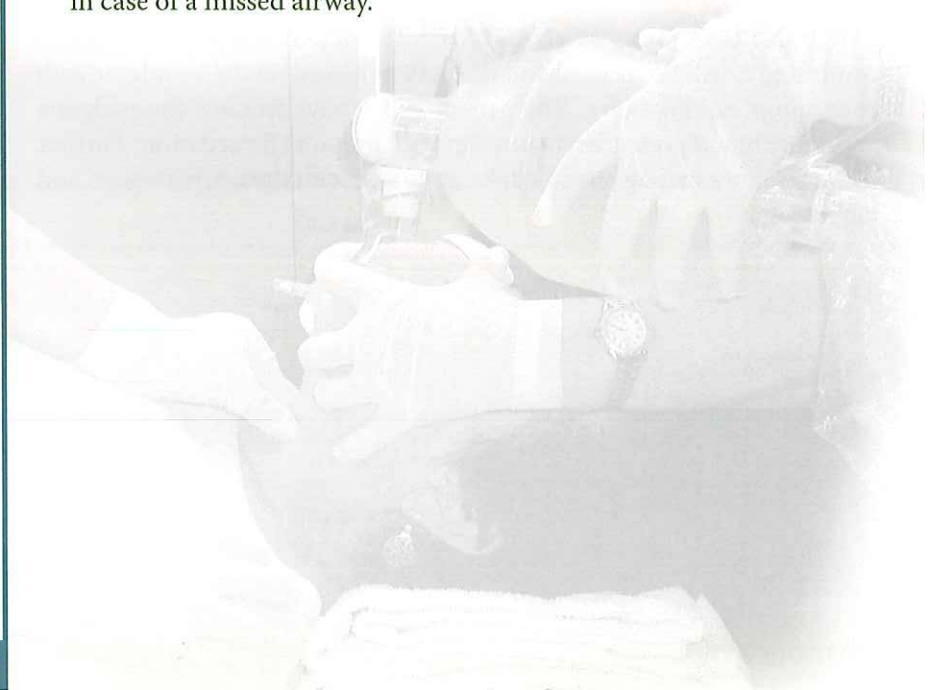
The Difficult and Missed Airway

Chapter 4

If you have not encountered a patient you could not intubate or bag-valve-mask ventilate then you have not encountered enough patients; it is just a matter of time. Not surprisingly the reported incidence of a difficult and missed (failed) airway varies with who is performing the intubation and where, the definition used and whether RSI is utilized. In the O.R. setting 2 in 100 patients require 3 or more attempts at laryngoscopy and 1 in 300 to 1000 intubation attempts fail completely. In the E.D. setting the incidence of failed airway is about 2 in 100. In the EMS setting 1 to 10 in 100 patients cannot be intubated after RSI. In addition, up to 5% of patients in the O.R. are difficult or impossible to oxygenate with BVMV. This number is likely to be even higher in other settings. Therefore, you must know how to assess the airway to best predict and prepare for difficult intubations and you must always have a back-up plan rehearsed in case of a missed airway.



Definitions

Difficult Airway:	1. Predicted to be difficult (see LEMONS and 4 D's below). OR 2. Proves to be difficult (more than ONE attempt required). Note that many intubations are difficult by this definition. If you are unsuccessful on your first attempt, there is a reason. It is imperative that you acknowledge a difficult airway so that you can make appropriate interventions rather than persist in a failed strategy.
Missed Airway:	1. The provider is unable to intubate within three attempts. OR 2. Critical oxygenation cannot be maintained at any time. Note that an airway may be declared "missed" before any intubation attempt is made if the patient desaturates during induction and paralysis and cannot be returned to adequate saturations with BVM and supplemental oxygen.
Crash Airway:	1. Patient is "dead" (cardiac or respiratory arrest) OR 2. Patient is "nearly dead" (agonal respirations). These patients do not usually require RSI as they should not have significant inherent muscle tone. Proceed directly to basic airway management and intubation without drugs. In the event that the patient proves to have more residual muscle tone than anticipated (i.e. they are not as dead as you thought!) you may revert to RSI.

Why "Missed" and not "Failed"?
The historical and pervasive terminology is the "difficult and failed airway." In my own experience I have found it very hard to convince some very intelligent and well-intended clinicians to abort an intubation attempt when things are not going well. In other words, the first step is admitting you have a problem. It turns out that many medical professionals have a hard time admitting failure. A wise friend, Dr. David Thomsom, the National Medical Advisor for PHI Air Medical, coined the term "missed airway" to replace "failed airway" in keeping with aviation nomenclature for instrument flight - i.e. when you can't see and must relay on your instruments. The situation in which a pilot descends through the clouds to a predetermined critical altitude without visualizing the runway is called a "Missed Approach" rather than a "Failed Approach". If it works for our Type A aviation colleagues perhaps it will work for us.

Predicting the Difficult Airway

It would be useful if we could reliably predict which airways are likely to cause us difficulty and which will not. For those likely to be difficult we could call for help in advance, consider deferring the procedure, consider alternatives such as awake intubation, or be better prepared, such as having a back-up airway sized, out of the package, lubricated and "sacrificed" to the procedure.

In emergency situations, a detailed airway assessment may not be practical. In many such cases RSI must proceed even when airway assessment predicts difficulty, due to patient acuity and a favorable risk-to-benefit analysis. For example, imagine the patient with a gunshot wound to the head who has a GCS of 5, grey matter exposed, seizure activity, vomiting, trismus and hypoxemia despite a non-rebreather mask, but who also happens to be morbidly obese, in cervical spine precautions and have lots of facial hair. While experience tells you this patient may be very difficult or impossible to intubate and/or BVMV, you also know that the patient is likely to die if they don't get an airway soon. In this situation you are obliged to proceed with RSI despite the risks, while simultaneously preparing for a difficult and/or missed airway. Common predictors of difficult BVMV include facial trauma, facial hair, obesity, and lack of teeth (assuming you don't have the dentures to

replace during BVMV). Other risk factors for difficult BVMV demonstrated in the anesthesia literature include age over 55, history of snoring, Mallampati grade 3 or 4, severely limited jaw protrusion and thyromental distance less than 6 cm.

Predictors of Difficult BVMV:	Facial Trauma
	Facial Hair
	Obesity
	Lack of teeth
	Age over 55
	History of snoring
	Mallampati 3 or 4
	Severely limited jaw protrusion
	Thyromental distance < 6 cm

Commonly used predictors of difficult laryngoscopy in anesthesia include facial trauma/anomalies, Mallampati grade, thyromental distance, sternomental distance, mouth opening, neck mobility, obesity and buckteeth.

Predictors of Difficult Laryngoscopy:	Facial trauma/anomalies
	Increasing Mallampati grade
	Decreasing thyromental distance
	Decreasing sternomental distance
	Limited mouth opening
	Restricted neck mobility
	Obesity/ increasing neck circumference
	Buckteeth
	Decreased anterior neck compliance

In emergency medicine and EMS some of these features have been assembled into the LEMON and 4 D's mnemonics. Unfortunately, most of these clinical assessments cannot be performed in typical patients undergoing emergency airway procedures.

The Mallampati score, for example, relies upon having a cooperative patient sit up, open their mouth fully and stick out their tongue so that the extent to which the hard palate, uvula and posterior pharynx can be visualized can be graded on a 1 (optimal) to 4 (poorest) score. Levitan found that only one third of patients undergoing intubation in the Emergency Department could sit up and cooperate for this assessment. And even at their best the Mallampati and other clinical measurements are only modestly predictive of difficulty. Combinations of variables may improve their predictive value.

Some authors have also described a class "zero" Mallampati score in which the tip of the epiglottis is visible on pharyngeal inspection. In an poetic twist, no sooner had these authors reported on the class "zero" airway than other authors reported a patient with a class "zero" airway that could not be intubated!

There are conflicting results about the impact of obesity at laryngoscopy. Much of the problem with intubation in the morbidly obese may be overcome with proper positioning, i.e. the "ramped" position. Obesity definitely makes BVMV more difficult. In addition, common rescue devices such as the LMA-Unique may not generate enough airway pressure to lift a very heavy chest. Obesity also limits the effects of pre-oxygenation due to reduced functional residual capacity as well as increased oxygen demand so that time to perform the intubation before critical hypoxemia may be limited.

Another major factor in intubation difficulty is time; a factor ignored in both common clinical mnemonics. Many intubations that are difficult when a patient's saturation is plummeting might be quite doable if time were unlimited. The time-factor in airway management is usually due to oxygen reserve. We have therefore modified the common LEMON mnemonic, adding an "S" for saturations, to make it LEMONS.

"LEMONS"

L	= Look externally
E	= Evaluate 3-3-2 rule
M	= Mallampati score
O	= Obstruction
N	= Neck mobility
S	= Saturations

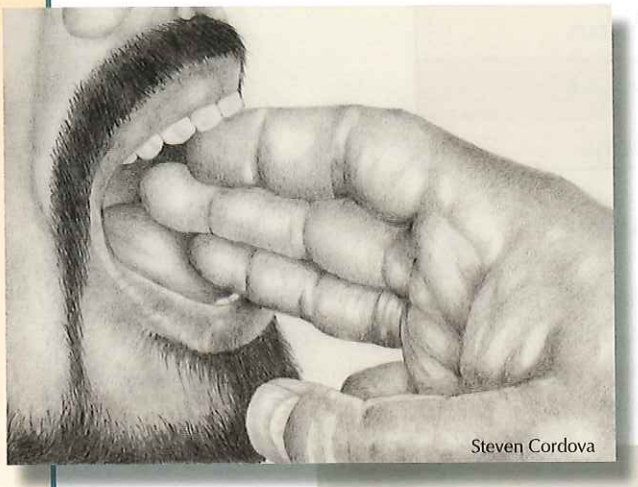
LOOK EXTERNALLY

Look for things that will make intubation or bag-valve-mask ventilation difficult. This includes facial hair, secretions, massive obesity, facial trauma, upper airway pathology and gross face/neck anatomical deformities.

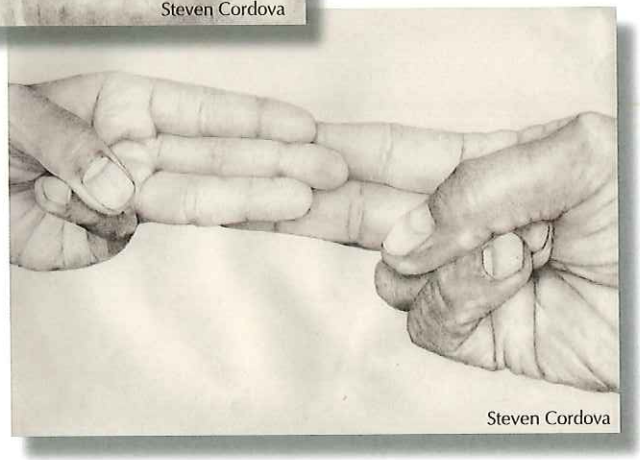
EVALUATE 3-3-2 RULE

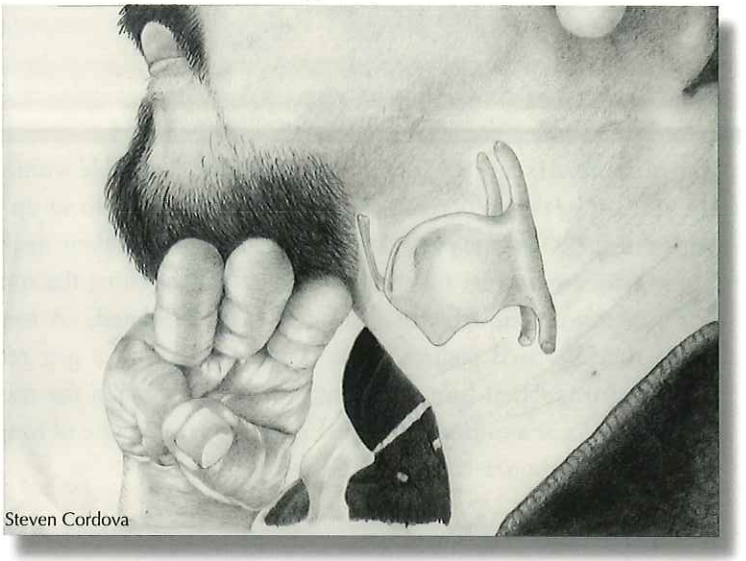
This rule is one tool to help estimate the difficulty of laryngoscopy by assessing anatomical limitations to visualizing the larynx, i.e. small mouth opening, short chin—no room to displace the tongue—and superior/anterior location. Criteria evaluated are as follows (using the patient's finger measurements):

- Check that the mouth opening is at least 3 fingers.
- Check that there is room for 3 fingers between the tip of the chin and the hyoid bone.
- Check that there is room for 2 patient-sized fingers between the hyoid bone and the top of the thyroid cartilage.

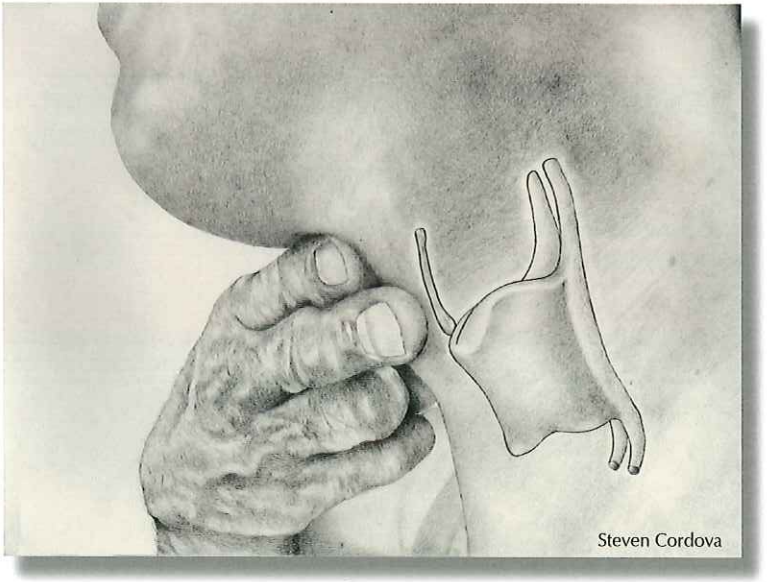


Three fingers mouth opening. This is based upon the patient's fingers not yours! The illustration below shows how you can quickly compare your fingers to the patient's. In this example 2 of the provider's fingers are equivalent to 3 of the patient's.





