Airway Management and Endotracheal Intubation

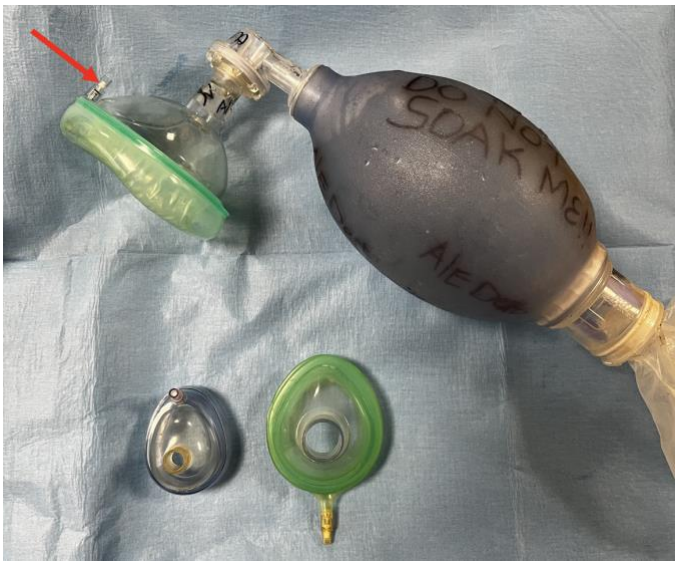
Gregory Sund, Rodger Barnette, Mark Newton

Endotracheal intubation is an advanced airway skill that is essential in the resuscitation and management of critically ill patients, and for the facilitation of general anesthesia when controlled ventilation is required. Successful endotracheal intubation requires not only the technical skills of laryngoscopy, which are learned by repeated supervised practice, but also an understanding of the indications for intubation, how to evaluate a patient's airway, and what instruments, medications and devices must be available to the practitioner. As with any other procedural skill, recognition and treatment of potential complications is necessary.

Before learning to perform endotracheal intubation, it is essential to learn effective bag-mask ventilation. It is important to keep in mind that patients do not die from lack of intubation, they die from a lack of VENTILATION and OXYGENATION, both of which can be provided by bag-mask ventilation.

Bag-Valve-Mask Ventilation

To perform bag-valve-mask (BVM) ventilation, it is important to start with an appropriately sized device. Ambu bags typically come in adult, pediatric and neonatal sizes. The corresponding volumes associated with those devices are approximately 1500 mL, 630 mL and 220 mL, respectively. It is also important to choose an appropriately sized face mask, one that completely covers the mouth and the nose of the patient, and with which the provider is able to create a seal that allows effective ventilation. Most suppliers of face masks provide three adult sizes (small, medium and large) and three pediatric sizes (neonatal, infant and pediatric).



Ambu-bag with various sizes of masks. The pressure of the inflatable portion of the mask can be changed by inflating with a syringe at the port (Red arrow.)

The most common technique for effective BVM ventilation is the "EC" clamp technique. Unless a cervical spine injury is suspected, the head is gently tilted back while the jaw is lifted.

One handed "EC" technique for bag-mask ventilation: The "C," formed by the thumb and index fingers, presses the mask downwards while the "E," formed by the 3rd, 4th and 5th fingers, pulls the body of the mandible upwards.

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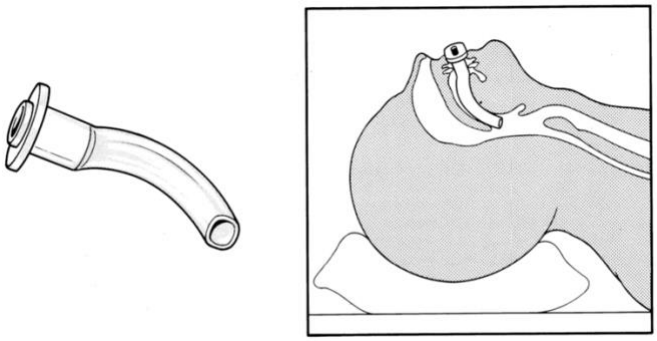
Two handed "EC" technique for bag-mask ventilation. An assistant manually ventilates the patient.

A breath is administered over 1 second, which should produce a visual chest rise. If the chest does not rise, airway obstruction should be suspected. This obstruction may be relieved by repositioning, or if this is unsuccessful, it may be necessary to place an oral airway. It is mandatory to use an appropriately sized oral airway. One that is too small can push the tongue backwards, worsening airway obstruction, while one that is too large can occlude the glottic opening. The easiest way to choose the appropriate size for an oral airway is to place the airway next to the patient's face. With the flange at the level of the patient's mouth, the posterior part should reach the angle of the patient's mandible



Oral airway in place. This is a rigid tube which extends beyond the base of the tongue and raises the soft palate away from the oropharynx. When it is in place, the bag-valve mask can be used more effectively to ventilate the patient.

Various sizes of oral airway are available and should be fitted to the patient as below:

How to choose an oral airway. When the flange is at the level of the patient's lips, the tip will reach the angle of the mandible.

It should be noted that an oral airway will not be tolerated in a conscious patient. Its placement can provoke gagging and vomiting which may lead to aspiration. If the patient is conscious a nasal airway will be better tolerated and will relieve soft tissue airway obstruction by lifting the patient's soft palate and tongue.

