



10 Rules for Approaching Difficult Intubation

Always Prepare for Failure

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We all fear the catastrophic *cannot intubate, cannot ventilate* scenario, but we often practice as though it will never happen to us.

You've heard the story: The intubation became more difficult than expected. Several attempts were made to improve visualization of the glottis and pass the endotracheal tube. The efforts failed. Ventilation became difficult and then impossible. What started as a routine procedure suddenly became a life-threatening emergency. We all know both the Difficult Airway Society's (Figure 1) and the American Society of Anesthesiologists' Difficult Airway Algorithm by heart.^{1,2} We all fear the catastrophic *cannot intubate, cannot ventilate* (CICV) scenario, but we often practice as though it will never happen to us.

My personal CICV experience occurred in the early 1990s. The case was a cesarean delivery for failure to progress in labor in an otherwise healthy but morbidly obese woman, with a body mass index (BMI) of 45 kg/m². The infant had developed a not-reassuring fetal tracing. My multiple attempts at a spinal were not successful. Our obstetrician was concerned about further delay because the infant's trace was deteriorating, and requested general anesthesia.

Without taking the time to optimally position this morbidly obese patient because I didn't anticipate problems, I induced anesthesia using a rapid sequence

essentially difficult intubation or ventilation, but remember difficult intubation or ventilation can occur at any time. You always be ready.

induction. Direct laryngoscopy with a MAC 3 blade gave me a Cormack-Lehane grade 4 view. Switching to a Miller 2, I again saw a grade 4 view. With oxygen saturation now dropping rapidly, I attempted to ventilate the patient, but couldn't. There was no anesthesia help immediately available. There was no gum elastic bougie in the operating room. The emergency airway cart with the jet ventilator was downstairs. I was terrified.

Fortunately for my patient, my hospital had just acquired the brand new (for us) laryngeal mask airway, and I had one in my cart. I had never used one clinically before. Fate was kind because it slid in without any problem and allowed easy ventilation. We delivered the infant and finished surgery using the LM airway.

Humbled by this experience, I learned a valuable lesson: Take no intubation for granted—*a/ways* prepare for failure.

Intubation is a very common and safe procedure. In 2010, there were an estimated 25 million intubations in the United States and more than 50 million worldwide.³ The fact that intubation is routine, and usually uneventful, can lull us into a false sense of security. When most of us talk to patients about the risk for intubation complications, we tend to mention minor things such as sore throat and broken teeth, not loss of the airway and brain death.

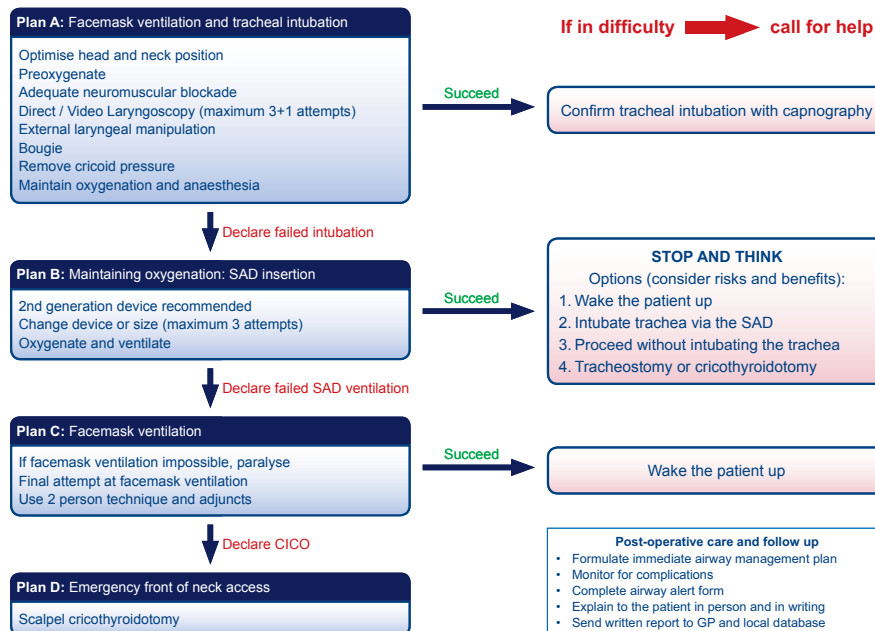
However, the relevant statistics are sobering. The incidence of difficult intubation has been reported as 0.15%.^{4,5} That sounds like a small number, but it calculates to 1.5 in 1,000 intubations, or multiplied by 25 million, would theoretically predict 37,500 occurrences per year in the United States alone. The CICV scenario is even more rare, and closed claims statistics in the United Kingdom show less than 1 in 5,000 routine general anesthetics.⁶ Emergency surgical airway (ESA) occurred in about 1 in 50,000 cases but accounted for up to 25% of anesthesia-related deaths.⁴⁻⁷ However, 1 in 5,000 would predict 5,000 CICV scenarios annually in the United States, with 500 ESAs.

Loss of the airway is one of the leading causes of injury and death in the ASA Closed Claims database. Half of the perioperative claims related to airway complications, and all of the claims in other settings involved death or brain damage.^{8,9}

Patients can be difficult to intubate because of anatomy or the circumstances surrounding the intubation. For example, failed intubations are more common in emergency room settings, prehospital settings, and delivery rooms.⁴ Emergency procedures tend to have more severe outcomes than elective ones.⁹ As intubators, we need to know how to anticipate and manage these potentially difficult intubations. How can we protect our patients?



Management of unanticipated difficult tracheal intubation in adults



This flowchart forms part of the DAS Guidelines for unanticipated difficult intubation in adults 2015 and should be used in conjunction with the text.

Figure 1.

The Difficult Airway Society's 2015 difficult intubation guidelines.

CICV, cannot intubate, cannot oxygenate; **DAS**, Difficult Airway Society; **GP**, general practitioner, **SAD**, supraglottic airway device

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1. Check Every Patient for a Potentially Difficult Airway

The ASA defines a *difficult airway* based on either ability to ventilate or ability to intubate⁹:

- *Difficult ventilation*: inability of a trained provider to maintain oxygen saturation greater than 90% using face mask ventilation and 100% oxygen, provided pre-ventilation oxygen saturation was within normal limits.
- *Difficult intubation*: need for more than 3 intubation attempts by a trained provider or attempts at intubation that last longer than 10 minutes.

Unfortunately, these definitions describe *after the fact*. Although it is sometimes true that you will be surprised by a difficult airway during intubation, usually there are warning signs. Recognizing the possibility of a difficult intubation or difficult ventilation *before* induction statistically decreases the risk for death and brain death, even if complications arise later.⁹

Unfortunately, intubators are not always diligent in performing an airway exam. Even if they are, they may not take the appropriate precautions. Closed claims reviews have shown that as much as 8% of CICV events did not have a documented airway exam, and if they did have one, the standard anesthetics were performed anyway in the face of airway risk factors.^{4,8,9}

Recognizing a patient with a potentially difficult airway is an opportunity that allows you to prepare ahead to have equipment, personnel, and a backup plan. It can help you decide between awake and asleep intubation, or to choose to use or not use muscle relaxants. It also can alert you to the fact that a patient may need to receive care in a different setting or with more experienced providers, if possible. It can help you prepare your team to assist you. Even if you plan for sedation, a spinal, or general with the use of a laryngeal mask airway, you must always be ready to intubate. I teach my students that before they start any anesthetic, they must ask themselves 2 questions: Will this patient be difficult to intubate? Will this patient be difficult to ventilate?

Will This Patient Be Difficult to Intubate?

There are 3 requirements for successful laryngoscopy. You must be able to:

1. adequately open the mouth to insert the blade and look inside;
2. align the 3 airway axes sufficiently to bring the larynx at least partially into view (ie, tilt the head back and bring the jaw forward); and
3. have enough room to shift the tongue forward, off the glottis.

Without these 3 conditions, the view during laryngoscopy is limited, and ventilation may also be challenging.

Assessment is going to be greatly affected by the clinical situation. Planned surgeries, emergency intubations in the field, codes on the clinical wards, and labor and delivery suites will all be influenced by unique complicating factors as well as time pressure.

A mnemonic to assist with rapid assessment, especially helpful in emergency circumstances, is the LEMON score (Table 1 and Figure 2).¹⁰⁻¹² The higher the score, with a maximum of 10, the more need for caution. However, don't just calculate a LEMON score without considering why those particular characteristics might make the intubation or the ventilation more difficult. Instead, use the criteria of *why* you expect difficulty to guide your planning and your actions.

Can I Ventilate This Patient?

Perhaps even more important than recognizing the patient who will be challenging to intubate is identifying the patient who will be challenging to ventilate. The frequency of difficult mask ventilation has been estimated at 5%.¹³ A review of 50,000 cases showed that impossible-to-ventilate cases occurred in 0.15% of inductions, or 1 in 690. Of those, 25% also were difficult to intubate.¹² The investigators found 5 independent predictors for impossible mask ventilation:

- radiation-related neck changes
- male sex
- sleep apnea
- Mallampati class III or IV
- presence of a beard (prevents tight mask seal)

Not all anesthesia providers routinely test for ventilation before administering a muscle relaxant because, in their experience, ventilation after muscle relaxation is almost always easier. Therefore, test ventilating first, even if it is difficult, will not change their plan, and in fact makes the apneic period longer. There is no clear evidence supporting or not whether to test ventilation.¹⁴⁻¹⁶ It is certainly worth considering the fact that if ventilation does prove impossible, then muscle relaxation arguably allows the intubator to proceed with placement of a definitive airway more quickly.¹⁷

The advent of sugammadex (Bridion, Merck) as a rapid reversal agent has made many practitioners more comfortable with this approach, because reversal of longer-acting relaxants can now occur reasonably quickly.