Three fingers from tip of chin to the hyoid bone.

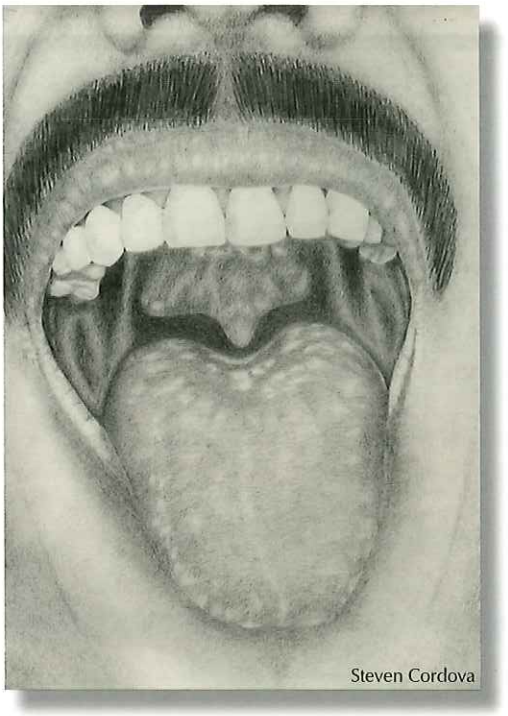


Two fingers from the hyoid bone and the top of the thyroid cartilage.

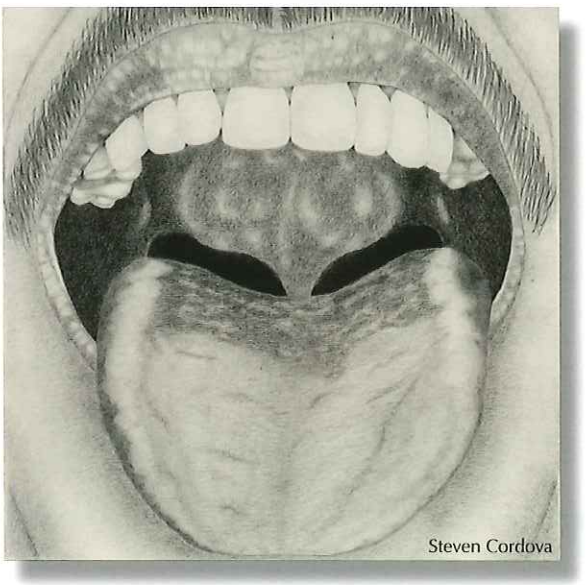
MALLAMPATI SCORE

The Mallampati score assesses the working space available within the mouth. To be done correctly the patient must be able to sit up and stick out their tongue; even better have them extend their neck. A crude estimate may be substituted by manually opening the mouth and looking in, though this has never been validated. A tongue blade may be used cautiously to avoid stimulating a gag reflex. The most important thing is to make sure you look in the mouth before RSI to, at a minimum, assess mouth opening, size of tongue, dentures/dentition, edema, trauma and secretions.

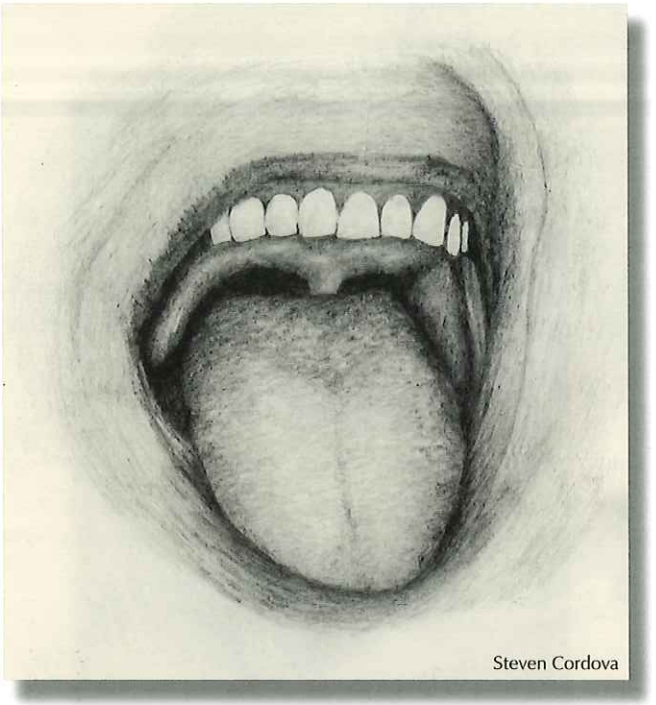
Mallampati Score		
Class I =	Visualization of the soft palate, fauces, uvula, anterior and posterior pillars =	"Easy"
Class II =	Visualization of the soft palate, fauces and uvula =	"Mildly Difficult"
Class III =	Visualization of the soft palate and the base of the uvula =	"Moderately Difficult"
Class IV =	Soft palate is not visible at all =	"Difficult"



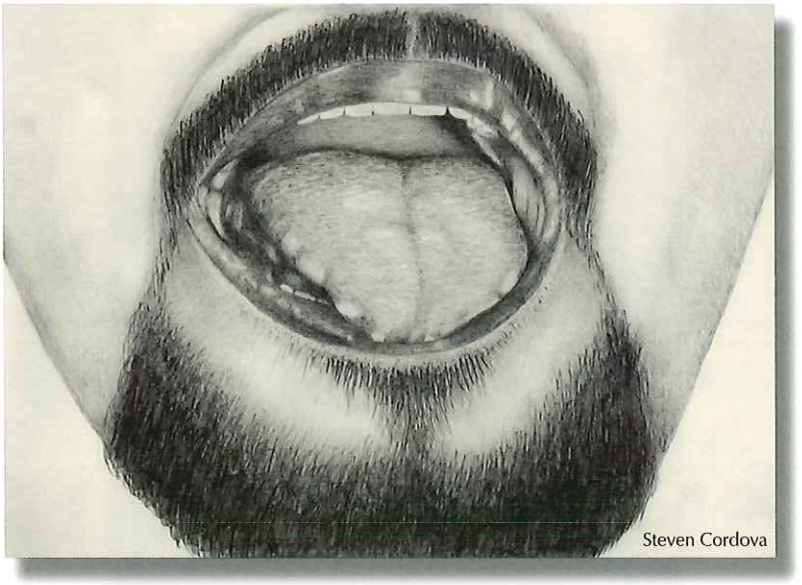
Mallampati I



Mallampati II



Mallampati III



Mallampati IV

OBSTRUCTION

The airway may be obstructed by a foreign body, the tongue, secretions, blood, vomitus and/or edema. Edema may result from trauma, infectious causes such as epiglottitis or abscess or from allergic reactions. Consider the age and history to predict possible obstruction. Intubating a pediatric patient with retropharyngeal abscess or an adult with Ludwig's Angina is a scary proposition.

NECK MOBILITY

This is most often limited by cervical spine immobilization, though patients with rheumatoid arthritis, spinal fusions and elderly patients with severe degenerative disease may also have restricted range of motion. This is another reminder that any patient in spinal precautions should be considered to have a difficult airway. It is important in these cases that the front of the cervical collar to be removed and manual stabilization with a jaw thrust be applied during intubation to allow forward movement of the chin.

SATURATIONS

One of the most critical elements in airway management is the time allowed to successfully complete the procedure. The primary determinant of time in these procedures is the oxygen saturation and, in turn, your ability to preoxygenate and create an oxygen reserve. As discussed in Chapter 2, patients may be roughly categorized into three groups according to their saturation after preoxygenation. A patient whose oxygen saturation is near 100% following preoxygenation has "adequate reserve," above 90% but less than 100% has "limited reserve" and less than 90% despite appropriate preoxygenation has "no reserve."

Although typical RSI technique is predicated on avoidance of positive pressure ventilation, the "no reserve" group is at particularly high risk of requiring supplemental ventilation before and between intubation attempts. In these cases the provider should

consider alternatives or be prepared to provide optimal BVMV and place a rescue airway device. It is important to note that some patients with an oxygen saturation of 100% may still desaturate rapidly, especially if they have underlying lung disease, morbid obesity or very high metabolic demands (See Chapter 2).

Is it realistic to assess Mallampati and the 3-3-2 in emergency situations?

While many of these assessments, particularly the Mallampati and 3-3-2, are neither perfect nor practical on most emergent patients, it does behoove the practitioner to look at gross facial morphology (we are really looking for extremes of disproportion) and to look in the mouth. I know of two cases where the physician discovered only at that moment that the patient they were about to paralyze had their jaw wired shut! The 4 D's below was created to address this issue.

"Four Ds"

Dentition
Distortion
Disproportion
Dysmotility

DENTITION

Check that the upper incisor teeth are not prominent ("buck teeth"), there are no loose teeth or dentures, that the mouth is not narrow and that the palate is not high-arched and narrow.

DISTORTION

Check for edema, blood, vomitus, tumor, infection, etc.

DISPROPORTION

Check for a receding chin (short chin-to-larynx distance) and large neck. Check the relative tongue-to-pharyngeal size by noting whether the base of the uvula is visible when the patient opens his mouth widely, and check whether the tongue is disproportionately large (modified Mallampati technique using a tongue blade in a supine patient).

DYSMOBILITY

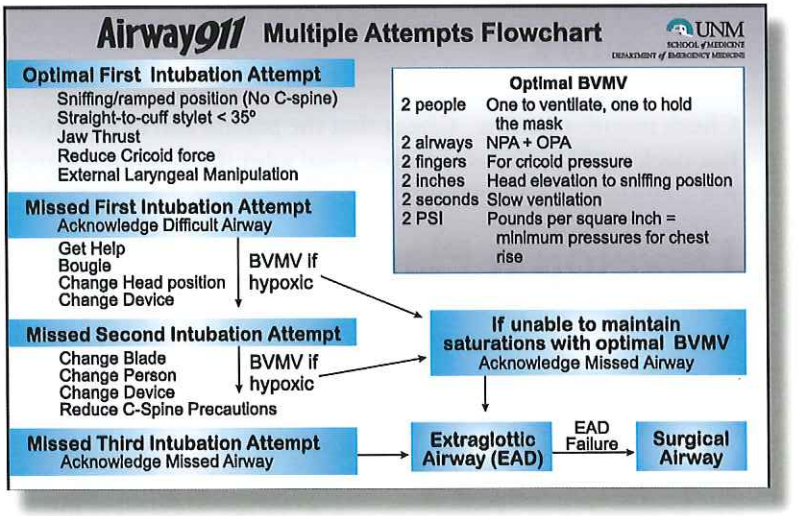
Check mouth opening. Check that the patient can extend his or her neck > 35° at the atlanto-occipital joint if a C-spine injury is not a clinical consideration.

Develop a Plan

There will be times when patient acuity will force you to proceed even when you predict a difficult airway. There will be times when an airway you predicted to be difficult turns out to be easy. And there are times that an airway you predicted to be easy turns out to be impossible. Therefore you should always have an organized plan of what you will do in the event of a difficult or missed airway. The *Airway911* courses are based around our "Multiple Attempts Flowchart" which serves as the basis of this chapter. We have found that outcomes are improved and stress dramatically reduced if you always know "where you are" and "what steps to take".

The greatest errors that I have witnessed in managing difficult airways are 1) not acknowledging difficulty, and 2) persisting in a failed strategy. I equate this to the situation in which you encounter a person that does not speak your language and you repeat the same question again and again, only louder each time. When lives are on the line we need a better plan.

This algorithm is merely a starting point and should be adapted as needed on a case-by-case basis; airways are dynamic processes. A multitude of factors will impact the specific approach to be undertaken, including but not limited to: your skills and experience, who is available to help, what equipment you have available, patient anatomy and whether saturations are maintained.



The Optimal First Attempt

The first part of managing the difficult airway is to make it not so difficult! We begin the Multiple Attempts Flowchart and every single intubation with an "Optimal First Attempt." When the stakes are this high it is imperative to maximize your chances of success on the first attempt. This means assuring proper positioning, proper stylet shape, appropriate utilization of assistants and appropriate manipulation of the neck and jaw.

HEAD POSITIONING

The optimal position for laryngoscopy in most adults and older children is the sniffing position. It is important to recognize that sniffing involves forward flexion of the neck on the shoulders AND extension of the head on the neck. The goal is to place the external ear canal at or above the sternal notch. In children this may require a towel roll behind the shoulders while in very obese adults this may require elevation of the head of the bed or placement of linen behind the back to achieve a "ramped position". There are now a variety of commercial devices available to assist in proper positioning. Patients in cervical spine immobilization cannot be positioned in a sniffing or ramped position; these cases should all be considered difficult airways.

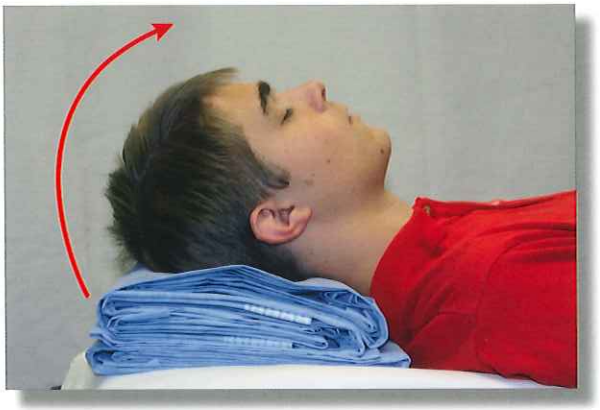
This photo illustrates the correct ramped position for an obese patient achieved using linen. Note that the ear canal and sternal notch are at the same level. Photo courtesy of AirwayCam Technologies.

