RAPID SEQUENCE INTUBATION

& Rapid Sequence Airway

2nd Edition

An *Airway911* Guide

RSI

Darren Braude, MD, EMT-P

Rapid Sequence Intubation

And Rapid Sequence Airway

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Rapid Sequence Intubation and Rapid Sequence Airway: 2nd Edition
An *Airway911* Guide

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The techniques and medications covered in this text should only be used by appropriately licensed healthcare professionals, trained and experienced in basic and advanced airway management, compliant with agency/institutional policies and state law. If this individual is not a licensed physician or nurse anesthetist, they must perform these skills under a physician's direct or indirect supervision and authority in the context of an organized airway program that includes guidelines/protocols, an active quality assurance program and continuing education. Some material in this book is dramatized and/or simplified for educational purposes and some material is controversial. Moreover this field is evolving on a daily basis. Therefore this book is not meant to establish a standard of care for medicolegal purposes. Experienced providers may find it necessary to deviate from the procedures and dosages contained herein.

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And last, but most definitely not least, August John, my little big man

Preface

I don't need to remind any of you that we are all way too darn busy - multiple jobs, multiple responsibilities, multiple electronic inputs, multiple hobbies and multiple headaches. That's why I set out to write a book that you can read in a weekend or a couple of slow shifts or on your lunch breaks or at night before bed, WITHOUT an overdose on Red Bull. I have made no attempt to write another comprehensive text on intubation or airway management; these have already been done and done well: *Manual of Emergency Airway Management, 3rd Edition* by Walls and Murphy, The *AirwayCam Guide to Intubation* by Levitan, *SLAM: Street Level Airway Management* by Rich, *Airway Management in Emergencies* by Kovacs and Law, *Management of the Difficult and Failed Airway* by Hung and Murphy, and *Paramedic: Airway Management by* Margolis, among others. Instead, I have focused on Rapid Sequence Intubation and the new related technique of Rapid Sequence Airway. There is material here for you whether you are a seasoned airway professional or have never even seen an RSI performed, though I do presume you already possess basic airway skills.

My intended audience, like the audience at our *Airway911* courses, is intentionally very broad: paramedics, nurses, respiratory therapists, flight teams, mid-level practitioners and physicians. This book is for you if you routinely use, or have ever even considered using, powerful drugs to facilitate airway management in critically ill or injured patients with full stomachs. This includes prehospital settings such as EMS and critical care transport, and hospital settings as diverse as the Emergency Department, Intensive Care Unit, Operating Room and Rapid Response Teams.

This book is best used as a supplement to the other texts listed above and in conjunction with hands-on airway training. If you are not in a formal training program that covers airway management you might consider taking one of the many excellent airway courses offered around the country. Information on our own *Airway911* courses as well as some free on-line training can be found at www.airway911.com .

All I ask from you is not to let this book sit on the shelf; the airway is just too damn important.

How to use this book

What the icons mean?

EBM: Evidence-based medicine. This indicates statements in this book that are specifically supported by papers included in the reference section for each chapter.

Caution: Highlights potential pitfalls in airway management that you should pay attention to in order to keep your patients and yourself out of trouble.

Key: the most important points as identified by the author.

What do the blue boxes mean?

The blue boxes contain advanced, controversial or otherwise supplementary material. Readers who are new to RSI and RSA may elect to skip these boxes on their first time through.

Take Home Points

- Most chapters contain selected Take Home Points on the last page.
- Review this material, and the items identified by green text and the associated "Key" icon throughout the chapter, to ensure you understand what I consider to be the most important information.

CONTENTS

Introduction

Chapter 1

What is RSI?

Rapid Sequence Intubation (RSI) is defined as a series of steps, which must include the administration of a paralytic agent, to a critically ill or injured patient who is presumed to have a full stomach, in order to facilitate rapid, successful oral intubation while minimizing complications.

Caution

Why does it seem like everyone eats and drinks right before their accident?
For one thing, many people do! However, as soon as your body suffers grave injury or illness, gastric motility shuts down. This means that the normal secretions into the stomach and swallowed saliva as well as any residual food and drink will not pass into the intestines. So every critically ill or injured patient really does have a full stomach and is waiting to aspirate, regardless of whether or not they just ate. This is a time bomb in airway management.

The nearly simultaneous administration of both a neuromuscular blocking agent (paralytic) and a potent induction agent will facilitate intubation while decreasing the risks of aspiration, elevated intracranial pressure and airway trauma. When properly done, the patient literally can no longer breathe without the clinician. There is ample evidence that both pediatric and adult patients emergently intubated with the principles of RSI by a trained, experienced provider, have both lower complication rates and higher success rates when compared to other common intubation techniques, including intubation without pharmacological assistance, blind nasotracheal intubation and sedation-facilitated intubation.

Rapid Sequence Intubation should be distinguished from both "Rapid Sequence Induction" and "Sedation-Facilitated Intubation".

Rapid Sequence Induction

In this technique, which is used by anesthesiologists and anesthetists in the O.R., the end-point is the induction of anesthesia rather than intubation. This technique is used primarily in fasted patients at low risk of aspiration (i.e. an empty stomach). Many such patients are managed exclusively with a laryngeal airway or other extraglottic airway device (EAD) rather than intubation for the duration of the case.

Sedation-facilitated Intubation (SFI)

This technique involves the administration of a powerful sedative drug such as midazolam or etomidate without a paralytic. While this sounds intuitively appealing in that it avoids the risks of paralysis, it is problematic for several reasons. A dose of medication that may only make a healthy person relaxed may have profound effects in a fragile patient. When given to critically ill or injured patients, these drugs may produce apnea and blunt the patient's ability to protect their airway without eliminating the gag reflex or their ability to vomit. Furthermore the sedative alone does not overcome muscle tone like a paralytic does, thus failing to optimize laryngoscopy. Taken together, this may be a recipe for disaster: sticking a big piece of metal down the mouth of a patient who still has the ability to gag and vomit, but limited ability to protect their airway, without improving your chances of success!

Caution

In the academic Emergency Department setting, Sagarin et al report a first-intubator success rate of 91% with RSI compared with 84% for SFI. This may seem to be a small difference but it can have important implications in this critical patient population, especially when associated with the potential for serious complications. Prehospital studies have found success rates for SFI from 25% to 87%, well below the rates for RSI.

In the case of a predicted difficult airway, the very situation when many providers are drawn to SFI, embarking on a procedure with a proven lower success rate and a higher potential for complications is probably not the wisest course of action. Appropriate options in this circumstance will be discussed later.

Airway911 bottom-line: avoid SFI if at all possible

Is there ever a time you would attempt sedation-facilitated intubation?
I have been doing this long enough to never say "never." Every circumstance is different. SFI may be safe and successful in the setting of elective intubations of fasted patients in the operating room setting or semi-elective intubations of fasted patients in the ICU setting, for example. I have had the unfortunate displeasure of actually witnessing several aspiration events that occurred from SFI using etomidate. I cannot imagine a time I would try it in any patient at risk of having a full stomach though I know of some excellent physicians experimenting with the use of ketamine in this circumstance.

What is drug-assisted or medication-facilitated intubation?
This terminology is becoming more common. Some sources consider it a more general term that covers everything from sedation-facilitated intubation to RSI. While this may become the "politically correct" terminology, I prefer to use more specific terminology. To me, a conversation or policy about sedation-facilitated intubation is very different than one about RSI or one about RSA.

What is RSA?

RSA stands for Rapid Sequence Airway. This is a new approach to emergency airway management being introduced in some EMS and air medical services. RSA involves all the same preparatory steps and pharmacology as RSI but the goal is insertion of an extraglottic airway device (EAD) rather than intubation. The fundamental concepts behind RSA are: 1. the greater than realized aspiration protection afforded by some EADs and 2. the potential for significant hypoxemia and transport delays during out-of-hospital RSI. RSA is discussed further in Chapter 7.

The Spectrum of Airway Management

Although this is a textbook about RSI, it is important to realize that not all patients need RSI. In fact, outside of the O.R., most patients do not require airway management at all. Of those patients who do require airway management, most do not need intubation. And of those who do need intubation, not all require RSI.

There is a spectrum of airway management that progresses from awake to nearly dead as mental status and respiratory failure worsen. RSI/RSA may occur at variable points along the middle of the spectrum. When performed earlier in the spectrum, the patient has more reserve to tolerate the procedure but the stakes are also much higher if something goes wrong.

The spectrum of airway management	
Position of comfort	Awake
Supplemental oxygen	
Non-invasive PPV	
Bag-valve-mask "assisted" respirations	
Nasopharyngeal airway	
Oropharyngeal	
Bag-valve-mask ventilation	
Blind Nasal intubation	
Extraglottic airway without medications	
Oral intubation without medications	Nearly Dead

Four Purposes of RSI

1. To permit laryngoscopy when the patient is awake, has intact airway reflexes and/or has trismus (jaw muscle spasm seen in some severely injured patients)
2. To improve laryngeal view and increase the success of intubation by overcoming intrinsic muscle tone
   - The three inherent obstacles to laryngoscopy are:
     - Patient anatomy - not modifiable
     - Muscle tone - modifiable with paralytic agents
     - Technique - modifiable with education and practice
3. To minimize complications such as aspiration and increased ICP as compared to intubation without RSI
4. To allow total control of the patient, thereby facilitating life-saving treatments and diagnostic studies

Five Indications for RSI

1. Impending or actual respiratory failure
   - Example: anticipated airway edema from burns and trauma
   - Example: marked fatigue due to increased work of breathing
2. Impending or actual inability to maintain airway
   - Example: GCS<9 or rapidly decreasing level of consciouness
3. Hypoxemia despite supplemental O2
   - Note that this is also a definition of failed airway. This potential confusion will be addressed later
4. Combative with high suspicion of significant head injury
   - Note that many such patients are simply intoxicated
5. To facilitate transfer, specific treatment or evaluation

Are these situations always handled with RSI?
No. Intubation should be the treatment of last resort for all of these conditions. When intubation becomes necessary and the patient is at risk for aspiration, RSI is usually the method of choice.

Contraindications for RSI

Absolute Contraindications

The absolute contraindications are cardiac or respiratory arrest. There is no advantage to using RSI in the patient who has had an arrest as they should have no muscle tone (except rigor mortis!). In most other patients, RSI is faster and safer than any alternative technique. RSI should be considered in every non-arrested patient requiring emergency intubation.

Relative Contraindications

The relative contraindications include: 1. an anticipated difficulty intubating the patient and/or 2. an anticipated difficulty in bag-valve mask ventilation (BVMV) should intubation fail. These considerations will be explored in depth later. When relative contraindications are present the provider should consider other potentially safer options such as bag-valve-mask ventilation, watchful waiting (with rapid transport if appropriate), awake intubation, nasal intubation, etc. These options will be discussed in later chapters.

The third relative contraindication is 3. the crash airway. This is the patient who is not yet in cardiac or respiratory arrest but very close. In these patients it is generally advisable to avoid any delays and attempt immediate intubation without RSI. In the event that the patient appears to have enough "fight left in them" that intubation is likely to be unsuccessful, traumatic or trigger vomiting, then the attempt can be aborted and RSI attempted.

Does this mean I should never attempt RSI if the airway looks difficult?

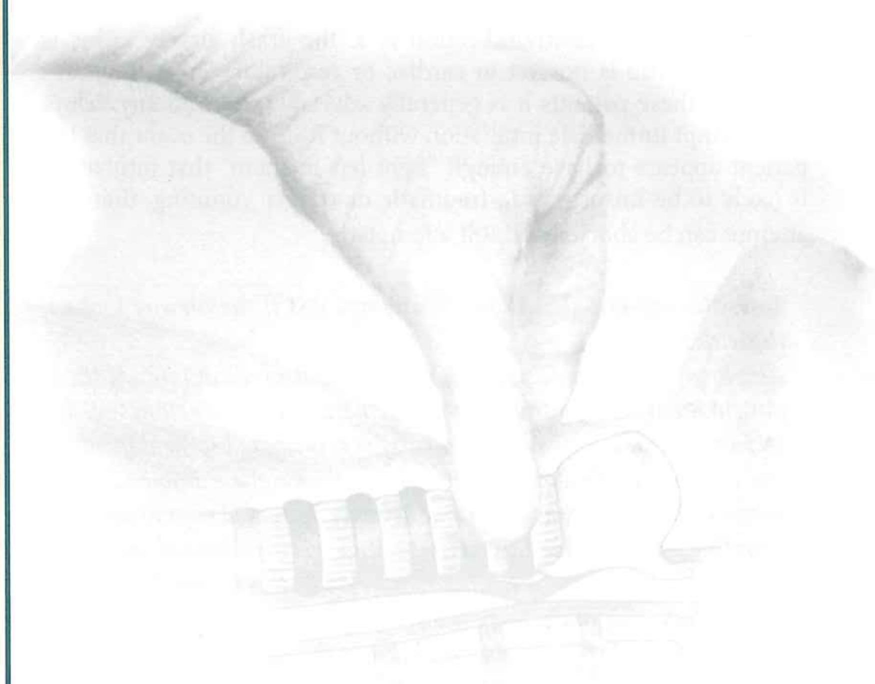
Absolutely not. These are only relative contraindications. If the patient needs emergent airway management you will sometimes need to forge ahead even when the airway is anticipated to be difficult. An extreme example would be the morbidly obese immobilized patient with multi-system trauma, severely decreased mental status, vomiting, seizure activity, trismus and very decreased oxygen saturations on a non-rebreather mask. While this may indeed be a true airway nightmare, there is little choice but to proceed with RSI if we hope to save the patient. We must be thinking ahead, however, and be prepared for a difficult and missed airway. This is our scary business!

Complications & Risks of RSI

The risks of RSI can be great and numerous. Since cardiac or respiratory arrest are absolute contraindications to RSI, anyone who undergoes RSI is, by definition, breathing. This may not be very effective breathing – hence the reason we may be considering RSI - but it is breathing nonetheless. If you take away that respiratory drive with medications and intubate the esophagus and fail to recognize it or are unable to maintain critical oxygenation, whether or not you are able to get them intubated, you are at risk of the "clean kill". Other potential complications of RSI include:

Caution

- Aspiration
- Hypoxemia
  - particularly dangerous for patients with acute neurological problems or underlying cardiovascular/cerebrovascular disease.
- Increased intracranial pressure
  - problematic in patients with critical ICP at the outset.
- Bradycardia
- Oropharyngeal and laryngeal trauma



Take Home Points

- Rapid Sequence Intubation (RSI) is defined as a series of steps, including the administration of a paralytic agent, to a critically ill or injured patient (who is presumed to have a full stomach) in order to facilitate rapid successful orotracheal intubation while minimizing complications

- Sedation-facilitated intubation is generally discouraged in emergency situations as the risk of complications is higher and the success rate is lower than with RSI

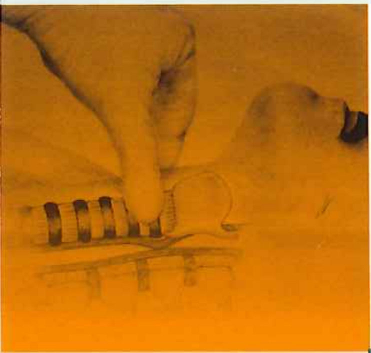
- Three obstacles to laryngeal view:
  1. Patient anatomy
  2. Muscle tone
  3. Operator technique

- Indications for RSI:
  1. Actual/impending respiratory failure
  2. Actual/impending inability to protect the airway
  3. Combative secondary to presumed head injury
  4. Hypoxemia despite supplemental oxygen
  5. Facilitate evaluation/treatment/transfer

- Absolute RSI contraindications:
  1. Respiratory arrest
  2. Cardiac arrest

- Relative RSI contraindications:
  1. Anticipated difficult intubation
  2. Anticipated difficult BVMV
  3. Crash airway

- RSI risks:
  1. Failure to intubate
  2. Aspiration
  3. Hypoxemia
  4. Increased ICP
  5. Bradycardia
  6. Trauma
  7. Esophageal intubation



Basic Principles

Chapter 2

No Positive Pressure Ventilation

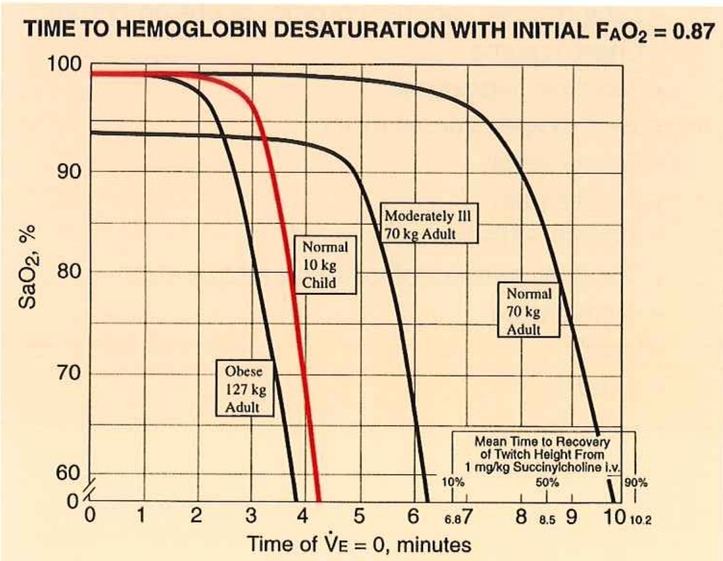
Bag-valve-mask ventilation (BVMV), even when done perfectly, results in some air entering the stomach. In the heat of battle BVMV is rarely done perfectly, which means lots of air may enter the stomach. This air entry into the stomach increases the risk of vomiting (active) or regurgitation (passive), either of which predisposes to aspiration. Therefore, you should not perform BVMV during RSI, even when the patient is apneic and multiple attempts at laryngoscopy are undertaken, unless the patient is hypoxic. This applies both to the time interval before the first intubation attempt and between each successive attempt, if the first or second attempts are missed. This clearly takes extreme self-control and a functioning pulse oximeter. The reason that most patients are able to sustain normal oxygen levels despite prolonged apnea is preoxygenation.

Am I really supposed to sit back and do nothing if my patient is not breathing?

Not surprisingly, most providers find it very difficult to stand by idle when a patient is not breathing, especially when they made them that way! But the answer is "yes" as long as critical oxygenation is maintained, usually indicated by saturations above 90%.

Preoxygenation

The air we are all breathing at this very moment is only 21% oxygen, regardless of your location or altitude; the remaining 79% is nearly all nitrogen. If all of the nitrogen in your lungs were replaced with oxygen you would have almost 5 times the oxygen present now. This is what occurs with preoxygenation; hence preoxygenation is sometimes called "de-nitrogenation" or "nitrogen washout". This five-fold increase in oxygen in the lungs creates an oxygen reserve that the body can draw upon once a patient is administered a paralytic agent and ceases to breath. Patients with healthy lungs and adequate functional residual capacity may develop enough reserve from preoxygenation to survive up to 8 minutes of medication-induced apnea without desaturation. Thus preoxygenation allows us to chemically paralyze a patient yet withhold positive pressure ventilation, thereby limiting the risk of gastric insufflation and subsequent aspiration, without the patient becoming hypoxemic.



From Benumof J, Dagg R, Benumof R. Critical hemoglobin desaturation will occur before return to an unparalyzed state following 1 mg/kg succinylcholine. Anesthesiology 1997;87(4):979-982 with permission.

If you look at the "Normal 70kg Adult" curve you can see that some patients may go as long as 8 minutes before their saturation drops below 90% if adequately preoxygenated. Note that illness, obesity, young age and inability to fully preoxygenate reduce the amount of time available. Even more importantly, notice what happens to the curves once they begin to fall...they plummet. This is why it is so important to abort your attempt when the saturation begins to fall rather than try harder.

Unfortunately, many critically ill or injured patients cannot tolerate 8 minutes of apnea. Common clinical variables that impact the amount of apnea time a patient can withstand before becoming hypoxic include age, obesity, pregnancy, metabolism, lung disease, baseline saturations, acute illness, etc (see table 2.1). Children, for instance, have shorter apnea times in large part because of their increased basal metabolism. Hyperdynamic patients such as those with fever, shock, alcohol withdrawal and cocaine/amphetamine intoxication have substantially increased oxygen demand and "chew through" their reserve very quickly. Obese and pregnant patients have less reserve in large part because of limited functional residual capacity. The worst case is a sick, fat, child!

2.1 High-risk characteristics that decrease oxygen reserve

Decreased oxygen storage capacity

- Elderly
- Obesity
- Pregnancy
- Lung disease: acute, chronic, acute on chronic
- Chest trauma
- Baseline hypoxemia

Increased oxygen consumption

- Fever/sepsis
- Severe pain
- Alcohol withdrawal
- Cocaine/methamphetamine intoxication
- Tachycardia
- Shock
- Children

In most cases preoxygenation will be accomplished with a tight-fitting non-rebreather mask with 10 – 15 liters/minute flow for at least 3 minutes. Such a system delivers 70 – 90% oxygen and is sufficient for most patients. A bag-valve-mask may be used *WITHOUT* positive pressure to deliver 100% oxygen if desired. Research has demonstrated that preoxygenation is more successful for most patients with at least 20 degrees of head elevation; this is especially true for obese patients. This highlights yet another reason that all trauma patients in spinal precautions should be considered difficult intubations: the inability to elevate their head limits preoxygenation which in turn limits the amount of time you will have to perform the procedure. This also emphasizes the importance of keeping patients, particularly those with respiratory distress, in their position of comfort as long as their mental status allows. If positive pressure must be used due to patient hypoxia, concentrate on good technique to minimize air entry into the stomach.

After preoxygenation patients may be roughly categorized as having "adequate", "limited" or "no" reserve with corresponding preparations made. Patients with underlying lung disease, especially acute or acute-on-chronic disease resulting in hypoxemia, are a particularly scary group to intubate because they are prone to very rapid desaturation after medication. They are already hypoxic and on the steep part of the saturation curve. See Figure 2.1.

EBM

EBM

Caution

Patients with a saturation of 100% after preoxygenation have an "adequate reserve", those less than 100% but above 90% have "limited reserve" and those less than 90% have "no reserve". In the first group (adequate reserve) the goal should be no positive pressure ventilation, though some patients, particularly those with high-risk characteristics listed in table 2.1, may still desaturate quickly. In the second group (limited reserve) the clinician should plan to optimize first-pass success and anticipate that some patients will require careful positive pressure ventilation if the intubation attempt is prolonged. In the last group (no reserve) positive pressure ventilation is unavoidable; the clinician should consider CPAP/BiPAP or assisted respirations before medication and be prepared to provide immediate optimal BVMV and place a rescue airway if saturations cannot be maintained.

Caution

Many inexperienced providers faced with a patient who is desaturating make the mistake of waiting too long to abort the procedure, trying even harder or trying "just one more time" only to face critical hypoxia and cardiac arrest.

Patient categorization following preoxygenation
Adequate reserve - saturation near 100% • Positive pressure usually not necessary • Potential false sense of security if patient has high-risk characteristics. See Figure 2.1
Limited reserve - saturation 90% - 97% • Some patients will require careful BVMV • Be prepared to abort intubation attempt • Have rescue airway immediately available: not necessary to remove from package
No reserve - saturation below 90% • Positive pressure ventilation is unavoidable • Consider CPAP/BiPAP/BVM assist before meds • Consider planned PPV with BVM or EAD after meds • Have rescue airway immediately ready for insertion: out of package and lubricated

So I was taught to hold my breath when I intubate because "when I run out of air the patient has run out of air". Is this a good idea or a bunch of hogwash?

I was taught the same thing years ago in paramedic school. While it is clearly impossible to perform a complicated stressful procedure holding your breath, the premise has merits when intubating patients in cardiac arrest when no oxygen saturation is available. During RSI, the patient should have reliable pulse oximetry available. In that case an intubation attempt can theoretically last up to 5 or 10 minutes in the preoxygenated patient as long as the saturation remains above 90 percent. Can you hold your breath that long?

I understand that I can take as long as necessary to intubate if the oxygen saturation is adequate but what about the CO_2....isn't it going up while the patient is apneic?

Yes, that is true. The arterial level of CO_2 rises about 3 mm Hg for every minute the patient is not ventilated. But don't worry. This is not a significant clinical concern over the short term and the level will be quickly corrected once the patient is intubated and ventilated.

If a patient is hypoxic and really needs positive pressure ventilation is there any way to do it better than with a bag-valve-mask?

First of all you need to be sure you are doing BVMV correctly, using the rule-of-twos (see page 104). I am a huge fan of placing an extraglottic airway for preoxygenation in hypoxic patients, after induction and paralysis. Not only are they more efficient at oxygenation but they also result in less gastric insufflation. Some devices even allow gastric decompression through a separate port. Once adequate saturations are achieved the device may be removed and the patient intubated. This will be discussed further in Chapter 4.

Is it possible to suffocate someone with a bag-valve-mask?

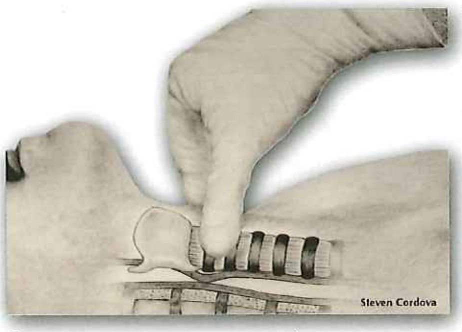
Unfortunately, yes. It is extremely important that clinicians recognize that all self-inflating bags have some type of valve. IF the bag and mask are held over the face without opening this valve and the patient is not generating enough negative pressure to open it, they are not receiving any oxygen! If a self-inflating bag-valve-mask set-up is used for preoxygenation and the patient does not require assisted respirations (either they are not hypoxic or breathing spontaneously) then the valve must be "fluttered" by softly squeezing the bag to allow oxygen to flow.