Currently, no definitive recommendations exist for specific management when difficulty is encountered with ventilating after induction.¹⁶ When faced with difficult ventilation, some practitioners proceed as planned; others wake the patient, if possible, and proceed with fiber-optic intubation. Some practitioners avoid muscle relaxation or skip direct laryngoscopy and immediately move to use alternate primary techniques, such as video laryngoscopy. Regardless of how you decide to proceed when faced with difficult ventilation, you must be ready to manage difficult intubation and a potential CICV scenario.

If you believe from the start, *before* induction, that ventilation will be difficult, then you need to stop and consider what you are doing. I always tell my trainees that proceeding with an induction, especially with

Table 1. LEMON Table With Reasons Why a Difficult Airway Is Expected¹²

Criterion	Score	What Makes This Difficult?
Look externally		
Facial trauma	1	Distortion of anatomy Increased potential for airway obstruction Possible bleeding into the airway
Large incisors	1	Blocks introduction of ETT May interfere with laryngoscopy, especially straight blade Risk for tooth damage
Beard or mustache	1	Harder to obtain a good mask fit; potential difficult ventilation
Large tongue	1	Shifting tongue off larynx more difficult Increased potential for airway obstruction
Evaluate 3:3:2		
Mouth opening ≤ 3 fingerbreadths	1	Difficulty introducing and manipulating laryngoscope blade and ETT Difficulty seeing anatomy around instruments and ETT
Hyoid-mentum distance ≤ 3 fingerbreadths	1	“Anterior” appearing larynx due to insufficient room to shift tongue forward off larynx
Thyroid to floor-of-mouth distance ≤ 2 fingerbreadths	1	Larynx higher in the neck: MAC blade tip pressure in the vallecula may fold epiglottis down rather than lift it
Mallampati score		
Score = 3 or 4	1	Failure to see uvula and palate predicts difficulty shifting tongue and soft tissues forward, off the glottis opening
Obstruction		
Presence of airway obstruction	1	Ventilation may be difficult Path to glottis may be hidden, blocked, or distorted
Neck mobility		
Neck mobility is decreased	1	Inability to extend the head on the neck impairs ability to bring the airway axes into alignment—no clear path to glottis. Especially difficult with straight blade

ETT, endotracheal tube; **LEMON**, Look externally, Evaluate anatomy, Mallampati, Obstruction of airway, Neck mobility

Each of the LEMON elements is worth 1 point. If the patient is unable to cooperate, the Mallampati status is not scored. Total maximum airway assessment score is 10 with Mallampati, and 9 without. The higher the score, the more likely intubation will be difficult.

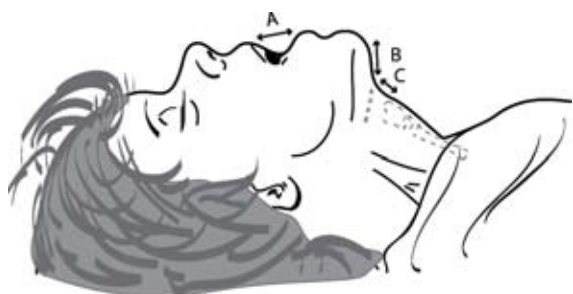


Figure 2.

The LEMON score uses measurable characteristics of the patient's anatomy to predict difficulty with intubation. **A:** Interincisor distance in fingerbreadths. **B:** Hyoid-mentum distance in fingerbreadths. **C:** Thyroid to floor-of-mouth distance in fingerbreadths.

All drawings courtesy of the author.

LEMON, Look externally, Evaluate anatomy, Mallampati, Obstruction of airway, Neck mobility



Figure 3.

This patient has a large rhinophyma, which would inhibit ventilation with bag-valve-mask. Always consider awake intubation for a patient who will be difficult to ventilate, even if the rest of the anatomy appears reassuring.

Photo: Wikimedia Commons.

long-acting muscle relaxants, is betting that patient's life that you will be able to ventilate him or her if for some reason the intubation is difficult. It's a decision that needs to be made thoughtfully.

In another of my cases, I provided care for a patient similar to the one in Figure 3. He had a large rhinophyma

but otherwise appeared to have a normal airway. My patient's nose would not fit inside even the largest ventilation mask, making it impossible to seal the mask against his face. I would not be able to ventilate him. Instead of risking a potential CICV crisis, I did an awake, sedated fiber-optic intubation.

2. Not Every Patient in Distress Needs Intubation

Case, "Acute Pulmonary Edema": As the anesthesiologist directing the OR that day, I was called emergently to the recovery room. A 60-year-old man, 5 feet 7 inches tall and weighing 350 lb (BMI, 50 kg/m²), was in extreme respiratory distress, sitting bolt upright in the bed. Blood pressure was 220/100 mm Hg, pulse was 100 beats per minute, and respiratory rate was 35 breaths per minute. Oxygen saturation was 88% on 10 L non-rebreather face mask. He was extremely anxious and on the verge of panic. He also complained of surgical pain from an abdominal incision. He had bilateral crackles halfway up his lung fields. Putting together the history, it appeared he was suffering from acute pulmonary edema from probable fluid overload. He had a round face with multiple chins, a large-circumference short neck, and was Mallampati class IV. The GlideScope (Verathon) had been used to electively intubate for surgery, but it was noted in the chart that he had been difficult to ventilate.

I called for the crash cart and a GlideScope to be brought to the bedside, but I really didn't want to induce and reintubate this patient in the recovery room. He was a potentially difficult intubation and, even more pertinent, a known difficult ventilation patient. He had a precarious hemodynamic status and might not tolerate a supine position. At this point, I was not sure if cardiac ischemia was involved; an EKG was still pending. While observing and waiting for my airway equipment, I administered sublingual nitroglycerin, 20 mg of IV furosemide (Lasix, Sanofi Aventis), and 4 mg of IV morphine for pain and anxiety, and had the patient hooked up to the recovery room BiPAP (bilevel positive airway pressure) machine.

Within minutes, the patient's clinical situation improved with oxygen saturation rising into the low 90s,

respiratory rate falling to 25, and systolic blood pressure decreasing to 170 mm Hg. His vital signs and ventilation continued to improve to the extent that by the time he was transferred to the ICU, he no longer needed BiPAP.

Discussion: When faced with a patient in severe respiratory distress, it can be very difficult to step back and not intubate. The risks of not intubating or of intubating are the same: potential loss of the airway, hypoxia, and hemodynamic stress. What circumstances demand immediate intubation?¹⁷ Questions include:

- Is there a failure to maintain or protect the airway?
- Is there a failure of oxygenation and ventilation?
- Is there a need for intubation based on the anticipated clinical course?

In this case, the patient was maintaining and protecting his airway and obeying commands. He was maintaining marginally adequate oxygenation and ventilation. He was at risk for needing intubation if his condition deteriorated, but there was a possibility that medical management might rapidly improve the situation. In this case, waiting and treating was an appropriate choice. Nevertheless, I had the emergency equipment I needed for a difficult intubation at the bedside.

In addition to the patient's condition, deciding if and when to intubate is a judgment call that should be based on the equipment and personnel resources available to manage both the intubation and any complications. The decision also must take into consideration the airway management skills and experience of the available intubators. Sometimes medical management is the safer choice.

3. Teamwork and Communication Are Essential

Case, "A Failure to Communicate": We were on a volunteer plastic surgery medical mission to Kenya, with 100 children scheduled over the next 5 days in 4 ORs, mostly cleft lips and palates. We had planned 12- to 14-hour surgical days, so the need for efficiency was great.

As anesthesia team leader, I was called to help with an intubation gone awry. The anesthesiologist had just done a mask induction to induce anesthesia in a 5-year-old patient for cleft lip without looking at the airway or the chart. When he went to intubate, he discovered that

the child had a frozen jaw from a previous temporomandibular joint (TMJ) infection. There was no way to perform direct laryngoscopy because the mouth literally could not be opened. In addition, the child had an extremely short chin, so this was obviously a difficult airway.

How did we get into this situation? The surgeon intended to operate on the TMJ as an additional procedure on this child but had not told the team, assuming we already knew (after all, it was in his chart note). I had screened all the children but had our physician's

assistant help with many of the physical exams because of the sheer number. She noted this child's inability to open the mouth in her notes but had not told me, assuming I had seen the note. The anesthesiologist doing the case, feeling time pressure, had not read the surgeon's or physician assistant's notes.

Fortunately, the child was easy to ventilate. I had previously anesthetized a very similar case on a mission to the Philippines (Figure 4). I was very experienced in blind nasal intubations in both awake and sleeping patients, including children, and felt comfortable proceeding.

I attached a nasal airway via an appropriately sized endotracheal tube (ETT) connector to the anesthesia circuit to maintain deep inhalational anesthesia. If there had been a red rubber catheter plus an insufflation hook adapter, I could have used that as well. With the child breathing spontaneously under halothane, we quickly did a blind nasal intubation through the other nostril.

