She required skin grafting.

ChloraPrep is a flammable, alcohol-based, antiseptic solution. Drying time on skin is three minutes. Drying time on cloth or hair can take an hour.

Discussion

Estimates suggest there are 500 to 700 OR fires each year, with more than 500 incidents that are unreported or near misses.[52,53] Fire requires three things: fuel, an ignition source and an oxidizer—three things that are abundant in our OR environment (Figure 16). Most closed claims involve OR fires that:

- occur in an outpatient setting (76%),
- involve the upper body (85%), and
- are cases managed with monitored anesthesia care (81%).[54]

Testing of draping materials shows that in an oxygen-rich environment, ignition and burn times are so fast that the ability to protect the patient from burn injury in a high fraction of inspired oxygen (FiO_2) setting is close to impossible (Table 5).[52] Therefore, prevention of OR fires is paramount.

I thankfully have not seen an airway fire myself, but I have seen sparking in the airway due to cautery use. Early in my career, in 1989, I was doing anesthesia for cleft palate repairs on a plastic surgery mission to Vietnam. The only carrier gas we had was oxygen; there was no air available on our machines. We were using uncuffed tubes in children, sealing the lower pharynx with a moist gauze pad. I suppose I am lucky that not

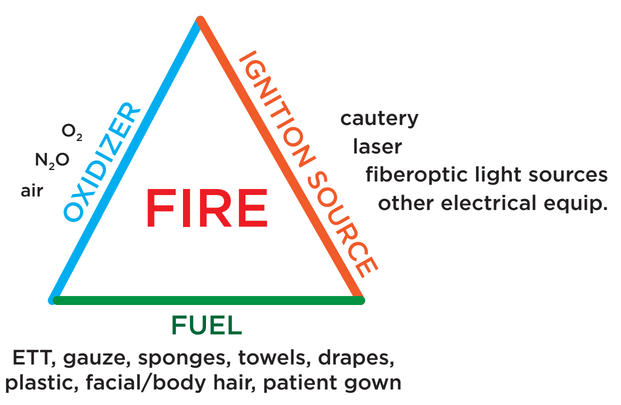

Figure 16.

Fire needs fuel, an ignition source and an oxidizer to burn, things that are common in an operating room environment.

ETT, endotracheal tube

only did we not get a major airway fire, I was too naive at the time to be alarmed by the sparks I was seeing. ETTs themselves will burn like a torch, especially in an oxygen-rich atmosphere.

It's important to remember that nitrous oxide is a potent oxidizer. Race car drivers sometimes use it to increase fuel combustion and power to their engines. Never use nitrous oxide to try to lower the FiO_2 of your gas mixture during a case at risk for fire.

OR Fire Prevention

First, identify patients at risk. In the OR, the three factors that greatly increase fire risk are:

1. surgical site or incision above the xiphoid,
2. open oxygen source (i.e., patient is receiving supplemental oxygen via face mask or nasal cannula), and
3. available ignition source (i.e., electrosurgery unit, laser or fiber-optic light source).

Many hospitals require the surgical team to identify any of the three key elements that are necessary for a fire to start before beginning any case. This discussion alerts the team and prompts them to take appropriate precautions:

- Red risk 3 = High risk. All three components of the fire triangle are present.
- Red risk 2 = Low risk with potential to convert to high risk. This score is given when the procedure is in the thoracic cavity, the ignition source is remote from an open oxygen source, the ignition source is close to a closed oxygen source, or no supplemental oxygen is used.
- Red risk 1 = Low risk. Only supplemental oxygen is being used.

Airway fires are more common in head/neck procedures including, but not limited to, tracheotomy, adenotonsillectomy, skin surgery and eye surgery. Any surgery above the xiphoid, such as the breast biopsy described above, presents higher risk.

However, fire can occur with any surgery. For example, I observed a near miss with a low-risk knee arthroscopy, using general anesthesia and an LM airway. The fiber-optic light source was detached and placed on top of the paper drape, still illuminated. Prolonged exposure to high heat caused the drape to smoke and then blacken. The alert ortho tech alerted the team and immediately bathed the area with saline from his Mayo stand. I dialed my FiO_2 to room air (21%) through the patient's LM airway as a precaution. We covered the wound, removed the drapes, checked the patient and underlying sheets for hidden fire, and then reprepped and redraped the patient. Surgery proceeded uneventfully after the close call. Fortunately he suffered no infection.

Not every patient receiving sedation requires oxygen. If they do, providing low-dose oxygen by using an oxygen blender reduces the risk. If higher oxygen concentrations are needed for surgery above the xiphoid, consider general anesthesia with either an LM airway or a cuffed ETT.