This photo illustrates the use of a commercial device, the AirPal RAMP, to achieve the ear canal-to-sternal notch ramped position. This device uses compressed air and several independently adjustable compartments to achieve optimal positioning.

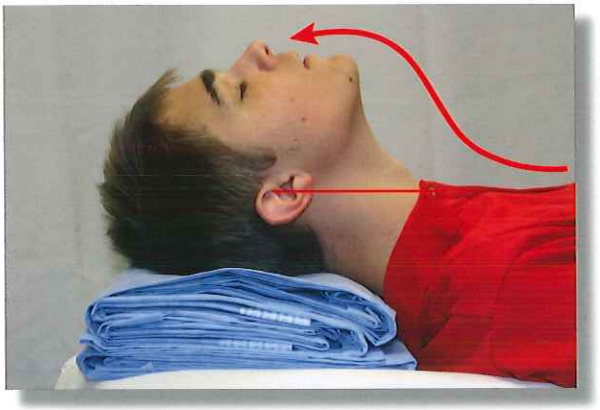
Achieving the correct "sniffing position"

Resting position. Laryngoscopy will be difficult in this position.

In the first step, the head is elevated, flexing the neck forward. Laryngoscopy will still be difficult in this position.

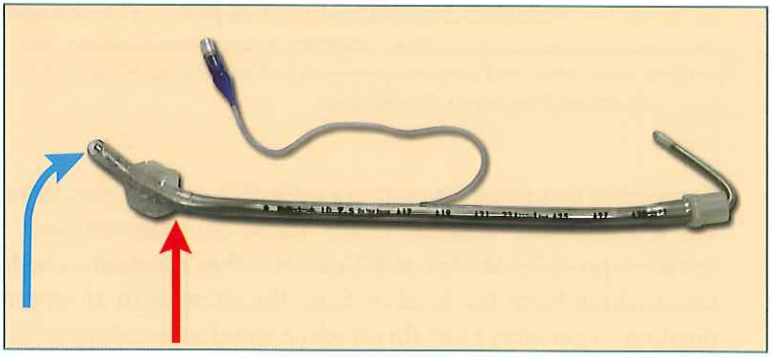


In the second step, the head is extended on the neck, achieving the correct sniffing position where laryngoscopy should be the easiest.



STYLET SHAPE

Most emergency intubations are done with a stylet. I was taught to use a "soft-curve" for medical intubations and a "hockey-stick" for trauma intubations. Based on recent research the stylet should initially be shaped so that the tube is straight all the way to the proximal start of the cuff (or where the cuff would be in the case of un-cuffed tubes) and then bent slightly, but not more than 35 degrees, in all patients. This is called "straight-to-cuff". In the event that the tube cannot be passed using this shape, the stylet can be reshaped to meet the particular anatomy encountered, removed entirely or replaced with a bougie.



In the ideal starting position, the ET tube is straight all the way to where the cuff begins (see red arrow) and then bent upwards no more than 35 degrees (see blue arrow).

JAW THRUST

A study from Japan demonstrated that having an assistant perform a jaw thrust during laryngoscopy improved visualization during laryngoscopy. While the study was small this is a simple technique that is familiar to most assistants and not associated with any potential complications or cost. In my personal experience having an assistant perform a jaw thrust allows more muscle energy to be put into small "finesse" movements that expose the larynx rather than gross movements that lift the jaw. This maneuver is particularly useful for patients in cervical spine precautions where optimal sniffing or ramped positioning is contraindicated.

The correct use of assistants during intubation of the patient in cervical spine precautions: one person to manually maintain in-line immobilization AND perform a jaw-thrust and a second person to perform cricoid pressure AND assist with external-laryngeal manipulation.

Remember that when intubating a patient in cervical precautions the front of the cervical collar must be removed and an assistant provides in-line stabilization. This assistant, whether approaching from the head or from the chest, is in an optimal position to perform a jaw thrust while simultaneously providing in-line immobilization.

This technique may also be valuable in non-trauma patients, especially for intubators with limited upper-body strength who find themselves using two hands on the laryngoscope or otherwise struggling to lift the jaw.

REDUCE CRICOID PRESSURE

Caution

As discussed in Chapter 2, cricoid pressure is intended to prevent gastric insufflation and regurgitation but may obscure your view of the vocal cords. Therefore, the first response to a difficult intubation - assuming that you are already utilizing the sniffing position and/or jaw thrust and appropriate stylet shape should be to have your assistant reduce pressure on the cricoid or release pressure entirely. They should maintain their hand position on the cricoid membrane until cricoid pressure needs

to be reapplied or you need to move their hand to the larynx to assist with ELM.

EXTERNAL LARYNGEAL MANIPULATION (ELM)

It turns out that laryngoscopy is really a two-handed procedure. Laryngeal view can often be improved dramatically by simply manipulating the thyroid cartilage, which contains the larynx. This is termed either "External Laryngeal Manipulation" or "Bimanual Laryngoscopy." It is critical to realize that this is NOT cricoid pressure. Cricoid pressure is simply backwards pressure performed below the thyroid cartilage, at the cricoid ring, with the goal of preventing or minimizing gastric insufflation and subsequent aspiration.

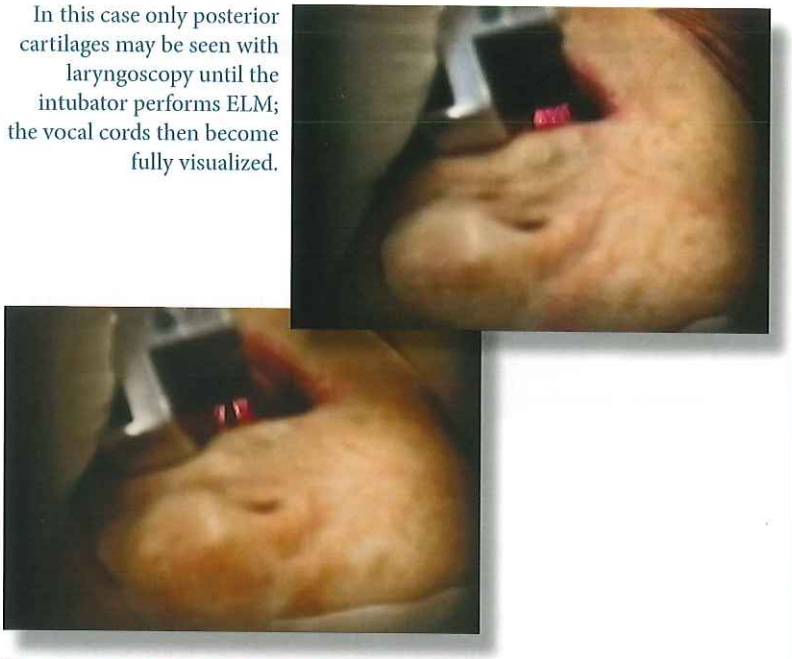
To perform ELM, cricoid pressure will need to be released and the assistant's hand moved up to the thyroid "laryngeal" cartilage (the Adam's Apple). The intubator then reaches around the front of the patient's neck with their right hand, while continuing laryngoscopy with the left hand; eyes should not be taken off the target. The intubator manipulates the larynx and the assistant's hands at the same time, in whatever direction improves their view. Once an adequate view for intubation is obtained the assistant holds the laryngeal cartilage in that exact position so the intubator can use their right hand to intubate. Once the tube is passed the assistant again performs cricoid pressure until the tube is confirmed.

The intubator performs laryngoscopy with their left hand while simultaneously manipulating the cords into position with their right hand manipulation.

An assistant must now maintain the optimal position for the intubator. I recommend having the assistant hold the larynx first so that the intubator manipulates the larynx and the assistant's hand at the same time, thereby eliminating a precarious changeover.

Photos courtesy of AirwayCam Technologies.

In this case only posterior cartilages may be seen with laryngoscopy until the intubator performs ELM; the vocal cords then become fully visualized.



Photos courtesy of AirwayCam Technologies.

Why have you stopped teaching B.U.R.P.?

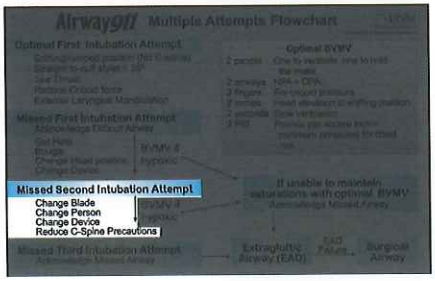
With ELM, the intubator can move the larynx in any direction necessary to improve view and is done in addition to cricoid pressure. The option of BURP, backwards, upwards and rightwards pressure applied blindly to the larynx by an assistant has previously been advocated. Recent research reveals that ELM is superior to BURP and should be the primary maneuver when the larynx cannot be visualized.

Why isn't the bougie listed here?

The bougie is discussed in the next section as a go-to device in case the first attempt at intubation is unsuccessful. This is the most common manner in which it is used. Some EMS services have elected to require bougie use instead of a stylet on all first attempts, which is very reasonable. Some experienced intubators will elect to use the bougie on a first attempt when they anticipate a difficult anterior or swollen airway.

The Missed First Optimal Attempt

If your first optimal attempt is missed, there must be a reason. In this circumstance you should give yourself credit for an optimal attempt,blame the patient, and declare a "difficult airway". Failure to acknowledge a difficult airway in this circumstance is a common reason for bad patient outcomes as the provider is likely to persist in a failed strategy. Additional measures to consider at this point include getting more help, the gum-elastic bougie, changing head position and changing device.



GET HELP!

One of the greatest threats to the patient in the event of a difficult airway is the provider's ego. Failure to get help when it is available is not only bad for the patient but it is a recipe for a lawsuit. Availability of help depends on your setting. For a ground paramedic it may be another unit or a field supervisor; some EMS services require two paramedics be present for an RSI. For a flight crew it may mean a physician (ED, ICU, anesthesia) or nurse anesthetist from the sending facility. For an ED physician it may be a colleague (even one who is less experienced), an anesthesiologist/anesthetist, respiratory therapist or paramedic. And so on.

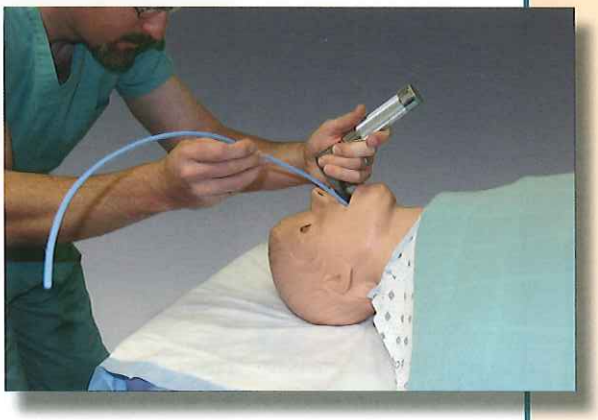
Caution

And of course there are situations where there really is no back-up available. Be very careful in such circumstances.

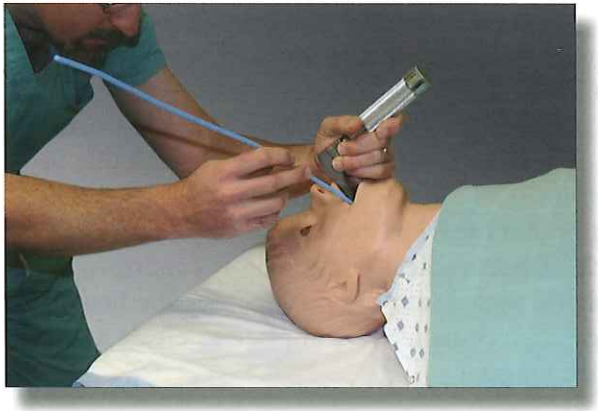
GUM-ELASTIC BOUGIE (AKA ENDOTRACHEAL TUBE INTRODUCER)

The bougie, as it is commonly and affectionately known, is an aid to difficult intubation, particularly in the case of an extremely anterior larynx that cannot be visualized despite optimal positioning and external laryngeal manipulation. This is a semi-rigid device 60 to 70 cm in length with an angled "coudé" tip that looks like a long flexible stylet or tube changer. The bougie is stiff enough to be directable at the tip but flexible enough for an endotracheal tube to pass over it freely. The bougie may be shaped slightly but not nearly to the extent of a stylet. Both reusable and disposable devices as well as adult and pediatric versions are available. There are even devices that allow for oxygenation thru the device during insertion.

Step 1: After appropriate airway landmarks are identified the bougie is inserted into the airway with the coude tip at the distal end.



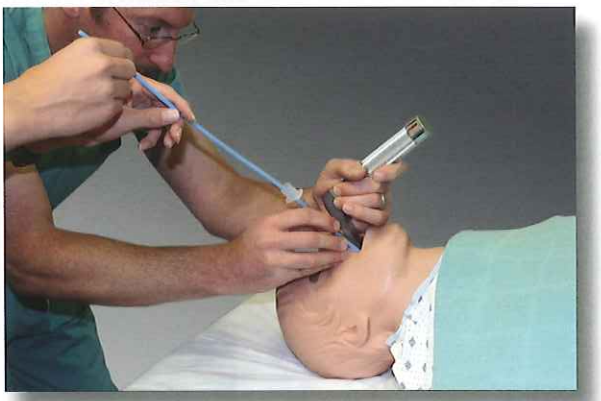
Four steps to bougie-assisted difficult intubation.