Discussion: The strategy we used to ventilate and maintain anesthesia during this blind nasal intubation is a useful one to know for maintaining deep inhalational anesthesia in either an apneic or a spontaneously ventilating anesthetized patient. If you keep the mouth sealed, you can even have an assistant provide manual

ventilation through the nasal airway while you perform blind nasal intubation (Figures 5 and 6). This technique is particularly helpful during blind nasal intubation or fiber-optic intubation in young children after induction of general anesthesia for surgery.

Note that if the nasal airway tip is inserted too far, it can block entry to the glottis and interfere with passage of the ETT. If the ETT keeps bypassing the larynx, try pulling the nasal airway back slightly.¹⁸

Intubation was successful. However, the failure of my team, including myself, to communicate led us to administer this anesthetic without either a plan or preparation—a failure that could have easily caused an airway disaster.

What if I had not been experienced in this technique, or if ventilation had been challenging? It would have been entirely acceptable to abort the anesthetic, wake the patient, and return again another day. A nonemergent difficult airway is not the best time to try a new technique in a risky airway.

The key factor that makes problem solving and crisis management successful or not is teamwork and communication.

First, take stock of the situation and yourself. Even experienced intubators get excited in emergency situations, but we control our excitement and let the



Figure 4.

This 6-year-old child's jaw was frozen by a previous TMJ infection. Inability to move the jaw led to mandibular hypoplasia. His age, disability, and jaw deformity were 3 characteristics for difficult intubation.

TMJ, temporomandibular joint

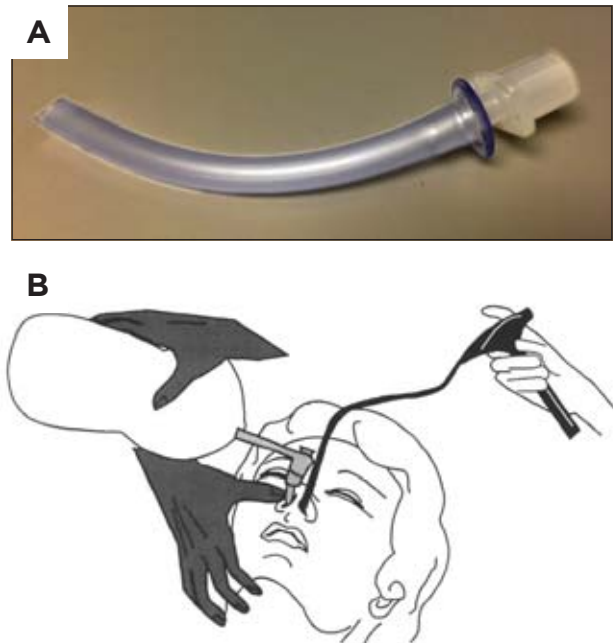


Figure 5.

A. You can use a nasal airway to insufflate the inhalational agent during a nasal intubation by connecting it to the breathing circuit with an ETT adapter.

B. You can manually ventilate an apneic patient by ensuring that any leak around both the nasal airway and the mouth is sealed.

ETT, endotracheal tube

adrenaline work for us instead of against us. Remain in control of your own sense of alarm. The leaders, which include the person in control of the airway, must stay calm. If you appear panicked, the rest of your team will follow your lead.

I teach my students that intubation is a team effort, which means it's a coordinated effort by a small group of people with a common goal. To succeed, everyone needs to know the problem and the plan, especially when you are expecting difficulty. If your helpers don't know the plan, then they either could fail to do what you need them to do or could even accidentally sabotage your efforts.

Assess the situation quickly. Consider where you are and what resources you have:

- *Is it clear to the team who the leader is?* Clear leadership allows for faster, more effective problem solving. Delegate. Doing everything yourself interferes with thoughtful problem solving.
- *Is the patient being ventilated?* Ventilation takes priority over intubation.
- *Do you have enough people to do what you need to do or are there too many people in the room causing noisy chaos?* Don't hesitate to ask for more or less help, and to demand silence so your helpers can hear your orders. You also want to be able to hear *their* suggestions, as thinking as a team in a crisis is invaluable.
- *Verbalize your thoughts* (your helpers aren't mind readers). I have noticed over the years that anesthesia providers may talk to other anesthesia providers in a crisis, but often are less skilled at keeping the surgeon, the OR nurse, and the scrub technicians informed. Don't just talk to your anesthesia colleagues (or yourself). Tell the whole team Plan A as well as Plan B. What you want to achieve is a shared mental model, with your entire team functioning with the same facts, everyone constantly updated on what is going on with the patient, and all operating on the same plan. That shared mental model also allows your team to make suggestions.

TeamSTEPPS

A shared mental model is an important part of TeamSTEPPS, or Team Strategies & Tools to Enhance Performance and Patient Safety. This approach to communication enables the creation of well-coordinated, highly effective teams. A complete review of TeamSTEPPS principles is too complicated to include here, but the key skill sets are improving communication, leadership, situation monitoring, and mutual support. Critical event training increasingly emphasizes practicing these skills on a daily basis so they are second nature in an emergency (Table 2).¹⁹

Case, "Communication the Optimal Way": I was called to the ICU to exchange an ETT in a patient with acute respiratory distress syndrome from sepsis. The patient's ETT cuff was blown and there was a significant

leak around the tube. This 75-year-old man had severe kyphosis secondary to ankylosing spondylitis and had been initially difficult to intubate because his head was tilted forward, almost touching his chest. He was ventilator dependent, requiring 20 cm H₂O of PEEP (positive end-expiratory pressure) and 100% FiO₂ (fraction of inspired oxygen) to maintain an oxygen saturation of 90%. Apnea for even a short period of time would cause severe hypoxia.

Although there was a cuff leak, we could still ventilate, so I had time to organize. My nurse anesthetist brought the difficult airway cart and the GlideScope to the ICU. I gathered my CRNA, my respiratory therapist and my two ICU nurses. I told them that I was concerned that if I lost the airway during the exchange, I might not be able to oxygenate the patient well using bag-valve-mask. Therefore, I would use a GlideScope to visualize the larynx. Once I saw the glottis, I would have my CRNA pass an ETT exchanger hooked to oxygen into the ETT. Next, I would exchange the tube under direct vision with the GlideScope. I wanted the exchanger as insurance in case of difficulty. I had the crash cart brought outside the room, knowing there was a cricothyrotomy tray in the bottom drawer if it was needed. The respiratory therapist stood by with suction. The second ICU nurse called out vital signs and oxygen saturation. I had the fiber-optic bronchoscope prepped on the difficult airway cart as a backup.

Once we started, the ETT exchange took less than a minute to execute because everyone knew the plan and their role. Did it matter that ultimately we didn't need all those precautions? No—always prepare for failure.



Figure 6.

The use of a nasal airway to insufflate the inhalational agent and/or to ventilate during a nasal intubation. Here, a blind nasal intubation is being performed, with the author listening and using the sound of breathing to direct the tube while slowly advancing it into the trachea.

Table 2. TeamSTEPPS

Barriers	
<ul style="list-style-type: none"> • Inconsistency in Team Membership • Lack of Time • Lack of Information Sharing • Hierarchy • Defensiveness • Conventional Thinking • Complacency • Varying Communication Styles • Conflict • Lack of Coordination and Followup With Coworkers • Distractions • Fatigue • Workload • Misinterpretation of Cues • Lack of Role Clarity 	
Tools and Strategies	
<p>Communication</p> <ul style="list-style-type: none"> • SBAR • Call-Out • Check-Back • Handoff <p>Leading Teams</p> <ul style="list-style-type: none"> • Brief • Huddle • Debrief 	<p>Situation Monitoring</p> <ul style="list-style-type: none"> • STEP • I'M SAFE <p>Mutual Support</p> <ul style="list-style-type: none"> • Task Assistance • Feedback • Assertive Statement • Two-Challenge Rule • CUS • DESC Script
Outcomes	
<ul style="list-style-type: none"> • Shared Mental Model • Adaptability • Team Orientation • Mutual Trust • Team Performance • Patient Safety 	

TeamSTEPPS is an approach to creating highly functional teams capable of effectively managing crisis situations. It is based on the identification and elimination of common barriers to good communication and interaction, with the goal of improving patient care outcomes.

CUS, Concerned-Uncomfortable-Safety;
DESC, Describe situation-Express concerns-Suggest alternatives-Consequences for team goal;
I'M SAFE, Illness-Medication-Stress-Alcohol and drugs-Fatigue-Eating and elimination;
SBAR, Situation-Background-Assessment-Recommendation;
STEP, Status of patient-Team members-Environment-Progress; **TeamSTEPPS**, Team Strategies & Tools to Enhance Performance and Patient Safety

4. If the Airway Looks Difficult, Consider Awake Intubation

When I was training, awake intubation for anticipated difficult airway was routine. Blind nasal intubation and fiber-optic intubation were common procedures. Primary use of instruments like the GlideScope and the McGrath video laryngoscope has revolutionized intubation of the marginal airway and made the need for awake intubation less common.

However, whenever you see a difficult airway you should at least consider awake intubation, if only to rule it out as a potentially safer approach. Providers may avoid awake intubation for a variety of reasons, including:

- concern for potential patient discomfort;
- lack of experience or skill with the technique;
- avoidance of surgeon irritation regarding potential case delay; and
- production pressure.