Can CPAP/BiPAP be used for pre-oxygenation?

Traditionally non-invasive positive pressure ventilation such as mask CPAP (continuous positive airway pressure) or BiPAP (Bi-level positive airway pressure) is thought of as either a bridge until intubation can be performed or a means to avoid intubation altogether. There are two small studies demonstrating the effectiveness of NIPPV for pre-oxygenation prior to intubation. One problem is that non-invasive ventilation is usually restricted to patients who are protecting their own airway and able to follow instructions, which limits applicability. I am now more apt to put CPAP or BiPAP on hypoxic patients even when I am doubtful that intubation can be avoided, knowing that if nothing else it may be helpful for preoxygenation.

Cricoid Pressure

Cricoid pressure is the application of gentle pressure to the front of the cricoid cartilage with the intent of occluding the esophagus between the back of the cricoid ring (the only complete ring in the trachea) and the anterior surface of the spinal column. Cricoid pressure was described as early as the 1700s to prevent air from entering the lungs during positive pressure ventilation.



It gained widespread modern usage during the 1960s as a means of preventing aspiration during rapid induction of anesthesia in patients with full stomachs, based on a landmark article by Sellick, hence the alternate name: "Sellick's Manuever". Cricoid pressure has subsequently become a mandatory step for RSI in most textbooks. Despite widespread use there are two major potential problems with cricoid pressure: it may occlude the airway and may completely obscure the intubator's view of the cords!

Cricoid pressure should be applied during any bag-valve-mask ventilation. However, if ventilation is difficult the assistant maintaining cricoid pressure should try reducing pressure to see if that was the source of obstruction. Cricoid pressure should be applied during RSI as well, from the time of drug administration to tube confirmation, as long as the laryngeal exposure is adequate. In the event the intubator cannot visualize the cords pressure should be reduced and, if the view remains inadequate, pressure should be released completely and the assistant should slide their hand up to the larynx to assist with external laryngeal manipulation (see Chapter 4). If the patient actively vomits (as opposed to passive regurgitation), pressure should be released to prevent potential esophageal rupture.

Is there really any controversy about cricoid pressure?
As a matter of fact there is. There is surprisingly little evidence that cricoid pressure prevents gastric insufflation and aspirtion. There is actually some evidence that pressure on the cricoid causes a reflex relaxation of the lower esophageal sphincter, which is the exact opposite of what you want. It also turns out that for many people the esophagus does not sit directly behind the trachea or is displaced by the cricoid pressure itself. For now it is still standard practice but the limitations mentioned above must always be kept in mind.

Airway911 Consensus: for now cricoid pressure remains standard practice but it is more important to know when not to use it than when to use it.

Caution

Caution

How do I figure out how much force to apply?
Technically, it is supposed to be 30 – 40 Newtons of force. I always imagine 35 fig newtons stacked on someone's neck, but that doesn't help much! Try taking a capped 50 cc syringe and compressing the plunger to the 30 cc mark. This is for adults only. In children you must use some "feel" to be sure you are not occluding the trachea.

Three Strikes and You're Out

The "Three strikes and You're Out" rule means that you should limit the number of laryngoscopy attempts on each patient to three. This is because each successive attempt has a lower chance of success (there's a reason you didn't get it on attempt one or two!), multiple attempts lead to airway trauma and edema which may make subsequent intubation or even use of BVMV and extraglottic airway devices impossible, and multiple attempts delay definitive care, whether that is transport to a hospital, transport between hospitals or transfer to another unit or for a diagnostic procedure such as CT.

When, if ever, do you consider exceeding the 3 attempts rule?
Like any rule, there are exceptions to the "three strikes and you're out" rule to be considered by advanced practitioners. If the patient is not a candidate for an extraglottic back-up device, i.e. a severe inhalation burn or penetrating neck trauma, I would consider additional attempts as long there was some reason to believe additional attempts will be successful where the prior attempts had missed. For example, a more experienced intubator has arrived or a new piece of equipment has become available or you remember some basic maneuver like external laryngeal manipulation that you forgot initially. Another example is when a junior practitioner or student makes the first 2 attempts and misses. The senior provider then steps in to rescue the situation but requires a second attempt of their own to modify their approach based on their initial look.

Does an intubation attempt really cause THAT MUCH airway trauma?

They can. A straightforward intubation attempt where you slip the tube in easily on the first attempt probably causes little if any trauma. On the other hand, difficult intubations where you are straining and manipulating and repositioning the laryngoscope many times can cause so much trauma that BVMV or an extraglottic airway may be unable to ventilate the patient.

I have heard that some people use a one-strike or two-strikes rule. Is that true?

Yes. The potential danger of multiple attempts is well recognized, as is the success of EADs. EMS services are leading the way here. PHI Air Medical has adopted a "two strikes and you're out" policy for their flight crews nationwide. I would expect and hope that other services and hospitals have and will embrace similar policies.

Does this rule mean that I should take all 3 attempts on every patient?

Definitely not. It is entirely appropriate to move on to a back-up device after one, two or even zero attempts. This is especially true in prehospital settings where additional attempts are delaying transport. But in any setting, imagine a patient whose oxygen saturation is 85% before RSI and rapidly starts dropping after medication administration despite optimal BVM ventilation. In this case it is appropriate to place a rescue device without taking any attempt at laryngoscopy. Once adequate oxygenation is established, the rescue device can be removed and intubation attempted, though in many settings it is best to leave it in place, i.e. "if it ain't broke, don't fix it!"

Tube Confirmation

After intubation you must confirm that the tube is in the trachea. This verification is more important than the intubation itself. Imagine using medications to take away a patient's ability to breath and then placing a tube in the esophagus without recognizing it. That would clearly be a clean kill.

There are two means of tube confirmation: subjective and objective. Each and every subjective indicator of proper tube placement has failed at some time. The astute provider will always use a combination of these subjective methods in conjunction with at least one objective technique. Astute clinicians will also re-confirm tube placement whenever clinical conditions deteriorate or the patient is moved.

Subjective Methods

Subjective methods of tube confirmation include direct visualization, tube misting and breath sounds. Well-performed EMS studies have demonstrated that reliance on subjective means alone results in a 10 – 20% rate of missed esophageal intubations.

DIRECT VISUALIZATION

While seeing the tube pass through the cords should be considered the gold standard, this method of tube confirmation has failed many, many times and people have died as a result. There are at least three possible explanations. First, in the emergency situation, visualization of the tube's passage through the cords is often unsatisfactory due to patient immobilization, positioning or blood/vomit in the airway. Secondly, the tube itself often obscures visualization. Thirdly, even if the tube is observed to pass through the cords it may become dislodged as the stylet is removed and/or the end-tidal CO_2 detector and BVM are attached and before the tube is secure. For these reasons direct visualization cannot be relied upon alone to confirm tube placement.

TUBE MISTING

Observing mist or condensation in the tube or a "vapor trail" has long been held out as a means of confirming tracheal placement of the tube. The take-home message: never make any decisions on tube placement based solely upon tube misting.

AUSCULTATION

After intubation breath sounds should be checked bilaterally and compared to pre-intubation breath sounds unless ambient noise (i.e. in an aircraft) makes this impossible. Sounds should be present bilaterally if they were present bilaterally before intubation. Newly diminished sounds on the left with strong breath sounds on the right are usually suggestive of right mainstem intubation. The absence of sounds over the epigastrium (suggesting esophageal placement) should also be confirmed. It is important to recognize that breath sounds have proved unreliable many times. This is particularly common in children (sounds are easily transmitted throughout the thorax), obese patients and those with lung pathology. Like the other subjective means of tube confirmation, breath sounds should not be relied upon entirely, nor should they be ignored.

Objective Methods

PULSE OXIMETRY

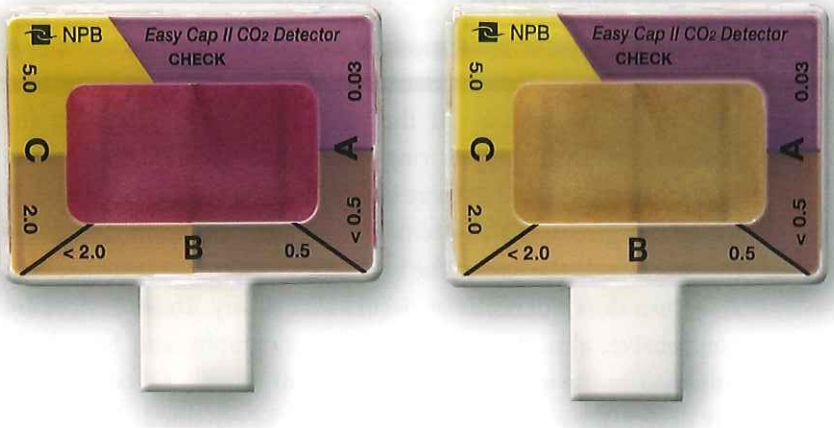
Pulse oximetry has long been a standard method of monitoring the patient with respiratory difficulties. If oxygen saturation is stable or increasing in a paralyzed patient, the endotracheal tube is in the trachea or above it; it is not in the esophagus. Unfortunately a pulse oximeter may not be useful to confirm placement in patients with poor peripheral circulation, cardiac arrest or if they are breathing spontaneously, as they could be breathing around an esophageal tube.

I'm confident I got the tube through the cords but the sat is dropping. Do I pull the tube?

A tube should not be pulled based on any one parameter. There is often a lag time before changes in saturations can be observed. This is because the newly oxygenated blood – thanks to your new endotracheal tube - needs to get from the lungs out to the periphery where the sensor is located. If all the other subjective and objective methods confirm tracheal placement, especially end-tidal CO_2, do not immediately pull the tube for falling saturations. On the other hand, if saturations continue to fall or if there is any question of placement from other methods, you should consider removing the tube, performing optimal bag-valve-mask ventilation and either re-attempting intubation or placing a rescue airway as appropriate.

END -TIDAL CARBON DIOXIDE DETECTORS

End-tidal CO_2 detectors – aka capnography - are now the standard of care in RSI. There are two types, qualitative (indicating only if CO_2 is present or absent) and quantitative (providing a measure—usually with a waveform for analysis—of how much CO_2 is present). Either type is acceptable for initial tube verification. The quantitative detectors are better for ongoing monitoring, especially during air medical transport where clinical means are limited. There are virtually no false positive readings with these detectors. This means that if the detector says CO_2 is present, you are not in the esophagus. On the other hand, false negatives may occur in the setting of cardiac arrest. During cardiac arrest, CO_2 production and transfer eventually cease. Therefore you may have the tube correctly in the trachea without evidence of CO_2 being present.



Nellcor Easy-Cap Qualitative End-Tidal CO_2 Detectors

The presence of exhaled CO_2, an acid, converts the litmus paper from purple to yellow/tan. If the tube is in the esophagus, the litmus paper will remain purple due to the absence of CO_2. Note the three categories around the outside:
A = no reliable CO_2 present, B = indeterminate, C = CO_2 present

Is it possible to have CO_2 present but not have the patient correctly intubated?

Yes. Except for the ridiculous scenario of the patient who codes while drinking a carbonated beverage or having Pop-rocks, the presence of end-tidal CO_2 assures you that the tube is not in the esophagus but it does not tell you if it is in the trachea or above it in the hypopharynx, i.e. a shallow tube. The waveform from continuous capnography, however, will show the difference.

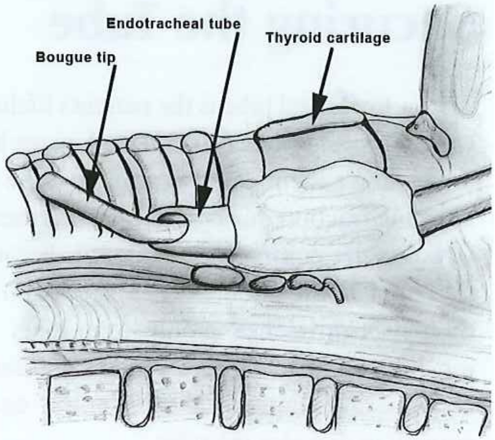
ESOPHAGEAL DETECTOR DEVICES

These are another means of objective tube verification. A syringe device or bulb is placed on the end of the endotracheal tube to create suction. If the tube is correctly placed in the trachea, the cartilaginous rings keep the trachea patent when suction is applied so that there is rapid air return into the device. If the tube is incorrectly placed in the esophagus, the soft distensible tissues occlude the end of the tube when suction is applied so that air return does not occur or occurs very slowly. These devices are inexpensive, almost as accurate as capnography and have been validated in the air medical environment as well. Of course, like any device, false results will occasionally be obtained. In settings where most intubations are performed for cardiac arrest (i.e. most EMS systems without RSI capability and some crash-carts in health care settings) these devices are preferred to end-tidal CO_2 detectors. These devices are FDA approved down to 20 kg patients and well studied down to 10 kg. It is important, however, to use the "off-deflate" method in children: squeeze the air out of the device before it is placed on the tube.

Examples of currently available EDDs. From left to right: Ambu TubeChek-B, Wolfe Tory EID-Syringe and Wolfe Tory EID-Bulb. Courtesy of Bound Tree Medical.

Can the bougie be used to confirm tube placement?

The bougie is discussed in Chapter 4. While classically used to facilitate difficult intubations, the bougie can also be used to confirm tube placement. For example, if you take over care of a patient in cardiac arrest who is already intubated, end-tidal CO_2 is probably unreliable due to decreased gas exchange. If an esophageal detector device is not available and the tube is at least 6.0 mm, a lubricated adult bougie can be passed quickly through the tube. If the bougie can be felt "bouncing off" each tracheal ring or if "hold-up" is present before 40 cm, the tube has been objectively confirmed. Further explanation of this technique may be found at www.airway911.com



The coudé tip of the bougie is seen as it is advanced into the trachea through the endotracheal tube. The operator assesses for tracheal rings and hold-up to confirm tracheal placement. From Bair AE et al. Am J Emerg Med 2005;23:754-8 with permission.

CHEST X-RAY

Following confirmation by subjective AND objective means, a chest x-ray will usually be obtained, when available, to check for depth. Ideally, the tip of the endotracheal tube should be in the middle third of the trachea. This correlates to the level of the clavicles or 2 to 4 cm above the carina. Radiography is not a means of confirming tube placement in the trachea because the trachea and esophagus overlie each other and it may be impossible to know which contains the tube. Furthermore, if a patient is ventilated through an esophageal placed endotracheal tube for all the time it takes to obtain, develop and interpret an x-ray they will likely suffer severe brain injury if not death. If the tube is confirmed by objective means and breath sounds are equal, obtaining a chest x-ray should not delay transport of the critically ill or injured patient.

I clearly saw the tube pass through the cords. Why should I take the time or expense to use other means to confirm the tube?

I like to use the example of an anesthesiologist in the O.R. who has intubated thousands of patients, has the patient in the perfect position with great lighting, and usually has no blood or emesis to contend with, yet she uses end-tidal CO_2 100% of the time to confirm her tube is in-place. Why would those of us who work in more difficult environments with less experience and more patient movement rely on anything less than a clear objective measure?

Securing the Tube

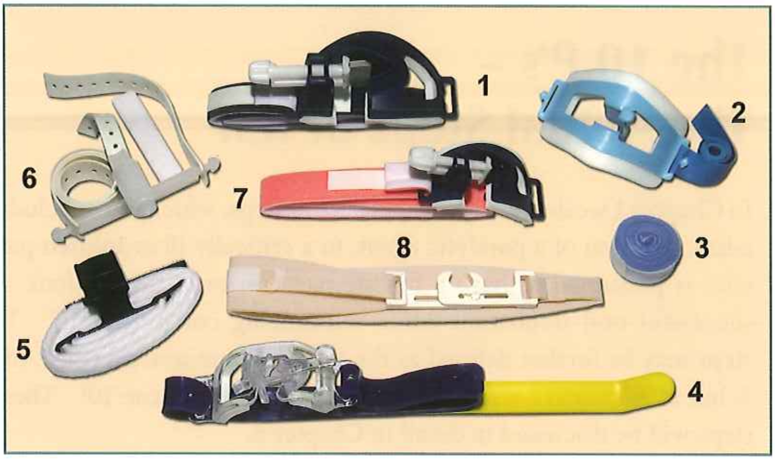
The endotracheal tube is the patient's lifeline and must be secured well to prevent inadvertent dislodgment by head movement, the awakening patient who is grasping at the tube or by accidentally applying traction during patient movement or patient care. This is especially common in children, because the tube does not sit as deep. The adult trachea is about 12-15 cm long whereas the newborn trachea is only 4 cm long. Since a child's neck is much more flexible than an adult's, motion of the neck can easily dislodge an endotracheal tube; only 1 cm of movement may be enough to dislodge the tube.

Caution

There are many means of securing the tube including both commercial devices and improvised techniques. Anything that is easy to apply, does not crimp the tube or injure the patient and maintains tube position is acceptable. Simple tape and cloth tying methods have fared very well in recent trials.

EBM

Security of the tube includes restraints, sedation and possibly paralysis to help ensure the patient does not move nor grasp the tube. Consideration should also be given to placing a cervical collar or lateral head blocks on the patient, especially in children, to further minimize the risk of excessive head movement.



Examples of currently available commercial tube securing devices (clockwise from top middle): Laerdal Thomas Tube Holder Adult, Precision Medical, ErgoMed Tube Restraint, Ambu, FireEMSProLine KwikICON, Olympic Endo Lok, Laerdal Thomas Tube Holder Pediatric, Biomedix EndoGrip. Products courtesy of Bound Tree Medical.

Sedation, Analgesia & Paralysis

The purposes of sedation are to alleviate the anxiety of paralysis/ intubation, facilitate mechanical ventilation, produce amnesia and prevent accidental extubation. A patient must never be kept chemically paralyzed without adequate sedation. Most recently intubated patients will also need analgesia; the intubation itself should be considered a painful procedure and many patients have underlying painful conditions. It is wise to have these medications drawn up and labeled prior to beginning the procedure so there is no delay in administration after intubation. Sedation and analgesia will ideally be administered by an assistant as soon as the tube is confirmed in place since replacing spinal precautions, securing the tube and placing the patient on the ventilator can take several minutes. The specific agents and dosages are discussed further in Chapter 3.

Caution

Not all intubated patients need on-going paralysis after RSI. Paralysis is used on a case-by-case basis primarily to optimize mechanical ventilation. Paralysis should be avoided when the patient cannot be adequately sedated or when the neurological exam is particularly important such as patients with head trauma or at risk for seizures.

The 10 P's – The Actual Steps of RSI

In Chapter 1 we defined RSI as "a series of steps, which must include the administration of a paralytic agent, to a critically ill or injured patient who is presumed to have a full stomach, in order to facilitate rapid successful oral intubation while minimizing complications." These steps may be further defined as the 10 P's. Some sources use 5, others 7, but at *Airway911* we are better than the rest and use 10! These 10 steps will be discussed in detail in Chapter 6.

1. ***Pre-oxygenation***
2. ***Protect the c-spine***
3. ***Pressure to the cricoid***
4. ***Ponder***
5. ***Prepare Equipment and People***
6. ***Pre-Medicate***
7. ***Position the Patient Optimally***
8. ***Paralyze and Induce***
9. ***Pass the Tube***
10. ***Post-Intubation Management:***
    - ***Confirm***
    - ***Secure***
    - ***Sedate***
    - ***Ventilate***

Take Home Points

- Avoid positive pressure ventilation unless the patient is hypoxic
  1. If PPV is unavoidable use the "Rule of Twos" to minimize gastric insufflation

- Preoxygenate before RSI to create a reserve that prevents hypoxemia
  1. Use a tight-fitting non-rebreather on high-flow oxygen for at least 3 minutes
  2. 20 degrees head elevation or position of comfort unless contraindicated
  3. Categorize patients as having "adequate", "limited" or "no" reserve

- Cricoid pressure
  1. Use with BVMV and from first RSI meds until tube confirmed in trachea
  2. Reduce if laryngeal view obscured

- Three Strikes and you're out: limit intubation attempts to 3 or less

- All endotracheal tubes must be confirmed objectively using end-tidal CO_2
  1. Alternatives include esophageal detector devices and the gum-elastic bougie
  2. Direct visualization, x-ray, lung sounds, tube misting are NOT acceptable

- Tubes should be secured using a commercial device, tape or cloth ties

- All patients should receive sedation and analgesia after emergency RSI
  1. Use ongoing paralysis on a case-by-case basis

- The 10 P's are the steps of every RSI

Case Scenario

"Bread and Butter" RSI

EMS is activated for a 14 year old who fell while doing stunts on his BMX bike. He was not wearing a helmet and landed directly on top of his head. He has not regained consciousness since the event. On arrival of first responders his best GCS was 11. On arrival of paramedics 5 minutes later his GCS is 8 and he is combative. He has vomited three times and 4 first responders are having trouble maintaining cervical precautions, oxygenation and keeping his airway clear. His blood pressure is 160/100, his heart rate is 100 and his oxygen saturation on a non-rebreather is 100%. ETA to the trauma center is 17 minutes. LEMONS assessment is all favorable except cervical precautions. What is your assessment and plan?

This is a bread-and-butter RSI. Ideally this would be done while enroute to the hospital but his combativeness will not allow that. This patient appears to have isolated head trauma with elevated ICP. The evil triplets hypoxemia, hypotension and hypocarbia must be avoided.

LEMONS: Favorable except cervical precautions. His agitation will also increase oxygen demand and therefore decrease the reserves, although a healthy 14 year old without lung injury will probably still have several minutes of apnea time.

PREOXYGENATE: I would stick with a non-rebreather. It appears to be working and BVM assisted respirations are likely to cause more agitation.

PROTECT C-SPINE: Clearly important for this patient during the intubation itself. Up to that point aggressive efforts to maintain strict alignment in a combative patient are only likely to increase the forces applied to the neck.

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: It does not appear that there is any alternative to RSI or RSA. The airway is complicated by spinal precautions and an increased likelihood of desaturation despite optimal preoxygenation because of his tachycardia and combativeness. Due to the presumed head injury it is important to avoid hypoxemia and hypotension.

PREPARE EQUIPMENT AND PEOPLE: I would have at least two sizes of cuffed endotracheal tubes available. I would also have a bougie and two sizes of EAD available though they probably do not need to be taken out of the package. I would have both straight and curved laryngoscope blades available. Assistants prepared to monitor saturations, assist with cricoid pressure/ELM, assist with cervical precautions/jaw thrust, assist with the bougie and hold the tube will all be very important so the intubator can stay focused on the airway.

PREMEDICATE: This is a classic case where premedications should be omitted in the interests of controlling the combativeness and getting the patient's airway managed as soon as possible.

POSITION THE PATIENT OPTIMALLY: Limited by cervical precautions.

PARALYZE AND INDUCE: Once ready I would induce with 0.4 mg/kg of etomidate and preferably paralyze with 1 mg/kg of rocuronium. Propofol or midazolam are potential options for induction and succinylcholine would be an acceptable alternative for paralysis.

PASS THE TUBE: The patient would continue to receive passive oxygenation via the non-breather while he is induced and paralyzed. One assistant would provide cricoid pressure. Once 60 seconds have passed since rocuronium administration I would remove the cervical collar and have another assistant provide in-line immobilization with a jaw thrust. I would use external laryngeal manipulation as needed and anticipate first-pass success.

POST-INTUBATION MANAGEMENT: Once intubated with direct visualization the tube would be immediately confirmed with quantitative end-tidal CO_2 and breath sounds. The patient would receive immediate post-intubation sedation and analgesia depending on his blood pressure. The tube would be secured and the cervical collar replaced. The transport ventilator would be utilized with an initial rate of 12 and a tidal volume of 8 cc/kg of ideal body weight. Rapid transport would be initiated if the procedure was not performed enroute. The patient would receive additional analgesia and sedation enroute as needed. End-tidal CO_2, heart rate and oxygen saturation would be continuously monitored and the blood pressure checked every 3 – 5 minutes. The trauma team would be notified.

Pharmacology

Chapter 3

Premedication

The sixth "P" of RSI is premedication. Intubation - placing a big piece of metal down someone's throat and then jamming a large plastic tube through their vocal cords - is a noxious procedure to which the body may appropriately respond with tachycardia, hypertension and increased intracranial pressure. The medications used to facilitate RSI may have their own dangerous side effects such as bradycardia or muscle contractions.

Premedications are those medications given before the induction agent and paralytic with the intention of reducing the patient's adverse physiologic responses to the subsequent medications and intubation.

Potential premedications fall into three classes: 1. drugs used to prevent bradycardia, 2. drugs used to prevent bronchospasm, and 3. drugs used to minimize sympathetic outflow/rises in intracranial pressure. All three classes of premedications require at least 3 minutes of circulation time in the body prior to the administration of subsequent medications and/or intubation to be effective; this often limits their usefulness in emergent airway cases. During that 3 minute interval be ready to provide BVMV and intubation; some fragile patients may become apneic from premedications alone.

Caution

Airway911 Consensus: Despite ongoing research and healthy debates, none of the premedications should be considered "Standard-of-care". None are without risk either.

Drugs to Prevent Bradycardia: Atropine

Kids are just one giant Vagus nerve covered in germs! Infants and young children may develop bradycardia during RSI from laryngoscopy, hypoxemia and/or direct medication effects. Infants and children may rarely develop profound bradycardia from propofol or succinylcholine as can anyone, young or old, receiving a second dose of succinylcholine.