The American Society of Anesthesiologists has published an algorithm covering operating room fires.[55]

Table 5. Ignition and Burn Test Times in Varying Oxygen Concentrations

Materials	Ignition Time, s			Burn Time, s		
	in 21% O_2	in 50% O_2	in 100% O_2	in 21% O_2	in 50% O_2	in 100% O_2
Laparotomy sponge	0.9	0.3	0.1	26.6	1.9	0.8
Utility drape	No burn	0.2	0.2	No burn	3.1	1.7
Surgical gown	No burn	0.4	0.3	No burn	21.8	2
Blue OR towel	1.6	0.5	0.1	21.8	7	0.9
Surgical drape	0.7	0.8	0.3	14.0	4.9	2.4

Adapted from reference 55.

9. ETT Obstruction: Out of Sight, Out of Mind

Case

The patient, a 30-year-old woman, was lying on a gurney outside the treatment room. Although she was intubated, the patient was quite cyanotic and it was obvious my colleagues were having difficulty ventilating her. Breath sounds were barely audible and the force required to squeeze the bag was impressive.

The patient had been undergoing a septoplasty under conscious sedation combined with local anesthesia when she suddenly lost consciousness. The CRNA monitoring her had intubated immediately. My partner had already treated her for bronchospasm even though there was no audible wheezing.

Oxygen saturation was now 65% and dropping. Worse, the patient was developing a bradycardia of 40 beats per minute. Acute bradycardia in the face of hypoxia is a bad sign that often means impending cardiac arrest. There was a lot of blood in her mouth—drainage from the nasal surgery that had stopped before completion.

I flashed back to a case I had managed years before. My prior patient had suffered from acute respiratory distress syndrome and had been on the ventilator in the ICU for about a week when she suddenly developed extremely high ventilation pressures. A chest x-ray ruled out pneumothorax. Like the present case, she was intubated but we couldn't ventilate through the ETT. After I had reintubated her, we had found her ETT was filled with hardened secretions, onion-skinned around the inner surface until barely 1 mm of open channel remained.

But this patient had just been intubated minutes before. I tried suctioning down the tube and couldn't pass a catheter. The tube didn't seem kinked.

"Take out the tube and reintubate," I suggested. My partner hesitated, as well she should have. Taking out a perfectly good ETT in a patient who you think is about to arrest is not something to be done lightly.

"Take it out. I think it's plugged."

My partner grabbed her laryngoscope and, under direct vision, extubated and quickly reintubated with a new ETT. Immediately we could ventilate. Oxygen saturation rose, blood pressure and pulse normalized. The patient started to wake up.

The ETT we had removed was plugged with a large, organized blood clot (Figure 17). Apparently our patient had been silently aspirating blood during the procedure because a combination of deep sedation plus topicalization had taken away her cough reflex. The blood clot had caused obstruction and an increasing carbon dioxide (CO_2) level. An acute partial pressure of CO_2 (PCO_2) above 70 mm Hg is sedating and can lead to worsening hypoventilation, leading to an even higher PCO_2. This ultimately can result in respiratory arrest and loss of consciousness.[56]

Discussion

We were very lucky that the initial intubation forced the clot into the ETT. While it didn't help the immediate crisis, this scenario made it easy to remove the clot during tube exchange. Had the clot been below and outside the tube, blocking the carina, we might not have figured it out in time.

Imagination can play a big role in diagnosis. Failure of imagination could have easily led to a bad result. After all, the patient had been easily intubated, and the ETT was inspected and properly placed. It would have been easy to assume that the fault lay in something other than the airway. In this case, it was very helpful that I had faced a similar situation before. Every patient you care for (or learn about) adds to your "database," and provides the scientific basis for your sixth sense: intuition. Listen to it, but always have a Plan B.

Obstruction of an ETT that occurs inside the oropharynx or trachea can be hard to recognize. It's much more common to encounter difficulty ventilating due to:

- Severe bronchospasm
- Pneumothorax
- Biting down on the ETT
- Kinking of the ETT
- Pulmonary mucus plugging
- Equipment failure

It can be especially hard to accept in the midst of an airway emergency that the ETT itself is at fault. Clots obstructing ETTs are not common but have been reported.[57,58]

Removal and replacement of the obstructed ETT is the optimal treatment, but that may not always be the safest choice. Bronchoscopy, removal of clot with a Fogarty catheter, and dissolving the clot with streptokinase have all been described.[57,59,60]

Figure 17.

A large organized clot obstructing the ETT prevented ventilation. The clot adhered to the ETT during removal, clearing the airway and allowing ventilation.