Step 2: The bougie is advanced under the epiglottis directed anteriorly, where the airway should be located. The bougie is advanced until the cartilage rings of the trachea can be palpated and/or hold-up is met or you have reached 40 cm without either of these confirmatory findings being found.

Step 3: Have an assistant slide an endotracheal tube onto the proximal end of the bougie and advance until the intubator can take control of it.

Step 4: The intubator advances the tube into the trachea over the bougie while maintaining the laryngoscope in position to create a clear passage around the tongue for the tube. If resistance is met the tube is gently rotated 90 degrees counterclockwise.

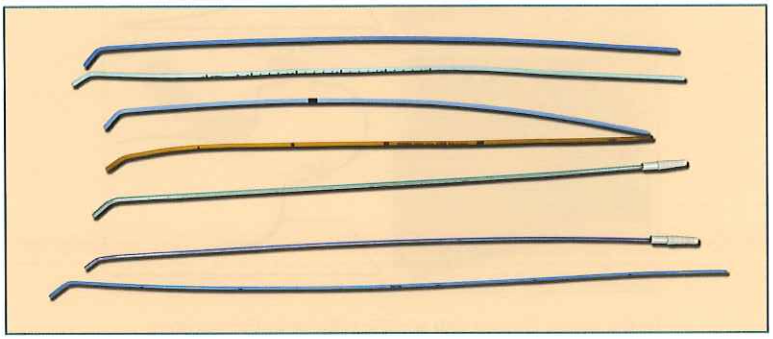


The bougie is most useful when at least some airway structures can be identified, so that the "approximate" position of the larynx can be ascertained. In this situation the bougie is advanced anterior to the arytenoid cartilages and in the mid-line, under as much direct visualization as possible. The tip is placed "semi-blindly" into the trachea, or where the trachea is likely to be. Tracheal position is confirmed by the palpation of "clicks" as the distal bent tip passes over each tracheal ring and/or the inability to pass it beyond 40 cm in an adult, indicating that it has been held up at the carina or in a bronchus as opposed to passing freely into the stomach. Once tracheal positioning is confirmed an endotracheal tube is passed into the trachea over the bougie, while the laryngoscope is maintained in place to create a free passage behind the tongue.

The bougie is also useful in cases where the vocal cords are well visualized at laryngoscopy but the selected tube will not pass, either because of the stylet shape, the size of tube selected, airway swelling or obstruction with a tumor. In these cases the bougie may be used as a "place-holder" and a more appropriate tube size selected and passed gently over the bougie. This averts the need for the intubator to "pull-out" or take their eyes off the glottis and potentially lose the view.

These devices are relatively inexpensive and surprisingly easy to use. While they have been used for many years around the world they are only recently becoming widely available in the United States.

The bougie is generally NOT a good technique for use in the case of a missed airway with significant hypoxemia, due to the time delays involved. Practicing with the bougie on easy intubations and having it immediately available can minimize these delays. Some EMS services and air medical programs have begun using the bougie an all first intubations in place of a stylet, both to gain experience with the device and because "If it is good for a difficult airway why wait to find out it is difficult?"

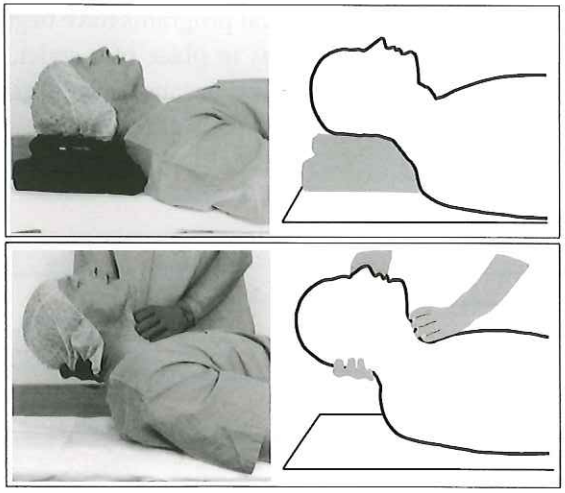


Some of the bougies currently available on the market. From top: SunMed adult, Portex adult, Greenfield adult, Eschmann adult, Boussignac adult oxygenating, Boussignac pediatric oxygenating, and SunMed pediatric.

CHANGE HEAD POSITION

While placing the ear at the level of the sternal notch, i.e. the sniffing or ramped position, may be the ideal starting point in the non-immobilized patient, it is not always the best position. Occasionally less elevation is effective. Alternatively, placing the patient into an extreme extension with a towel roll behind the shoulders has been shown to be effective. Additional elevation beyond the sniffing position may also be effective. This is called the "Head Elevated Laryngoscopy Position".

I remember one medical case where a senior resident I was supervising had performed optimal laryngoscopy, including the sniffing position and ELM, but was still unable to visualize the larynx. I manually lifted the head 6 to 8 inches off the bed into an exaggerated sniffing position at which time the cords came into view. I am aware of other similar cases.



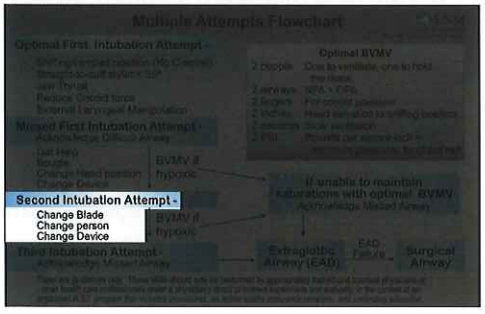
In the upper frames you see the patient in the optimal sniffing position. In the lower frames you see the hyper-elevated head position, in this case maintained by an assistant who is also helping with ELM. Used with permission from Schmitt HJ, Mang H. Head and neck elevation beyond the sniffing position improves laryngeal view in cases of difficult direct laryngsocopy. J Clin Anesth 2002;14:335-338.

CHANGE DEVICE

There are now a variety of enhanced laryngoscopy devices on the market including video laryngoscopy, lighted stylets, optical stylets, optical laryngoscopes and intubating extraglottic airways. These devices may be considered for use on the first, second or third attempt. They are most commonly used after the first or second attempt is missed. They are discussed in the following section.

The Missed Second Attempt

When the second attempt is also missed the stakes are very high. If you are practicing in a "two strikes and you're out" system then this is the time to place a back-up airway. If you are in a "three strikes and you're out" system you need to balance the patient's likelihood of tolerating another attempt and your likelihood of success on a third attempt. The overall success on the third attempt is very low unless significant changes in technique or intubator can me made. Potentially significant changes include change of blade, change of intubator, change of device and relaxation of cervical precautions.



CHANGE BLADE

Most intubators have a favorite blade (curved or straight, longer or shorter) that they use routinely. Most people find the curved-blade easiest for adult intubations. Many experts recommend a straight-blade for pediatric intubations to control the commonly floppy epiglottis in this age group. It is important to be facile with both blade types as some patients will be easier to intubate with one or the other. This is true for children as well as adults. If the obstacle to laryngoscopy is control of the tongue switching to a curved-blade may be useful. If the obstacle to laryngoscopy is locating or controlling the epiglottis switching to a straight-blade may be useful.

Many, if not most, providers do not use a curved-blade correctly. It is also important to realize that straight-blade technique is substantially different from using a curved blade; the optimal technique is "para-glossal". I particularly endorse the "Blind Insertion Approach" to straight-blade use described in the *Manual of Emergency Airway Management* by Walls. Readers are referred to the texts listed in the Preface for further detailed instruction on laryngoscopy techniques. The *AirwayCam Guide* by Levitan is particularly detailed in this area.

CHANGE PERSON

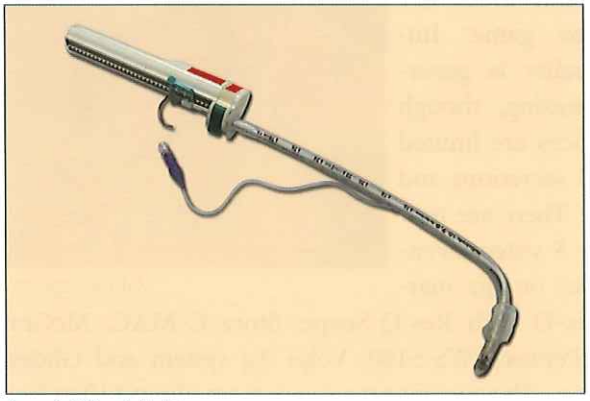
If you have managed enough airways you have undoubtedly encountered a difficult intubation and you have most likely been "scooped" by someone with less experience; I know I have. Everyone brings a different skill set, different experiences and a different perspective to the bedside. On any given day for any given patient one person's skill set may be more effective than another's. Since we discourage more than 2 or 3 overall attempts, you should call for help early and let another intubator try after only one or two missed attempts.

CHANGE DEVICE

There are now a variety of enhanced laryngoscopy devices on the market including video laryngoscopy, lighted stylets, optical stylets and laryngosopes and intubating EADs. In fact, there are so many products being introduced that it is nearly impossible to keep up, let alone try them all. These devices may be considered for use on the first, second or third attempt. They should definitely be employed no later than the third attempt if the airway is proving difficult.

Lighted Stylets

A lighted stylet (aka lightwand) allows for intubation by transillumination, i.e. placing a bright light on the end of a stylet and positioning it so that the light may seen through the soft tissues of the neck when the tip has passed into the trachea. Once tracheal placement of the stylet has been obtained the endotracheal tube is passed over the stylet, much like a bougie. Several brands of lighted stylet are available though the Trachlight by Laerdal is the most widely favored by most experts. A very similar product is available from Rusch under the name Trachlite. Both devices can be used in adults and pediatrics, for oral and nasal intubation, and alone or through a laryngeal airway. One common handle is purchased along with wands for adults, children and/or infants. The total price to get started is generally under $500 U.S.



Laerdal Trachlight

Success rates in studies with experienced anesthesia providers have been extremely high though results in less experienced providers have been mixed. This likely reflects the fact that the technique for intubation with a lighted stylet is substantially different than direct laryngoscopy or devices intended to enhance direct laryngoscopy necessitating special training, practice and skill maintenance. While some providers, departments and agencies swear by these devices they have not been widely adopted in non-OR settings despite being available for over 10 years.

Video Laryngoscopy

McGrath by LMA

This is the most exciting current area of research and development in airway management. These devices use a small video camera to transmit a magnified image of the airway onto an external screen that is either mounted on the device itself or a separate monitor. The intubation is performed while looking at the screen rather than in the mouth, much like a video game. Image quality is generally amazing, though all devices are limited by oral secretions and blood. There are now at least 5 video laryngoscopes on the market: Res-Q-Tech Res-Q-Scope, Storz C-MAC, McGrath from LMA, Pentax AWS-S100, Volpi Ag system and Glidescope by Verathon. The current prices vary from about $1000 for the Res-Q-Scope to $40,000 for a complete Storz high-definition system. These devices have not all been compared head-to-head but have been shown to be superior to traditional laryngsocopy.

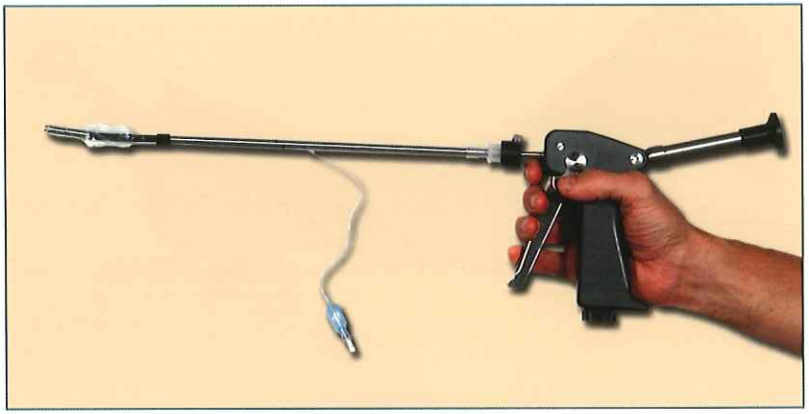
Glidescope by Verathon

Optical Stylets and Laryngoscopes

Optical stylets are rigid or semi-rigid devices that allow for an image to be transmitted from the tip to a proximal eyepiece along a fiberoptic bundle. Optical laryngoscopes are similar but shaped more like a curved blade and allow for some manipulation of the tongue. In both cases the endotracheal tube is pre-loaded onto the device so that once it is placed through the cords the tube may slid off the device and into the trachea. These devices are most similar to flexible fiberoptic scopes but are easier to use for those with less experience.

Options in this category include the Airtraq, Shikani, Levitan FPS, TruView, Airway RIFL, StyletScope, Bullard, Bonfils Retromolar, UpsherScope and WuScope. Prices for these devices range from about $700 U.S. for the TruView to nearly $10,000 U.S. for a WuScope. The AirTraq is a disposable device that sells for about $100 U.S. Of these devices the Airtraq, Levitan FPS and RIFL have been most heavily marketed for non-anesthesiologists. The Airtraq has the most extensive validation in the literature. Many of these optical stylets and laryngoscopes have a substantial learning curve; they should be used routinely to maintain competence for use in an emergency.

The Airway R.I.F.L. by AI Medical. This is a semi-rigid fiberoptic device with a tube-stop to accommodate any length tube. Squeezing the trigger allows manipulation of the end of the tube in one plane only through a limited range of motion. This may allow the tube to be guided during advancement without the complexity and learning curve of flexible fiberoptic devices. A video version has recently been developed.



The Levitan F.P.S. by Clarus

Product courtesy of Bound Tree Medical

TruView

Airtraq by Prodol

Intubating Extraglottic Airway Devices

A variety of EADs are now available which are intended for intubation to be performed through the device. These intubations are either done completely blind with bougie or lighted stylet guidance or under direct visualization, either with flexible fiberoptics or embedded fiberoptics (C-Trach). For many experienced airway practitioners intubation compatible EADs are the "go-to" device in the case of a difficult airway, since they allow continued oxygenation and ventilation while simultaneously offering a conduit for endotracheal intubation. Success rates at intubation are highly variable.