It is often recommended that atropine be given "prophylactically" before succinylcholine is administered to any child less than 6 years of age. Some sources recommend atropine to pretreat any infant less than 1 year of age being intubated, regardless if succinylcholine is used. Potential risks of atropine include dysrhythmias and masking hypoxemia. There is very little evidence to support or refute atropine pretreatment. Whether or not it is given prophylactically, atropine should be readily available at the bedside during any pediatric intubation and any time succinylcholine is being used.

Airway911 Consensus: Skip the atropine but have it immediately available. Avoid succinylcholine altogether in kids when possible. If using succinylcholine use large enough doses that re-dosing is never necessary.

Atropine	
Action:	Acts to antagonize vagal stimulation.
Dose:	0.02 mg/kg, minimum of 0.15, maximum of 0.5 mg
Peak:	3 minutes
Duration:	30 minutes
Adverse:	Tachycardia (rare)

Is bradycardia with succinylcholine real or just theoretical?

I have personally witnessed profound bradycardia after succinylcholine in a toddler with a hydrocarbon ingestion; the child started out tachycardic and we were doing chest compressions by the time someone could get the atropine out of the crash cart. Like most cases of succinylcholine-associated bradycardia, this case was complicated by hypoxemia. The literature would suggest these are rare events, however.

Is there any controversy to giving atropine?

Of course! Isn't there some controversy to everything in this business? On one end of the spectrum are experts and guidelines that call for routine use of atropine in any child less than 1 year of age undergoing RSI regardless of the chosen paralytic, children less than 8 years of age getting succinylcholine for RSI, and any age patient getting a second dose of succinylcholine. On the other end are the experts that cite the paucity of evidence that atropine is actually effective in this situation as well as the potential dangers of atropine including tachydysrhythmias and increased risk of aspiration.

Drugs to Prevent Bronchospasm: Lidocaine

In a patient with underlying stable asthma, intubation may provoke bronchospasm which can be mitigated with the use of lidocaine. In a patient being intubated because of their reactive airways disease, i.e. status asthmaticus, intubation may cause worsening of their acute bronchospasm. There are no trials, however, that have looked at this rare population of patients, which is the group we are concerned about for emergent RSI. The best current evidence is therefore limited and somewhat contradictory; it is impossible to make any evidence-based recommendation on the role of lidocaine in this scenario. Pending further research, lidocaine may be considered as a pretreatment for any patient with a history of severe asthma, any patient with detectable wheezing and any patient being intubated for status asthmaticus. Like most pretreatment agents, lidocaine should not be considered standard-of-care.

Airway911 Consensus: use it for unstable asthmatics when time permits.

Lidocaine	
Action:	blunt airway reflex-mediated bronchospasm
Dose:	1.5 mg/kg given 3 minutes before laryngoscopy
Peak:	3 minutes
Duration:	20 minutes
Adverse:	• Hypotension • Allergic Reactions • Seizures • Bradydysrhythmias

Drugs to Minimize Hypertension, Tachycardia and Rises in Intracranial Pressure

Patients with healthy brains tolerate elevations of intracranial pressure (ICP) very well. Consider that your ICP goes up every time you cough or bend over to tie your shoes. Contrast this with patients who have unhealthy brains, particularly ischemic brain tissue or elevated intracranial pressure from head injury or stroke; this is a fragile group at constant risk of secondary injury from anything that decreases perfusion of injured neurons. Rises in ICP adversely effect cerebral perfusion pressure and may, rarely, cause brain herniation.

Caution

Most patients are also tolerant of elevations of blood pressure and heart rate. Many patients undergoing emergent intubation are only alive because their sympathetic flight-or-fight system is kicking in full blast. Occasional patients undergoing RSI, such as those with severe coronary artery disease, may not be so tolerant of tachycardia and hypertension.

Caution

The airway contains a wealth of nerve endings; stimulating these nerves with a laryngoscope may cause elevations of ICP. For this reason a variety of premedications have been advocated to block or blunt these nerve stimulation mediated rises in heart rate, blood pressure and ICP for patients at risk of secondary injury. This includes lidocaine, fentanyl, beta-blockers and defasiculating doses of paralytics. When specifically used in this manner these drugs belong to a class of drugs known as "cerebro-protective" or "cardio-protective" agents".

Lidocaine

Among the most commonly used but least validated cerebral protective premedications is lidocaine. There is little evidence that it produces the desired effects, at least when given intravenously. Lidocaine may be more effective when administered topically in the airway but this is rarely done in the emergency setting for this indication. Moreover there are legitimate concerns about hypotension and allergic reactions. Intubation should never be delayed to give lidocaine if the patient is moribund, combative, or hypoxemic as these conditions are far more dangerous to nervous tissue than the rise in ICP associated with well-performed RSI.

Airway911 Consensus: don't bother.

Lidocaine	
Action:	Anesthetize the airway reflexes that lead to elevated ICP
Dose:	1.5 mg/kg (100 mg in an average adult) 3 minutes prior to laryngoscopy
Peak:	3 minutes
Duration:	20 minutes
Adverse:	• Hypotension • Allergic reactions • Seizures • Bradydysrhythmias

Beta-blockers (Esmolol)

Beta-blockade for cerebral protection and cardiac protection is usually attempted with esmolol (Brevibloc) because it is unique among available beta-blockers: it is administered intravenously, it has a rapid onset and short duration, and it is selective for the *B*1 receptor. Esmolol is among the best-studied and validated agents to blunt the hemodynamic response to intubation though it is unknown if this truly equates to less elevation of ICP. Esmolol is rarely used in emergency settings because of cost and concerns for precipitating hypotension or bronchospasm.

Airway911 Consensus: nice touch for your hypertensive cardiac patients, especially those that have missed routine doses of beta-blockers. Otherwise just say no.

Esmolol	
Action:	Blunts sympathetic response to laryngoscopy
Dose:	1-2 mg/kg 3-5 minutes before laryngoscopy +/- infusion
Peak:	5 minutes
Duration:	10 minutes (heart rate effect shorter and blood pressure effect longer)
Adverse:	• Bradycardia • Hypotension • Bronchospasm

Opiates

High-potency fast-acting synthetic opiates, especially fentanyl, have been evaluated extensively for this indication for over 25 years. The results are not surprisingly contradictory. A non-scientific "meta-analysis" suggests that does over 2 mcg/kg, up to 6 mcg/kg, are most likely to be effective.

Patients with normal-to-high blood pressures, such as most patients with isolated severe head trauma, will rarely become hypotensive from these doses.

Caution

Use caution, however, in critically ill and sympathetic-dependent patients, such as severe multi-system trauma. These patients may only be alive because of their sympathetic drive.

Airway911 Consensus: generally safe and provides analgesia if nothing else. Go for 3 mcg/kg if possible.

Fentanyl	
Action:	Analgesic and sympatholytic. Thought to act on ICP through a combination of these two mechanisms.
Dose:	1.5 - 6 mcg/kg 3 minutes before laryngoscopy push slowly
Peak:	3 minutes from end of bolus
Duration:	30 minutes
Adverse:	• Hypotension (primarily if living on their sympathetic drive) • Respiratory depression • Chest wall rigidity - big doses - pushed fast - very young patients

Defasciculating Agents

Fasciculations are chaotic contractions of muscle fibers that may be produced in some adult patients receiving succinylcholine. They are not generally seen in children nor when non-depolarizing paralytics are used. These fasciculations begin in the small muscles of the head and neck and progress towards the lower extremities. These contractions last until paralysis occurs and are thought to contribute to the rise in ICP seen with succinylcholine. At least one small study of patients in the OR with cerebral pressure monitors demonstrated that blocking fasciculations did minimize the elevation of ICP that occurred following succinylcholine administration.

Many studies have shown that fasciculations may be minimized or eliminated by pretreatment with a small dose of a non-depolarizing paralytic – rocuronium appears to be among the most effective. Succinylcholine has also been evaluated as its own defasciculating agent in small doses but it appears less effective than a non-depolarizing paralytic. The clinical significance of this in acute elevations of ICP is unknown. Effect is time-dependent with up to 5 minutes required for maximal effect. Unfortunately there is also some evidence that the effectiveness of succinylcholine is reduced following pretreatment and dosage may need to be increased.

Airway911 Consensus: On balance, defasciculation does not seem worth the drawbacks and delays and is not recommended. If you are that worried about ICP and you have a non-depolarizing agent available to use for pretreatment, you should probably just use it for the intubation and skip the succinylcholine altogether.

Succinylcholine	
Action:	Block fasciculations
Dose:	0.05 mg/kg 5 minutes before succinylcholine
Peak:	5 minutes
Adverse effects:	• Apnea/hypoventilation • Decreased effectiveness of succinylcholine

Are there any general risks to premedications?
On rare occasions a patient in extremis will become apneic from the premedication, in particular defasiculating doses of paralytics or large doses of fentanyl. You should always have your airway equipment prepared before administration of these medications and monitor the patient carefully. I have seen providers get in trouble when they thought they could use the three minutes it takes for premedications to be effective to prepare their equipment only to find they were totally unprepared for an apneic patient!

So when should I consider these "cerebroprotective" premedications?
These drugs should be considered only if there is a high suspicion of a critically increased intracranial pressure (ICP) and there is time to delay intubation for 3 minutes for the drugs to take effect. If a patient with suspected elevated ICP is combative or hypoxic, delaying intubation for 3 minutes is probably far worse for the patient than the ICP rise associated with intubation without premedications. In such cases, it is likely better to intubate rapidly than wait the three minutes for the medications to have an effect.

So what do you do in practice?
In many cases I do not use any cerebral protective agents. When I have a patient in the ED who is unlikely to tolerate any further rise in ICP, in whom a three minute delay is tolerable and in whom blood pressure is at least high-normal, I will premedicate with fentanyl. A classic example is a patient who returns from CT scanning with an unexpected large intracranial bleed with mid-line shift and deteriorating mental status but no imminent need for intubation. I do not defasciculate since I use rocuronium for paralysis.

Induction Agents

The purpose of an induction agent is to do exactly what you would want done if you were about to have someone paralyze you and stick a tube down your throat: render the patient unconscious and unresponsive. An ideal induction agent should:

- Have a rapid onset and a short duration
- Induce unconsciousness and unresponsiveness
- Provide amnesia
- Have minimal effects on hemodynamics
- Have minimal adverse side effects

Potential induction agents for RSI include etomidate, midazolam, ketamine, propofol, thiopental, and methohexital. The first five agents, the most widely used and available, will be discussed here.

Etomidate (Amidate)

Etomidate is a commonly used induction agent with a generally predictable response and minimal hemodynamic effects; it does not generally raise or lower blood pressure or heart rate. Etomidate may be used in any clinical circumstance including the patient with hypotension or head injury. Seizures have been noted with etomidate, especially in patients with partial seizure disorders, though they are short-lived and this does not represent a significant contraindication for induction. Etomidate is particularly beneficial when increased intracranial pressure is a concern as it has been shown to decrease intracranial pressure, cerebral blood flow and cerebral oxygen metabolism.

The only clinically significant drawback to etomidate is adrenal suppression. There is a great deal of debate in the literature recently regarding this issue, particularly for septic patients. The issue has not been resolved.

The package insert recommends a dose range of 0.2 – 0.6 mg/kg. Most texts suggest 0.3 mg/kg as a standard RSI dose. Dose reduction is often recommended in the hypotensive patient but I have not personally found that to be necessary. On the other hand we have had cases of awareness with 0.3 mg/kg both during induction and during procedural sedation.

Airway911 Consensus: etomidate remains the best single induction agent for RSI. Consider using at least 0.4 mg/kg.

Etomidate	
Dose:	0.2 - 0.4 mg/kg true body weight
Peak:	30 seconds
Duration:	10 minutes
Adverse:	• Adrenal suppression - see below • Myoclonus - not seen when followed by a paralytic during RSI • Vomiting - not seen when followed by a paralytic during RSI • Seizures - not likely clinically significant

So is this adrenal suppression really an issue?

The adrenal glands secrete stress hormones that are incredibly important to critically ill and injured patients. Even a single does of etomidate will suppress the adrenal glands up to 48 hours. In most patients a single dose is probably not clinically significant especially since it may be treated with stress-dose steroid administration. The patients who are most at risk for complications from adrenal suppression, septic shock patients for instance, are the very same patients who require an induction agent that is hemodynamically stable. Suitable alternatives are limited to ketamine which is not widely available. Adrenal suppression is the reason that you cannot use infusions of etomidate for ongoing sedation after intubation; otherwise it would be the perfect drug.

Propofol (Diprivan)

Propofol is beloved for induction of anesthesia in the O.R. and for procedural sedation. Propofol has an extremely rapid onset time and short duration, much like etomidate. Its use in the emergency setting is limited primarily by hypotension. Propofol is considered a cerebroprotective agent as it decreases intracranial pressure and cerebral metabolism though this may be offset by hypotension. It also has antiemetic properties, though this is less important when used with a paralytic as part of RSI. Unlike etomidate, propofol can be used for on-going sedation after the intubation, especially in the hypertensive neurological patient.

Airway911 bottom-line: style points in status epilepticus, isolated neuro patients with hypertension and severe alcohol withdrawal but you can't do anything with this drug that you can't do with etomidate.

Propofol	
Dose:	1 - 2 mg/kg
Onset:	15 - 30 seconds
Duration:	8 minutes
Adverse:	• hypotension • bradycardia

Midazolam (Versed)

Benzodiazepines are common induction agents outside the O.R. though they may not be the best choice for most patients. Benzodiazepines are excellent anterograde and retrograde amnestic agents. This means that patients lose recollection of events that occurred both after and before the drug was given. Benzodiazepines are also excellent anticonvulsant agents and appear to be cerebral-protective agents. They are readily available in most settings, including EMS.

The major problem with these agents is hypotension, especially at induction doses. Dose response can also be quite variable from one patient to another, which can make it difficult to ensure the patient is truly unaware of what is happening. They are also controlled substances, which must be kept secure.

Midazolam is the best of the benzodiazepines for RSI due to its rapid onset and short duration, but it is slower in onset than most other induction agents and should be administered 2 to 3 full minutes before intubation is attempted. This increases the chances that the patient will desaturate and require BVMV and/or be paralyzed before they are fully unaware.

The recommended induction dose for RSI is much higher than the dose used for sedation so high that many providers are uncomfortable giving enough. In clinical practice many patients are induced with low-to-moderate procedural sedation doses. While most patients will still not recall the intubation due to the amnestic effects of the benzodiazepines, would YOU want to be aware? This falls into the "if a tree falls in the forest and nobody hears it, did it really fall?" category of medical practice. Moreover, patients that are aware during the procedure may have dangerous catecholamine responses that raise ICP and stress hearts.

All the benzodiazepines may be used at lower doses for on-going sedation of the intubated patient. While benzodiazepines can be reversed with flumazenil, this is rarely indicated and often dangerous in the emergency setting due to potential seizure activity, particularly in the patient with unrecognized chronic benzodiazepine use.

Airway911 Consensus: skip the benzos for induction if anything else is available.

Midazolam	
Dose:	0.2 - 0.4 mg/kg
Peak:	3 minutes
Duration:	30 minutes
Adverse:	hypotension
Uses:	any non-hypotensive patient though most suited for patients in status epilepticus.

Ketamine (Ketalar)

Ketamine is a dissociative anesthetic agent - the patient may appear to be awake, but is amnestic and unresponsive – often used as part of procedural sedation. Ketamine is used as a surgical anesthetic throughout the developing world due to its excellent safety profile. It is the only induction agent with analgesic properties in addition to sedation. Ketamine is not commonly used as an induction agent in the U.S. but it can be an excellent agent in the hypotensive patient due to catecholamine release. Ketamine may also be a suitable substitute for etomidate in the septic patient. Ketamine is relatively contraindicated in patients with hypertension, coronary artery disease, and/or suspected increased-intracranial pressure (unless hypotensive).

Ketamine increases cardiac output, pulse rate, blood pressure, myocardial oxygen consumption, cerebral blood flow, intracranial pressure and intraocular pressure. While traditionally scorned in the setting of potential neurological injury, ketamine is now being investigated as a cerebro-protective agent. It may be particularly useful in head trauma patients who are hypotensive. Ketamine also increases salivary and bronchial secretions though this is rarely clinically significant. Ketamine may cause emergence reactions but this is not an issue when the patient is to remain intubated and sedated.

Ketamine has been suggested as the preferred induction agent for asthmatic patients. Case reports suggest that induction doses may be effective bronchodilators though recent evidence has challenged the clinical utility of lower doses of ketamine, especially when the patients are simultaneously being treated aggressively with conventional medications. There is insufficient evidence to support routine use of ketamine for asthmatic patients.

Airway911 Consensus: you are likely to see resurgence in use of this old medication for induction, especially for septic patients. Not worth stocking only for this purpose, unless you intubate lots of septic patients.

Ketamine	
Dose:	1.5 mg/kg
Peak:	1 minute
Duration:	15 minutes
Adverse effects:	• HTN • tachycardia • secretions • elevated ICP?
Contraindications:	• HTN • heart disease • pregnancy • age < 3mos • elevated ICP unless hypotensive
Uses:	• Asthma • absolute or relative hypotension • sepsis

Thiopental (Pentothal)

Thiopental is an ultra-short acting barbiturate that has been used as an induction agent forever; the other agents discussed in this section have largely replaced it. The last remaining indication for thiopental is for patients with critical elevations of intracranial pressure and patients with status epilepticus.

Caution

Thiopental is a classic cerebroprotective agent. It decreases ICP while also decreasing cerebral oxygen consumption and serving as an anticonvulsant. These benefits are easily offset by potentially disastrous decreases in blood pressure that are particularly common in volume-depleted patients, those with a history of hypertension and those receiving doses at the higher end of the range. Propofol has a very similar risk-benefit profile and is more readily available in most settings. One small advantage to thiopental compared to propofol, especially in children, is the relative lack of burning on injection. Etomidate also has neuroprotective properties with a much better hemodynamic profile than either propofol or thiopental.

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Airway911 Consensus: just use propofol or etomidate.

Thiopental	
Dose:	3 mg/kg
Peak:	30 seconds
Duration:	10 minutes
Adverse:	hypotension bronchospasm
Uses:	increased ICP or seizures when blood pressure and volume-status are not an issue

Is it ever appropriate to skip the induction agent?
I have heard of some EMS guidelines that limit RSI to patients with severely depressed mental status and skip the induction agent on the basis that the patient is already unconscious and unaware. I do not personally practice this approach since there is no way to guarantee that the patient is unaware and the risks of awareness are substantial, including catecholamine surge and increased intracranial pressure. The one exception that I occasionally make is the patient with profoundly depressed mental status secondary to overdose with an induction agent such as diazepam. However, it is not inappropriate to give such patients an induction agent if for no other reason than to always be consistent in these critical situations.

Paralytics (Neuromuscular Blockers)

Use of a paralytic is fundamental to the concept of RSI. Recall the definition of RSI from Chapter 1: a series of steps, which must include the administration of a paralytic agent, to a critically ill or injured patient who is presumed to have a full stomach, in order to facilitate rapid successful oral intubation while minimizing complications. The purposes of a paralytic are threefold: 1) to allow intubation in the non-flaccid patient, 2) eliminate muscle tone to optimize laryngoscopy and 3) prevent vomiting. Paralytics should always be used concurrently with an induction agent.

Caution

If you elect to paralyze a patient as part of RSI, but you are unable to successfully place the tube and unable to maintain oxygenation through other means the patient may suffer serious harm and/or death. These drugs are wonderful tools but they must be respected for the good they can do and the risks they involve.

There are two general types of paralytics:

1. Depolarizing (non-competitive)
2. Non-depolarizing (competitive)

Depolarizing Agent (Non-Competitive): Succinylcholine (Anectine)

The only clinically available depolarizing neuromuscular blocking agent is succinylcholine. Before we explain the mechanism of action I need to ask any biochemists or pharmacologists or general all-around smarty pants to cover their ears. Thank you on behalf of the rest of us.

Succinylcholine is structurally very similar to acetylcholine - so similar in fact that when succinylcholine binds to acetylcholine receptors at the neuromuscular junction it actually triggers the receptors and stimulates one strong depolarization of the muscle cell. One last hurrah, shall we say? This stimulation of muscle depolarization is seen clinically in many adults as fasciculations; children generally do not have enough muscle mass to demonstrate this.

After the initial depolarization succinylcholine stays locked on the receptor until it is metabolized by pseudocholinesterase, blocking further depolarization and thereby finally producing paralysis. Fortunately the whole process of binding, depolarization and eventual paralysis occurs very quickly. Because succinylcholine fits so well into the acetylcholine receptor and stays so tightly bound, increasing the amount of acetylcholine in the area of the receptor has no effect on the state of paralysis until the succinylcholine is metabolized. The additional acetylcholine just can't get to the receptors to overcome the state of paralysis. Therefore succinylcholine is considered a "non-competitive" neuromuscular blocker. In practical terms this means that the onset time and duration of action of succinylcholine may be considered independent of dose.

Airway911 Consensus: despite lots of potential adverse effects and complications, succinylcholine has saved tens of thousands of lives, and remains a workhorse for RSI. We find rocuronium to be better a choice overall but many respected experts would disagree.

Succinylcholine	
Action:	depolarizing neuromuscular blockade
Dose:	2 mg/kg true body weight
Peak:	45 seconds
Duration:	8 minutes
Adverse:	see below
Contraindications:	see below

ADVERSE EFFECTS

Succinylcholine may have significant potential side effects, largely related to the depolarization of the muscle cell that occurs. These side effects include:

• **Hyperkalemia:** all patients who receive succinylcholine will have small increases in serum potassium on the order of 0.5 mmol/L. Patients with pre-existing hyperkalemia and those with conditions that cause "up-regulation" of acetylcholine receptors (see table) are at risk for fatal increases in potassium. Succinylcholine should also be used cautiously in dialysis patients whose potassium level is not known, especially if it has been more than 24 hours since their last dialysis. If considered in such patients, intravenous calcium should be immediately available as a potential antidote for cardiac complications.

Conditions that Predispose to Exaggerated Hyperkalemia from Succinylcholine	
Neuromuscular Diseases	**Rhadomyolysis**
Muscular dystrophies	**Burns > 24 to 48 hours old**
Myopathies	**Spinal cord injury > 72 hours and < 9 months old**
Guillian-Barre	**Prolonged immobility/paralysis**
Stroke	**Severe infection (esp. abdominal and neuro)**
Severe Parkinson's	**Severe trauma (esp. muscular)**
Tetanus	
Botulism	

• **Bradycardia:** Bradycardia occurs primarily in children though it can occur in any patient receiving a second dose of succinylcholine. This is one of the reasons to use a larger dose of succinylcholine from the outset lest you get in a situation where you need to give a second dose. Higher dosing also increases your first-pass success and decreases the risk of vomiting; there is little downside to a larger dose with a non-competitive agent.

• **Prolonged paralysis:** Succinylcholine can cause prolonged paralysis in patients who have a deficiency of, or defective, pseudocholinesterase, the enzyme that metabolizes succinylcholine. Several drugs have also been associated with prolonged paralysis, including magnesium, cocaine, lithium, quinidine and cholinergic overdoses. Although confirmed or suspected pseudocholinesterase deficiency is a relative contraindication to the use of succinylcholine, the only complication would be prolongation of the paralysis.

• **Malignant hyperthermia:** This is a very rare but often-fatal condition associated with markedly increased temperature, metabolic acidosis, rhabdomyolysis, and disseminated intravascular coagulopathy. It is most common in patients receiving succinylcholine in combination with inhaled anesthetics in the operating room and extremely rare in other settings. However, if a patient has a known personal or family history of malignant hyperthermia, succinylcholine should not be used.

• **Increased intraocular pressure:** Succinylcholine causes a transient rise in intraocular pressure, which could theoretically cause expulsion of vitreous humor in an open eye injury. I am not aware of any documented case of this complication despite widespread use in open eye surgery. The prudent practitioner will still consider use a non-depolarizing agent in penetrating eye injuries if readily available.

• **Increased intracranial pressure:** Succinylcholine is known to raise ICP transiently. The significance of this rise is not known. The rise is probably due to a combination of the fasciculations and direct medication effects. Succinylcholine is routinely used in the emergency intubation of head-injury patients despite these concerns. Various pre-medications may be considered to minimize these effects in patients for whom even a small increase in ICP may be detrimental (see Premedications).

• **Muscle fasciculations:** Fasciculations are asynchronous contractions of every muscle fiber within a muscle. These fasciculations usually begin in the small muscles of the head and neck and progress towards the larger muscle groups of the lower extremities. They last until paralysis occurs. Fasciculations are thought to contribute to the rise in potassium, ICP and IOP seen with succinylcholine. Fasciculations are not usually seen in children due to their smaller muscle masses.

• **Trismus:** Paradoxical spasm of the Masseter muscle which may make intubation difficult or impossible is a well documented though rare complication of succinylcholine. If it occurs it may be reversed by administering a non-depolarizing neuromuscular blocker. The mechanism of action is not well understood. It certainly makes no sense intuitively that a drug used to cause paralysis could cause muscle spasm. Some reported cases may have been due to ineffective vials of medication or dosing and administration errors such as infiltrated lines and forgotten tourniquets. Don't let that happen to you.