Awake intubation, even with minimal sedation, can be comfortable as long as the patient is properly prepared. With practice, you can intubate with the fiber-optic bronchoscope fairly quickly.

I choose awake intubation as a primary technique when my patient may:

- be difficult to ventilate;
- not tolerate induction agents or apnea; or
- have risk for neurologic injury with manipulation of the head and neck.

Patient Preparation Key to Fiber-Optic Intubation

Fiber-optic intubation is often impossible to perform in a patient with an intact gag reflex and a mouth full of saliva. You should start to prepare your patient as soon as you consider the need for the fiber-optic bronchoscope, even if it's as a potential rescue device.

Give an antisialogogue, such as glycopyrrolate, plus a nasal vasoconstrictor as soon as you consider fiber-optic intubation. Both require time to work, and additional time is required to eliminate any saliva already present. Even if fiber-optic intubation is not performed, no harm has been done by giving these medications.

Good rapport with the patient is essential. Tell the patient why you need to intubate awake, realistically what to expect, and what you will need them to do. You need their cooperation. It's the rare patient who objects after hearing safety concerns about the risks of losing the airway.

Numbing the airway is absolutely key to success. Fiber-optic intubation can potentially be performed without any sedation provided there is optimal local anesthesia.

Sedate cautiously. Unfortunately, it is very easy to sabotage an awake intubation by oversedating the patient and removing inhibitions. The now uncooperative patient forces giving more and more sedation, risking loss of the airway. It's better to rely on good airway local anesthesia than sedation. Supplementation with newer agents, such as dexmedetomidine, can provide sedation without

depressing ventilation or clouding the ability to follow commands.

Of course, you may not have time to prepare if you're using fiber-optic intubation to rescue a failed intubation. As a rescue technique, use it early before blood, secretions, or edema make visualization impossible. The

longer you wait, the more likely a fiber-optic intubation will fail.

Consider practicing with the fiber-optic bronchoscope in patients with easy airways following induction of general anesthesia. Don't wait until you need to use one in an emergency.

5. Position Is Critical

Some of the most difficult intubations can occur in normal airways but in challenging circumstances. Emergency intubations are frequently accompanied by high stress and major distractions. A lack of your usual equipment takes you out of your comfort zone, and you may not have everything you need. The patient may be in an awkward position. Time is critical and the pressure to intubate quickly is high. Take any patient with an easy airway, place him on the floor in cardiac arrest, surrounded with providers whom you don't know offering help but not knowing what you need, and that intubation will be difficult.

Optimizing the position of the patient before you start can be key. The angle of the jaw should be level with the top of the chest, with the ability to tilt the head back. In an elective OR situation, most of us rely on mounds of blankets to build a ramp that optimizes the sniffing position, which is especially crucial in the morbidly obese patient (Figure 7). However, what do you do if you've already begun the induction and then discover that the patient is not optimally positioned?

Using the OR Table to Ramp

You can, in fact, easily use the standard OR table to ramp the patient as long as the head rest is on and the patient is positioned with his back on the back section of the table (Figure 8). Raise the back section about 20 to 30 degrees and then tilt the head section back, checking to ensure the ear canal and the sternal notch are aligned.²⁰

If the patient is rotated on the OR table (ie, the patient's head is at the table's foot), you can accomplish the same effect by placing the table in reverse Trendelenburg and tilting the head back with a rolled

towel under the shoulder and head. The disadvantage of this maneuver is a greater risk for hypotension with the legs down.

The helpful aspects of using the OR table to create the ramp are that you:

- can adjust the degree of ramp easily during intubation if it's not optimal;
- don't have to remove the linen that you used to build the ramp after the patient is intubated if it interferes with surgical positioning. Removing a sizable linen ramp from underneath an anesthetized morbidly obese patient can be difficult, and strains providers' backs;

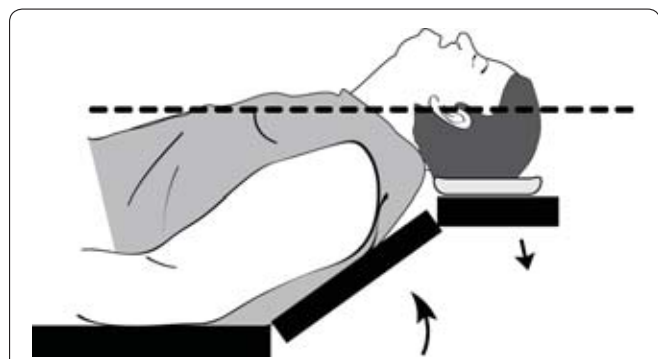


Figure 8.

Using the OR table to ramp the patient. Raise the back up about 20 to 30 degrees and then tilt the head section back to extend the neck. You can adjust this as needed during the intubation, flatten the patient for surgery, and re-ramp the patient at the end for extubation.

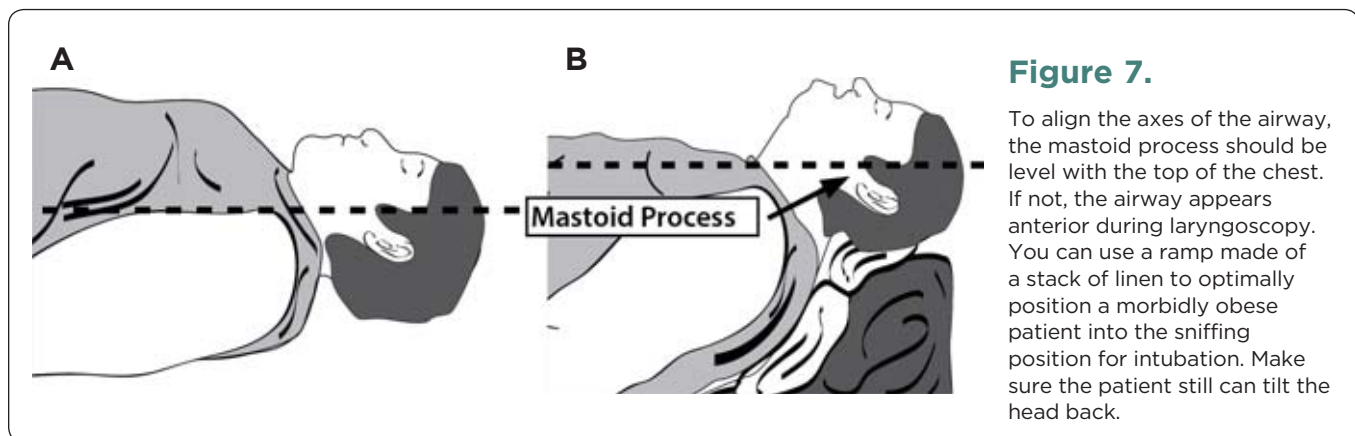


Figure 7.

To align the axes of the airway, the mastoid process should be level with the top of the chest. If not, the airway appears anterior during laryngoscopy. You can use a ramp made of a stack of linen to optimally position a morbidly obese patient into the sniffing position for intubation. Make sure the patient still can tilt the head back.

Figure 9.

Optimize the patient's position when intubating in a hospital bed. **A.** The intubator can't reach the airway easily; the headboard blocks her; and the patient's head is not in the sniffing position. Chest compressions create a moving target. **B.** These factors have been corrected, giving the intubator good mechanical advantage and a stationary target. Avoid delaying CPR for more than 10 seconds.

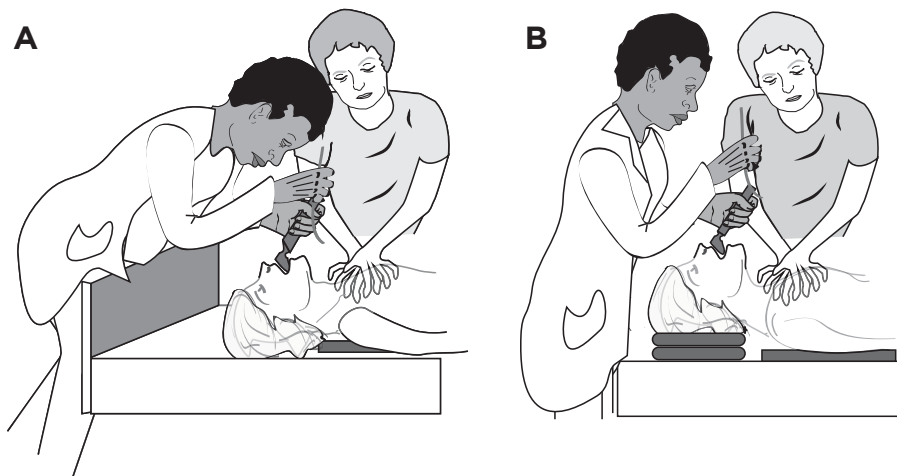


Figure 10.

When the patient is lying on the ground during intubation, you must get down to the patient's level. **A.** This position is awkward and relies solely on forearm strength to lift. The weight of the head pulls you off balance. **B.** Positioning the head between the knees and leaning back allows you to use the strength of your back and shoulders to lift. You have greater mechanical advantage.