C-Trach by LMA

REDUCE CERVICAL SPINE PRECAUTIONS

Dogma is defined in Wikipedia as "the established belief or doctrine held by...any kind of organization, thought to be authoritative and not to be disputed, doubted or diverged from." One of our airway dogmas has always been the strict maintenance of cervical spine precautions for any patient with the potential for cervical spine injury. Manoach and Paladino have recently challenged that dogma in a comprehensive review article. They conclude, "It is prudent for clinicians to use manual in-line stabilization when it does not hinder intubation attempts. There are data to support allowing some flexion and extension of the upper cervical spine if needed to facilitate visualization of glottic structures during direct laryngoscopy." In other words, maintain cervical spine precautions until it becomes a matter of airway or no airway. Hypoxemia probably contributes more to secondary spinal cord injury than the relatively minimal forces of laryngoscopy. With appropriate use of ELM this should rarely be necessary.

Do all these maneuvers need to be utilized in the order presented?

No. This is a suggested order that works in most circumstances but the clinician should make appropriate adjustments in each individual case. For example, if the obvious problem on the first attempt is the inability to control the tongue with a straight-blade then the intubator should not wait until the second attempt fails to switch to a curved blade. Likewise, some intubators use a bougie on every first attempt to maximize their success and gain experience with the bougie. If a patient proves extremely difficult on the first attempt and a more experienced intubator is available it is probably wise to switch positions immediately.

With all this new technology is there a future for the laryngoscope?

I don't believe that the laryngoscope as we have known it for the past 100 years plus will exist in 10 years. The technology that is out and coming out is just too good. As the price point comes down and a few devices rise to the top of the pack we will all be using this advanced technology and it won't be limited to difficult airways; these will be first-line tools.

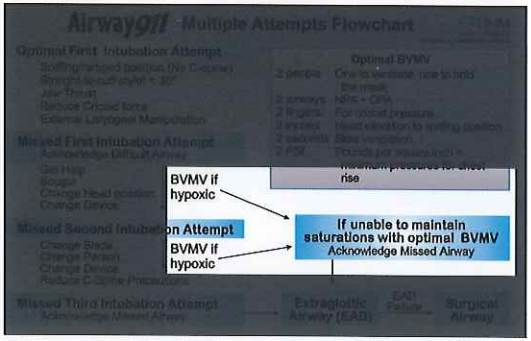
We have limited funds available. Which of these devices do we spend our money on?

Good skills and judgment don't cost a dime. A disposable bougie costs less than $10 U.S. and a disposable set of typical simple EADs cost $100 to $300 U.S. depending on the brand. This, along with a scalpel for a cric, should be the minimum starting point for everyone doing RSI. From here the choices get broader, more personal and definitely more expensive.

Depending on the setting in which you work you may rarely need to go beyond this point as you can hopefully keep most any patient alive while you await further help. It is important to be sure that whatever device you purchase is either something simple enough that you can pull out in the middle of the night, totally stressed, two years from now and get the job done or something you can and will realistically use for routine intubations to keep your skills and comfort level high.

Between Attempts

There is no specific time limit to an attempt as long as the patient is maintaining adequate oxygen saturations. Adequate is determined on a case-by-case basis but usually implies saturations above 90%. Once an attempt is aborted, i.e. to change personnel, positioning or equipment, the patient should be placed back on high-flow oxygen for passive diffusion; they should NOT receive positive-pressure ventilation unless oxygen saturations are falling. If positive pressure is required and saturations continue to fall, be sure to use optimal technique, namely the "Rule of Twos".



Rule of Twos

For Optimal Bag-Valve-Mask Ventilation

2 people	One to ventilate, one to hold the mask
2 airways	NPA + OPA
2 fingers	For cricoid pressure
2 inches	Head elevation to sniffing position
2 seconds	Slow ventilation
2 PSI	Pounds per square inch = minimum pressures for chest rise

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Department of Emergency Medicine

We developed this Rule of Twos as a teaching aid. Note that it actually requires 3 people to perform correctly. "'2 PSI" is meant to remind you to use minimal pressures, not really 2 PSI.

This photo demonstrates rule of twos BVMV. Note one person is holding a tight seal on the mask using the "E-C" grip, one person is squeezing the bag slowly and gently, and a third person is providing cricoid pressure. The head is elevated into the sniffing position since the patient is not in spinal precautions. An OPA and NPA are in-place as well.

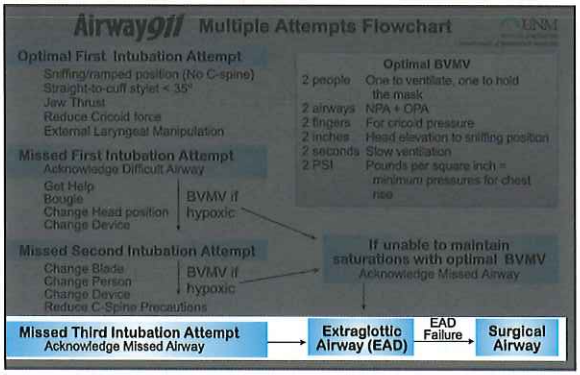
If adequate saturations cannot be maintained with optimal BVMV the provider should recognize a missed airway and move immediately to a back-up airway, even if less than 3 attempts have been made. In some rare circumstances, usually when intubating a patient for severe refractory hypoxemia, a missed airway may occur before any attempt at intubation has been made because the saturation falls as soon as RSI medications are administered and the patient cannot be adequately oxygenated with BVMV.

What is RSA and how is it different?

RSA stands for Rapid Sequence Airway. This is a new airway concept particularly well-suited to prehospital settings. In RSA, all the ten P's of RSI are utilized, including paralysis and induction, but an EAD is placed without any planned attempt at laryngosocopy. This is different than a situation in which intubation was planned but fails, even if that failure occurs before any attempt at laryngoscopy. It is all a matter of intent. See Chapter 7 for more information on RSA.

The Missed Third Attempt

As previously discussed in Chapter 2, intubation attempts should generally be limited to three – the "Three strikes and you're out" rule – unless there is some compelling reason to believe you will be successful on the next attempt and intubation is the only acceptable way to manage the patient. For example, the patient has upper airway edema secondary to inhalation burns - therefore not a good candidate to be managed with an EAD - and a more experienced intubator has arrived. This would be a reasonable exception to the rule. In most other cases it is now appropriate to declare a missed airway and move to a back-up airway. In some systems, there has been a move to optimize the first intubation attempt and move to declaring a missed airway after only 2 attempts.



BACK-UP (RESCUE) AIRWAYS

A rescue or back-up airway is a device used to maintain oxygenation and ventilation in the case of a missed intubation. The most common rescue airway is BVMV, however this has limitations: it is often difficult, it is tiring, it ties up personnel, it is subject to great variations in tidal volume and pressures which can impact outcomes, and it does not provide any aspiration protection.

The next most common back-ups are the EADs, which I divide into 3 groups: larngeal airways, dual-lumen airways and the King airways . Everyone performing RSI should have at least one appropriate EAD available and be knowledgeable in its use. It is essential that you at least be familiar with the EAD available in your practice setting. A surgical airway should not be considered a routine back-up airway but rather an alternative airway or back-up of last resort.

In some situations an EAD may be placed without any attempt at laryngoscopy; this may occur because the patient quickly desaturates and cannot be salvaged with optimal bag-valve-mask ventilation (missed airway) or by original intent (RSA).

Laryngeal Airways

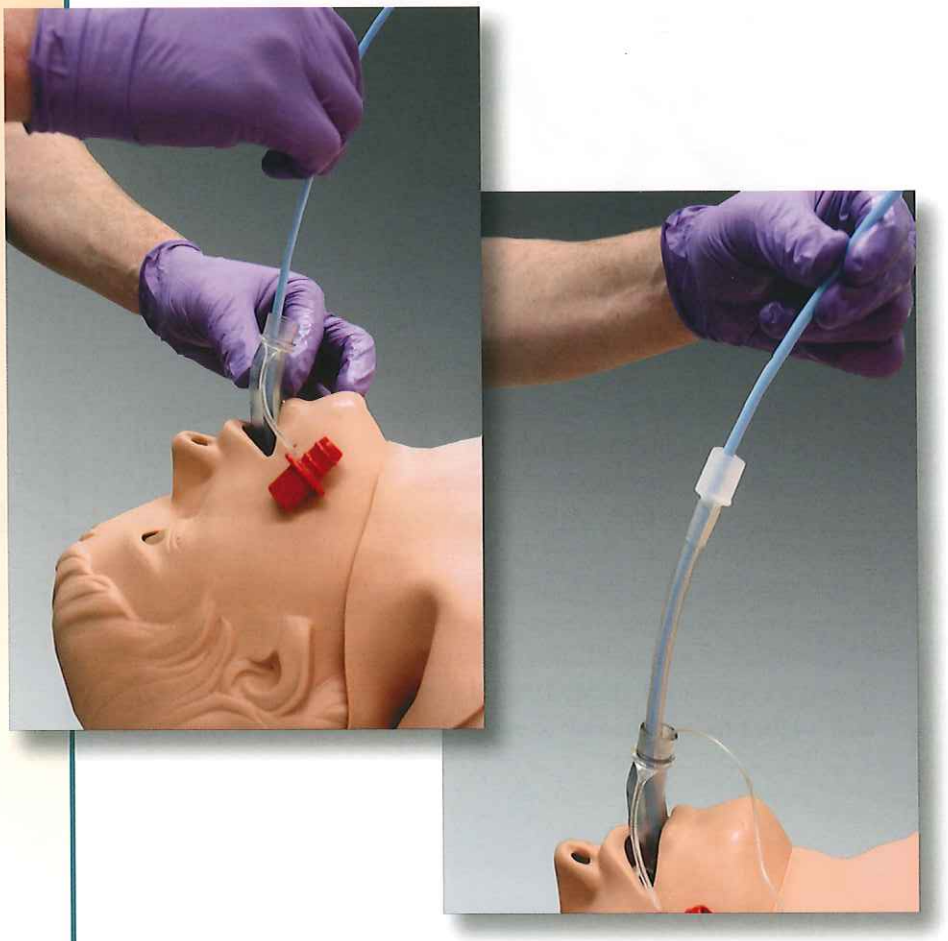
Laryngeal airways are very simple devices that are a cross between a bag-valve mask and an endotracheal tube. Essentially the "mask" is placed directly over the larynx rather than the mouth. The original and best-known laryngeal airways are made by the Laryngeal Mask Airway Company ® and commonly known as LMAs, but there are now several excellent competing products on the market. Laryngeal airways are used extensively in the operating room setting as primary airways for elective cases. They are now becoming more widely used as a rescue airway for missed RSI. Laryngeal airways are also being used

in some jurisdictions as a primary emergency alternative airway for pre-hospital providers not trained to perform endotracheal intubation. Laryngeal airways are easier to use than BVMV and can be inserted very rapidly with extremely rare insertion failures.

This photo demonstrates just some of the laryngeal airways now on the market. From left: iGel, Ambu, LMA-Supreme, AirQ, Cobra PLA and LMA-Unique.

The commonly stated drawbacks to these devices are that they offer less aspiration protection than an endotracheal tube and cannot generate high airway pressures. As it turns out, even the older versions offer greater aspiration protection than most practitioners realize. Newer versions such as the LMA-ProSeal, LMA-Supreme, iGel and AirQ offer even greater aspiration protection and higher airway pressures. The LMA-ProSeal, LMA-Supreme and iGEL also allow placement of a gastric tube through a separate dedicated channel to decompress the stomach and further reduce the risk of aspiration.

Another group of laryngeal airways allow for endotracheal intubation through the device. The most commonly used device for this indication is the LMA-Fastrach. Success rates as high as 90% have been reported though it is probably closer to 50 or 75% in most hands. Another device that advertises potential placement of an endotracheal tube is the AirQ. Insertion of the tube through the AirQ may be done blindly or via a bougie, and is simpler than with the Fastrach, though there is less experience with it in the literature. Some authors have reported up to a 50% success rate at intubation just using a bougie and a standard LMA-Classic. The important thing with any of these devices is that they first be used to establish critical oxygenation and ventilation; endotracheal tube placement should be considered a potential though unguaranteed perk.

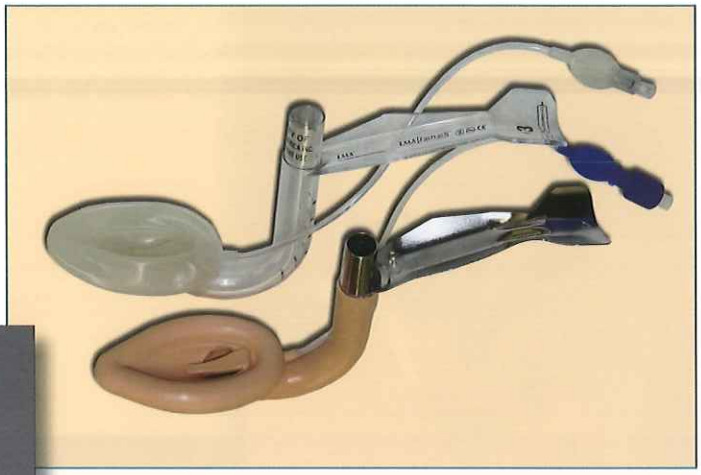


This series of photos demonstrates blind intubation though an EAD, in this case an AirQ, using a bougie. The bougie is inserted gently through the EAD. If tracheal position is confirmed an endotracheal tube may be advanced into the trachea over the bougie and through the EAD.