ETT, endotracheal tube

10. Accidental Extubation: What Goes In Can Easily Come Out

Case

The patient, a 40-year-old man, had Ludwig's angina, a serious, potentially life-threatening cellulitis infection of the tissues of the floor of the mouth, often occurring in an adult with a dental infection. The swelling was so bad that it was hard to tell where his chin ended and his neck began. He was a big man, well over 6 feet tall and 110 kg (240 lb).

After 5 mg of diazepam, 50 mcg of fentanyl and an aerosolized lidocaine/tetracaine mixture, he was ready. We did not perform injected nerve blocks because of concern about injecting into infected tissue. We needed to be gentle to avoid rupturing an abscess into the oropharynx.

The nasal fiber-optic intubation went gratifyingly easily. The patient cooperatively took deep breaths on command as I pulled his tongue outward with a gauze pad. My resident expertly intubated him in less than two minutes.

We taped the tube. With the airway secure and the anesthetic proceeding uneventfully, I left OR 3 and went to the adjacent OR 4 to see how my other resident was doing with his case. As I walked out, the surgeons were just starting to position the patient for surgery.

It wasn't three minutes before the door burst open and a nurse yelled that they needed me stat in OR 3. Upon arrival, I saw my resident mask ventilating our Ludwig's angina patient, with the ETT on the floor. The surgeon had tripped over the anesthesia breathing circuit while turning the table and pulled the tube out.

Normally we could have awakened him and redone the awake intubation, but my resident had just paralyzed him with a long-acting agent. Rapid reversal with sugammadex (Bridion, Merck) was decades from being invented.

Instead, I inserted a lubricated nasal airway with an ETT adaptor into the left nostril, to which we attached our breathing circuit. My resident ventilated, closing the patient's mouth with his left hand while squeezing the bag with his right (Figure 18).

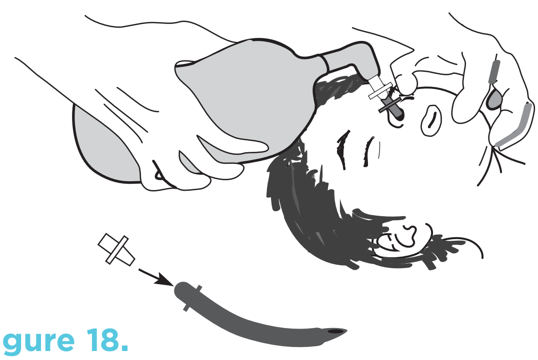

Figure 18.

You can use a nasal airway to ventilate a patient by sealing the opposite nostril and mouth while you squeeze the bag. Make sure the airway is open by lifting the chin and tilting the head as appropriate. Ensure the chest is rising as you ventilate.

In the meantime, I inserted a new ETT into the right nostril and repeated the fiber-optic visualization. With the mouth tightly closed, there was a fortuitous fold in the swollen tongue, forming an open channel in the midline leading straight to the larynx. I followed it down and reintubated the patient. We retaped the tube and this time we turned the table for the surgeon, while holding the tube securely. The rest of the case was uneventful.[61]

Case

The patient, a 66-year-old man, was prone, with his head secured in tongs, undergoing posterior cervical laminectomy. About halfway through the procedure, a large leak was noted around the ETT. Checking showed that the tape holding the ETT in position had gotten saturated with saliva draining from the patient's mouth and had released. My partner's patient had an unplanned extubation!

My partner alerted the surgical team, called for help, and asked the circulating nurse to bring the gurney into the OR in case we needed to turn the patient. However, turning the patient would require releasing the tongs and exposing the patient's neck to movement at a critical juncture.

My partner slipped an LM airway into the patient's mouth. Fortunately, ventilation was easy. The anesthesia team that responded to his call for help brought the difficult airway cart and the fiber-optic bronchoscope. Using the LM airway as a guide, he successfully reintubated the patient using the fiber-optic bronchoscope. He chose to leave the LM airway in place after intubation since he was concerned that removing the airway with the patient prone would be a greater risk than leaving it. He deflated the cuff on the LM airway to minimize pressure on the tongue and posterior pharynx. The surgeons completed the surgery and the patient was extubated supine at the conclusion of the case.

Case

The patient was a 30-year-old woman undergoing maxillofacial surgery with oral intubation. I was urgently called to the OR after the patient was accidentally extubated by the surgeon. My resident had already reintubated the patient but now could not ventilate. Oxygen saturation was 80% and dropping. My first thought was the reintubation had been esophageal.

The head and neck surgeon grabbed his laryngoscope to verify placement and said, "It looks like it's in." He was an expert in airway management so I trusted him.