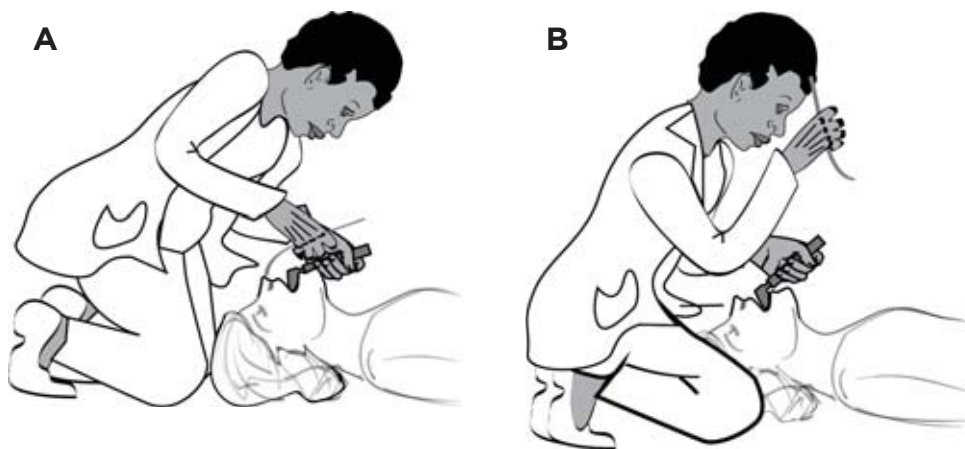


Figure 11.

As an alternative to Figure 10, sit on the ground to the right of the patient's head. By twisting slightly and leaning back, you will have decent mechanical advantage.



Figure 12.

This child has a large tongue and tense swelling from a cystic hygroma under the chin. Only an expert should attempt intubation in such a patient unless a life-threatening emergency exists.

- can put the patient back into the ramped position at the end of the case for extubation, thereby being better prepared to ventilate the patient and to reintubate should the patient fail the extubation attempt; and
- don't need a lot of linen to build a ramp.

Resuscitation on a Hospital Bed

You should try to optimize patient positioning even when out of the OR. During resuscitation, a patient in a hospital bed often is lying too far down to easily reach from the head of the bed, and often is sinking into the mattress. The headboard on the bed blocks access. If chest compressions are in progress, then the head often is hanging off the backboard and bouncing up and down, making the view of the larynx very anterior during laryngoscopy.

Don't hesitate to move the patient toward you, place folded linen under the head to obtain a sniffing position,

and remove the headboard from the bed. Those few seconds of activity can avert difficult intubation and make ventilation easier (Figure 9).²¹

Intubation on the Ground

If you must intubate a patient on the ground, put yourself at the best mechanical advantage (Figures 10 and 11).²² Kneel with the patient's head between your knees. Lean backward during direct laryngoscopy to provide yourself binocular vision and enable yourself to use the strength of your shoulders, not just your arms, to lift the head.

Alternatively, sit to the right side of the patient, with your knees bent, and twist leftward while leaning slightly backward to view the glottis (Figure 11).²³

Don't hesitate to ask helpers to move the patient, help lift or stabilize the head, pull the cheek tissue out of the way, or provide cricoid pressure. In an emergency, sometimes the basics are forgotten.

6. People, Places, and Things: Gather Your Resources

Once you have a plan for a difficult airway, and a backup plan, you need the resources to carry it out.

What Type of Help Do You Need?

As mentioned above, I consider intubation to be a team effort. When faced with a difficult airway, often I will ask one of my anesthesia colleagues, MD or CRNA, to stand by for intubation and sometimes extubation, as an extra pair of expert hands. If you think loss of the airway is a significant risk, have your surgeon present and scrubbed with a tracheostomy tray in the room.

In addition, you must set your ego aside and realistically assess whether you are the optimal person to intubate that particular patient based on your skills, your experience, and your setting. *Asking for help is a sign of strength, not weakness.*

Sometimes there is no choice, but many times you do have a choice of delaying intubation, requesting help, and even moving locations. Asking another experienced intubator to be present for a difficult airway, or even to do the intubation if specific skills are required, makes good sense. For example, this infant with cystic hygroma (Figure 12) should be intubated by or with assistance from an intubator skilled in pediatric difficult airways—not solo by an anesthesia provider who rarely provides care to children.

Should This Patient Be Intubated Here?

The obvious example typically given is the wisdom of transferring the child with airway obstruction from epiglottitis to the OR to perform intubation under controlled circumstances, instead of doing it in the emergency room.

However, there are many other patients for whom we should be asking this question:

- Should a patient with super morbid obesity, such as a BMI of 55 kg/m² and a history of sleep apnea, be intubated at the surgicenter, where rescue resources and extra hands are in short supply?
- Should we transfer the ward patient in respiratory failure who needs intubation to the ICU prior to intubation?
- Should we schedule surgery on a child with a congenital facial anomaly at the local community hospital or transfer to a children's hospital?

The answers to these types of questions require thought, planning, and established procedures.

What Equipment Do You Need?

You don't need to have every type of difficult airway equipment in the room with you. But if you think you might need something, then you and your team need to know where it is, how to get it, and how long it will take to bring it and set it up.

Equally important, ensure that you have all the spare parts you need to use that equipment. I once started a fiber-optic intubation only to find out midway that there was no connector to attach the device to suction. A jet ventilator will not help you if you lack the adapter to hook the jet up to a high-pressure oxygen source, or if you don't have what you need to puncture the cricothyroid membrane in a CICV crisis. Run the checklist through your mind during preparation.

Practice With Your Rescue Devices

You should know many alternative intubation and ventilation techniques because you never know which ones you will need. Practice with your devices during routine intubations to become proficient. Use a bougie

electively. Intubate with the LMA Fastrach (Teleflex) intubating airway on easy airways. Use the fiber-optic bronchoscope. Do you know how to use the jet ventilator safely? If you have never performed an emergent cricothyrotomy, a CICV crisis is not the time to learn. Read the instructions; watch videos on the internet; practice on a mannequin or participate in a cadaver lab if possible. Practice gives you muscle memory for when you must use the device in real life.

Create a Difficult Airway Cart

Any intubation can turn difficult unexpectedly. Having a difficult airway cart with your emergency airway equipment available in your area is a wise precaution. However, make sure your staff knows where the difficult airway cart is stored and what it looks like. Label it clearly. If it's in a locked storeroom, ensure your staff can retrieve it without you.

Make sure your staff is familiar enough with the devices that they can hand things to you and set them up if required. I have found through years of educating code teams on the nursing wards that without training,

the average nurse does not know what a bougie or a laryngeal mask airway looks like. If you are the lone intubator during a CICV scenario, you will not be able to find or assemble any complex equipment by yourself while you are also managing the airway. You are dependent on your team to assist you. Educate them *before* you need their help.

Use a Critical Event Checklist

No one can remember everything in today's complex medical world. On top of that, the stress, distractions, and sometimes chaos associated with a critical event often cause highly skilled providers to forget crucial, potentially lifesaving steps and drug dosages. Access to a critical event checklist can be lifesaving.²⁴ The aviation industry has used checklists for decades. Use of such a resource in an emergency is a wise decision, not a sign of weakness.

Many online resources are available. The current resource used by my hospital is the Crisis Event Checklist from Brigham and Women's Hospital.²⁵

7. Don't Rely on Video Laryngoscopy to Save the Day (or Your Patient)

Video laryngoscopy has had great success both as a primary device for intubation of marginal airways and as a rescue technique for difficult intubation. First-pass success with the GlideScope has been reported to be 80% to 90%, with an ultimate success rate of 98%.²⁶⁻²⁹

However, an 80% to 90% success rate implies a 10% to 20% first-pass failure rate, and a 2% ultimate failure rate. Even video laryngoscopy can fail. If you're managing one of those difficult-to-ventilate patients discussed earlier, first-pass success is critical. Patient characteristics associated with first-pass failure using video laryngoscopy include²⁸⁻³⁰:

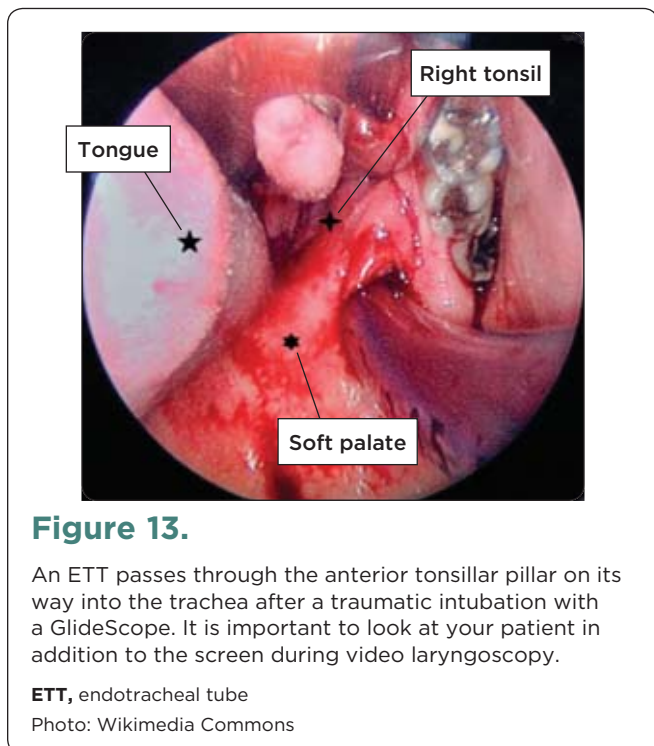
- restricted neck motion
- morbid obesity
- blood in the airway
- limited mouth opening
- airway edema
- preexisting scar
- history of radiation
- mass

The more characteristics that a patient has on this list, the greater is the potential for difficulty.