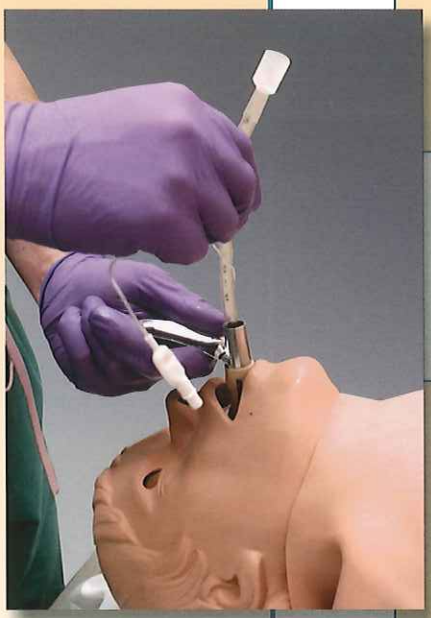
Here the "patient" is ventilated via the endotracheal tube with the EAD still in place. The EAD may be removed electively when the situation has stabilized.

An alternative to placing the endotracheal tube through the laryngeal airway is to first remove the airway over the bougie, once placement of the bougie in the trachea is confirmed.

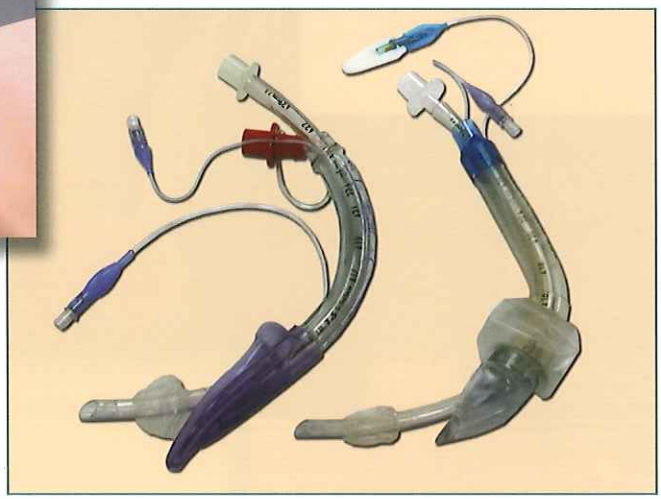
The endotracheal tube is then inserted into the trachea over the bougie.



Single-use (top) and reusable(bottom) LMA-Fastrach.



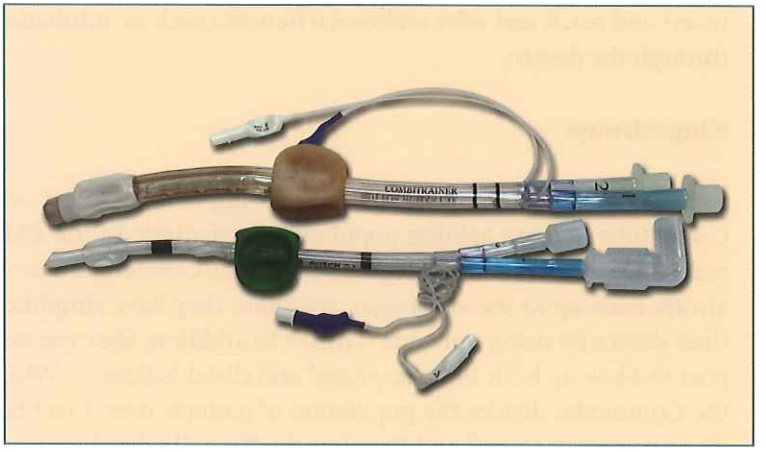
This photo demonstrates blind placement of a well-lubricated endotracheal tube through the LMA-Fastrach. Note that use of a special tube is recommended.



If a bougie is not available an endotracheal tube may be blindly placed through most laryngeal airways. This photo demonstrates endotracheal tubes being placed through a LMA-Unique (left) and CobraPLA (right). This technique is much less likely to be successful than using a laryngeal airway that was specifically designed for blind intubation such as the AirQ or LMA-Fastrach.

Dual-lumen Airways: Combitube, Rusch EasyTube

Dual-lumen airways are essentially an endotracheal tube and an esophageal obturator airway in one. They are designed to be placed blindly and to be useable whether they end up in the trachea or esophagus, although they virtually always end up in the esophagus. There is a large proximal balloon that completely fills the pharynx and prevents air from escaping out the mouth and a smaller distal balloon to occlude the esophagus or trachea (depending on tube position).



Top: Combitube Bottom: EasyTube Products courtesy of BoundTree Medical.

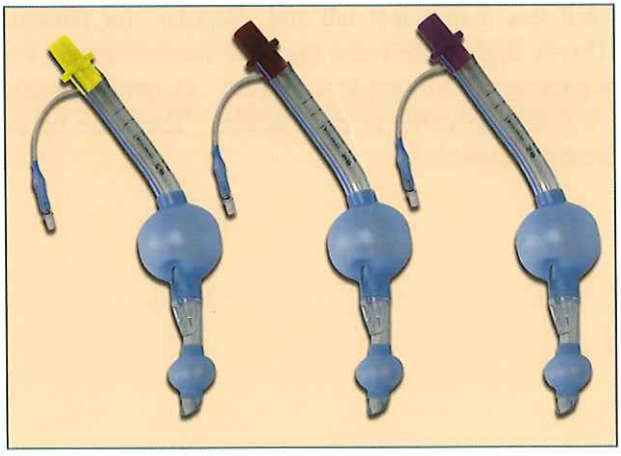
The primary dual-lumen airway on the U.S. market is the Combitube, which comes in two sizes: "Small" for patients over 4 feet but less than 6 feet tall and "Regular" for patients 6 feet tall. This is slightly different than the manufacturers suggested height parameters but evidence-based. Generally speaking the small will be applicable to most adults. There are no pediatric Combitubes available.

The Combitube is widely used in the pre-hospital setting as a primary emergency alternative airway or as a rescue device in case of missed intubation. The Combitube provides excellent aspiration protection, generates relatively high airway pressures and may tamponade some oral bleeding. It is contraindicated when a gag reflex or esophageal pathology is present.

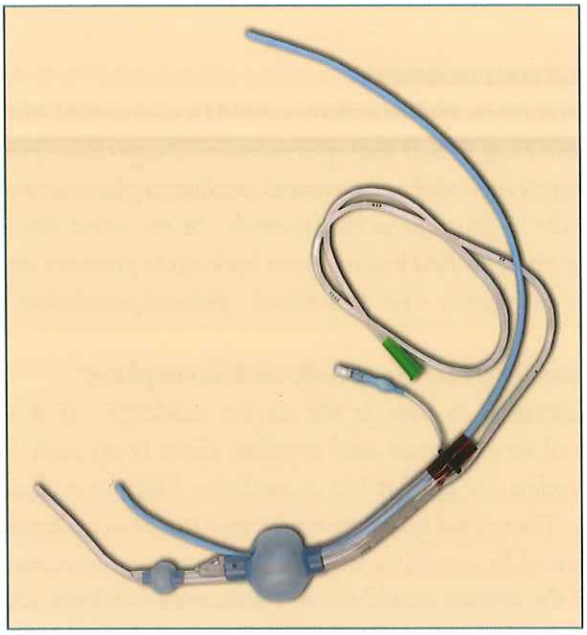
Unfortunately the Combitube is associated with serious potential complications in some studies. While the Combitube has saved many lives over the years I suspect it is on its way out, overshadowed by new generation EADs that are easier to insert and teach and offer additional benefits such as intubation through the device.

King Airways

King airways represent a substantial improvement on the Combitube and are gaining popularity, particularly in the EMS market They are based on the premise that the Combitube almost always ends up in the esophagus; therefore they have simplified their device by using only one lumen. In addition, they use one port to blow up both the pharyngeal and distal balloons. While the Combitube divides the population of patients over 4 feet tall into two groups (Small and Regular) the King divides this group into 3 airways. Like the Combitube they generate relatively high airway pressures and provide above-average aspiration protection.



The King Systems LTS-D airway has a channel for a gastric tube and another to pass a bougie. This version is not yet available in pediatric sizes.



The King LTS-D has one channel for passage of a gastric tube and another to potentially direct a bougie towards the glottis to facilitate blind intubation.

There are two disposable versions of the King, the LT-D and the LTS-D. The LTS-D has both a channel for a gastric tube and a ramp designed to accommodate a bougie. The LT-D model is now available in some pediatric sizes as well, extending the lower height limit to 35 inches.

Why would you choose one device over another for a missed airway?

In a pediatric patient the decision is easier as there are fewer choices available, though the market is expanding. For now only laryngeal airways are available in a full-range of pediatric sizes. I believe King is close to offering a full-range of pediatric sizes. In adults there are many more choices. For a first line airway the laryngeal devices are simple to insert and available in a full-range of sizes. In the adult and larger pediatric population the King and LMA-Supreme are very appealing due to greater aspiration protection and airway pressures. Devices which provide an option for blind intubation, such as the LMA-Fastrach, Air-Q, and King LTS-D are nice to have available though it is very easy to get distracted with this feature when the primary goal is to keep the patient oxygenated.

What is "GI tract isolation?"

GI isolation is a term applied to the newer EADs such as the LMA-Supreme and King LTS-D that offer substantial aspiration protection through high seal pressures and facilitated placement of a gastric tube to decompress the stomach. In my mind this is the turning point for EADs going from back-up to primary airways in the emergency – i.e. non-fasted – patient population.

What do you do if there is already an EAD in place?

The first question is how is the device working? If it is working well to oxygenate and ventilate there is no rush to change it unless the patient has a condition likely to occlude the glottis. The second question is why was the device placed? If it was placed by providers without training in endotracheal intubation the airway should not be traumatized and you can make your usual assessment of difficulty of intubation using LEMONS. If it was placed by extremely experienced intubators who failed to visualize the larynx after multiple intubation attempts, beware: this may be a very difficult airway due to patient anatomy and/or subsequent airway trauma. The third question is what is the patient's anticipated clinical course? For example, a patient with inhalation burns or anaphylaxis is not likely to be helped by an EAD if their larynx swells shut. The final question is where are you? Are you in the field with a short transport time or at a tertiary care center with multiple resources available? In general, however, most well-functioning EADs should be left in place.

ALTERNATIVE AIRWAYS

Alternative airways must be distinguished from rescue airways. An alternative airway is a means of securing the airway other than RSI/oral intubation, that is used when oral intubation is not deemed possible, because of anatomic constraints (i.e. severe facial trauma) or situational constraints (i.e. patient is not in a good position to perform laryngoscopy or a short transport time). Alternative airways include nasal intubation, awake intubation, digital intubation, retrograde intubation and surgical airways. Note that a cricothyroidotomy is usually not a rescue airway but rather an alternative airway of last resort.

Cricothyroidotomy

Cricothyroidotomy (aka cricothyrotomy or "cric") consists of three different techniques: surgical airways, percutaneous airways, and needle airways.

Surgical Cricothyrotomy

Cricothyroidotomy is an invasive alternative airway technique with serious potential short and long-term morbidity. It is difficult and time-consuming to perform in all but the most experienced hands. Under emergency conditions surgical airways have up to a 50% complication rate and often take up to 3 minutes to perform. Complications include bleeding, placement in the soft tissues, airway injury, nerve injury, thyroid injury, etc. *The Manual of Emergency Airway Management* and *Management of the Difficult and Failed Airway* use the SHORT mnemonic to recall predictors of difficult cricothyrotomy: Surgery, Hematoma/Abscess, Obesity, Radiation history and Tumor.

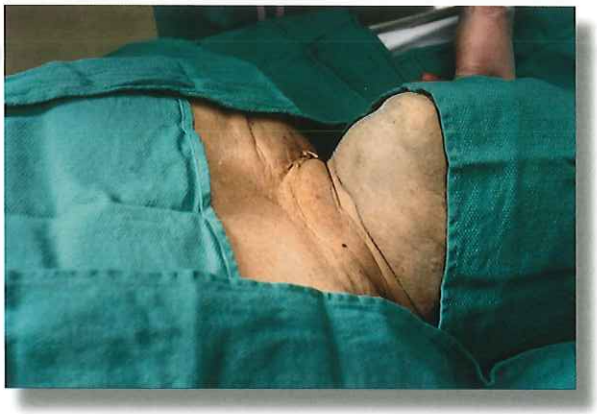
Cricothyroidotomy should not be the first-line rescue airway in the event of a failed RSI unless an unexpected proximal airway obstruction is encountered or the patient cannot be oxygenated with optimal BVMV or an EAD. It should only be attempted when an airway must be established urgently to prevent death or serious hypoxic injury and no other means are acceptable or available. The most common scenario is a critical trauma patient with trismus in an EMS system that does not permit RSI. When RSI is available, cricothyroidotomy is rarely indicated; the incidence is further decreasing as EADs become better and more pervasive.

There are 3 major approaches to the surgical airway: the traditional, the rapid four-step, and the bougie-aided technique. My personal preference is for the bougie-aided approach, which I now teach almost exclusively. Surgical airways are contraindicated for children < 8 years of age.

What is a "double set-up"?

When RSI is to be performed on a patient where there is a reasonable suspicion of impossible oral intubation AND rescue device placement (i.e. massive facial trauma) it is best to prepare for a surgical airway before proceeding with RSI. In this way you may move seamlessly to a surgical airway without delay if the intubation proves impossible. This is called a "double set-up" and it is probably underutilized.

The Bougie-Aided Cricothyrotomy



Step 1: Prep and drape the neck as time allows.

Step 2: Make a midline vertical incision, if necessary, to locate the cricothyroid space between the inferior edge of the thyroid cartilage and the cricoid ring.

Step 3: Make a horizontal incision, about 2 cm in length, through the cricothyroid membrane.

Step 4: Bluntly enlarge the opening using your finger.

Step 5: Place the bougie into the incision with the coude tip directed towards the patient's feet.