EBM

CONTRAINDICATIONS

Because of the potential adverse effects listed above, especially hyperkalemia, succinylcholine is relatively contraindicated in a number of conditions including, but not limited to:

- Personal or family history of malignant hyperthermia
- Neuromuscular diseases
- Known or suspected hyperkalemia
- Crush injury/Rhadomyolysis
- Burns > 24 to 48 hours old
- Spinal cord injury > 72 hours and < 9 months old
- Increased intracranial pressure
- Orbital injury
- Prolonged immobility/paralysis
- Severe infection (esp. abdominal and neuro)
- Severe trauma (esp. muscle trauma)

Where do you come up with these big doses of succinylcholine?
It's true that some sources recommend dosages as low as 0.5 mg/kg. I obviously disagree. I have seen many patients in whom 1 mg/kg was clearly not enough to achieve adequate paralysis. In emergency situations we cannot afford the risks of inadequate dosing on the first attempt: aspiration from placing a laryngoscope into the mouth of a "half-paralyzed" patient, time delays to give a second dose often resulting in the need for BVMV to maintain oxygen saturations, and the risk of bradycardia with a second dose. I have personally observed each of these complications. On the flip side, what does an "overdose" of succinylcholine look like? It looks exactly like what you are aiming for: paralysis. Because succinylcholine is a non-depolarizing agent, side effects and duration do not change dramatically with a larger dose. So why aim low???

Can succinylcholine be used intramuscular (IM)?
Yes, succinylcholine has been used IM at doses of about 4 mg/kg. The onset time is about 4 minutes in a well-perfused patient; probably longer in patients needing emergent RSI. With the widespread availability of adult and pediatric intraosseous devices this should almost never be necessary. As an alternative, I have given succinylcholine directly into the femoral vein – "main-lined" - in a few extreme situations.

Non-depolarizing (Competitive) Agents

The other class of paralytics are the non-depolarizing agents such as vecuronium (Norcuron), pancuronium (Pavulon), cisatracurium (Nimbex) and rocuronium (Zemuron) among others. These agents also bind to the acetylcholine receptors in the neuromuscular junction but because they do not share the structural similarity with acetylcholine that succinylcholine does - "vecuronium" doesn't sound much like "acetylcholine" - they do not stimulate the receptor. Hence these agents are "non-depolarizing" and they do not produce fasciculations. This would be another good time for the PhD and PharmD types to tune out...

Since the non-depolarizing agents do not fit into the receptors well they do not stay tightly bound like succinylcholine; instead they bind, fall-off and rebind constantly. Each time the drug releases from the receptor there is a "race" between acetylcholine and the remaining drug to see which will bind to the open receptor next. If the drug wins then paralysis is maintained and if acetylcholine wins the paralysis wanes. If the concentration of drug in the synapse is increased, the chances that the drug will make it past a paralytic molecule to the receptor are increased, and vice-versa. Therefore these are considered "competitive" agents.

The clinical significance of this competition is that the speed of onset and duration of all drugs in this class is dose-dependent. If a larger dose is administered the drug will out-compete the acetylcholine sooner (faster onset) and for a longer period of time (longer duration). Anesthesiologists and anesthetists may take advantage of this competition in the O.R. to "reverse" the paralysis by administering agents that increase the amount of acetylcholine in the synapse. Unfortunately, this only works once about 75% of paralysis has waned by metabolism. Therefore it is not very useful in the emergency setting.

The major clinical advantage to the non-depolarizing agents outside of the O.R. is the relative paucity of adverse effects and contraindications. Not only does this add potential safety but also the RSI sequence is simplified by the absence of most pre-medications. Atropine is not indicated as these drugs do not induce bradycardia. Defasiculation is not indicated as these drugs do not induce fasciculations. Lidocaine, beta-blockers and fentanyl are less important because the non-depolarizing agents do not have the inherent potential to raise ICP like succinylcholine.

Traditionally the major drawback to the competitive agents has been a prolonged onset time and duration. Now some of the newer agents such as rocuronium have an onset time comparable to succinylcholine. The longer duration of action is less clinically important now that we have excellent extraglottic airways and practice "three strike and you're out" intubation. Previously, when the only back-up airway was a cricothyroidotomy, there was safety in being able to let succinylcholine wear off. Today, we move to back-up airways long before even short-acting agents like succinylcholine wear off. Many emergency physicians, critical care specialists, pediatricians and flight programs now favor these agents over succinylcholine for RSI. These agents have always been used for maintenance of paralysis in the intubated patient.

Rocuronium (Zemuron)

Rocuronium is a non-polarizing neuromuscular blocker. The published dose range is from 0.6 to 1.2 mg/kg. Doses at the higher end of the range are necssary in emergency situations to improve intubating conditions and reduce onset time to near 1 minute (remember, this is a non-depolarizing and therefore competitive agent). Rocuronium is commonly used to replace succinylcholine for RSI as long as the greater duration of action is acceptable.

It may also be used to maintain paralysis after RSI. Many clinicians prefer rocuronium, especially for pediatric patients, as you can use one drug for RSI and maintenance, there is less reason to consider premedication and it has few adverse effects and contraindications:

- No bradycardia
- No increased ICP/IOP
- No fasciculations
- No hyperkalemia
- No malignant hyperthermia

The slightly longer onset time (15 seconds or so) is rarely clinically significant and can be overcome if necessary by giving the rocuronium before the induction agent: the timing principle. However, in most patients, the traditional order of induction agent then paralytic works fine with rocuronium.

Airway911 bottom-line: Love it! We use it virtually exclusively both in the hospital and air medical setting.

Rocuronium	
Action:	non-depolarizing neuromuscular blocker
Dose:	1 mg/kg ideal body weight
Peak:	60 seconds
Duration:	30 minutes
Adverse:	Usually minimal. Anaphylaxis has been reported rarely.

Is rocuronium safe to replace succinylcholine for RSI?

The primary argument against rocuronium has been its long duration, especially at the higher suggested intubation dosages. This argument is a holdover from the days when the only back-up airway was a surgical airway. Today, we have excellent back-up extraglottic devices and we would rarely if ever consider waiting for even a short-acting paralytic like succinylcholine to wear off before placing one. For an elective case in the O.R., where there may be an option of letting the paralytic wear off and rescheduling the case, it may make some sense to choose a shorter acting paralytic for difficult intubations. In the emergency setting this is rarely a good option: if the patient did not mandate intubation RSI would not have been undertaken in the first place. Our patients require airway management one way or another so the duration of action is not that important. Overall, rocuronium is an excellent drug for emergent RSI if used appropriately. It is widely used for this indication.

Wasn't rocuronium recently blasted by the Cochrane Collaboration?

It is true that rocuronium was recently blasted in a Cochrane Collaboration review but close reading reveals that most studies reviewed used dosages on the low end of the range. It is no surprise with a competitive neuromuscular blocker that results would be poor with lower doses. They go on to state that "We found no statistical difference in intubating conditions when succinylcholine was compared to 1.2 mg/kg rocuronium..." So there!

Vecuronium

Vecuronium is a non-depolarizing neuromuscular blocker which is no longer commonly used for RSI. A dose of 0.15 mg/kg persists for about 30 minutes. Onset is typically 2 – 3 minutes, but can be reduced to at best 90 seconds by increasing the dose up to 0.3 mg/kg and/or using the timing and priming principles discussed below. The chances of a patient needing interposed BVMV are higher with vecuronium than other available paralytics. At a dose of 0.3 mg/kg the paralytic effect will persist over one hour.

Caution

The timing principle simply dictates that you administer the dose of paralytic first and wait to give the induction agent until the onset time of the two drugs will be the same. For instance, if you are using etomidate which has a 30-second onset time and standard-dose vecuronium which has an onset time of approximately 2.5 minutes you would give the paralytic first and wait 2 minutes to give the etomidate. Both drugs would then take effect at more or less the same time--or 2.5 minutes from beginning. Unfortunately, the paralytic effect phases in gradually rather than suddenly, so the patient could be sufficiently paralyzed to be extremely distressed before the 2.5-minute mark.

Caution

The priming principle calls for the administration of a small dose of vecuronium in advance of the intubating dose, similar to defasciculation. Unfortunately it creates some confusion and produces onset and duration times similar to simple high-dose vecuronium.

In the emergency setting vecuronium is primarily used at standard dosing to maintain paralysis after RSI.

Airway911 bottom-line: Say no if possible. If vecuronium is the only agent available for RSI, use 0.3 mg/kg and a modified timing principle: give the vecuronium first but follow immediately with the induction agent. Be prepared for careful BVMV.

Vecuronium	
Regular Dose:	0.15 mg/kg
High-dose:	0.3 mg/kg
Peak:	90 seconds (high-dose) 3 minutes (regular-dose)
Duration:	30 - 90 minutes (dose dependent)
Adverse:	Minimal
Adverse:	Minimal

Sugammadex

Sugammadex is a new drug that will reverse paralysis from intubating dosages of rocuronium (and vecuronium to a slightly less extent) within 2 minutes. Sugammedex works by encapsulating the rocuronium molecules. The drug is approved in Europe but was rejected by the FDA in August 2008 due to concerns about hypersensitivity reactions. If the experience in Europe is favorable it will likely gain approval in the United States but may be very expensive.

It is unclear how the availability of a drug to reverse rocuronium would affect emergency airway management. Those who believe a short-acting agent provides a significant safety margin may finally be convinced to switch from succinylcholine to rocuronium. Those who already believe rocuronium is safe for RSI and practice based on moving to plan B in the event of difficulty even before 2 minutes have passed may not find much benefit.

Airway911 Consensus: let's wait and see if it becomes available and how much it costs.

Sedatives & Analgesics

Sedatives

The purpose of sedation is to alleviate the anxiety of paralysis and intubation and to produce amnesia. A patient must never be given paralytics without adequate sedation. The primary sedative agents after RSI are the benzodiazepines of which midazolam is probably the most common; diazepam and lorazepam are also acceptable. Propofol may also be considered for emergency use, especially for patients with isolated neurological conditions. Occasionally a patient will be too hypotensive to tolerate benzodiazepines; ketamine may be an effective sedative in this situation.

Analgesics

The purpose of an analgesic as part of RSI is to combat pain both from the pre-existing conditions associated with the need for intubation (major trauma or myocardial infarction with cardiogenic shock for example) and from the intubation itself. Fentanyl is commonly used because of its rapid onset, minimal side-effects, and widespread availability.

Fentanyl (Sublimaze)

Fentanyl is a rapid-acting synthetic opiate of relatively short duration. At appropriate does it produes peak analgesia within 2 to 3 minutes, with an effective duration of about 30 minutes. It does not have significant sedative properties in adults. In young children it may have profound sedative effects, which may allow it to be used for both post-intubation analgesia and sedation. Fentanyl is well tolerated by most patients with little hypotension seen except in the most fragile, sympathetic dependent, patients. Fentanyl may be administered in boluses or by infusion.

Fentanyl	
Bolus Dose:	Adults: 25 - 100 micrograms every 3 - 5 minutes as needed Children: 1 - 2 micrograms/kg every 3 - 5 as needed
Infusion:	Adults: 100 - 500 micograms/hour Children: 2 - 5 micrograms/kg/hour
Peak:	3 minutes
Duration:	30 minutes
Adverse:	• Hypotension (primarily if living on their sympathetic drive) • Chest wall rigidity - big doses - pushed fast - very young patients

Caution

I hear that fentanyl does not cause hypotension but I swear I've seen it. Is that possible?

Yes! It is true that fentanyl usually does not cause hypotension compared to other narcotics such as morphine sulfate. However, in addition to being a potent analgesic, fentanyl is a sympatholytic agent which means it blocks sympathetic outflow. Some critically ill patients are only alive because of an exaggerated sympathetic "fight-or-flight" response. Fentanyl may block this compensatory response and cause hypotension or vascular collapse; it should be used very cautiously in such patients.

Midazolam (Versed)

Midazolam is probably the most commonly used sedative for recently intubated patients in most settings, particularly in the ED and during critical care transport. It is preferred because of its rapid onset and short duration making for easy titration. Midazolam also provides excellent amnesia. It may be administered by bolus or infusion.

Caution

The major limitation to midazolam for post-intubation sedation is hypotension. This effect is most pronounced in volume-depleted patients, the elderly and/or those concurrently receiving narcotics. Dosage should be reduced in these groups. Some critically ill patients may be too hypotensive to tolerate even small doses of midazolam. Pregnancy class D.

Midazolam	
Bolus Dose:	Adults: 1 - 5 mg every 3 - 5 minutes as needed Children: 0.05 - 0.1 mg/kg up every 3 - 5 minutes as needed
Infusion Dose:	Adults: 5 - 10 mg/hr Children: 0.1 - 0.2 mg/kg/hr
Peak:	3 minutes
Duration:	20 - 30 minutes
Adverse effect:	hypotension
Uses:	any non-pregnant patient unless hypotensive

Ketamine (Ketalar)

Ketamine is a unique dissociative sedative with profound analgesic properties as well. Ketamine is most commonly used for procedural sedation, especially in children, though it can also be used as a general anesthetic, induction agent and sedative/analgesic for intubated patients. This latter use is surprisingly uncommon given that ketamine is the only strong sedative/analgesic that does not cause hypotension. In fact, ketamine will often raise blood pressure. It may be administered by bolus or infusion.

Caution

Ketamine is absolutely contraindicated in patients with hypertension and relatively contraindicated in coronary artery disease and elevated intracranial pressure. As discussed above, concerns regarding ketamine and ICP are now being debunked.

Ketamine	
Dose:	0.25 - 1 mg/kg every 3 - 5 minutes as needed
Peak:	1 minute
Duration:	15 minutes
Adverse effect:	• hypertension • tachycardia • oral secretions • elevated ICP?
contraindications:	• Hypertension • Heart disease • Pregnancy (class X) • Age less than 3 months • Elevated ICP - unless hypotensive
Uses:	• asthma • hypotension ▪ absolute or relative • septic shock

Propofol (Diprivan)

Propofol is a unique sedative agent. It is commonly used in the O.R. setting as an induction agent and in the O.R. and ICU settings as a sedative for intubated patients. Propofol is also used for procedural sedation. Propofol has the advantage of rapid onset and short duration of action. In fact, propofol infusion may be turned off and the patient's neurologic status rapidly assessed. This is extremely beneficial in patients with underlying neurological conditions such as stroke, head trauma

and seizures. Propofol is an anti-convulsant and also highly effective in alcohol withdrawal. It may be administered by bolus or infusion but is most common as an infusion.

Caution

The major limitation to propofol as a sedative for intubated patients is the associated hypotension. This may be particularly marked in the volume-depleted patient. For this reason propofol is not recommended for trauma patients in whom internal bleeding has not be effectively ruled-out or patients with signs of sepsis or cardiogenic shock. Administration by infusion generally results in less hypotension than bolus administration.

Propofol	
Bolus Dose:	0.25 to 0.5 mg/kg every minute as needed
Infusion dosing:	0.5 - 5 mg/kg/hr
Peak:	1 minute
Duration:	20 - 30 minutes
Adverse effect:	• hypotension • Bradycardia
Uses:	• neurotrauma • stroke • seizures • alcohol withdrawal • pregnancy

Etomidate seems like the perfect drug for post-intubation sedation. Why do I never see it used that way?
While its hemodynamic stability is unparalleled, the problem with etomidate is suppression of the adrenal glands, which are critical in the body's response to stressors such as major illness or injury. Etomidate must NEVER be used for ongoing sedation; only a single dose for RSI is acceptable.

Do you ever give medications during the airway procedure?

Yes. If you are using a short-acting induction agent and/or paralytic such as etomidate and succinylcholine you may need to give additional doses in the event that the airway procedure is longer than usual, i.e. difficulties are encountered. Second doses of succinylcholine are associated with bradycardia in any age patient and additional doses of etomidate increase the risk of adrenal suppression. I usually use rocuronium, a long-acting paralytic, so I rarely need to give additional doses until well after the procedure. However, I will often give a dose of fentanyl and midazolam (blood pressure permitting) during a long procedure to be sure that the patient is comfortable.

What is "PISA"?

"PISA" stands for "paralyze, induce, sedate and analgese". This is a new approach that attempts to minimize the time that a recently intubated patient goes without analgesia and sedation in emergency situations. The usual practice is to give premedications, then give an induction agent and paralytic, perform the intubation, confirm the tube and then draw up and administer the sedation and analgesia. In chaotic environments and/or if there are a limited number of hands (i.e. a flight crew in the aircraft) this can result in unacceptable delays to give the sedation and analgesia; delays in which the patient is often extremely anxious and uncomfortable resulting in increased blood pressure, heart rate and ICP. When using the PISA approach, premedications are generally not administered as the rocuronium is used as the paralytic. Rocuronium is given immediately before the etomidate taking advantage of the more rapid onset of etomidate. The first dose of analgesia and sedation is given at the same time as the induction agent and paralytic, before the intubation. Additional analgesia and sedation should still be titrated as soon as possible after the tube is confirmed.

Take Home Points

- Premedications are those medications given before the induction agent and paralytic with the intention of reducing the patient's adverse physiologic responses to the subsequent medications and intubation
  1. None of the premedications are "standard-of-care"
  2. All require at least 3 minutes to work
  3. Consider fentanyl in the setting of elevated ICP or coronary artery disease and lidocaine for patients with asthma

- Induction agents make the patient unaware of the impending intubation
  1. Etomidate is the overall safest agent for most emergency situations
  2. Consider ketamine as an alternative for septic patients

- Paralytics permit laryngoscopy, eliminate muscle tone and prevent the patient from actively vomiting
  1. There are two categories of paralytics:
     - Depolarizing/non-competitive (succinylcholine)
       - Dose-independent onset and duration
       - Multiple though rare adverse effects and contraindications
     - Non-depolarizing /competitive (rocuronium, vecuronium, others)
       - Dose-dependent onset and duration
       - Few adverse effects and contraindications

- All chemically paralyzed and/or recently intubated patients should receive immediate and frequent analgesia and sedation
  1. Midazolam with fentanyl most common
     - Adjust for blood pressure
  2. Consider propofol in isolated neuro patients with hypertension
  3. Consider ketamine if hypotensive

Case Scenario

Neuro Case

A 68-year old woman with history of 3-vessel CABG and 1-vessel stenting presents to a rural ED with a severe headache with vomiting for 2 hours. She also has a history of rheumatoid arthritis. She has dentures. She has not taken any of her routine medications including her metoprolol today. Her mental status is normal and her neuro exam is non-focal. Her blood pressure is 220/160, heart rate 86, respirations 20 and saturation 95% on room air. She is taken to CT scanning where a large subarachnoid hemorrhage is detected. On return from the scanner her mental status is noted to have dropped to GCS 12. The accepting neurosurgeon recommends intubation prior to critical care ground transport to a neurosurgical referral center. What is your assessment and plan?

This patient has an unclipped aneurysm as well as severe CAD and great care has to be taken not to elevate her ICP or blood pressure too much. The airway may be complicated by limited neck mobility but that will probably be offset by removing her dentures for the intubation.

LEMONS: Neck mobility may be limited by her rheumatoid arthritis and this should be assessed before proceeding. Unless severe this will probably be offset by removing her dentures for the intubation.

PREOXYGENATE: Use non-rebreather mask on high-flow oxygen.

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: This is NOT a crash airway. There is no reason not to take enough time to do it calmly and correctly. There is plenty of time to call for assistance if you anticipate difficulty. The primary alternative is to defer intubation but that has already been discussed with the neurosurgeon. It is important that the neurosurgeon be informed of any anticipated difficulties with intubation so they can factor that into the risk-benefit analysis. The back-up will be any appropriately sized EAD.

PREPARE EQUIPMENT AND PEOPLE: I would have at least two sizes of cuffed endotracheal tubes available. I would also have a bougie and two sizes of EAD available though they probably do not need to be taken out of the package. I would have both straight and curved laryngoscope blades available. Assistants prepared to monitor saturations, assist with cricoid pressure/ELM, assist with the bougie and hold the tube will be very important so the intubator can stay focused on the airway.

PREMEDICATE: I would give the patient a small fluid bolus to make sure her tank is full and then premedicate with esmolol 1 mg/kg 5 minutes before intubation and fentanyl 3 micrograms/kg 3 minutes before intubation.

POSITION THE PATIENT OPTIMALLY: There should be time to insure a perfect sniffing position.

PARALYZE AND INDUCE: I would induce with etomidate as I would be fearful of hypotension combining esmolol and fentanyl with propofol or midazolam. I would paralyze with rocuronium to avoid any additional risk of elevated ICP from fasciculations.

PASS THE TUBE: The dentures would be left in-place until just before the intubation in case BVMV were required. They would be replaced if BVMV became necessary for a missed intubation.

POST-INTUBATION MANAGEMENT: Immediately after the tube is confirmed it will be secured and the patient placed on the ventilator with continuous capnography. The patient will receive fentanyl for analgesia and, if her blood pressure remains elevated, propofol for sedation. Further blood pressure management will be discussed with the neurosurgeon and flight team.

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

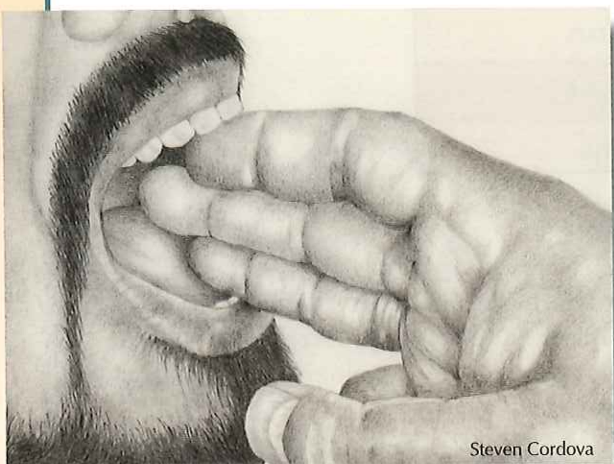
LOOK EXTERNALLY

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.

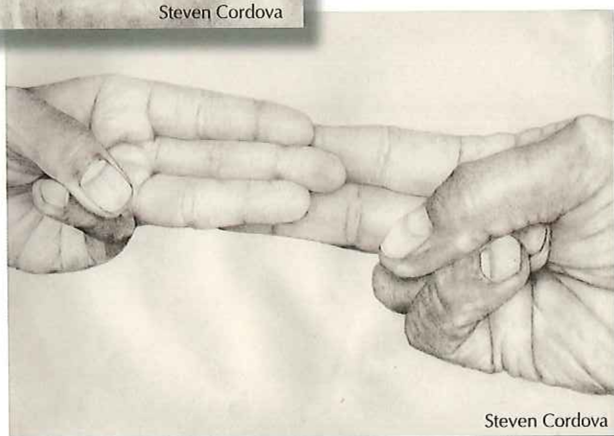
EVALUATE 3-3-2 RULE

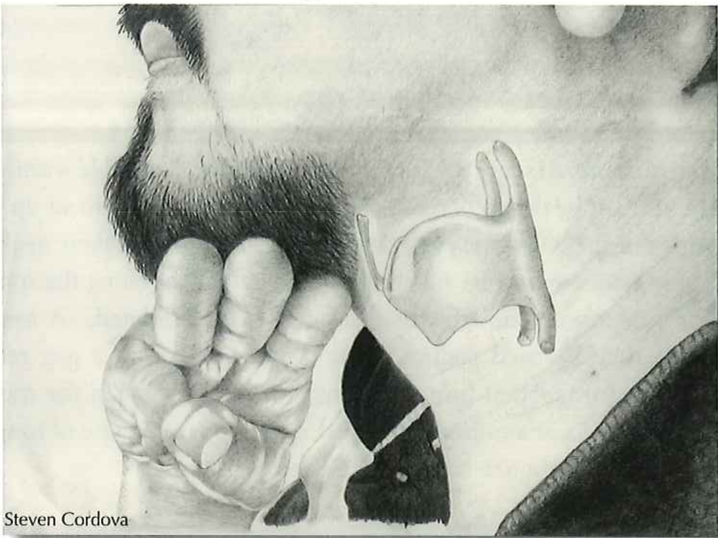
This rule is one tool to help estimate the difficulty of laryngoscopy by assessing anatomical limitations to visualizing the larynx, i.e. small mouth opening, short chin—no room to displace the tongue—and superior/anterior location. Criteria evaluated are as follows (using the patient's finger measurements):

- 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.

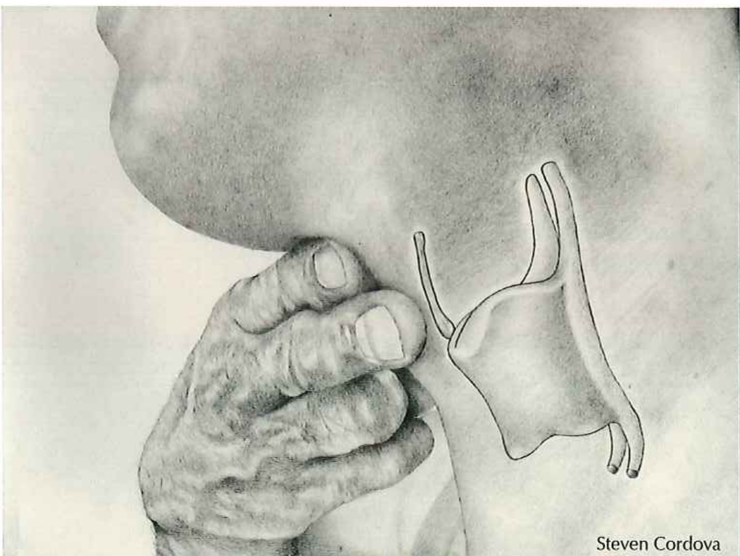


Three fingers mouth opening. This is based upon the patient's fingers not yours! The illustration below shows how you can quickly compare your fingers to the patient's. In this example 2 of the provider's fingers are equivalent to 3 of the patient's.





Three fingers from tip of chin to the hyoid bone.