Failure of video laryngoscopy can also be related to technique. The ease of obtaining a clear view of the larynx can fool you into forgetting you still need to get alignment between the larynx and ETT. I have often seen novice GlideScope users struggle to intubate because of a few easy-to-correct technical mistakes.³¹

Look at the Patient Until the ETT Tip Appears on the Monitor

There is a strong temptation to just look at your GlideScope monitor while you're inserting the blade and the ETT, especially in an emergency. It may seem obvious, but remember to look at the patient during insertion of the ETT until its tip has passed out of view beyond the tonsillar pillars. Only after the tip of the



ETT has turned the corner into the pharynx should you look at the monitor. There are case reports of injury to teeth, lips, tongue, and other pharyngeal structures. It's possible to injure structures and pass the ETT through the tonsillar pillar and into the trachea (Figure 13).³²⁻³⁴

A More Neutral Head Position Helps

Optimizing the angle that the ETT must travel can help.³⁵ Unlike with the MAC blade, this typically means placing the head and neck in a more neutral position rather than an extreme sniffing position.

Don't Insert the Blade Too Deeply

Because of the short focal length of the camera lens, the larynx is positioned a lot closer than it appears on the monitor—just like objects in your car's rear view mirror. Placing the tip of the GlideScope blade deeply into the vallecula like a MAC blade limits the room you have to manipulate the tip of the ETT into the larynx.

Instead, place the tip of the GlideScope blade further back to allow you to see the entire larynx, leaving room to maneuver the tube and change the angle of the blade.

Don't Insert the ETT Too Posteriorly

Another common error is inserting the ETT too posteriorly, allowing the curve of the tube to drop against the back of the throat. When you look at the monitor, the tip of the ETT tends to approach the glottis from the bottom of the screen.²¹ From this position, the arc that the tube follows tends to lead toward the esophagus. The tip of the ETT then curves upward to hit the back of the arytenoids. You can see the glottis, but you just can't get the tube to enter.

Instead, pull the ETT back until you can just see its tip in the middle to right upper quadrant of your monitor. Rotating the tip forward from that position puts it in the correct plane and typically allows the tip to enter the glottis (Figure 14).

Don't Forget to Lift the Blade and Jaw Upward

Video laryngoscopy gives providers such a good view of the larynx that they can forget they sometimes still need to lift. Lifting the head and jaw upward changes the insertion arc that the ETT follows. Even if you are avoiding neck motion for cervical spine precautions, you can still lift the jaw, which will change the angle of insertion.

Ask for Cricoid Pressure

Because we usually ask for cricoid pressure when we can't see the larynx, we may forget that cricoid pressure also can help change intubation angles when we can see it. Use cricoid pressure to bring the larynx downward into the arc of the ETT curve.

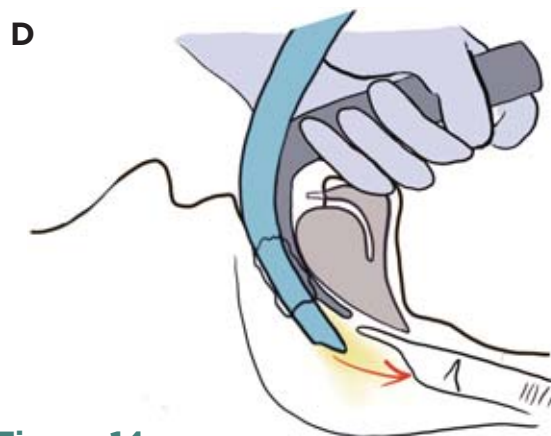
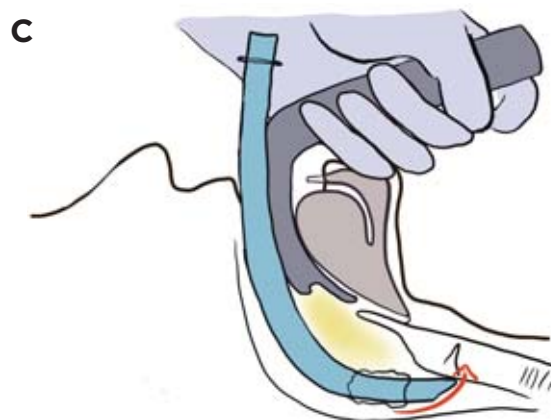


Figure 14.

If the ETT can't make the turn into the larynx, it often is inserted too deeply into the back of the pharynx.

A. The ETT appears to approach from the bottom on the monitor. **B.** Pull the tube back until it approaches from the middle to right upper quadrant of the monitor. This places the ETT tip in the correct plane to enter the larynx. **C.** Shows the ETT too deep from the side. **D.** Optimal positioning.

ETT, endotracheal tube

8. There Is No Situation So Bad That You Can't Make It Worse

Case, "An Uncomfortable Plan": I was called to assist in an OR by another anesthesiologist. My colleague was anesthetizing a morbidly obese man with a BMI of 50 kg/m². He had placed a number 4 LMA Classic (Teleflex) airway because he thought intubation might be difficult for this short, noninvasive procedure. Although he hoped to avoid intubation, he did have a GlideScope in the OR in case he needed to convert to an ETT.

Although able to ventilate through the LMA, it was difficult. The patient was breathing spontaneously but with an obstructive pattern, and tidal volumes were small. He called me because he had decided to perform intubation by passing a fiber-optic scope down the lumen of the standard LMA to cannulate the trachea (Figure 15). He would then use the fiber-optic scope as a stent to pass a size 6 Mallinckrodt Micro-laryngeal Tube (MLT) into the trachea through the LMA.³⁶ The MLT is longer than the standard size 6 ETT and therefore extends past the lumen of the classic LMA into the trachea. He wanted another skilled set of hands in case he had difficulty.

He judged this to be the safer course rather than proceeding straight to the GlideScope. He reasoned

that he had a lot of experience with this technique. He could ventilate the patient adequately, although not optimally. The blood oxygen saturation was 100%. It also allowed this patient, who he expected to be difficult to intubate, to keep breathing spontaneously.

We placed an endoscopy adapter on the LMA to allow continued ventilation while he passed the fiber-optic scope down the LMA. He cannulated the trachea with the fiber-optic scope, but then could not pass the ETT through the LMA. At this point, he decided to switch to an LMA Fastrach. I suggested using the GlideScope, but he was reluctant to move away from a technique that allowed ventilation.

So he removed the LMA Classic and placed the LMA Fastrach and tried ventilating. This time we could not ventilate well at all. He quickly removed the LMA Fastrach. Mask ventilation was difficult and saturation started to drop into the 80s. My colleague grabbed a number 5 LMA Classic and placed it, thinking the larger lumen would help pass the number 6 ETT. Once again we could ventilate, but it was harder than it had been initially. Saturation only rose to 95%. He reached for the fiber-optic scope to try the combined technique again.

At this point, I said I was uncomfortable with that plan. I said I was afraid that if we continued with this technique, we would lose the airway. I again suggested the GlideScope. If that failed, we could wake the patient and use awake intubation.

After some thought, my colleague agreed. Intubation with the GlideScope was slightly challenging due to the patient's large lingual tonsils, but we succeeded on the first pass. No doubt the presence of the lingual tonsils had made ventilation, and use of the fiber-optic scope through the LMA, difficult. The patient did well.

Discussion: This case illustrates several important points, starting with the need to have a plan to intubate with difficult airway equipment in the room when you choose to use a laryngeal mask airway in a patient with a difficult airway.

Call for Help Early

In the event of an unexpected airway problem, you will need help and equipment quickly. Ask your team to bring the video laryngoscope or the difficult airway cart as soon as you start to experience significant problems. Call for help early. Don't wait until saturation plummets. It takes time to run to your location. If it turns out you don't need the help, thank the responders and send them on their way. Minutes count in saving brain cells and lives, and it's better to be safe than sorry.

When Do You Stop If Something's Not Working?

There was nothing inherently wrong with my colleague's plan. In fact, I suspect that each member of my department might easily have come up with

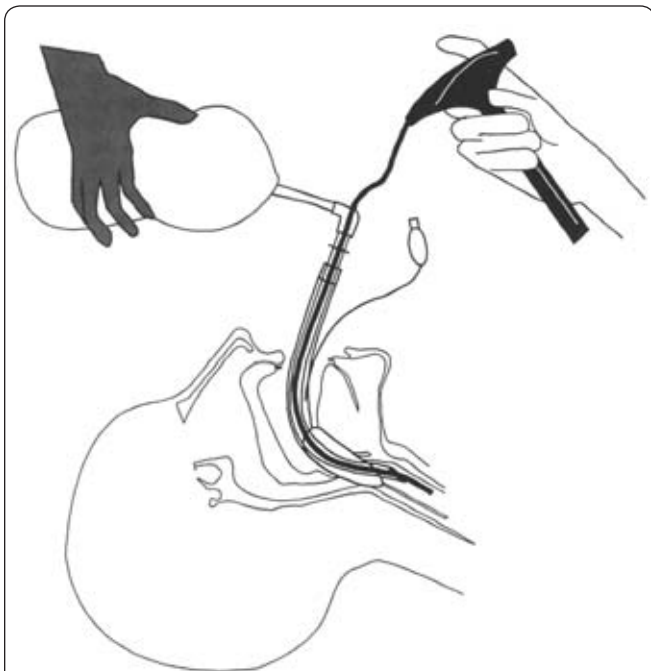


Figure 15.