Step 6: Pass the bougie and confirm tracheal positioning by assessing for "clicking" over the tracheal rings. If this cannot be appreciated pass the bougie no more than 20 cm to assess for firm hold-up at the smaller airways.

Step 7: Pass a 6.0 mm cuffed endotracheal tube over the bougie. Note that some adult bougies will accommodate a 5.5 mm tube.

Step 8: Pass the tube into the trachea. It may be necessary to apply gentle pressure and a twisting motion. The tube should be passed only until the balloon passes completely through the cricothyroid membrane.

Step 9: Withdraw the bougie and ventilate the patient. Use capnography and/or an EDD to further confirm placement. The tube may be carefully cut shorter if desired. The tube should be secured in place.

Percutaneous Cricothyrotomy

The second major category of cricothyrotomy is the percutaneous approach. These techniques include both direct insertion and Seldinger (guide-wire) techniques of which the Cook Melker wire-guided kit is the most commonly recommended. The arguments in favor of percutaneous techniques include less morbidity, faster insertion and less risk of injury to the operator, though results in the literature have been very mixed. While physicians in emergency medicine, critical care and anesthesia are very comfortable with Seldinger-based techniques; other providers may not have such familiarity. These techniques all require special equipment and/or kits.

Needle Cricothyrotomy

This technique is performed even more rarely than surgical cricothyroidotomy. Rather than using a scalpel to make an incision and placing a cuffed tube into the trachea, this technique places only a large bore IV catheter through the cricoid membrane. High-pressures must be used to ventilate the patient through such a small opening. Usually a 50 psi oxygen source is used, in which case the technique is called transtracheal jet insufflation. Alternatively, a self-inflating bag may be used but it is more difficult to generate adequate pressure.

Needle cricothyroidotomy is considered a temporizing means of oxygenation and ventilation only; it is best limited to less than 30 minutes. It is primarily a pediatric technique because surgical cricothyroidotomy is contraindicated in this age group. However, most children can be adequately oxygenated and ventilated over the short-term with a BVM or laryngeal airway. The other disadvantage to this technique is that it requires having specialized adapters ready or being able to remember how to improvise in the heat of battle. Needle cricothyroidotomy has been removed from the scope of practice for paramedics in many states due to the rarity with which it has been performed.

Blind Nasotracheal Intubation (BNTI)

The blind nasotracheal technique for intubation was the preferred technique for intubation before the development of paralytics and RSI. It is still occasionally used as an alternative airway for intubating spontaneously-breathing patients, either because the provider is not trained/authorized to use RSI or in cases of anticipated difficult intubation. Unfortunately, the success rate is relatively low (50 – 75%), it is associated with increased ICP and epistaxis, and smaller endotracheal tubes must be used. BNTI relies upon using the patient's breathing to guide the tube into the trachea; it cannot be used to rescue failed RSI in the paralyzed apneic patient.

Several commercial products exist to improve BNTI success including Endotrol endotracheal tubes, the BAAM device and end-tidal CO_2 detectors. Other tricks include the use of backward external pressure on the larynx and brief inflation of the tube cuff in the posterior pharynx to direct the tube anteriorly. The current generation of physicians is relatively uncomfortable with this technique, as RSI has taken over airway management in the teaching hospitals; the same may happen for EMS providers. Like most alternative techniques, BNTI is rarely indicated, but still a skill worth mastering.

Retrograde Intubation

Occasionally, a patient cannot be intubated by direct laryngoscopy but may be intubated in a reverse fashion, usually because of airway obstruction. In this technique, a needle is passed through the cricothyroid membrane directed towards the mouth; a guide-wire is inserted through this needle and retrieved from the mouth. An endotracheal tube is then threaded over this catheter into the trachea. The tricky part is that the tip of the endotracheal tube is barely through the glottis before running out of wire (since the wire is coming through the cricioid). One solution to this dilemma is to place a catheter or bougie or tube changer through the endotracheal tube and into the trachea as a "place-holder" before the guidewire is removed and the endotracheal tube advanced. Retrograde intubation is a relatively time-consuming procedure limited to situations in which oxygenation is easily maintained.

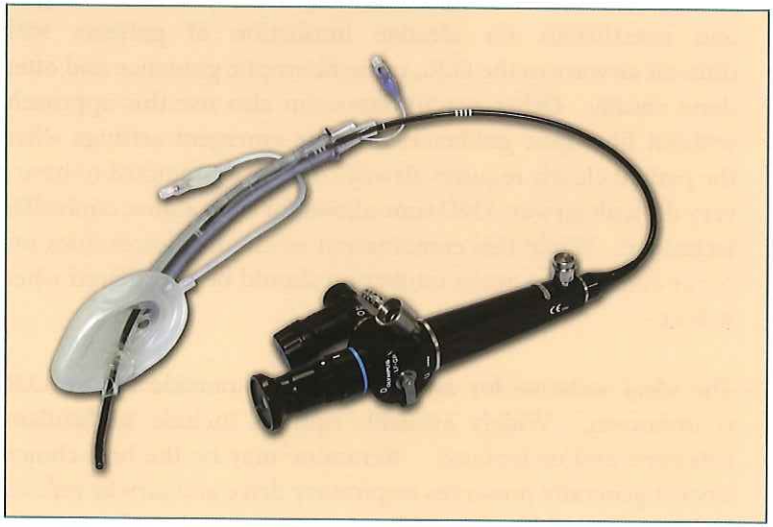
Flexible Fiberoptic Intubation

Traditional fiberoptic laryngoscopy with a flexible scope and television monitor is usually restricted to the O.R. setting; the equipment is expensive with a significant learning curve so that it must be practiced regularly to be useful in emergencies. Flexible fiberoptic intubation is most commonly used for stable, cooperative, lightly sedated, awake patients with difficult airways. Very few emergent patients are candidates for this procedure.

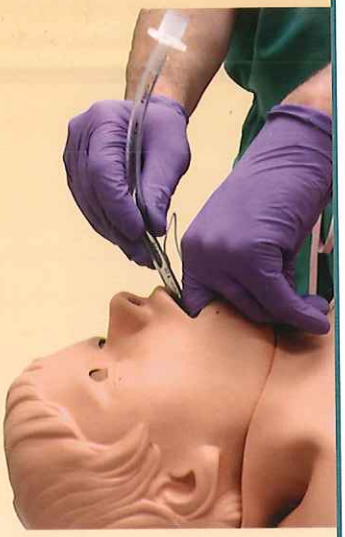
One important exception is the management of a patient being ventilated with a simple laryngeal airway after a missed intubation. Once the patient is stabilized, an endotracheal tube may be loaded onto the flexible scope, which is in turn passed through the LMA and through the vocal cords. Once the tracheal rings are seen the endotracheal tube may be slid over the scope and through the LMA, using lots of lubrication. Be sure to test that the selected tube will fit through the EAD before attempting on the patient. While this still takes practice it is a reasonable and very useful ED or ICU skill.

An endotracheal tube has been preloaded onto the flexible fiberoptic scope. The tip is advanced through the laryngeal airway keeping the scope as straight as possible. The scope tip is manipulated through the vocal cords under direct visualization.

Here the well lubricated endotracheal tube has been advanced into the airway over the scope and through the laryngeal airway. The scope is then removed, the tube confirmed in place using capnography and the patient ventilated. The laryngeal airway may be deflated and left in place until assistance arrives.



Here we see the endotracheal tube emerging from an LMA-Unique as it passes over the short flexible fiberoptic scope.



Digital Intubation

Digital intubation is the passage of a tube into the trachea guided by the intubator's fingers rather than under direct visualization. This technique is rarely used but may be considered in cases when the patient cannot be positioned for laryngoscopy, such as a patient trapped in a vehicle, difficult airway cases with limited back-ups or equipment failure.

Awake Intubation

Awake intubation is a fascinating airway management technique in which the patient is given both systemic sedatives and topical anesthetics to allow laryngoscopy without the risks of RSI or sedation-facilitated intubation. This technique is different from sedation-facilitated intubation in that the sedatives are carefully titrated rather than given as large bolus and because topical anesthetics are used to blunt the gag reflex.

Awake intubation is most commonly used by anesthesiologists and anesthetists for elective intubation of patients with difficult airways in the O.R., using fiberoptic guidance and often done nasally. Other practitioners can also use this approach, without fiberoptic guidance, in more emergent settings when the patient clearly requires airway control, is predicted to have a very difficult airway AND time allows for such a slow, controlled technique. While this combination of circumstances does not occur commonly, awake intubation should be considered when it does.

The ideal sedative for awake intubation outside of the O.R. is unknown. Widely available options include midazolam, ketamine and/or fentanyl. Ketamine may be the best choice, since it generally preserves respiratory drive and airway reflexes and provides analgesia in addition to sedation, though increased secretions and dysphoria may be problematic. Whichever agent is selected it is important to titrate slowly. While anesthesiologists have multiple methods to achieve topical anesthesia, many of these require time, a cooperative patient, unique equipment

and/or special skills. Topical anesthesia "for the rest of us" is most easily obtained using a typical hand-held nebulizer and 4% lidocaine.

Further research in this area is necessary to define the best combination of systemic and topical agents for use outside of the Operating Room.

Non-invasive Positive Pressure Ventilation (NIPPV)

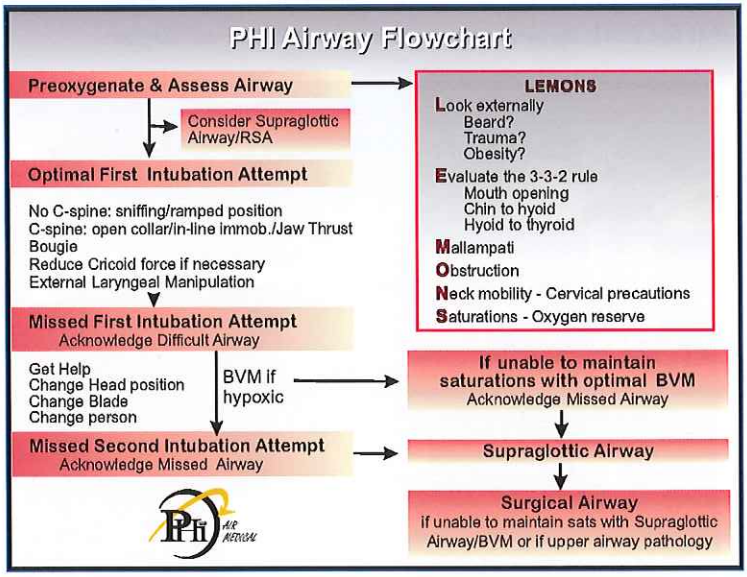
Non-invasive positive pressure ventilation, in the form of CPAP (continuous positive airway pressure) or BiPAP (bi-level positive airway pressure), may be used as an alternative to intubation to maintain oxygenation and support ventilation in some patients. CPAP is primarily useful for hypoxemia where as BiPAP is useful for both hypoxemia and hypoventilation/fatigue.

This photo demonstrates the increasingly common prehospital use of CPAP by ground and air medical crews. Photo courtesy of Bound Tree Medical.

In some cases NIPPV may entirely prevent the need for intubation, bridging the gap until the underlying pathophysiology can be corrected. In other cases it serves as a bridge until intubation can be performed in a more controlled setting. There is also some evidence that it can be an excellent means of pre-oxygenating hypoxemic patients prior to inevitable intubation. In other words, when available and not contraindicated due to patient mental status, it is worth trying. I find it particularly useful in patients with pulmonary edema and pneumonia.

Other Guidelines

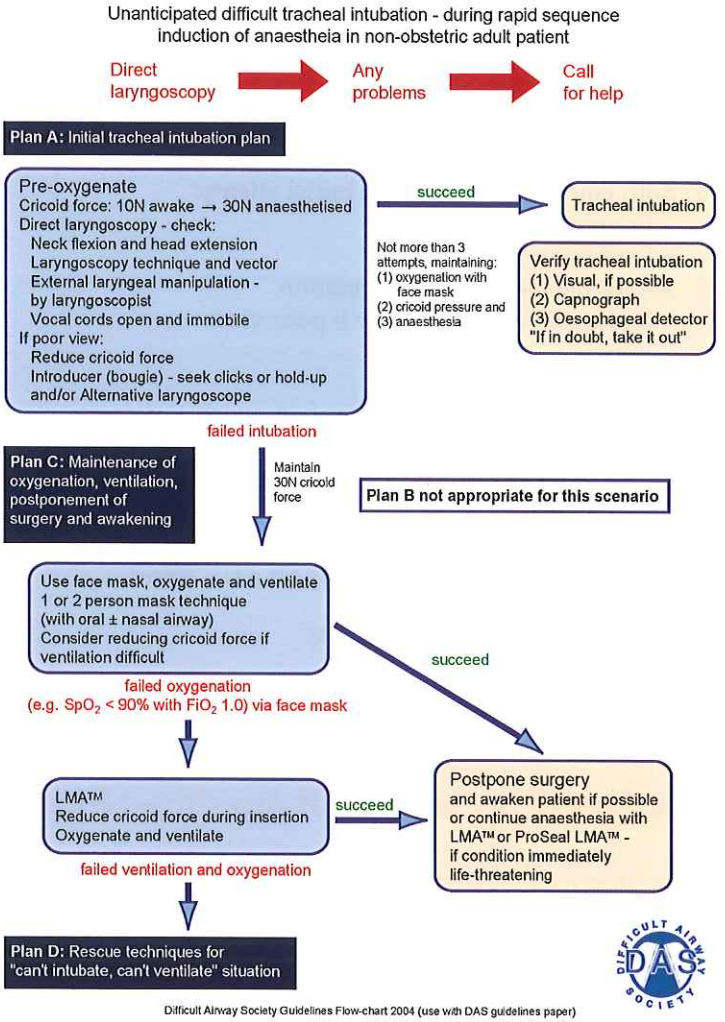
PHI Air Medical



The national airway flowchart for PHI is based upon the *Airway911* algorithm with several important modifications:

1. Supraglottic (aka extraglottic) airways and RSA are an option before intubation.
2. The bougie is used routinely on first intubation attempts
3. Only two attempts are permitted before moving to a back-up airway.