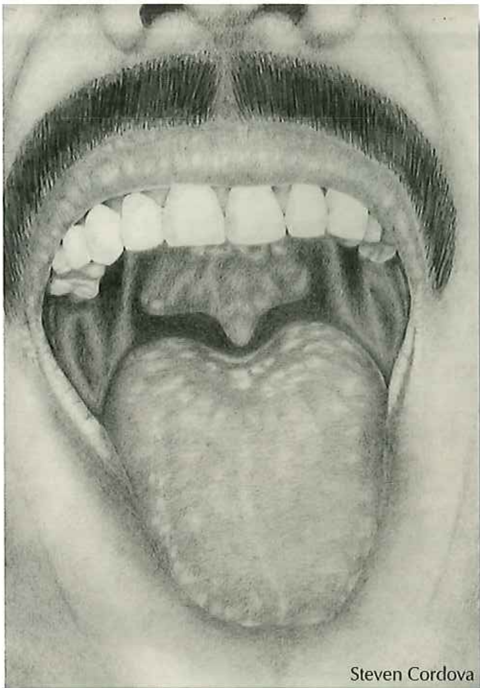


Two fingers from the hyoid bone and the top of the thyroid cartilage.

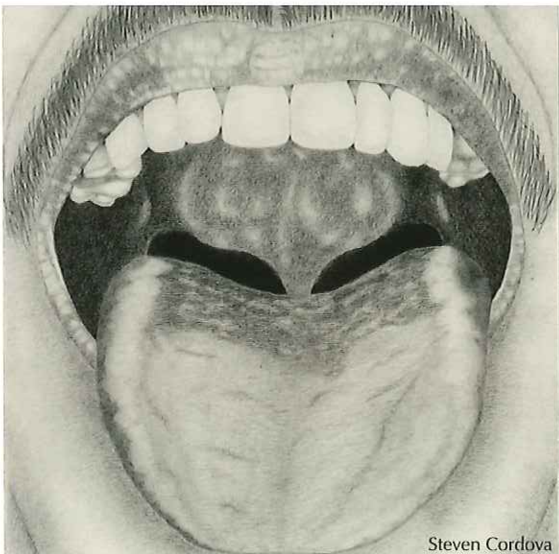
MALLAMPATI SCORE

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.

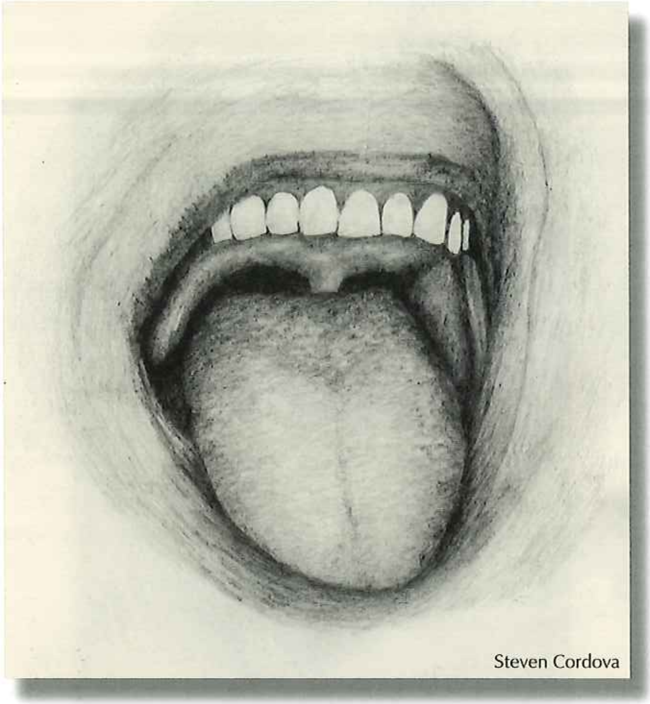
Mallampati Score		
Class I =	Visualization of the soft palate, fauces, uvula, anterior and posterior pillars =	"Easy"
Class II =	Visualization of the soft palate, fauces and uvula =	"Mildly Difficult"
Class III =	Visualization of the soft palate and the base of the uvula =	"Moderately Difficult"
Class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



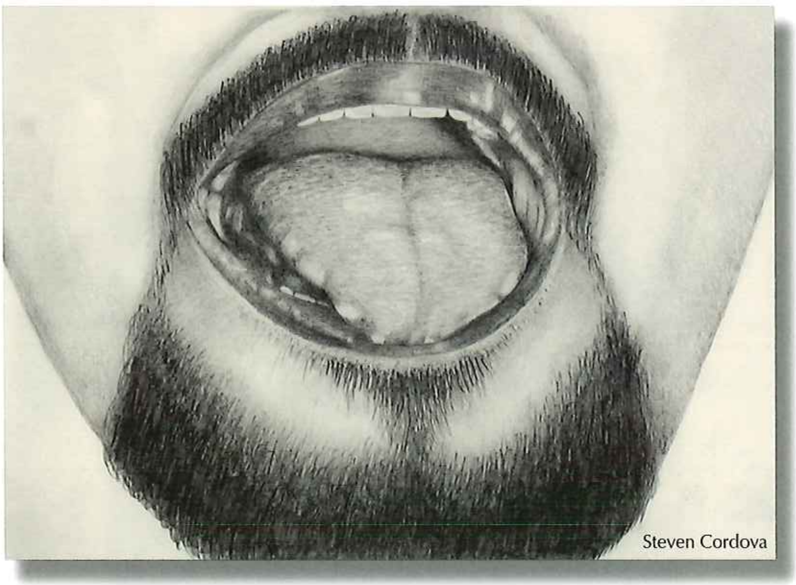
Mallampati I



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.

Caution

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

Caution

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

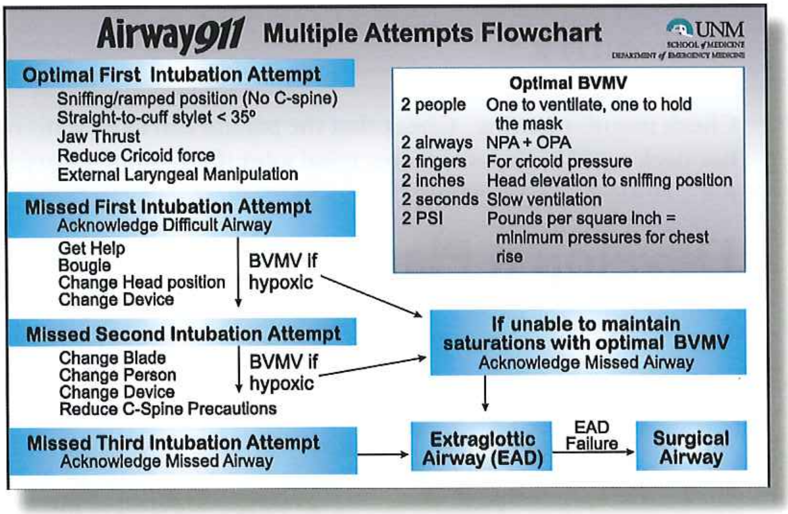
Check mouth opening. Check that the patient can extend his or her neck > 35° at the atlanto-occipital joint if a C-spine injury is not a clinical consideration.

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.

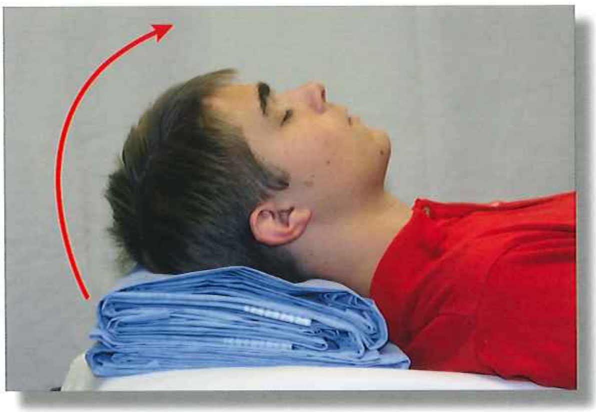
This photo illustrates the correct ramped position for an obese patient achieved using linen. Note that the ear canal and sternal notch are at the same level. Photo courtesy of AirwayCam Technologies.

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.

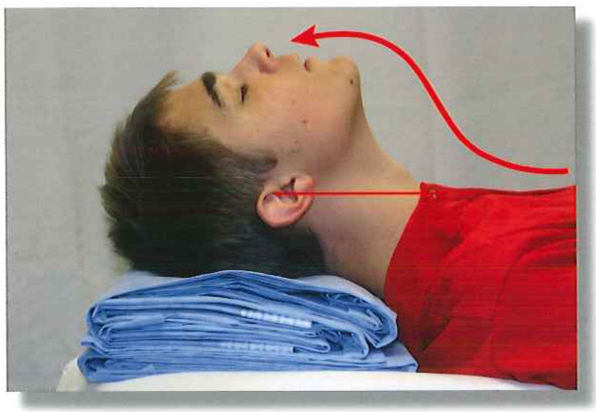
Achieving the correct "sniffing position"

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.

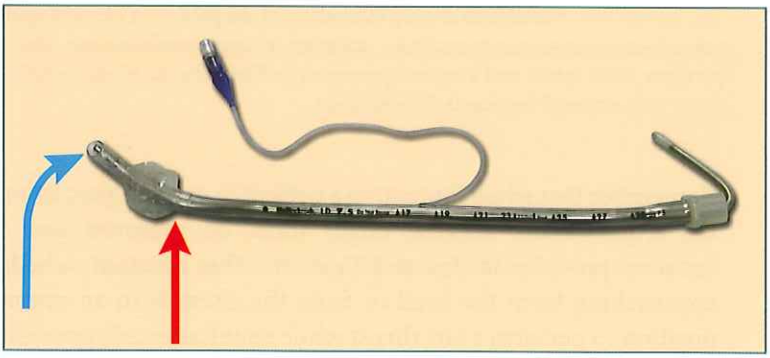


In the second step, the head is extended on the neck, achieving the correct sniffing position where laryngoscopy should be the easiest.



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.

Caution

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

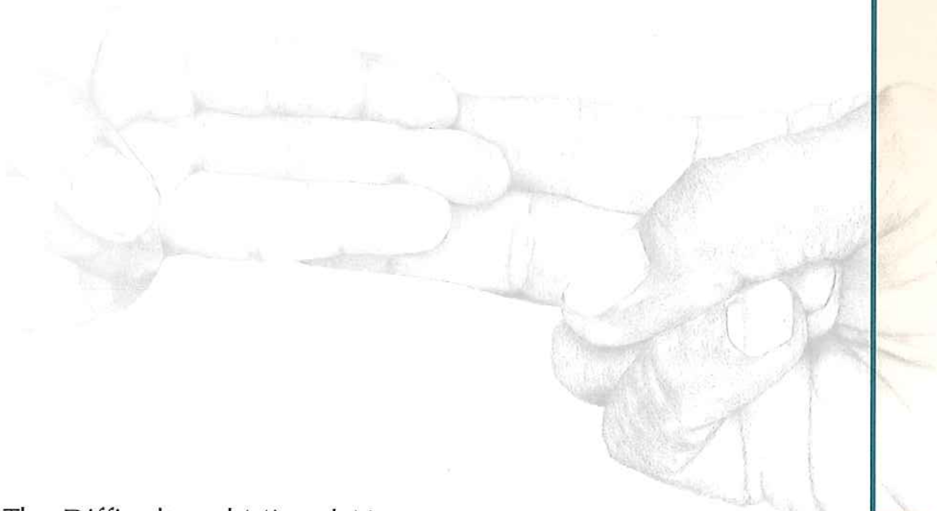
Caution

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.

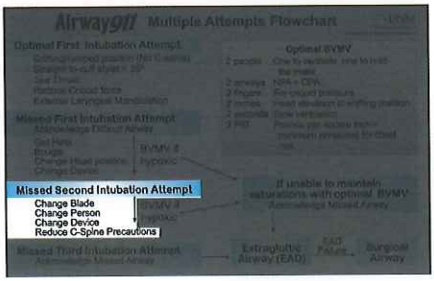
Photos courtesy of AirwayCam Technologies.

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

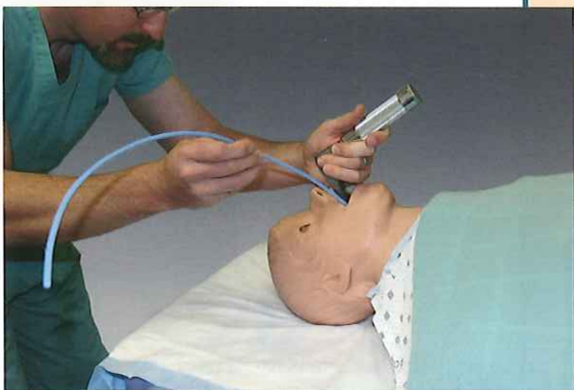
And of course there are situations where there really is no back-up available. Be very careful in such circumstances.

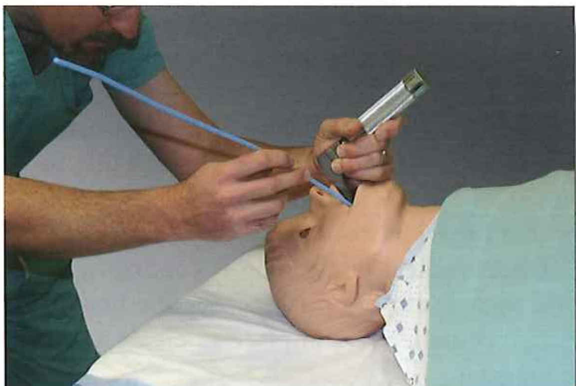
GUM-ELASTIC BOUGIE (AKA ENDOTRACHEAL TUBE INTRODUCER)

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.

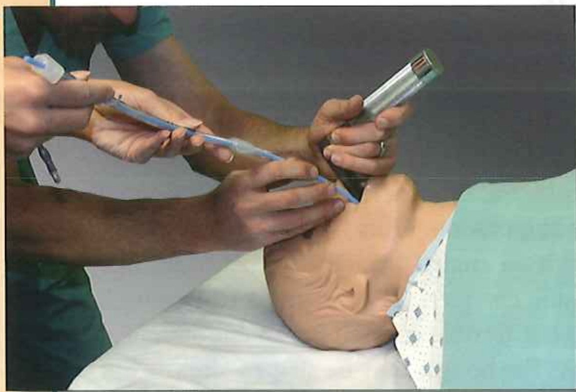
Four steps to bougie-assisted difficult intubation.

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





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.

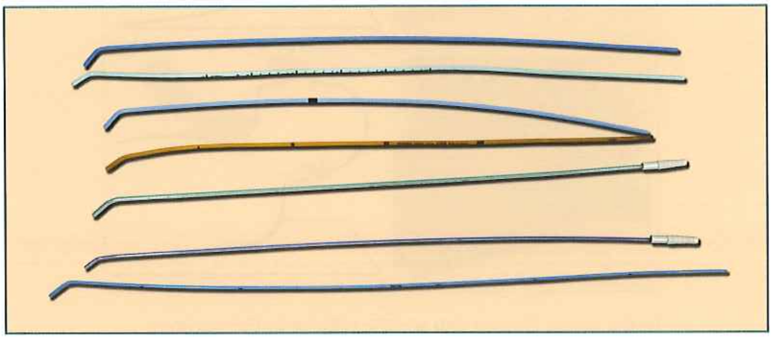
Step 4: The intubator advances the tube into the trachea over the bougie while maintaining the laryngoscope in position to create a clear passage around the tongue for the tube. If resistance is met the tube is gently rotated 90 degrees counterclockwise.

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?"

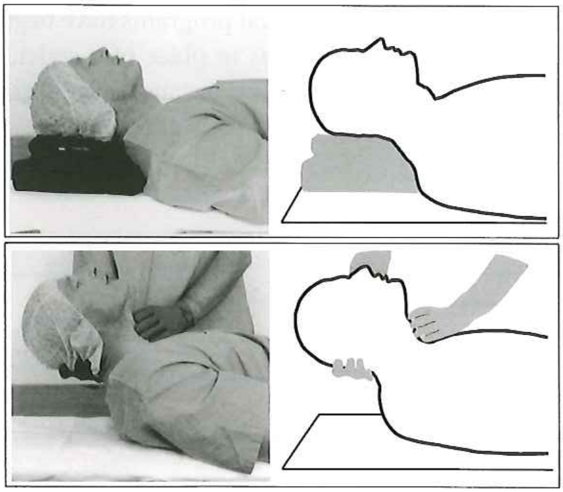


Some of the bougies currently available on the market. From top: SunMed adult, Portex adult, Greenfield adult, Eschmann adult, Boussignac adult oxygenating, Boussignac pediatric oxygenating, and SunMed pediatric.

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.



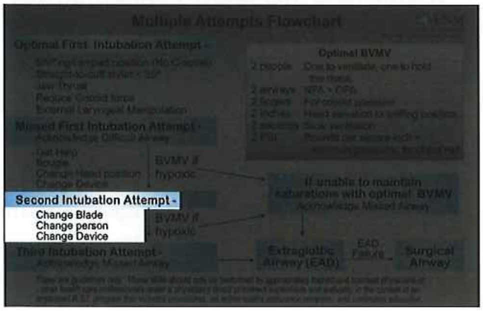
In the upper frames you see the patient in the optimal sniffing position. In the lower frames you see the hyper-elevated head position, in this case maintained by an assistant who is also helping with ELM. Used with permission from Schmitt HJ, Mang H. Head and neck elevation beyond the sniffing position 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

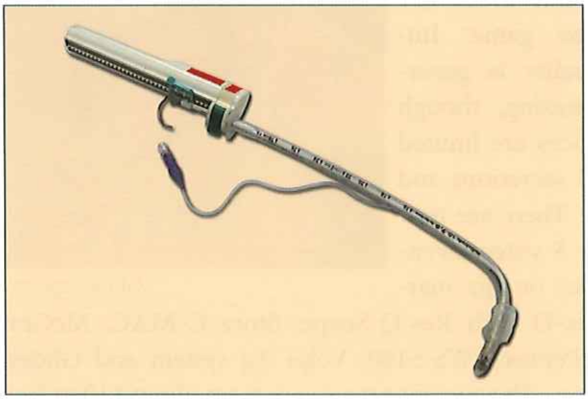
If you have managed enough airways you have undoubtedly encountered a difficult intubation and you have most likely been "scooped" by someone with less experience; I know I have. Everyone brings a different skill set, different experiences and a different perspective to the bedside. On any given day 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

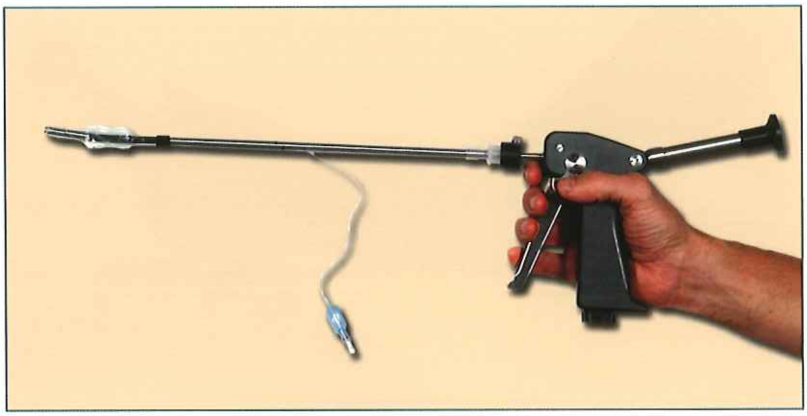
Optical Stylets and Laryngoscopes

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.

EBM

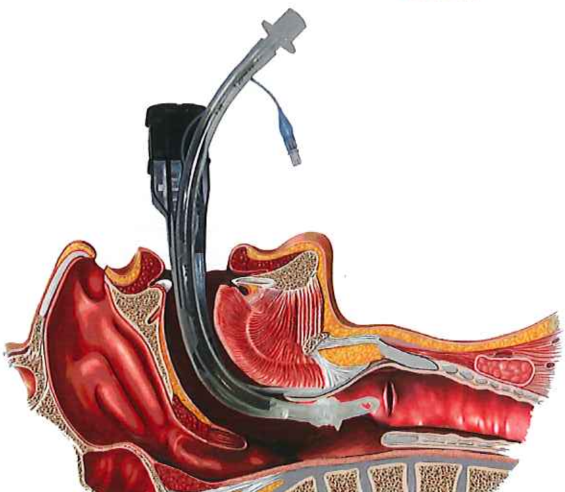
The Airway R.I.F.L. by AI Medical. This is a semi-rigid fiberoptic device with a tube-stop to accommodate any length tube. Squeezing the trigger allows manipulation of the end of the tube in one plane only through a limited range of motion. This may allow the tube to be guided during advancement without 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

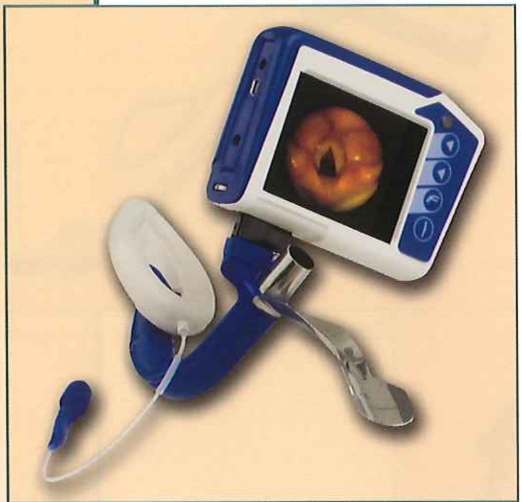
TruView



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.

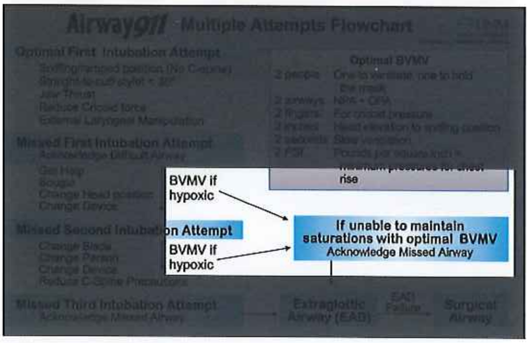
We have limited funds available. Which of these devices do we spend our money on?

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.

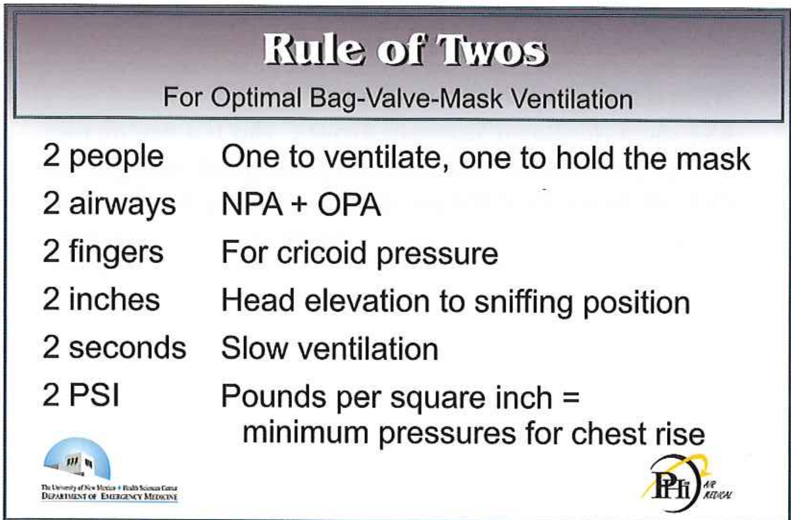
Depending on the setting in which you work you may rarely need to go beyond this point as you can hopefully keep most any patient alive while you await further help. It is important to be sure that whatever device you purchase is either something simple enough that you can pull out in the middle of the 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".



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.

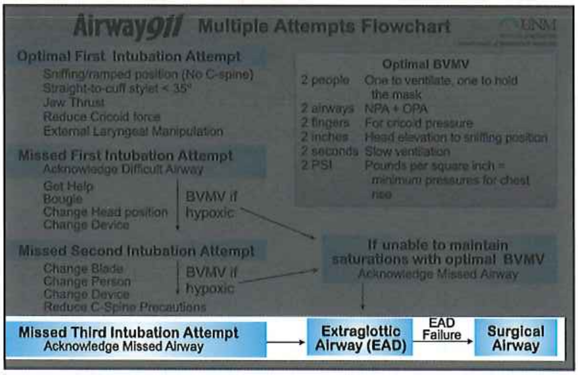
This photo demonstrates rule of twos BVMV. Note one person is holding a tight seal on the mask using the "E-C" grip, one person is squeezing the bag slowly and gently, and a third person is providing cricoid pressure. The head is elevated into the sniffing position since the patient is not in spinal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

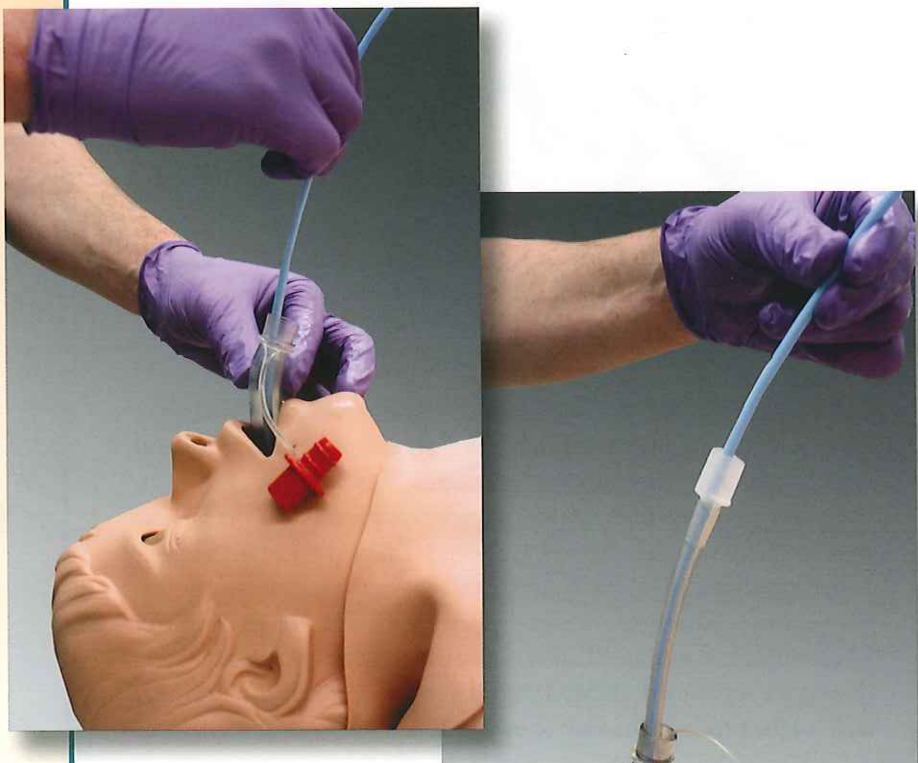
Laryngeal airways are very simple devices that are a cross between a bag-valve mask and an endotracheal tube. Essentially the "mask" is placed directly over the larynx rather than the mouth. The original and best-known laryngeal airways are made by the Laryngeal Mask Airway Company ® and commonly known 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.