Consider combining advanced intubation techniques. A fiber-optic bronchoscope, inserted into an ETT and used to identify the trachea, is passed through an LM airway. It then will be used as a stent to guide the ETT. The fiber-optic scope also can be used with the intubating LMA Fastrach (Teleflex).

ETT, endotracheal tube; LM, laryngeal mask

different plans when faced with the same patient. In one report, 9 internationally recognized airway management experts were asked to review a challenging airway case and make recommendations on how they would have proceeded. Eight different plans emerged, with several of the experts ruling out as too dangerous some of the proposed management steps that had been offered by their peers.³⁷

What is difficult to know is when to change to a different technique, or stop. Failure to recognize the potential point of no return on the way to loss of the airway can be very hard. The temptation is strong to protect your ego by proving to yourself, and your audience of staff members, that you are skilled at performing that technique. "This should work, I've done it before; I will make it work now." I've watched colleagues repeat spinal attempts at the same interspace over and over without changing anything, yet expecting success with each new needle pass. As has been said, "The definition of insanity is doing the same thing over and over again, expecting different results."

Another confounding factor in deciding to abandon a technique, or even the entire intubation attempt, is the fact that one simply is not aware of time passing in the middle of an emergency. What seems like 1 to 2 minutes can really be 10 to 15. Force yourself to keep track of the clock.

This case also illustrates the challenge in questioning another provider's decisions. In TeamSTEPPS (Table 2) there is something called the Two-Challenge Rule for when you feel there has been a potential breach of safety. The Two-Challenge Rule states that if your first verbal observation of a problem is not

acknowledged or acted upon, then you should challenge again. If the safety issue persists, then becoming more assertive is recommended. Don't curse, but use "CUS" words,¹⁹ that is:

- I am **C**oncerned about ...
- I am **U**ncomfortable because ...
- This is a **S**afety issue ...

It's very difficult to challenge anyone in authority. The airline industry recognized this prior to initiating industry-wide retraining in teamwork and communication. There were accident reports of airplanes crashing, flying into mountains and running out of fuel, because copilots and other flight personnel did not feel empowered to point out mistakes they had recognized.³⁸ The airlines realized they had a culture that showed³⁹:

- excessive deference to a leader;
- hesitation of subordinates to speak up; and
- reluctance to immediately question a clearly unusual or suspect event.

If a copilot facing personal death in an airplane crash can't question the pilot, how easy is it for a nurse, for example, to challenge a doctor?

In closed claims analyses, human error has been implicated in 80% of critical events.⁴ Human error is unavoidable. However, if we improve our skills in teamwork, leadership, and communication, we can help make those errors much less likely to occur, and much less damaging when they do.

We need the leaders in a critical event to be open to feedback and suggestions. We need to foster a clinical environment in which all of our staff feels empowered enough to speak up when they see something.

9. Don't Forget There's a Patient Attached to That Airway

Just as it's easy to lose sight of respiratory status while treating hypotension, hemorrhage, or seizures in a critically ill or injured patient, it is equally easy to lose track of the rest of the patient when dealing with an airway emergency. This is another reason why having strong teamwork and good communication is so important.

Oxygen desaturation, hypercarbia, hypertension, hypotension, tachycardia, and ischemia are all potential events during the stress of intubation, in addition to other medical conditions that the patient might have. Don't hesitate to designate an assistant to help you monitor and treat the patient while you deal with the airway. Your assistant(s) must keep you updated on changes in vital signs. They can alert you if the apneic period during intubation attempts becomes prolonged. They also can help you keep track of other treatments that are occurring simultaneously.

During awake intubation, your assistant(s) can provide judicious conscious sedation under your direction as well as perform much-needed support and reassurance—often the more valuable anxiolytic.

Don't Skimp on Preoxygenation

One of the most important safety measures we use in anesthesia is to preoxygenate our patients prior to induction of anesthesia and in preparation for intubation. Under daily work pressure, we may be tempted to skip providing full preoxygenation to our patients. We sometimes count the manual ventilation with oxygen we provide our patients right after induction to make up for any shortfall in formal preoxygenation. However, if your patient is difficult to ventilate, failure to preoxygenate puts your patient at risk. In an average healthy adult breathing room air, oxygen saturation drops precipitously to below 90% within about a minute of the start of apnea. Speed of onset of hypoxia with apnea depends on metabolic rate and on the actual amount of oxygen available in the patient's functional residual capacity. I have seen septic, febrile, and obese patients start to desaturate almost as soon as they stopped breathing.

Preoxygenation is especially critical if you plan a rapid sequence induction. Adequate preoxygenation can more than double the time to hypoxia during apnea, allowing more time for intubation to be accomplished.

How Does Metabolic Rate Affect Oxygen Drop?

A nonfebrile adult at rest uses roughly 3 mL/kg of oxygen per minute. A child can use 6 mL/kg per minute. Fever, seizure, increased activity, or stress all raise that oxygen consumption significantly. When we inhale room air with an oxygen concentration of 21%, we usually exhale gas containing about 15% oxygen. In between, the average 80-kg adult removes about 240 mL of oxygen from his lungs. If the metabolic rate goes up, then oxygen will be removed from the lungs at a much faster rate.

How Fast Can Oxygen Saturation Fall?

A quick review of some simple physiology helps to illustrate why we try to limit intubation attempts to less than a minute before we ventilate the patient. The average person starts to become hypoxic after about a minute of apnea.⁴⁰

You can estimate the PaO₂ of a patient with normal lungs to be roughly equal to about 5 times the inspired oxygen concentration. Breathing room air equals an expected PaO₂ of 105, corresponding to an oxygen saturation of 100%.

For an 80-kg adult with a total lung volume of 3,000 mL filled with room air, there would be about 640 mL of oxygen available. After 1 minute, assuming we've removed 240 mL of oxygen, there is now 640 mL minus 240 mL of oxygen, or 400 mL, left in 3,000 mL, or 13%.

An alveolar oxygen concentration of 13% corresponds to a PaO₂ of about 65, corresponding to an oxygen saturation of about 90%. Within a minute, oxygen saturation falls to the steep part of the dissociation curve and starts to drop quickly. If the patient is febrile or excited, or has a premonitory condition such as obesity, chronic obstructive pulmonary disease, or sepsis, oxygen saturation will actually drop faster than this. Because the pulse oximeter warning can lag behind the actual drop in saturation, it's best not to delay until the alarm sounds.

Adequate preoxygenation can more than double the time to hypoxia during open airway apnea, allowing more time for intubation to be accomplished. However, increasing the time to critical hypoxia from 1 minute to 2 or 3 minutes with preoxygenation, as important as that is, still can be too short if the intubation turns out to be truly difficult.

Apneic Oxygenation

During apnea, the oxygen saturation only starts to decrease after the store of oxygen in the lungs is depleted. Apneic oxygenation relies on increasing the availability of oxygen in the lungs during apnea. The simplest technique is holding the airway open after induction while administering oxygen by face mask. Absorption of oxygen from the lungs will create negative intrathoracic pressure. With a tight seal against the face, this pressure differential then pulls oxygen through the open airway and into the lungs to replace it. The airway must be open. Airway obstruction prevents mass inflow of oxygen.

Proactive Apneic Oxygenation

Adding oxygen flow through nasal prongs into the pharynx while the patient is apneic can greatly increase the time to desaturation.

A study⁴¹ analyzed 30 obese patients with BMIs between 30 and 35 kg/m². The investigators provided 5 L per minute nasal oxygen flow during a prolonged apneic period. They simulated difficult laryngoscopy by gently inserting the laryngoscope, visualizing the larynx, and then delaying tracheal intubation until 6 minutes after succinylcholine administration or when arterial oxygen saturation (SpO₂) decreased to 95%. Patients who received oxygen during apnea maintained an SpO₂ of 95% or greater for significantly longer than controls (5.29 vs 3.49 minutes) and had significantly greater mean SpO₂ nadir (94.3% vs 87.7%). Time to resaturation to an SpO₂ of 100% after initiation of ventilation with 100% oxygen did not differ significantly between groups.

When you are managing a difficult intubation, extending the time to critical hypoxia to as much as 5.5 minutes is tremendous. Can we do better?

Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE) is a more aggressive technique for providing high-flow, positive-pressure, humidified oxygen via nasal cannula. In an observational, cross-sectional study,⁴² researchers in the United Kingdom used the THRIVE technique in 25 patients with known or anticipated difficult airways who were undergoing general anesthesia for otolaryngology procedures.

The investigators elevated the head to 40 degrees (thereby increasing baseline functional residual capacity and improving preoxygenation). They preoxygenated with 70 L per minute for 10 minutes using a commercial device (OptiFlow, Fisher & Paykel) to deliver high-flow, humidified oxygen via a modified nasal cannula. After induction, they lowered the head to 20 degrees head-up and continued the nasal cannula flow to provide apneic oxygenation until intubation had been accomplished. The mean time to intubation was 17 minutes, and no patient desaturated below 90% despite apnea.

Not everyone is going to have a device capable of providing humidified nasal oxygen at a 70-L flow. But even short-term, 15-L unhumidified nasal prong flow has been shown to be tolerated and effective in delaying the onset of critical hypoxia.

What About Hypercarbia?