I then started down a different diagnostic tree thinking severe bronchospasm or mucous plug, since breath sounds were barely audible and squeaky. There was an end-tidal CO_2 ($EtCO_2$) wave on the monitor, but it was blunted and dropping in value.

Oxygen saturation hit 50% and the pulse rate dropped to 20. $EtCO_2$ vanished. Cardiac arrest was imminent.

At this point, I grabbed the laryngoscope, did my own direct laryngoscopy and clearly saw that the ETT was esophageal. I immediately extubated and reintubated the patient. We were able to ventilate. Oxygen saturation and pulse rate quickly rose together. All the providers in the room took a collective sigh of relief.

As the dust settled, I discovered that my resident, during reintubation, had not had a good view of the larynx due to the blood and distortion in the airway from the surgery. It turned out that our surgeon, who had done the laryngoscopy to check placement, had not actually seen the ETT passing between the cords. He saw it turning the corner around the tongue in what looked like the right direction and in the crisis atmosphere of the moment had called it good.

The initial $EtCO_2$ on the monitor was deceptive. Most likely, CO_2 entered the stomach during the initial efforts to ventilate after the first unplanned extubation. Over the next few minutes, this $EtCO_2$ got washed out.

Fortunately, the patient tolerated the episode well and surgery was completed without any further complication.

Discussion

Unfortunately, unplanned extubation is a common and costly risk to your patient. Most of these extubations occur in the ICU or NICU. By one calculation using a median unplanned extubation rate of 7.3% for ICU and 18.2% for NICU patients, an estimated 120,000 ICU patient and 80,000 NICU patients suffer unplanned extubations each year.[62] Unplanned extubations in the OR are more rare, but potentially more difficult to manage if occurring intraoperatively, where factors such as prone positioning or lack of access to the airway complicate care.

Factors in unplanned extubations in the OR include inadequately securing the ETT, repositioning the patient and/or rotating the bed, lack of access to the airway during surgery, operating close to or around the ETT, and patient restlessness or agitation during emergence. Note that head extension causes the tip of the ETT to rise in the trachea, increasing the risk for accidental extubation. Young children, whose tracheas are quite short, are especially at risk.[63]

Complications from unplanned extubation can be catastrophic (Table 6).

Preventing Unplanned Extubation in the OR

Watch your feet. Every room is different. Take note of the arrangement of equipment before you begin. Make sure all your cables and ventilation hoses are either disconnected or protected when moving the patient or the OR table. Always re-verify tracheal placement after any move.

Always tape your ETTs as though your patient's life depends on it, because it does. One of my instructors used to joke that if you couldn't lift the patient's head up by the ETT without pulling it out, it wasn't taped well enough.

When the patient's face must be prepped, I find that OR nurses love to vigorously scrub ETT tape to make sure it's sterile. This loosens the tape and frees the ETT to move. In these situations, I routinely cover my ETT tape with a moisture-proof barrier such as Tegaderm (3M Medical) or a 10/10 drape to protect it. Check after the prep and before the drape.

When moving the patient, hold onto the tube where it exits the mouth. That way, if the head moves one way, your hand and the ETT will move with it—even if you're not looking. If you hold the tube near the adapter, and the head moves when you aren't looking, you may accidentally pull the tube out yourself.

Always be ready for accidental extubation with the equipment and supplies you would need for that particular patient's needs. If the patient is prone, make sure the gurney is kept outside your OR, ready in case there is an emergency requiring immediate supine flipping of the patient.

Summary

The practice of medicine is an art, based not only on knowledge and skill, but also on imagination. To be a good anesthesia provider means becoming a catastrophist. You must look at the things you do and the objects you work with and imagine all of the possible things that can go wrong. Every drug, every tool

Table 6. Complications Associated With Unplanned Extubation

Clinical Complications
Aspiration pneumonia
Brain damage
Cardiac arrest
Death
Hemodynamic instability
Hypoxemia/hypoxia
Respiratory failure
Vocal cord injury
Other Complications
Increased hospital costs
Increased hospital length of stay
Prolonged ICU length of stay

we use on a day-to-day basis can potentially hurt your patient. It is only our realization of this, and our compulsive attention to minute detail, that makes anesthesia as safe as it is today.

As you care for your patients, always take a moment to consider what you're about to do:

- Practice with your equipment before you need it.
- Know the potential complications that the equipment can cause.
- Make sure you have equipment and supplies, or ask for them.
- Check and recheck.
- Trust but verify.
- Be prepared for the unexpected and plan for failure.

Let's keep our patients safe out there.

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