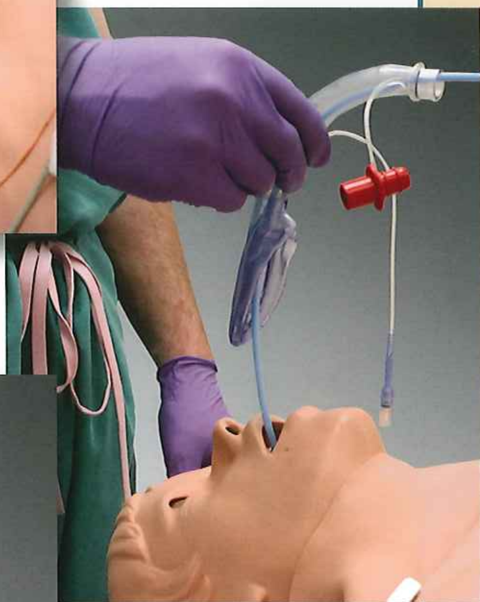
The commonly stated drawbacks to these devices are that they offer less aspiration protection than an endotracheal tube and cannot generate high airway pressures. As it turns out, even the older versions offer greater aspiration protection than most practitioners realize. Newer versions such as the LMA-ProSeal, 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.

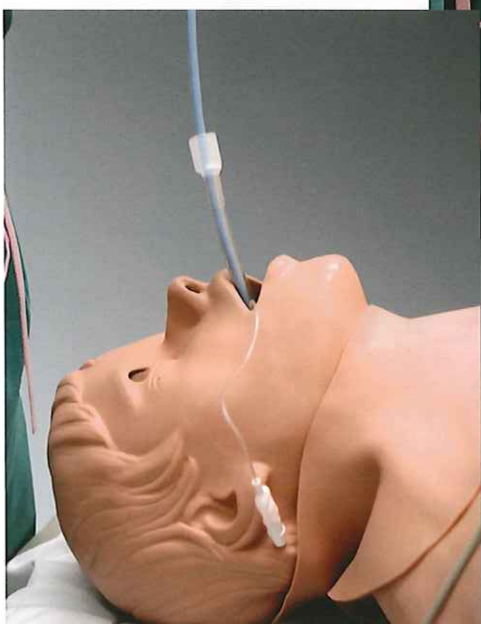
This series of photos demonstrates blind intubation though an EAD, in this case an AirQ, using a bougie. The bougie is inserted gently through the EAD. If tracheal position is confirmed an endotracheal tube may be advanced into the trachea over the bougie and through the EAD.



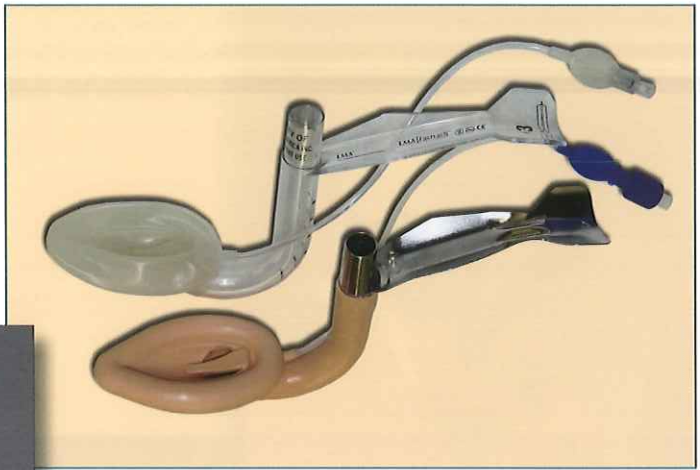
Here the "patient" is ventilated via the endotracheal tube with the EAD still in place. The EAD may be removed electively when the situation has stabilized.



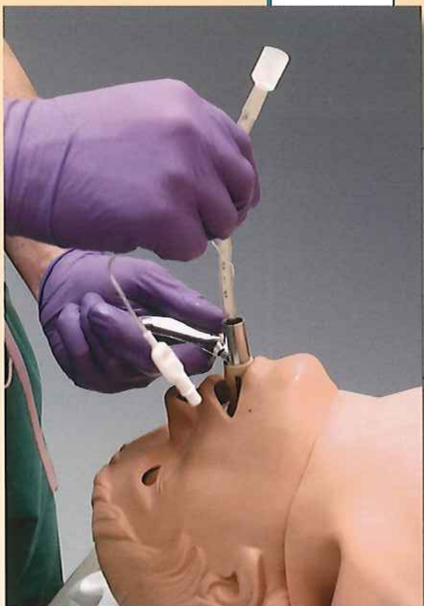
An alternative to placing the endotracheal tube through the laryngeal airway is to first remove the airway over the bougie, once placement of the bougie in the trachea is confirmed.



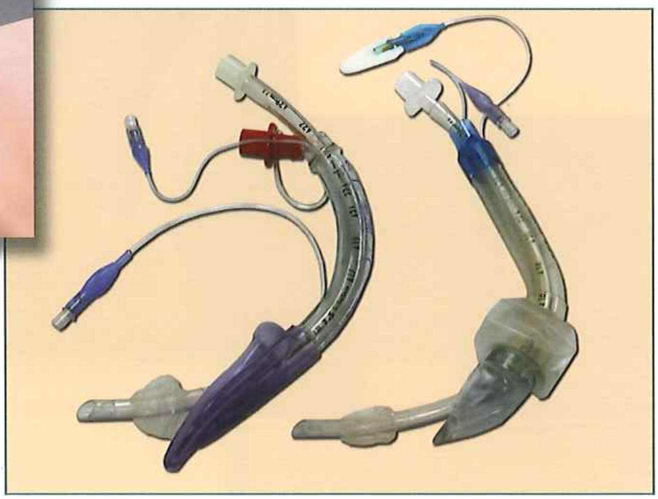
The endotracheal tube is then inserted into the trachea over the bougie.



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



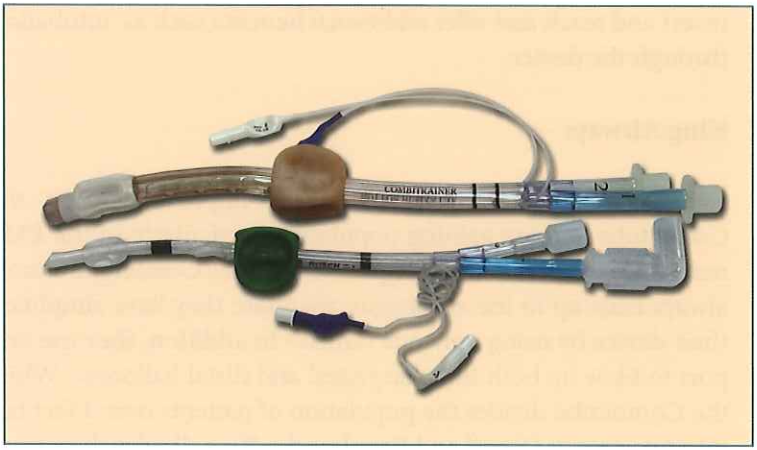
This photo demonstrates blind placement of a well-lubricated endotracheal tube through the LMA-Fastrach. Note that use of a special tube is recommended.



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.

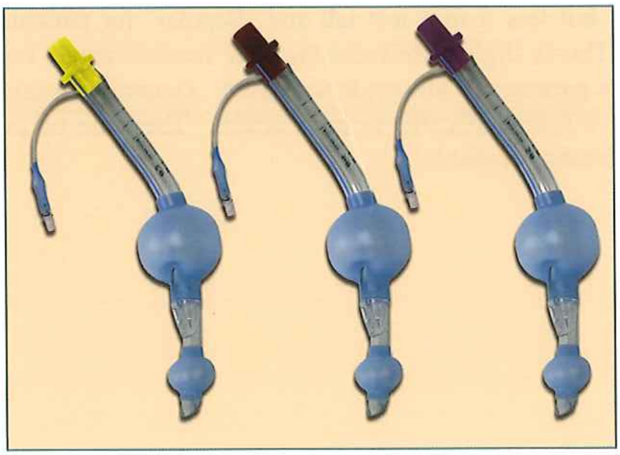
The primary dual-lumen airway on the U.S. market is the Combitube, which comes in two sizes: "Small" for patients over 4 feet but less than 6 feet tall and "Regular" for patients 6 feet tall. This is slightly different than the manufacturers suggested height parameters but evidence-based. Generally speaking 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.

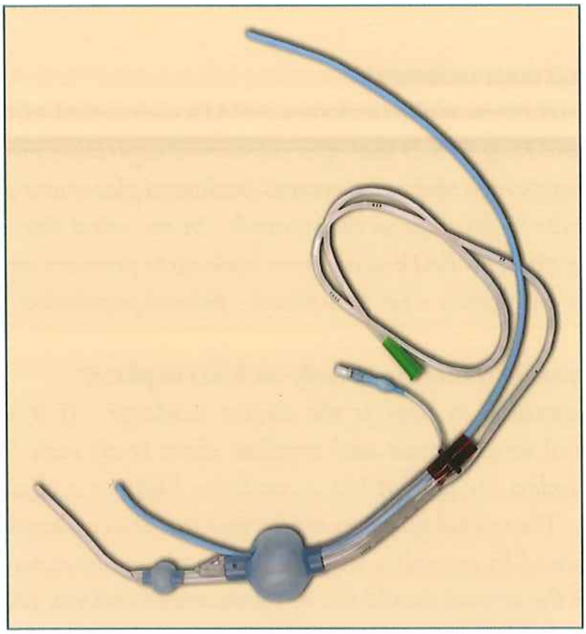
Unfortunately the Combitube is associated with serious potential complications in some studies. While the Combitube has saved many lives over the years I suspect it is on its way out, overshadowed by new generation EADs that are easier to insert and teach and offer additional benefits such as intubation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

Caution

Caution

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.

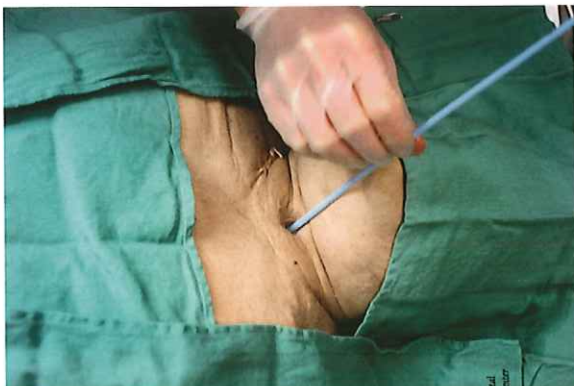
Step 2: Make a midline vertical incision, if necessary, to locate the cricothyroid space between the inferior edge of the thyroid cartilage and the cricoid ring.

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.

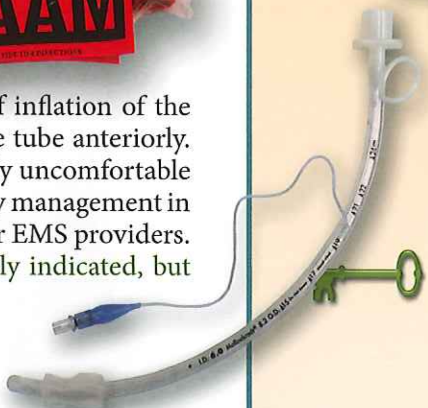
Needle cricothyroidotomy is considered a temporizing means of oxygenation and ventilation only; it is best limited to less than 30 minutes. It is primarily a pediatric technique because surgical cricothyroidotomy is contraindicated in this age group. However, most children can be adequately oxygenated 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.

Caution

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

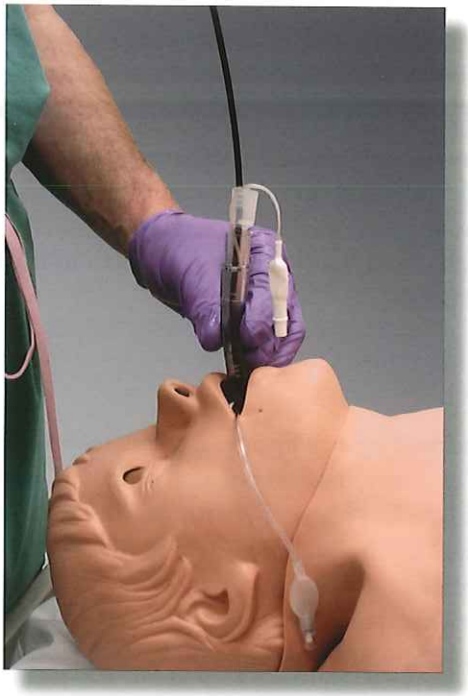
Occasionally, a patient cannot be intubated by direct laryngoscopy but may be intubated in a reverse fashion, usually because of airway obstruction. In this technique, a needle is passed through the cricothyroid membrane directed towards the mouth; a guide-wire is inserted through this needle and retrieved 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

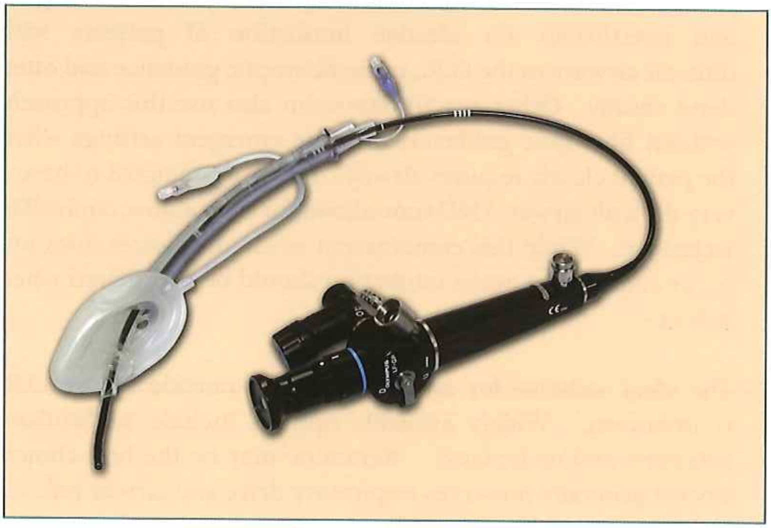
Traditional fiberoptic laryngoscopy with a flexible scope and television monitor is usually restricted to the O.R. setting; the equipment is expensive with a significant learning curve so that it must be practiced regularly to be useful in emergencies. Flexible fiberoptic intubation is most commonly 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)

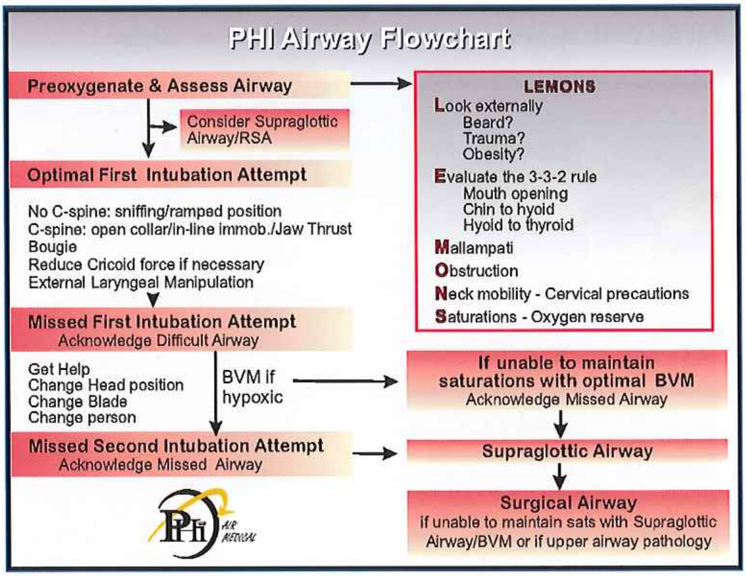
Non-invasive positive pressure ventilation, in the form of CPAP (continuous positive airway pressure) or BiPAP (bi-level positive airway pressure), may be used as an alternative to intubation to maintain oxygenation and support ventilation in some patients. CPAP is primarily useful for hypoxemia where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

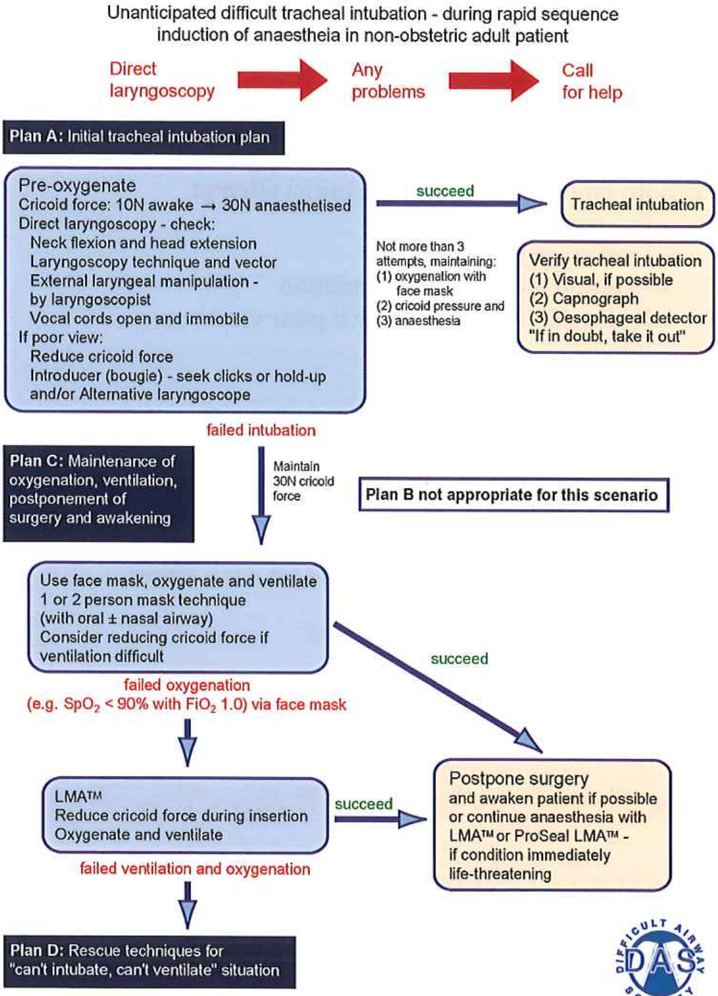
PHI Air Medical



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

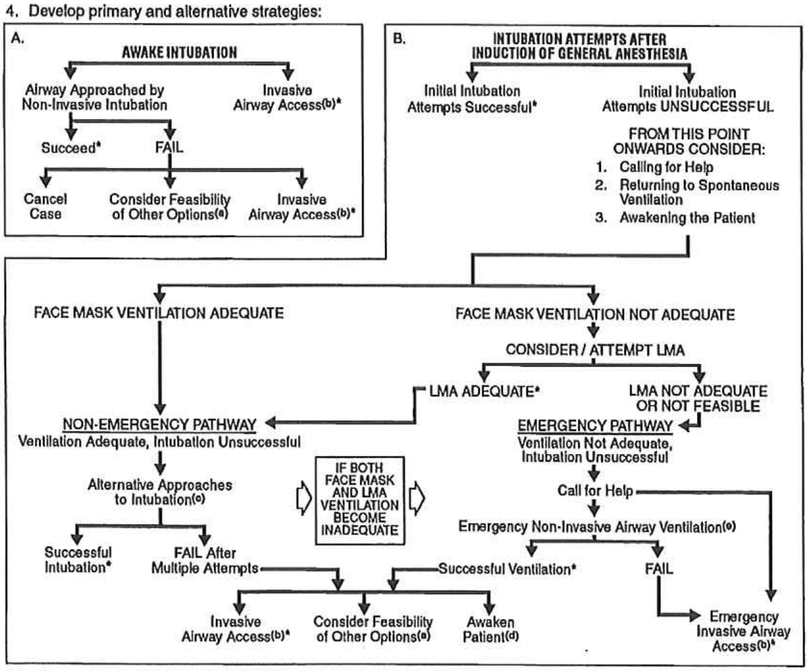
The American Society of Anesthesiologist's (ASA) Difficult Airway Algorithm is widely referenced. It was last updated in 2003. As expected, it is oriented toward the O.R. setting and therefore includes both RSI and induction without paralytics. In the latter case there are options available which may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

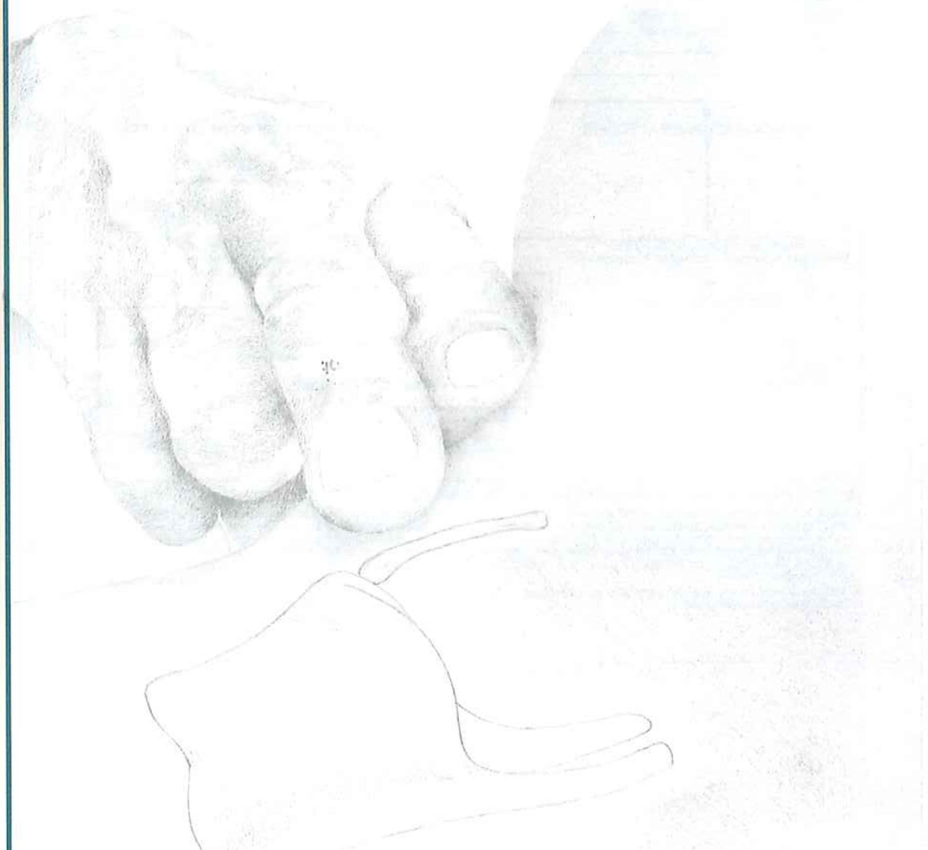
d. Consider re-preparation of the patient for awake intubation or canceling surgery.

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.

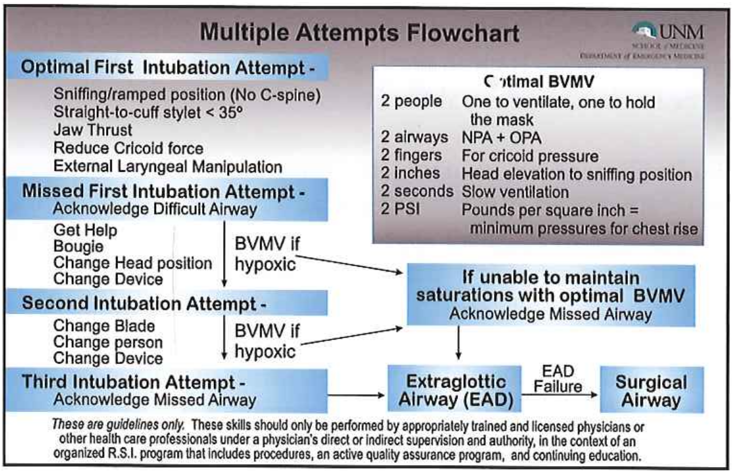
If, on the other hand, BVMV is successful they offer multiple options including fiberoptics, bougie, lighted stylet, intubating LMA, etc. They do not specify a maximum number of attempts nor do they mention positioning, cricoid pressure reduction or ELM. Newer devices such as the King, EasyTube and alternate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

Pediatric Considerations

Chapter 5

Pediatric airways provoke lots of anxiety for those who do not manage them routinely. Fortunately, most children are relatively easy to intubate and BVMV. The same general pharmacology and multiple attempts algorithm also apply to children with only a few minor modifications. There are still plenty of ways to get into trouble if you are not careful. It is important to recognize anatomical and physiological differences between adults and children, the importance of weight-based dosing and the importance of using equipment designed for, and sized for, pediatric patients.