During apnea, not only is oxygen falling but carbon dioxide is rising. Although apneic oxygenation increases the time to hypoxia, it does not change the rate of increase of carbon dioxide. Compared with 250 mL per minute of oxygen moving out of the alveoli into the bloodstream, only 8 to 20 mL per minute of carbon dioxide moves into the alveoli during apnea, with the remainder being buffered in the bloodstream. This typically causes a rise of 8 to 16 mm Hg carbon dioxide during the first minute and then 3 to 4 mm Hg carbon dioxide per minute thereafter. An increasing PCO₂ will progressively reduce pH.

You can increase the time to significant hypercarbia by asking your patient to hyperventilate for a minute or so prior to induction, or by hyperventilating your patient manually using bag-valve-mask after induction of unconsciousness.

However, use of higher flow (>15 L per minute) nasal prong oxygen during apnea actually may help slow the

increase in carbon dioxide by washing out dead space, and stenting open airways allowing better washout of gas.

We should consider the use of nasal prong oxygen flow for apneic oxygenation in patients at risk for rapid development of hypoxia, such as known or potentially difficult airway patients, and those who are critically ill, obese, or pregnant.

10. Plan for the End at the Beginning

Extubation of the patient with a difficult airway must be approached with caution because of the potential for problems if the patient fails extubation.⁴³ This is especially true if you are considering deep extubation as a means to avoid coughing and bucking. Laryngospasm, if it occurs, could worsen any preexisting obstruction. The Difficult Airway Society (Figure 16) and the American Society of Anesthesiologists's Task Force on Management of the Difficult Airway have published clinical practice guidelines for managing the difficult airway, including an extubation algorithm.^{43,44}

Before extubation, assess carefully when there is:

- a history of difficult intubation;
- potentially difficult intubation/ventilation (eg, from obesity, edema, obstruction);

- airway edema from trauma or infection, which is now felt to be sufficiently resolved for extubation to occur;
- administration of large volumes of IV fluids or colloids; or
- any fixed instrumentation impeding reintubation, such as halo traction or a jaw that is wired shut.

Optimize your patient for extubation. Hemodynamics should be stable; preoxygenate well; suction the airway clear of secretions; and make sure muscle relaxation is reversed. If possible, raise the back of the bed to optimize ventilation and open the airway.

If you're concerned about airway edema, consider direct examination of the airway with a laryngoscope or fiber-optic scope. Alternatively, you can perform a leak test. After suctioning, deflate the ETT cuff and

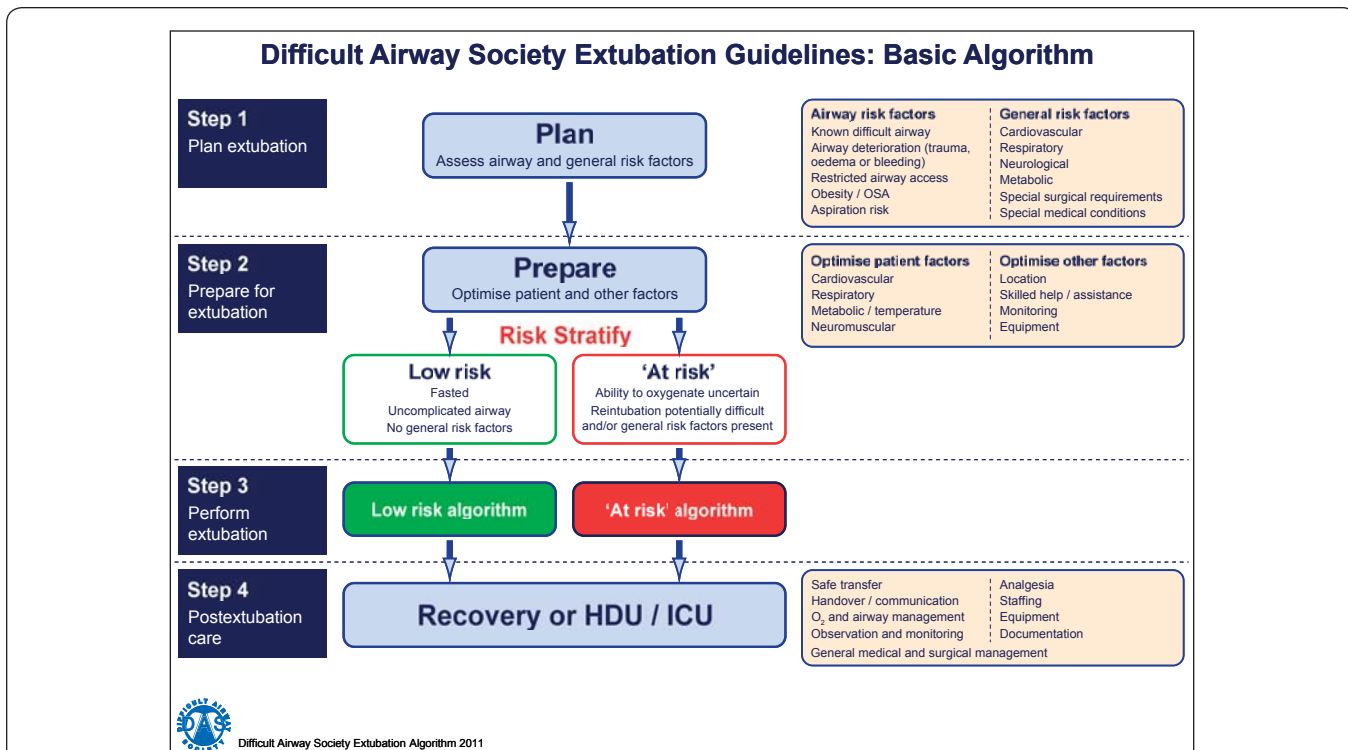


Figure 16.

The Difficult Airway Society's extubation algorithm for difficult airways.

HDU, high dependency unit; **ICU**, intensive care unit; **OSA**, obstructive sleep apnea

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listen for a leak around the tube as the patient exhales. If there is no leak, there may be too much edema to ensure an open airway after extubation. In this case, you may wish to postpone extubation.

Always have the equipment needed to reintubate at the bedside whenever you extubate. Have an assistant available to help. Remember that reintubation is often more difficult than the initial intubation, as a result of edema from IV fluid administration, intubation trauma, or surgical insult.

Monitor the patient's pulse, blood pressure and oxygen saturation following extubation. Hypoventilation, hypoxemia, and airway obstruction can occur if the patient goes back to sleep after the stimulus of the ETT is removed.

Advanced Techniques for Extubation

If you're worried about the potential need to reintubate and are concerned that reintubation might be difficult, consider the use of a device such as an ETT exchange catheter as a stent.^{45,46} The exchanger can be inserted down the ETT until it is between the middle of the trachea and carina. The ETT is removed over the top, leaving the exchanger in place as a possible guide for reintubation if needed. Because a tube exchanger is hollow, oxygen can be insufflated or jet ventilated down the tube if the patient develops respiratory distress. Tape the exchanger at the corner of the mouth and note the depth.

Usually, the patient will tolerate the presence of the exchanger. You can assist this by injecting 50 to 100 mg of lidocaine down the ETT before inserting the exchanger and pulling the tube. You also can inject lidocaine down the exchange catheter.

Reintubation over an exchanger usually works fairly well, but always be prepared to perform laryngoscopy just in case. Deciding when to remove the exchanger must be based on careful observation of the patient, but typically you can remove it in about an hour if no problems have occurred.

During the wake-up process for specific surgical procedures such as brain surgery, we occasionally wish to extubate a patient deep, to avoid coughing or bucking against the ETT and thus avert increasing intracranial pressure. Typically, the patient is allowed to breathe spontaneously and then is assisted to breathe with a mask until fully awake. If such a patient also has a difficult airway, deep extubation carries greater risk. One way to minimize this risk is replacement of the ETT with an LM airway prior to wake-up. Once ventilation is verified, the patient is allowed to awaken with the laryngeal mask airway in place.

Conclusion

The difficult airway carries a significant risk for serious patient injury and even death. As airway experts, we should give our patients our best effort to maximize prevention and minimize risk.

1. Check every patient for potentially difficult intubation or ventilation, but remember difficult intubation or ventilation can occur at any time. You must always be ready.
2. Remember, not every patient needs to be intubated right now. Sometimes medical management is the better choice.
3. Teamwork and communication are essential for both prevention of problems and management of emergencies. With these behaviors, we can progress to a culture centered on patient safety.
4. Awake intubation always should be an option if you feel safety warrants it.
5. Position can make intubation easy or it can make intubation hard. Optimize patient positioning before you start.
6. Resources include equipment and people, and must be tailored to the needs of that particular patient. However, resources are only as good as your knowledge of them and your ability to use them. Practice with multiple techniques and devices before you need them. You never know which ones you might need. Make sure your staff knows how to find and assemble your equipment, and help you in an emergency.
7. Video laryngoscopy has revolutionized intubation safety, but don't rely on it to always save the day. Have a Plan B.
8. There is no situation so bad that you can't make it worse! Change techniques when something isn't working. Call for help early. Don't be afraid to stop, if the patient's situation permits.
9. Don't concentrate on the airway to the exclusion of the rest of your patient's needs. The ability to tolerate your intubation attempts depends on optimizing overall clinical status.
10. Eventually, the ETT must come out. Make extubation safety as much a priority as intubation safety. Plan for it from the beginning.

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