The Difficult Airway Society



Difficult Airway Society Guidelines Flow-chart 2004 (use with DAS guidelines paper)

The Difficult Airway Society, a group based in the UK, "aims to improve management of the patient's airway by anaesthetists and critical care personnel". They publish excellent guidelines which are available on their website, www.das.uk.com, and reprinted here with their permission. It is very interesting to note the similarities between these O.R. based guidelines for the "Unanticipated difficult tracheal intubation – during rapid sequence induction of anaesthesia in non-obstetric adult patient" and our own Multiple Attempts Algorithm:

1. Both emphasize an optimal initial attempt
   - Preoxygenation
   - Sniffing position
   - External laryngeal manipulation
   - Reduction of cricoid view if poor view
   - Bougie

2. Both emphasize no more than 3 attempts

3. Both call for use of an extraglottic airway in the failed or "missed" airway

4. Both reserve cricothyroidotomy for a last resort

5. Both emphasize optimal BVMV
   - Two people
   - Sniffing position
   - Two airways – both nasal and oral

The American Society Of Anesthesiologists

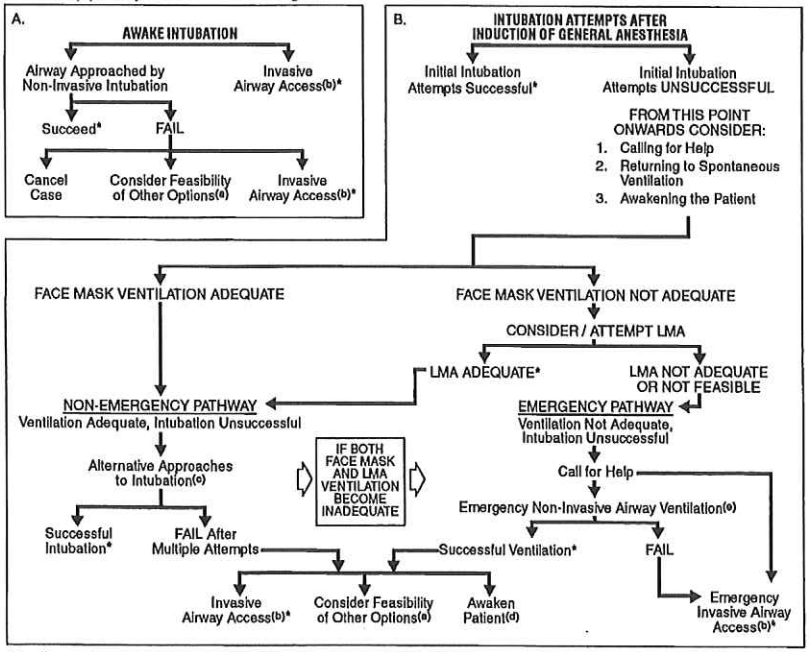
The American Society of Anesthesiologist's (ASA) Difficult Airway Algorithm is widely referenced. It was last updated in 2003. As expected, it is oriented toward the O.R. setting and therefore includes both RSI and induction without paralytics. In the latter case there are options available which may be unavailable during RSI such as "awakening the patient".

The algorithm begins with assessing various options including the use of awake intubation. The primary branch point is the feasibility of BVMV. Their primary rescue device in the event that BVMV fails is the LMA.

AMERICAN SOCIETY OF ANESTHESIOLOGISTS

DIFFICULT AIRWAY ALGORITHM

1. Assess the likelihood and clinical impact of basic management problems:
   - A. Difficult Ventilation
   - B. Difficult Intubation
   - C. Difficulty with Patient Cooperation or Consent
   - D. Difficult Tracheostomy
2. Actively pursue opportunities to deliver supplemental oxygen throughout the process of difficult airway management
3. Consider the relative merits and feasibility of basic management choices:
   - A. Awake Intubation -vs- Intubation Attempts After Induction of General Anesthesia
   - B. Non-Invasive Technique for Initial Approach to Intubation -vs- Invasive Technique for Initial Approach to Intubation
   - C. Preservation of Spontaneous Ventilation -vs- Ablation of Spontaneous Ventilation
4. Develop primary and alternative strategies:



*** Confirm ventilation, tracheal intubation, or LMA placement with exhaled CO_2**

a. Other options include (but are not limited to): surgery utilizing face mask or LMA anesthesia, local anesthesia infiltration or regional nerve blockade. Pursuit of these options usually implies that mask ventilation will not be problematic. Therefore, these options may be of limited value if this step in the algorithm has been reached via the Emergency Pathway.

b. Invasive airway access includes surgical or percutaneous tracheostomy or cricothyrotomy.

c. Alternative non-invasive approaches to difficult intubation include (but are not limited to): use of different laryngoscope blades, LMA as an intubation conduit (with or without fiberoptic guidance), fiberoptic intubation, intubating stylet or tube changer, light wand, retrograde intubation, and blind oral or nasal intubation.

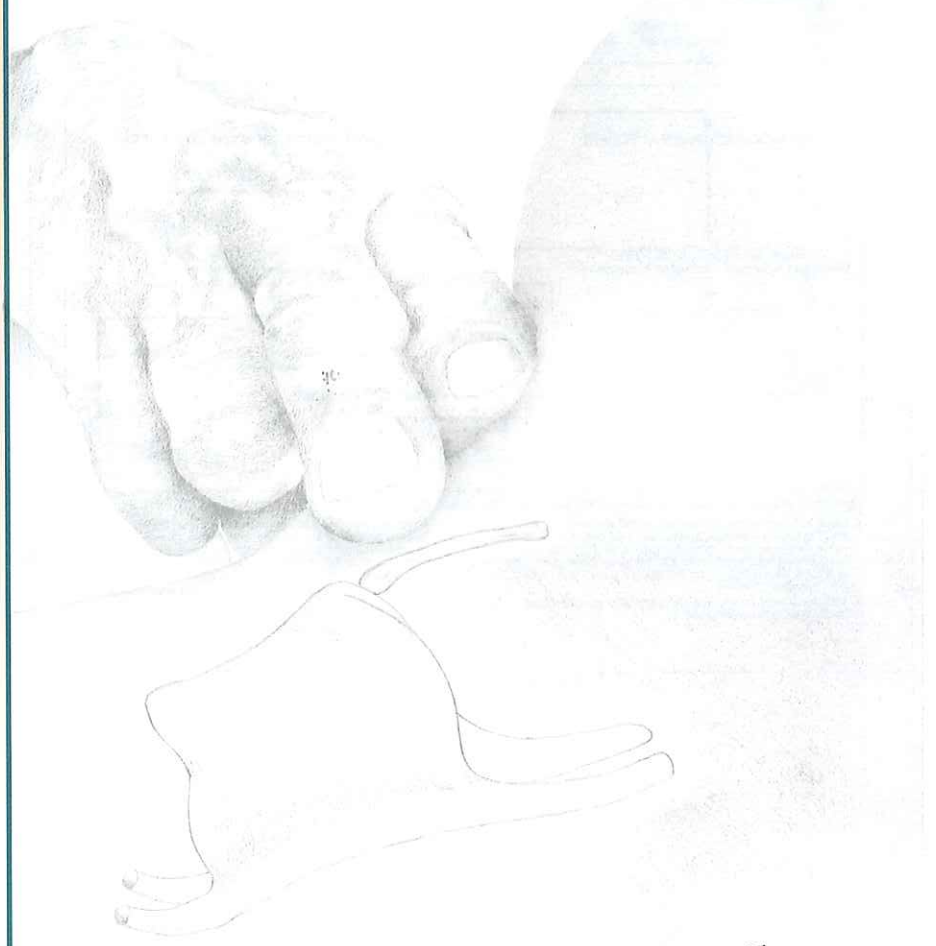
d. Consider re-preparation of the patient for awake intubation or canceling surgery.

e. Options for emergency non-invasive airway ventilation include (but are not limited to): rigid bronchoscope, esophageal-tracheal combitube ventilation, or transtracheal jet ventilation.

In the event that an LMA fails they recommend rigid bronchoscopy, a Combitube or transtracheal jet ventilation. If these fail they recommend tracheostomy or cricothyrotomy.

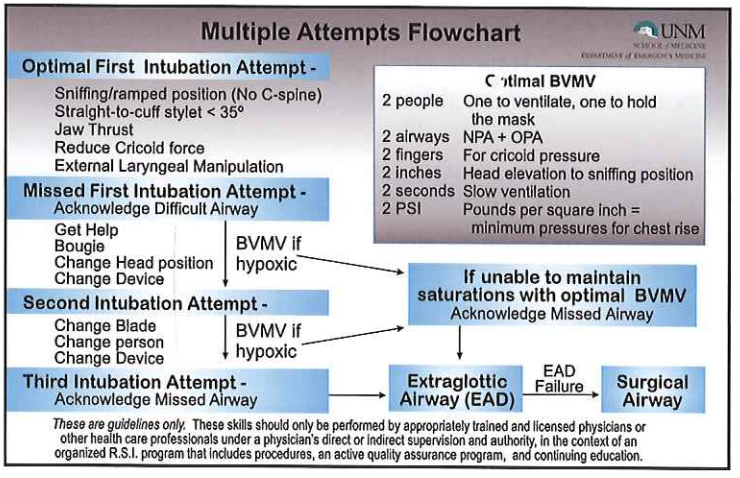
If, on the other hand, BVMV is successful they offer multiple options including fiberoptics, bougie, lighted stylet, intubating LMA, etc. They do not specify a maximum number of attempts nor do they mention positioning, cricoid pressure reduction or ELM. Newer devices such as the King, EasyTube and alternate laryngeal airways are not included.

Overall, the ASA Difficult Airway Algorithm is a valuable teaching device for anesthesiologists and anesthetists though it is now somewhat outdated. It is not as useful for non-anesthesia providers nor is it particularly user-friendly at the bedside in the event of an emergency.



Take Home Points

- Difficult Airway
  1. Predicted to be difficult (LEMONS or 4 Ds) OR
  2. Proves to be difficult (more than one attempt required)
- Failed Airway
  1. Unable to intubate within 3 attempts ("Three strikes and you're out") OR
  2. Critical oxygenation cannot be maintained at any time
- Crash Airway
  1. "Dead" (cardiac or respiratory arrest) OR
  2. "Nearly dead" (agonal respirations)



Case Scenario

Difficult airway – The morbidly obese patient

A morbidly obese 45-year old male with a history of coronary artery disease, obstructive sleep apnea, pulmonary hypertension, arterial hypertension, diabetes and dilated cardiomyopathy with congestive heart failure is admitted to the sub-acute unit on BiPAP for respiratory failure due to either CHF or pulmonary embolism. Unfortunately, the patient it too obese for CT scanning and nuclear medicine studies are not available after-hours so he has been empirically treated for both including heparin. Several hours after admission he is noted to be deteriorating. He is now lethargic and his oxygen saturation has dropped to 91% on BiPAP with high-flow oxygen. Blood gas reveals a mixed respiratory and metabolic acidosis. The ICU resident, Rapid Response Team and respiratory therapy have been paged. How would you manage this patient?

LEMONS: There are several potential difficulties including his obesity and poor oxygen reserve. Patients with sleep apnea present additional difficulties including difficult BVMV.

PREOXYGENATE: Continue BiPAP.

PROTECT C-SPINE: Not indicated.

PRESSURE TO CRICOID: Will be used, but very gently, from the time induction medication is given until the tube is confirmed in the trachea, unless the intubation proves difficult.

PONDER: First of all we must recognize that this is a potentially disastrous airway but it is not a crash airway. He requires intubation but there is time to make all appropriate preparations. I would begin by contacting anesthesia if they are available. I would also move the patient immediately to the MICU if a bed were available. Let's assume anesthesia is not available. Family would be advised about the procedure and the potential difficulties involved. I would consider blind nasotracheal intubation but his saturations are likely to fall too quickly and anticoagulation is a contraindication. He is probably too lethargic for awake intubation. RSI is clearly risky but offers the best chance for success. I would assume that his sats will plummet as soon as he is medicated. He may be difficult to oxygenate with a BVM or EAD, especially devices with lower seal pressures. Surgical airway is likely impossible with his obesity.

PREPARE EQUIPMENT AND PEOPLE: I would have at least two sizes of cuffed endotracheal tubes available. Whichever EAD is selected should be out of the package and ready for immediate insertion. I would be sure to have a bougie ready and plan to use it on my first attempt. I would have both straight and curved laryngoscope blades available. Assistants will be prepared to monitor saturations, assist with cricoid pressure/ELM, assist with the bougie and hold the tube so the intubator can stay focused on the airway.

PREMEDICATE: Fentanyl could be considered as a cardioprotective agent however he may only be alive because of his sympathetic drive. I would skip any premedications.

POSITION THE PATIENT OPTIMALLY: Ramped position with ear and sternal notch at the same level.

PARALYZE AND INDUCE: Any induction agent except ketamine would be acceptable. Succinylcholine or rocuronium would be acceptable as well though a strong argument could be made for a shorter-acting agent.

PASS THE TUBE: As soon as he is medicated the BiPAP will be removed and assisted respirations using the "rule-of-twos" begun. If saturations can be maintained at an acceptable level I would proceed to an optimal intubation attempt with the most experienced intubator available, external laryngeal manipulation, ramped position and the bougie. If saturations cannot be maintained the EAD would be inserted to achieve maximum oxygenation before intubation is attempted.

POST-INTUBATION MANAGEMENT: Once the tube is confirmed with capnography the patient will be placed on the ventilator. Capnography will be continued. Patient will receive analgesia and sedation as appropriate.