Anatomical and Physiological Differences in Children

- **The larynx is more superior and anterior in the neck**
  - External laryngeal manipulation is particularly useful
  - A bougie may be helpful

- **The trachea is shorter**
  - It is easier to place a tube in the mainstem bronchus
  - It is easy to accidentally extubate

- **The trachea is smaller in diameter and more fragile**
  - Overly aggressive cricoid pressure could occlude the airway

- **The epiglottis is relatively large and floppy**
  - Straight blades may be preferred

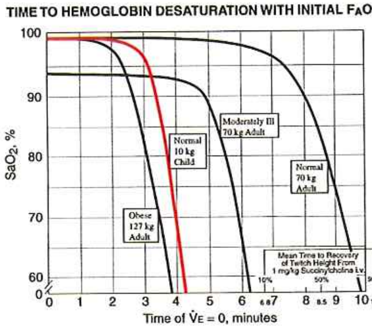
- **The narrowest point in the upper airway is below the vocal cords at the cricoid ring rather than at the cords themselves**
  - Traditionally uncuffed endotracheal tubes have been used in pediatric patients
  - Many clinicians and centers are now moving towards routine use of cuffed tubes in pediatric patients
    - The cuff need not be blown up unless an air leak is detected
    - Consider using 1/2 size smaller tube if cuffed

- **The tongue is relatively large for the size of the mouth**
  - A curved blade may be required to manage the tongue
  - Appropriately sized oral and nasal airways may be very helpful

- **The head and occiput are relatively large**
  - Towel roll placed under the shoulders in an infant will achieve optimal airway positioning rather than sniffing position

Here we see an infant with a shoulder roll to compensate for her large occiput and achieve perfect airway positioning.

- **The functional residual capacity is small and basal metabolism is high**
  - Children may desaturate rapidly despite pre-oxygenation, especially if the indication for intubation was hypoxemia
  - Be prepared to perform optimal BVM ventilation and have the appropriately sized extraglottic airway available



From Benumof J, Dagg R, Benumof R. Critical hemoglobin desaturation will occur before return to an unparalyzed state following 1 mg/kg succinylcholine. Anesthesiology 1997;87(4):979-982 with permission.

- **High resting vagal tone**
  - Hypoxemia, airway stimulation and medications (especially succinylcholine) may all result in bradycardia
  - Atropine should be readily available at the bedside during any pediatric RSI, especially if using succinylcholine

- **Small lungs**
  - Children are more prone to barotrauma from over-aggressive ventilation
    - Use the lowest possible tidal volume to achieve gentle chest rise
    - Watch ventilator pressures closely and use pressure-controlled ventilation when possible
    - When bagging use the "squeeze, release, release" method to allow adequate exhalation time and avoid breath stacking

So I'm confused. Is it straight-blades or curved-blades for children? *Many of us were taught that you must use a straight-blade for children to control the relatively large and floppy epiglottis. If this were always true there would be no reason that we all carry curved-blades in pediatric sizes! It turns out that it is a case-by-case decision depending on whether the obstacle to laryngoscopy is the epiglottis (straight-blade may be better) or a big, floppy tongue (curved-blade is probably better). I usually start with a straight blade but always have an appropriately sized curved blade ready to go.*

What's the deal with all the cuffed ET tubes being used on kids these days?

Even though the narrowest portion of the pediatric airway is below the vocal cords it is not surprising that an uncuffed endotracheal tube may not seal the airway well for optimal ventilation or airway protection. When used, you may need to select a cuffed tube one-half size smaller than the appropriately sized uncuffed tube for that patient. The cuffs are not generally inflated unless an air leak is detected and then only the minimum amount of air necessary to overcome the leak is used; this pressure is then meticulously monitored. It is still appropriate to use an uncuffed tube and most EMS services and general EDs are not stocking cuffed tubes unless specifically requested by the pediatric ICU specialists in their area.

RSI Pharmacology for Children

Visual estimates are notoriously inaccurate. In children it is very important to base dosages upon body weight. If the child's weight is not accurately known the parent's estimate is the next best thing. After that use the length-based Broselow tape or another validated estimation tool. Note that with many medications children require a higher, rather than lower, dose per body weight, i.e. propofol and midazolam.

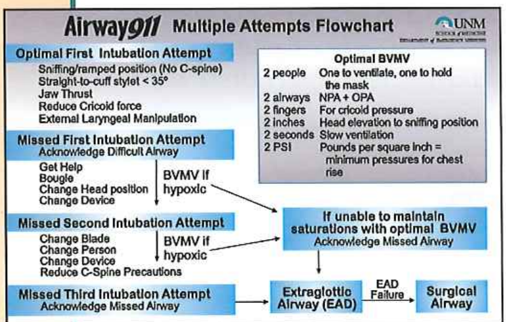
All of the pre-medications, induction agents, paralytics, sedatives and analgesics included in this text are appropriate for children. Some providers consider succinylcholine relatively contraindicated in children due to the propensity for bradycardia and the risk of fatal hyperkalemia in the setting of undiagnosed muscular dystrophies. While a non-depolarizing agent is a modestly better choice for children, millions of children have been intubated uneventfully with succinylcholine. It is highly recommended, however, that atropine be readily available. *Airway911* is no longer recommending routine pretreatment with atropine.

Caution

RSI Technique for Pediatric Patients

Overall, RSI technique for adults and pediatric patients is very similar. Clearly, drug dosages and equipment sizes vary and should be based on known weight or estimated height, using the Broselow Tape or other validated tool.

The Multiple Attempts Algorithm is essentially the same for children with a few caveats. The optimal position for the pediatric airway and intubation varies with the age, from a towel roll behind the shoulders in infants, nothing in toddlers and sniffing position in school-age children. Stylet shape may be better with a bit more of a "hockey-stick" shpape than the less than 35 degree straight-to-cuff shape recommended in adults. A straight-blade is the usual starting point but appropriately sized curved-blades should also be available if tongue control is difficult. Be sure to use ELM to help visualize anterior airways and be gentle with cricoid pressure to avoid occluding the airway. Pediatric bougies are manufactured though not yet used as commonly as in adults. Surgical airways are not performed in patients less than 6 - 8 years of age.



Tube confirmation may be done with end-tidal CO_2 detection at any age but there are specific pediatric products for qualitative capnography. In very small infants these devices may represent enough dead-space to be problematic and are removed after confirmation. Esophageal detector devices are FDA approved down to 20 kg but well studied down to 10 kg using the "off-deflate" method.

Nellcor adult CO_2 detector on the left and pediatric detector on the right.

It is noteworthy that children without unusual congenital malformations are usually easier to intubate than adults and, unlike adults, children can almost always be oxygenated and ventilated with a BVM.

Pediatric Difficult Airways

Causes of difficult airways in children are often the same as in adults but there are several issues that are either specific to children or much more common in children. These include:

- Infections: epiglottitis, retropharyngeal abscess, tracheitis
- Non-Infectious: foreign body, airway edema, congenital defects

The same decision tree for adults may be used for pediatric patients. Whenever possible obtain expert help when dealing with pediatric difficult airways.

Pediatric Back-Up Airways

BVMV is the first back-up as most children can be easily ventilated and oxygenated with this technique. Gastric distention from BVMV is common and may limit ventilation, cause bradycardia through vagal stimulation, and predispose to regurgitation and aspiration. To prevent this, use only enough pressure and tidal volume to cause chest rise and maintain cricoid pressure. Also, be sure to use a 450ml BVM for pediatric patients less than 40 kg or smaller for neonates. When abdominal distension occurs it should be treated with a gastric tube.

Until recently only the LMA-Classic and LMA-Unique were available in pediatric sizes. Extraglottic airways currently available in pediatric sizes include many of the laryngeal airways as well as the King LTS-D airway. Many of the other EADs are being developed for pediatric patients. There is little information available at this time to tell us if any of these devices are clearly superior.

Do you recommend anesthesia bags?

Anesthesia bags (i.e. those floppy thin walled bags found on every anesthesia machine) do not self-inflate. Instead, inflation is controlled by a valve on the end of the bag and the amount of oxygen flow. These bags require some practice to use but allow much better assessment of lung complance and therefore limit the potential for barotrauma. I use them whenever possible in very young infants and neonates.

Pediatric Alternative Airways

Surgical cricothyroidotomies are contraindicated in children; most physicians use a cut-off around 8 years of age. Transtracheal jet insufflation (TTJI) is acceptable, though rarely indicated. For this reason it has been taken out of the prehospital scope of practice for paramedics in many jurisdictions.

Nasal intubation is rarely used in pediatric patients due to the small caliber of endotracheal tube that would be required.

Digital intubation is not possible in all but the largest children and/or by practitioners with very small hands.

Non-invasive positive pressure ventilation is being used much more commonly in pediatrics as in adults. There is generally less experience with this technology in children outside of the PICU setting.

Retrograde intubation can be performed in children though it is very rare.

Awake intubation is a very reasonable pediatric procedure using the techniques described in Chapter 4. This manner of emergency awake intubation is a bit of a misnomer in that the patients are quite sedated and not expected to be cooperative.

Take Home Points

- Children have distinct anatomical and physiological differences with important clinical correlations for airway management.
- RSI medications should be based upon a reliable weight estimate.
- External laryngeal manipulation is particularly useful in children due to their anterior larynx.
- Succinylcholine is relatively contraindicated for children yet commonly used in emergency settings.
  1. Atropine should be available at the bedside.
- Children are more prone to hypoxemia during RSI because of high resting oxygen metabolism.
- Children are usually easier to bag-valve-mask ventilate than adults. This is the primary back-up.
- Gastric insufflation in children may result in profound bradycardia. Use the minimum pressure and volumes necessary and place a gastric tube after intubation to decompress the stomach.
- Back-up airways available in pediatric sizes include the LMA-Unique, LMA-Classic, AmbuLMA, AirQ, CobraPLA and King LT-D. Have at least one available at the bedside.
- Surgical airways are contraindicated under 6 - 8 years of age and TTJI is rarely used.

Case Scenario

Peds Case

A 1-year old ex-28 week premature female with some residual bronchopulmonary dysplasia but no other medical problems is referred to a Pediatric Emergency Department by her primary pediatrician because of difficulty breathing and presumed RSV bronchiolitis. On exam she is sitting up in Mom's arms, lethargic, and in severe respiratory distress with grunting, retractions and accessory muscle use. Lung sounds are diminished but remarkable for scattered wheezes and crackles. Oxygen saturation is 89% on blow-by with a non-rebreather. Her heart rate after rectal Tylenol and a 40 cc/kg fluid bolus is 160. Chest x-ray is consistent with bronchiolitis and a focal infiltrate. The decision is made to intubate. What is your assessment and plan?

PREOXYGENATE: the patient is unlikely to tolerate any assisted respirations unless extremely lethargic. Blow-by in the position of comfort, likely held by parent, is probably the best available option.

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: This represents an unfortunately routine intubation for a busy pediatric referral center. On LEMONS assessment the major difficulty will be the oxygen saturation. Given that even healthy pediatric patients have less oxygen reserve it can be anticipated that the patient will desaturate quickly after induction and paralysis. Fortunately she is also likely to tolerate the hypoxemia relatively well for a brief period. The intubation will probably be relatively easy and she most likely can be oxygenated very well with BVMV or an EAD. I would consult with the PICU and the patient's parents before RSI.

PREPARE EQUIPMENT AND PEOPLE: I would have at least two sizes of cuffed endotracheal tubes available. I would also have a pediatric bougie and two sizes of EAD available though they probably do not need to be taken out of the package. I would have both straight and curved laryngoscope blades available. Assistants prepared to monitor saturations, assist with cricoid pressure/ELM, assist with the bougie and hold the tube will be very important so the intubator can stay focused on the airway.

PREMEDICATE: I would not premedicate this patient though I would have atropine available.

POSITION THE PATIENT OPTIMALLY: The patient should probably stay in the position of comfort until induced unless she is lethargic enough to tolerate assisted respirations. BVMV and intubation should start with a towel roll behind the shoulders.

PARALYZE AND INDUCE: Any induction agent would be fine for this patient including etomidate, ketamine and midazolam. Paralysis with rocuronium would be slightly preferable to succinylcholine to avoid additional risk of bradycardia and the extremely rare chance of undiagnosed muscular diseases. Succinylcholine is perfectly acceptable however. Whichever agents are selected I would have atropine available at the bedside though I would not pretreat.

PASS THE TUBE: Optimal first attempt would include age-appropriate positioning, selection of a straight-blade and appropriate management of cricoid pressure and use of ELM. If the initial attempt were missed, most likely because time runs out due to hypoxemia, the patient would be oxygenated with BVMV while preparations made for a second attempt. If the problem was tongue control I would switch to a curved blade. If the problem was an anterior airway despite ELM I would try the bougie. If the problem were none of the above I would probably switch intubators if someone else were available and/or try repositioning the patient.

POST-INTUBATION MANAGEMENT: The tube will be confirmed with end-tidal CO_2 and secured with a commercial pediatric tube holder or tape. A cervical collar or towel rolls can be considered to minimize head movement. The patient will be placed on the ventilator with continuous end-tidal CO_2 monitoring to monitor for tube displacement. Sedation and analgesia with midazolam and fentanyl is appropriate.

The 10 P's of Rapid Sequence Intubation

Chapter 6

Now that we have explored so many aspects of airway management in detail, let's go back and expand on these ten critical steps first introduced in Chapter 2. Recall that the "P's" are a useful clinical and teaching mnemonic to recall the critical steps of RSI. Other sources may break RSI down into only 5 or 7 steps.

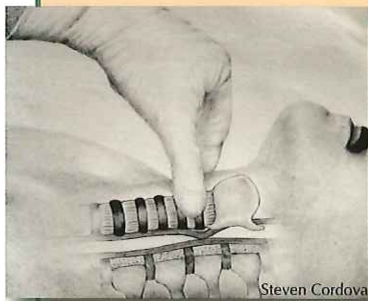
1. Pre-oxygenate

- Tight-fitting non-rebreather mask at 10 – 15 liters/ minute.
    - Requires at least 3 minutes.
- No positive pressure unless patient is hypoxic.
- Ideally with at least 20 degrees of head elevation.
- CPAP/BiPAP or assisted ventilations may be used in the hypoxic patient.
- Patients then categorized as having "adequate", "limited" or "no" reserve.

2. Protect the C-spine

- Whenever the mechanism of injury suggests a possible cervical spine injury maintain cervical spine immobilization during the entirety of the intubation process.
- You MUST remove the front of the cervical collar so that the mandible can be displaced anteriorly to allow visualization of the vocal cords.
- Have an assistant provide in-line stabilization and a jaw thrust.
- Consider gentle relaxation of cervical precautions if absolutely necessary to facilitate intubation.

3. Pressure to the Cricoid

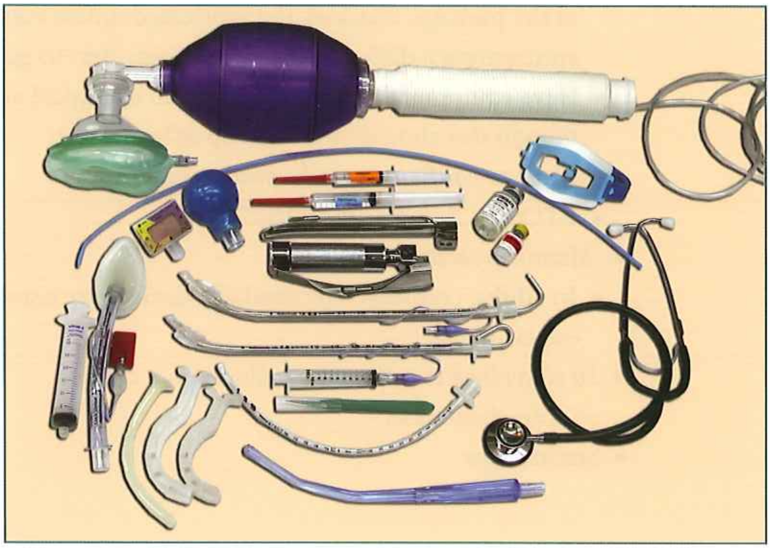


- Applied from time RSI meds given until tube confirmed in trachea.
- Applied during any BVMV.
- Avoid over-compressing the larynx and obstructing the airway.
- Pressure should be reduced/released in the event of difficult laryngoscopy.

4. Ponder

- Equivalent to the JCAHO "time-out".
- Assess LEMONS.
- Is RSI is really the best option for this patient?
- How much reserve does this patient have?
- Is this likely to be a difficult intubation?
- What is your back-up plan in case of a difficult or missed intubation?

5. Prepare Equipment and People



- ***Equipment***
  - ***Medications*** to perform the procedure AND maintain sedation, analgesia and paralysis after the procedure should all be drawn up, labeled and ready to go.
    - Labeling is critical to avoid drug errors in hectic environments.
    - Paralysis after RSI is maintained on a case-by-case basis and best avoided whenever possible.
  - ***Nasal and Oral Pharyngeal Airways*** appropriately sized for the patient.
  - ***Laryngoscope*** checked, with choice of blades.
  - ***Self-inflating bag/mask*** sized for patient with reservoir & oxygen connected.
  - ***Suction***
  - ***Endotracheal tubes***
    - At least one size smaller in adults and one size smaller and larger in pediatrics readily available.
    - The recommended starting shape in adults is "straight-to-cuff" then bent < 35 degrees.
  - ***Gum-elastic bougie/Endotracheal Tube Introducer.***
  - ***Back-up extraglottic airway device.***
    - The device does not necessarily need to be taken out of the package, checked and lubricated unless you are anticipating a difficult airway or things start to go awry.
    - Have equipment available to perform a surgical airway, though this should be a back-up of last resort.
  - ***Means to confirm the tube placement .***
    - $ETCO_2$ is first-line in RSI/RSA.
  - ***Means to secure the tube.***
    - In adults, commercially available devices are usually the easiest to use.
  - ***10 cc syringe*** to inflate the balloon on a cuffed endotracheal tube.
  - ***Stethoscope***

- ***People*** should be assigned appropriate tasks before the procedure begins.
  - Administer medications.
  - Watch the oxygen saturation and report any drop.
  - Maintain in-line cervical immobilization and jaw-thrust.
  - Maintain cricoid pressure/assist with ELM with one hand and hold the tube and corner of the mouth with the other.
    - The intubator should never take their eyes off the vocal cords.

6. Pre-Medicate

- The first medications given should ideally help reduce the patient's adverse physiologic responses to the subsequent medications and laryngoscopy.
- No premedication should be considered mandatory or standard-of-care.
- All premedications require at least 3 minutes to work before laryngoscopy.
- Consider fentanyl 3 micrograms/kg for patients with critically high ICP.
- Consider lidocaine 1.5 mg/kg for unstable asthmatics.

7. Position the Patient Optimally

- The optimal head position in older children and adults is the sniffing position - head flexion with neck extension.
  - The goal is to put the ear canal and sternal notch at the same level.
  - In infants airway position may be optimized with a towel roll behind the shoulders and in small children no padding at all.
- In some cases additional or hyper-elevation of the head may be beneficial and in the morbidly obese the "ramped position" is preferred.
- These positions are contraindicated in the patient with potential cervical spine injury.

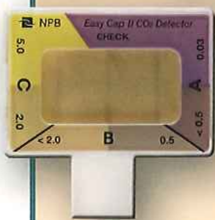
8. Paralyze and Induce

- The induction agent renders the patient unconscious and unresponsive.
  - Options: etomidate, midazolam, ketamine, propofol, thiopental.
- The paralytic eliminates muscle tone to optimize laryngoscopy and prevent vomiting.
  - Options: rocuronium, succinylcholine.

9. Pass the Tube

- You must wait until the patient is fully paralyzed or risk vomiting and aspiration.
  - 60 seconds from administration of rocuronium 1 mg/kg.
  - 45 seconds from administration of succinylcholine 2 mg/kg.

10. Post-Intubation Management: Confirm, Secure, Sedate, Ventilate



- Tube placement should be confirmed objectively, ideally with end-tidal CO_2.
- As soon as the tube is confirmed in the trachea cricoid pressure may be released.
- The tube should be secured with tape or a commercial device.
- The patient should receive sedation and analgesia as soon as possible.
- Patient should be placed on a ventilator in almost all circumstances.
- Ongoing paralysis is an option at this time.

This is a nice learning tool but you don't really expect me to go through all this at the bedside during a real intubation, do you?
Until recently I thought this was just a learning tool as well. Then one day I was doing a flight shift with our helicopter program and watched our pilot, who has probably done hundreds if not thousands of take-offs in this very same aircraft, get out his checklist and go through each and every step. At that moment it occurred to me that RSI is far riskier than a routine take-off, and we do them far less often, yet we are prepared to "wing it". With the stakes this high why would we not go through a checklist too?

Case Scenario

Difficult intubation
The hypotensive & hypoxic patient

A patient arrives in the ED with fever, hypoxemia and altered mental status. The patient is brought to the resuscitation area where she is noted to be cyanotic, awake but lethargic and in severe respiratory distress. Her pulse is 140, her blood pressure is 90/60, her respirations are 40 and shallow, her temperature is 38.5 and her oxygen saturation on room air is 66%. After placement on a non-rebreather her sat improves to 77%. Her lung exam reveals bilateral crackles without wheezing and there is no evidence of CHF. What is your assessment and plan?

LEMONS: Most likely the patient has pneumonia and has become septic. Based on the LEMONS mnemonic we know that the "S" for saturations indicates a difficult intubation regardless of any anatomic impairment. She falls into the category of "no-reserve". Given this and her hyperdynamic state we can anticipate that the patient will desaturate very quickly and will clearly require positive-pressure ventilation.

PREOXYGENATE: My first goal would be to improve pre-oxygenation with a combination of positioning (at least 20 degrees of head elevation) and BVM assist with PEEP valve or CPAP/BiPAP if tolerated.

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: It is possible that the patient might respond to non-invasive ventilation well enough to avert the need for intubation but I would be simultaneously preparing for RSI. My plan for the RSI would be to keep the patient in her position of comfort until the last possible moment. I would have everything prepared to place her in a sniffing position after medication. I would be planning on immediate positive pressure ventilation with either BVMV or an EAD after medications. There does not appear to be any other viable alternatives.

PREPARE EQUIPMENT AND PEOPLE: I would call for help if available. All assignments, including who will assist with the BVM and who will perform cricoid pressure/ELM, will be made in advance. All equipment will be prepared for intubation including post-intubation sedation and analgesia before any RSI medications are given. An EAD that generates high-pressures will be sized, taken out of the package, and prepared for insertion. Two sizes of endotracheal tube with straight-to-cuff stylet shape, both straight and curved blades and a bougie will be at the bedside. It would also be prudent to have supplies available for a surgical airway.

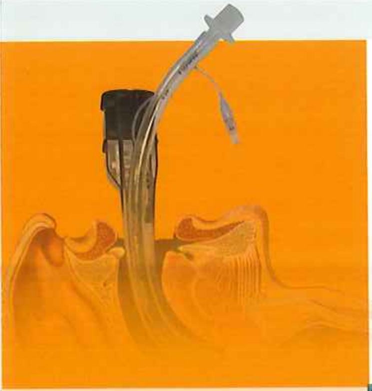
PREMEDICATE: Not indicated.

POSITION THE PATIENT OPTIMALLY: This patient should be in a perfect sniffing position for the procedure.

PARALYZE AND INDUCE: I would induce with etomidate or ketamine and paralyze with succinylcholine or rocuronium.

PASS THE TUBE: Gentle "rule-of-twos" BVMV will be performed as the medications are administered. If the saturations are not markedly improving by the time the paralytic has taken effect (45 seconds for succinylcholine and 60 seconds for rocuronium) an EAD will be placed and positive pressure ventilation continued. In almost all cases the saturations will improve with this technique. Once the saturations have reached a plateau, hopefully in the 90s, an optimal attempt at laryngoscopy will be made. If the saturations start to fall rapidly the EAD will be replaced and the patient re-oxygenated until a plateau is again reached before further attempts at laryngoscopy. If long delays are encountered the patient may be given additional analgesia, sedation and paralysis during the procedure.

POST-INTUBATION MANAGEMENT: Once the patient is intubated the tube will be secured in place and the patient placed on continuous capnography. Sedation and analgesia will be provided based on the patient's blood pressure. Ketamine would be an excellent choice if available and the patient remains hypotensive. A chest x-ray will be obtained to confirm appropriate tube depth only. If etomidate were used for induction I would notify the ICU team so they can monitor for adrenal suppression.



Rapid Sequence Airway

Chapter 7

What is RSA?

RSA is a new approach to emergency airway management being introduced in some EMS and air medical services. RSA involves all the same preparatory steps and pharmacology as RSI but the express goal is insertion of an extraglottic airway device rather than intubation. The fundamental concepts behind RSA are:

1. The greater than realized aspiration protection afforded by some EADs.

2. The potential for significant hypoxemia, transport delays and airway trauma during out-of-hospital RSI.

History and Development

Over a five year period beginning in 2000, we instituted the aggressive use of back-up airways, specifically the Combitube and LMA-Unique, to limit the number of airway attempts, shorten scene times, minimize the use of surgical airways, prevent critical hypoxemia and improve patient outcomes. Our crews and the receiving hospitals became very comfortable with these devices and their use increased. Initially they were recommended only for use after all reasonable attempts at intubation had failed and before a surgical airway was performed. Then we began limiting attempts to three, the "three strikes and you're out" rule. Eventually we began using back-up devices after only one or two attempts at intubation had failed. There were even a few cases where the crews planned to do RSI, but the oxygen saturation dropped precipitously and they appropriately elected to go straight to a back-up airway. That coincided with a renewed focus on prehospital scene times.

It occurred to us that these devices were working so well that we could theoretically give the induction agent and paralytic and immediately place a back-up airway, rather than waiting for a missed airway situation. We elected to call this Rapid Sequence Airway.

We currently use this approach in very selected cases, usually scene responses with short flight times to the trauma center or airways managed in the aircraft while enroute. The majority of our advanced airways are still traditional RSI though we continue to move to back-up devices very early. In the last three years, approximately 10% of advanced airways managed by our flight teams utilized RSA and the remainder were RSI. However, in an additional 10% or so of these cases where the team planned RSI, they ended up appropriately placing a back-up airway without any prior attempt at laryngoscopy, due to falling oxygen saturations that could not be rescued with BVMV. We do not call such cases RSA because the original intent was to intubate the patient.

While it is clear that an endotracheal tube provides the optimal degree of airway protection, EADs provide much more aspiration protection than most people realize. Ideally an EAD that provides maximal airway protection would be used. Currently available products that appear to offer superior airway protection include the Combitube, EasyTube, LMA-Supreme, LMA-ProSeal and King LTS-D.

Case Report

At 1809 two of our helicopters were dispatched to the remote scene of a motor vehicle collision involving a tractor-trailer and an SUV. The first crew, composed of two flight nurses, was asked to care for a 42 year old male who was an unrestrained passenger in the back of the SUV and was being extricated. The patient was noted to be alert and oriented complaining of head and abdominal pain. After a prolonged extrication, a rapid secondary survey was performed and an IV established prior to loading the immobilized patient into our Eurocopter AS350 B3 aircraft for a 23 minute flight to the nearest trauma center.

Care enroute included maintaining spinal precautions, oxygen administration at 15 liters/minute by non-rebreather mask and infusion of normal saline. During flight the patient was noted to become increasingly somnolent. With 18 minutes remaining in the flight, the crew determined that the patient required an airway intervention, as he was no longer able to protect his airway and would soon be unable to adequately ventilate.

The crew prepared for a difficult airway due to spinal precautions, darkness, turbulence and tight working conditions. The patient was pre-oxygenated then given etomidate followed immediately by rocuronium. The front of the cervical collar was removed and the second crewmember applied cricoid pressure with one hand and maintained cervical stabilization with the other hand. Utilizing options allowed in our treatment guidelines, the crew elected to place an LMA without any prior attempt at intubation. A #4 LMA-Unique was placed rapidly without complication and confirmed with end-tidal CO2 detection and good chest rise. The cervical collar was replaced and the patient was given 50 micrograms of fentanyl for analgesia; sedation with midazolam was withheld as blood pressure could not be determined.

They arrived at the hospital and the patient was taken to the trauma room where he was noted to have an oxygen saturation of 98% and was being ventilated without difficulty; there was no evidence of aspiration. The trauma team elected to leave the LMA in place for emergency CT scanning.

Indications and Contraindications

Indication – Same as RSI

1. Impending or actual respiratory failure
2. Impending or actual inability to protect airway (typically GCS < 9)
3. Inability to maintain saturation > 90% with supplemental 02/BVM/CPAP
4. Combative secondary to head injury

Contraindications

ABSOLUTE

1. Patient already unconscious and flaccid – i.e. cardiac arrest
2. Upper airway pathology – known or suspected
   a. Blunt or penetrating anterior neck trauma
   b. Inhalation injury
   c. Angiodema
   d. Anaphylaxis
   e. Tumor
   f. Infection – croup, epiglottitis, parapharyngeal abscess
   g. Caustic ingestion

Note that an EAD may still be considered as a rescue airway in these clinical situations in the event of a missed RSI – though a surgical airway may be better - but should not be used by original intent, because there is the possibility that the process will progress to the point that the airway is occluded and the patient cannot be ventilated from above.

RELATIVE

1. Patient may be managed by BNTI or oral intubation without medications
2. Anticipated difficult placement of EAD
3. Anticipated inability to BVMV in the event of failed EAD insertion
4. Anticipated need for very high airway pressures
5. Very high aspiration risk
6. Short ETA to hospital or arrival of flight team

Sample RSA Protocol from Espanola Valley EMS

Procedure

1. *Preoxygenate* with 100% oxygen
   a. Manual ventilation only if patient unable to maintain saturations
      - Use optimal "Rule-of-twos" technique
   b. Consider CPAP

2. *Place continuous saturation monitors*

3. *Protect c-spine* if indicated

4. *Pressure to cricoid*
   a. During any positive pressure ventilation
   b. From time first RSA meds administered until LMA confirmation

5. *Ponder* situation and options
   a. If crash airway (code or near code) proceed directly to LMA placement or intubation without medications
   b. Consider ETA to hospital or arrival of flight crew
   c. Consider contraindications

6. *Prepare*
   a. LMA-Supreme w/ gastric tube, suction, $ETCO_2$, BVM
   b. Back-up equipment: King, intubation and cricothyrotomy supplies
   c. All medications including post-airway sedation and analgesia
   d. Assistant(s) to maintain cricoid pressure and in-line immobilization

7. *Position patient optimally*

8. *Paralyze and induce*
    a. Etomidate 0.4 mg/kg IVP
    b. Rocuronium 1 mg/kg IVP

9. *Pass airway*
    a. Wait 60 seconds after rocuronium administration
    b. In the event of failed LMA-Supreme insertion/ventilation
        - Oxygenate with BVM if saturations < 90% or falling
        - Place larger/smaller LMA-Supreme if patient on border of sizing
        - Place King if LMA-Supreme failure
        - If able to maintain oxygenation with any of above TRANSPORT
        - If unable to maintain oxygenation with any of above:
            - Single attempt at oral intubation (ETI)
                - Assumes LMA, King and BVM failure
            - Surgical cricothyrotomy
                - Assumes LMA, King, BVM and ETI failure

10. *Post-airway management*
    a. Confirm placement including end-tidal CO_2
        a. Place patient on continuous $ETCO_2$
    b. Continue cervical precautions if indicated
    c. Place gastric tube through port and decompress stomach
    d. Place patient on transport ventilator
    e. Secure airway device
    f. Provide on-going sedation, on-going analgesia and paralysis if indicated
        a. Rocuronium 0.5 mg/kg every 30 minutes as needed
        b. Midazolam 1 – 5 mg every 10 minutes as needed if SBP >100
        c. Fentanyl 25 – 100 micrograms IV q 10 minutes as needed

Note: This is a representative protocol only. The King LTS-D or other EAD with good seal and a port for a gastric tube could substitute for the LMA-Supreme. Likewise drug choices and dosages could vary.

Case Scenario

In-flight airway management/RSA

A flight team is transporting an otherwise healthy 40-year old male who rolled an ATV without a helmet from the scene to a trauma center, 20 minutes away. He was confused for first responders but had improved when the flight team arrived, complaining only of nausea and neck pain. He is in c-spine precautions, has two large-bore IVs running normal saline and is on a non-rebreather at 10 liters/min. Half way to the receiving hospital he has a generalized seizure and his pupils are now unequal. His GCS following the seizure is 5, he has snoring respirations and his saturation is still 100%. Blood pressure and heart rate are mildly elevated. What is your assessment and plan?

LEMONS: It appears that the major potential difficulty is cervical precautions.

PREOXYGENATE: Already on a non-rebreather at 10 liters/min. He should have already achieved maximal "nitrogen washout".

PROTECT C-SPINE: Indicated.

PRESSURE TO CRICOID: Only once medications administered.

PONDER: This patient meets criteria for airway intervention to "protect his airway" but his saturations are fine, flight time is only 10 minutes and intubation is complicated by the confined space of the aircraft and c-spine precautions. Most likely the patient has a head injury with elevated intracranial pressure. It will be critical to avoid hypoxemia, hypotension, abnormal CO2s and any additional elevation of his ICP. Options include positioning the patient on his side to allow secretions to drain, nasal intubation, RSI and RSA.

Given the concerns for elevated ICP, nasal intubation is relatively contraindicated. Given that RSI is never as rapid as the name suggests, I would discourage in-flight RSI with such a short transport time. If any difficulties are encountered it would be hard to justify, especially when done only for theoretical protection of the airway. You would not want to be messing with the airway on the helipad when there is a full trauma team waiting inside for the patient. Either watchful waiting with BVM assist as needed or RSA are appropriate. Let's assume RSA is selected.

PREPARE EQUIPMENT AND PEOPLE: Prepare the appropriate size EAD, hopefully one that permits passage of a gastric tube, which should be lubricated and ready. Cricoid pressure is still indicated though ELM is not necessary with RSA. It is still prudent to remove the front of the collar and have someone maintain in-line immobilization. A jaw thrust is not necessary with RSA.

PREMEDICATE: I would forego any premedications due to the limited time available and because the EADs are generally less noxious than intubation and therefore less likely to elevate ICP.

POSITION THE PATIENT OPTIMALLY: Limited by cervical precautions.

PARALYZE AND INDUCE: Etomidate 0.4 mg/kg is a likely choice for induction. Because this is a head trauma patient who also has the potential for multisystem trauma, I would avoid propofol and induction doses of midazolam if possible. Rocuronium or succinylcholine are both appropriate for paralysis. Given the need to monitor for additional seizures and mental status changes and the short time before evaluation by the trauma team a case could be made that succinylcholine is a marginally better choice than rocuronium.

PASS THE TUBE: Maintaining in-line immobilization. Jaw thrust and ELM are not necessary with RSA.

POST-INTUBATION MANAGEMENT: The patient will be placed on the ventilator with continuous capnography. The stomach will be decompressed with a gastric tube passed through the EAD if using a King LTS-D or LMA-Supreme. The device may be secured in place if time permits or it may be closely monitored and repositioned as necessary. Fentanyl and midazolam would be administered for sedation and analgesia at doses dependent on patient size and blood pressure. The patient should be ready for off-loading upon arrival to the trauma center in 10 minutes.

Legal Stuff and Quality Assurance

Chapter 8

Prehospital RSI – the Bad News

The benefits of advanced prehospital airway management are unclear. Whereas endotracheal intubation has become a fundamental part of prehospital care in many locations, there is very little evidence that it is superior to basic airway management such as positioning, suctioning, oral and nasopharyngeal airways, oxygen administration and bag-valve-mask ventilation. In a landmark study by Gauche and colleagues pediatric patients in Los Angeles were randomized to endotracheal intubation or basic airway management. Outcomes were equivalent. While this study was performed in a setting with short transport times that did not permit RSI, it has certainly contributed substantially to the controversy.

With the advent of prehospital RSI it was presumed that outcomes for critical patients would improve. This has not consistently been the case. In fact, the majority of studies have demonstrated equivalent or worse outcomes, particularly for severely head-injured patients, the very group believed to be most likely to benefit. Hypotheses to explain this discrepancy have included inadequate education, delayed transport, hypoxemia, increased aspiration and over-ventilation with decreased $PaCO_2$ with subsequent impaired cerebral blood-flow. Some experts have called for a moratorium on prehospital RSI programs though this has not been widely embraced.

The ultimate role for prehospital RSI has not yet been elucidated. While RSA may offer a solution to many of these concerns, RSI will remain a part of prehospital care in selected regions, particularly for critical care transport services. However, there must be greater attention to:

1. *Selecting patients that are most likely to benefit and least likely to be harmed.*

2. *Basic principles – particularly preoxygenation and limiting intubation attempts.*

3. *Appropriate technology from bougies to video laryngsocopy.*

4. *Routine use of checklists.*

5. *Earlier and more aggressive use of back-up devices.*

6. *Human patient simulation for education.*

7. *Quality assurance and medical oversight.*

8. *Redefining success as a good patient outcome without complications rather than a tube in the trachea 100% of the time.*

Legal Issues

Although still very infrequent, there is increasing litigation related to airway management, likely due to some combination of the following factors:

- RSI/RSA is a high-profile procedure wherever it is done.
- High-risk patients: By definition, any patient undergoing emergent RSI/RSA is very sick and at high-risk for poor outcome, which may be completely unrelated to the airway management. Family and lawyers may not recognize the difference.
- RSI is a technically difficult procedure.
- RSI/RSA is generally not done frequently outside of the O.R. so it is difficult to maintain competency.
- There are lots of potential complications, even in the best of hands.
- For prehospital patients there is justifiable controversy over its use, as discussed on the previous page.

The best offense is a good defense. The first question that will always arise after a bad airway outcome is "Why did the patient need to undergo this risky procedure?" The more emergent the indication the easier it is to defend a bad outcome. For example, take the patient described in the blue box on page 7. This patient's chance of survival is extremely low, but their ONLY chance is a secure airway. If you attempted intubation and had difficulty and there were a bad outcome, it would not be hard to defend the decision to intubate, even in hindsight. On the contrary, take the patient described on the vignette on page 159. His saturation is fine, he is not vomiting, he is not combative and he is 10 minutes from a Trauma Center. In this case intubation would be performed primarily for airway protection, a theoretical problem. If this patient were to suffer harm from an RSI gone bad, it would be much more difficult to justify why the procedure was performed. In this case it is much more important to carefully assess the risks and benefits.

Of course it is also critical that you do the procedure correctly:

- *Be as prepared as the situation allows.*
- *Be as calm and meticulous as the situation allows.*
- *Consider risks, benefits and alternatives.*
- *Use a checklist if time permits.*
- *Always confirm your tube objectively.*
- *Use the Multiple Attempts Algorithm.*
- *Move quickly to an EAD in the event of a missed RSI.*
- *Document carefully and accurately.*

Documentation

It is hard to say enough about the importance of documentation for critical procedures such as advanced airway management. Whenever possible documentation of risk-benefit analysis, plan and consent should occur BEFORE the procedure.

- Who performed the procedure.
- What was performed (i.e. RSI, RSA, etc.).
- When was it performed.
- Where was it performed:
  - Physical location (ED, radiology, street, back of the ambulance, etc.).
  - Anatomic location.
- Why was it performed:
  - Be as specific about the indications as possible.
  - Do not assume the indication is obvious.
- How was it performed:
  - Include pertinent details: cricoid pressure, pre-oxygenation, use of ELM, tube size, number of attempts, means of tube confirmation, etc.
  - Include any abnormalities seen at laryngoscopy: swelling, vomit, soot, etc.
- Response

- Complications: hypoxia, aspiration, trauma, etc.
    - If none, note this specifically.
    - Never attempt to hide complications – this will come back to haunt you.
- Consent: implied, verbal, written.
    - Discuss with family BEFORE the procedure whenever possible.

Sample Documentation 1: Burn Patient

RSI for airway protection 2º potential deterioration 2º edema. Pre-ox 100% O_2. Risk/benefits/alternatives explained to Pt. (+) verbal consent. Meds as charted. 8.0 ETT on 2nd attempt by DB. Good visualization. No airway burns/edema noted. +$ETCO_2$, =BS, Sat > 95%. No complications.

Sample 2: Head Injury

RSI 2º decreasing LOC. Preox 100% O_2. Meds as above. 7.5 ETT by DB 1st attempt. (+) visualization. (+)$ETCO_2$. =BS. Sat > 90%. No complications.

Sample 3: Difficult Medical Airway (Air Medical)

45 female RSI for airway protection, oxygenation and to facilitate transport due to decreased GCS, combativeness and hypoxemia. Family not available for consent. Discussed with sending physician. Preox w/ 100% O_2. Cricoid pressure. Etomidate 30 + Roc 100. Attempt x 1 with ELM failed. Sat to 80%. BVM to 88%. Combitube unsuccessful x 1. Sat to 80%. BVM to 88%. LMA #5 placed successfully but unable to move chest 2º obesity. Sat to 79%. BVM to 87%. Blind ETI #7.5 successful on next attempt with bougie. Confirmed with $ETCO_2$ and breath sounds. Sat to 93% on vent. No complications except hypoxemia as noted.

Do you always spend the same amount of time documenting every airway intervention?

Realistically, most documentation is performed after the fact. For EMS providers or critical care transport teams this is usually after arrival at the receiving hospital or back at their base after a call. For hospital-based providers this is as early as after the resuscitation is complete or as late as the end of a shift. The bottom-line is that by the time you are doing your documentation you usually have a good idea of the outcome and therefore the medicolegal risk exposure. If the airway was uncomplicated and the patient is likely to have a good outcome my documentation is more brief and oriented more at providing important medical information to the providers who will take over care after me. If the airway went badly or the patient did poorly despite a perfect airway intervention or other red flags arise, I take extra time to be sure that the documentation is complete and accurate and equally oriented to medicolegal issues. Imagine your chart projected on a big screen in front of a jury 3 years from now. Will it stand up to careful scrutiny?

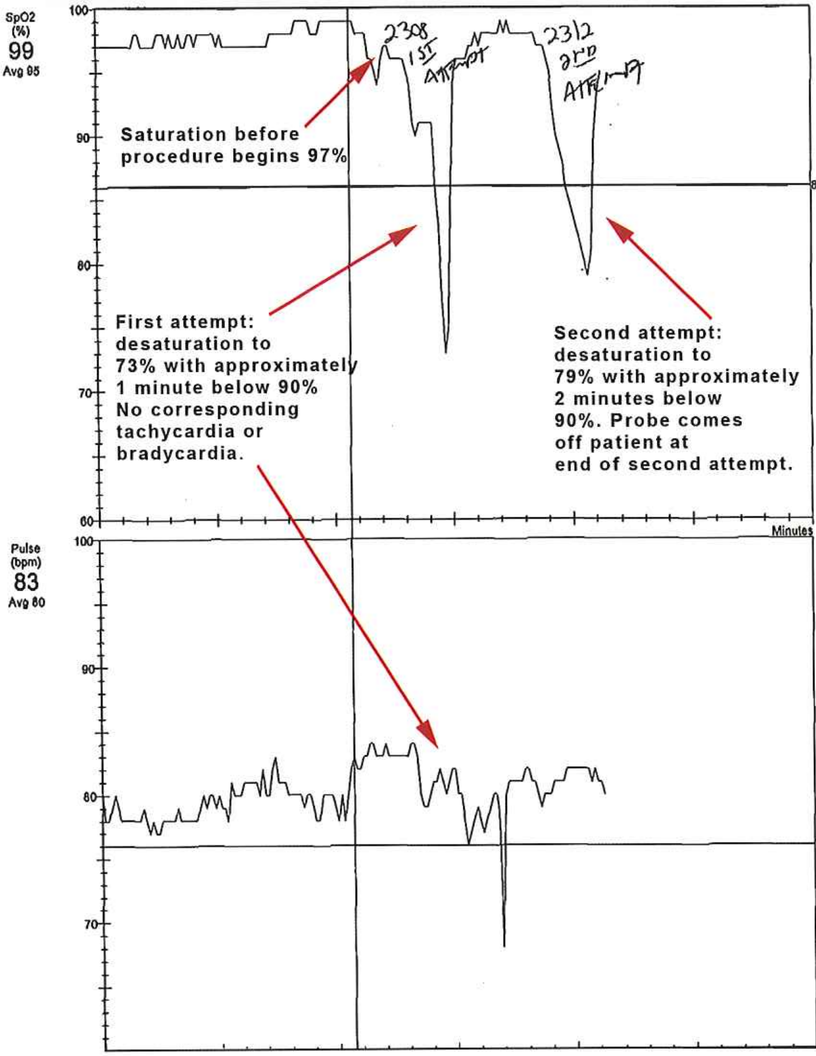
Quality Assurance/Improvement

Any RSI/RSA program, whether hospital-based or prehospital, should have an active quality assurance component. The QA program should monitor indications, potential alternatives, technique, documentation, and outcomes. EMS systems should also evaluate scene time, decisions to manage airways enroute versus on-scene and the time at scene versus time to the receiving hospital. In some low-volume settings it may be possible to review every airway case. In other settings only critical cases will be reviewed. Cases in which RSI/RSA should have been performed but was omitted are as important to review as cases in which it was performed. It is helpful to avoid what practitioners may perceive as a "punitive" QA program as this may discourage full-disclosure. Whenever possible the goal should be to identify correctable systematic issues.

Based on the work of Dunford and colleagues in San Diego, the addition of continuous, downloadable, saturation monitors is highly encouraged. They required paramedics to use a pulse oximeter/capnographer that recorded and saved nearly continuous data during every prehospital RSI in San Diego County for 3 ½ years. Their protocol for RSI was limited to adult patients with severe head injury, defined as a GCS of 8 or less. Despite rigorous education, continuing education and medical oversight, they demonstrated significant hypoxemia and bradycardia in 57% and 19% of patients respectively, most of whom were not initially hypoxic nor difficult to intubate using the paramedics' own assessment. This is especially concerning as head injury patients do not tolerate hypoxemia well.

It is my opinion that far more hypoxemia occurs during RSI than most providers realize since they are very focused on the airway. My own experience with the addition of continuous downloadable saturation monitoring in a flight program has been very positive. Flight crews are often surprised to see how much desaturation occurs and how often it happens in patients who started with a good saturation. We have all become much more vigilant about assessing risk factors for desaturation (see p11) and observing the saturation during RSI/RSA procedures.

Sample Tracing



This is the pulse oximetry and heart rate print-out from an actual patient during a prehospital RSI procedure. Note that on initial appearance the desaturation might not be predicted since the patient is on the border of "limited" and "adequate" reserve. This patient, however, had a chest injury and was requiring BVMV before the RSI to maintain the saturation of 97% so the desaturation is not completely unexpected. If this patient also had a head injury, this degree of desaturation could be expected to more than double the patient's morbidity and mortality.

Is percentage of success a good airway QA indicator?

It is very common for EMS systems to use percentage of success at intubation, both overall and on first attempt, as indicators of performance. This gives providers exactly the WRONG message: "if you are good at what you do you will get a tube in on the first attempt and you won't show up at the hospital without one". It was because of messages like this that I can personally recall times that I continued to struggle with an intubation while parked in the ambulance bay at the hospital lest I walk in without a tube! This was good for my ego and my statistics but the wrong thing for the patient.

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Acronyms and Abbreviations

ASA – American Society of Anesthesiologists

BiPAP – Bilevel Positive Airways Pressure

BMX – Bicycle Motorcross

BNTI – Blind Nasotracheal Intubation

BURP – Backwards, upwards, rightwards pressure

BVM - Bag-valve Mask

BVMV – Bag-valve Mask Ventilation

CABG – Coronary Artery Bypass Graft

CAD – Coronary Artery Disease

CHF – Congestive Heart Failure

CPAP – Continuous Positive Airways Pressure

CT – Cat Scan

EAD – Extraglottic Airway Device

EBM – Evidence-based Medicine

ED – Emergency Department

EDD – Esophageal Detector Device

ELM – External Laryngeal Manipulation

EMS – Emergency Medical Services

EMT – Emergency Medicine Technician

EMT-P – Emergency Medicine Technician – Paramedic

ETA – Estimated Time of Arrival

$ETCO_2$ – End-tidal Carbon Dioxide

ETI – Endotrachael Intubation

FDA – Federal Drug Administration

Acronyms and Abbreviations

GCS – Glasgow Coma Scale

GI – Gastrointestinal

HTN - Hypertension

ICP – Intracranial Pressure

ICU – Intensive Care Unit

IM - Intramuscular

IOP – Intraocular Pressure

IV - Intravenous

JCAHO – The Joint Commission on Accreditation of Healthcare Organizations

LOC – Level of Consciousness

MICU – Medical Intensive Care Unit

NIPPV – Non-invasive Positive Pressure Ventilation

OR – Operating Room

PEEP – Positive End-expiratory Pressure

PICU – Pediatric Intensive Care Unit

PISA – Paralyze, induce, sedate and analgese

PPV – Positive-pressure Ventilation

QA – Quality Assurance

RSA – Rapid Sequence Airway

RSI – Rapid Sequence Intubation

SFI – Sedation-facilitated Intubation

TTJI – Transtracheal Jet Insufflation

UK – United Kingdom

About the Author

Dr. Braude began messing with airways as an EMT in 1985. He worked as a rural volunteer EMT and Advanced EMT-Intermediate for Southern Madison County EMS in Central New York from 1986 to 1990, while a student at Colgate University. Here he learned what it was like to be the only intubation trained provider on scene and gained nothing but respect for long transport times, volunteer EMS providers and EMT-intermediates. Following graduation he attended paramedic school at Daniel Freeman Paramedic School in Southern California, interned with the Los Angeles City Fire Department and then honed his prehospital airway skills while working in Ventura, California before starting medical school at New York Medical College. Upon graduation from medical school in 1996 he spent 4 years tackling bloody airways at UCSF-Fresno while being molded into an emergency physician and EMS medical director by the best-of-the-best. Finally he was fortunate enough to land among amazing airway colleagues at the University of New Mexico where he spent 5 years as the Medical Director of the EMS Academy and Lifeguard Air Emergency Services. He currently tortures the crews about each and every airway as Medical Director of PHI Air Medical of New Mexico and co-directs the *Airway911* program, which strives everyday to put an end to airway death.

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