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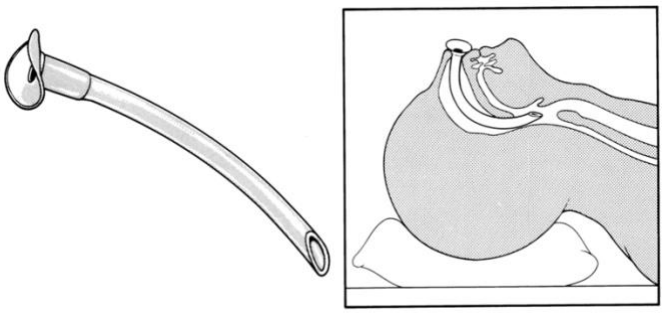


Nasal airway in place. This is a soft tube which extends beyond the soft palate into the oropharynx or hypopharynx. When it is in place, the bag-valve mask can be used more effectively to ventilate the patient.

If you are unable to ventilate using the one-handed EC clamp technique (with or without an oral or nasopharyngeal airway), using a two-handed EC technique (with an assistant squeezing the bag) may improve your ability to effectively ventilate. If all of these techniques fail, plans should be made for an advanced airway, such as a laryngeal mask airway or endotracheal intubation.

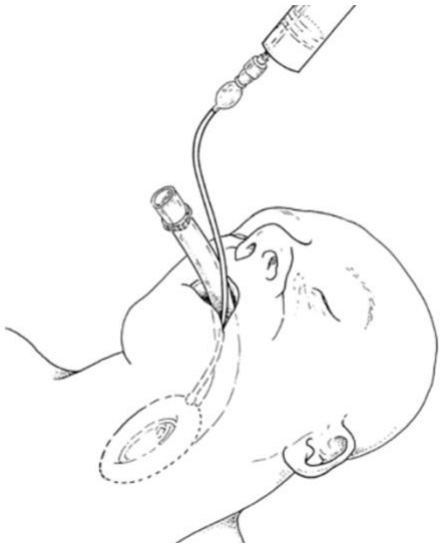
Laryngeal Mask Airway

A laryngeal mask airway (LMA) is more invasive than an oral or nasopharyngeal airway, but less invasive and easier to perform than endotracheal intubation. LMAs are available in multiple sizes based on the weight of the patient. They can be used as airway rescue devices or as the primary airway in patients requiring general anesthesia who are not paralyzed and remain spontaneously ventilating. The inflatable portion of the LMA produces a seal around the glottic opening and allows ventilation to be achieved. As with the oral airway, the LMA will not be tolerated in the conscious patient and will not protect against aspiration of gastric contents in a patient with a full stomach. Lubricating the posterior surface of the mask and tip of the LMA will facilitate insertion. The LMA is inserted gently until resistance is encountered, at which point the entry port can be connected to an Ambu bag or breathing circuit.

The laryngeal mask airway is designed to fit in the hypopharynx, with the pointed tip in the opening of the esophagus, and direct air into the larynx across the vocal cords. It is inserted along the posterior oropharynx and then directed downwards to its position. It is inserted with the inflatable portion partially inflated, pressure can be added to improve the seal if necessary.

Size 1 for use in infants up to 5 kg	4ml
Size 1 ½ for use in infants of 5-10 kg	7ml
Size 2 for use in infants of 10- 20 kg	10ml
Size 2 ½ for use in children of 20-30 kg	14ml
Size 3 for use in children and small adults of 30-50kg	20ml
Size 4 for small or normal-sized adults.	30ml
Size 5 for normal or large sized adults	40ml

Table: sizes of laryngeal mask airways, their appropriate weight patients, and amounts of air to fill their balloons.



Laryngeal mask in place, having been inserted by sliding along the soft palate and posterior oro- and hypopharynx.

Endotracheal intubation

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Endotracheal Intubation

Indications for endotracheal intubation include relief of airway obstruction (if this cannot be achieved using the previously mentioned techniques), airway protection, failure of ventilation and/or oxygenation, an expected clinical course that requires intubation (eg. evidence of airway injury after fire exposure) as well as general anesthesia when controlled ventilation is needed. Preparation is vital to successful intubation. A checklist for steps to take in preparation for endotracheal intubation is a useful tool.

- Rapidly assess the airway
- Place monitors: SaO2, BP, EKG
- Ensure Oxygen flowing and pre-oxygenate if there is time
- Ensure equipment is present and **FUNCTIONING!**
  - Ambu-bag with high-flow oxygen
  - Functioning laryngoscope
  - Endotracheal tubes of appropriate size
  - Smaller sized endotracheal tubes, unopened
  - Stylet for endotracheal tube
- Ensure suction is available and **FUNCTIONING!**
- Medications drawn up and labeled
- Patient in position
- Assign someone to apply cricoid pressure
- Bougie and Laryngeal Mask Airway available
- Back-up plan (surgical airway?) and appropriate equipment and personnel available (surgeon aware?)

A checklist of steps prior to intubation

In addition to the other equipment and medications listed, it is important to have an appropriately sized endotracheal tube (ETT) as well as laryngoscope. It is best to choose which size ETT you think will be used based on the patient's age as well as an ETT one size larger and one size smaller than your estimated size. It is also best practice to have a variety of laryngoscope blades (Macintosh and Miller) available.

- Adult males: 7-8
- Adult females: 6.5-7.5
- Children:
  - (Age/4) + 4
  - >3.5kg and <1 year: Uncuffed 3.0mm inner diameter tube
  - Tube should be size of child's smallest (pinky) finger

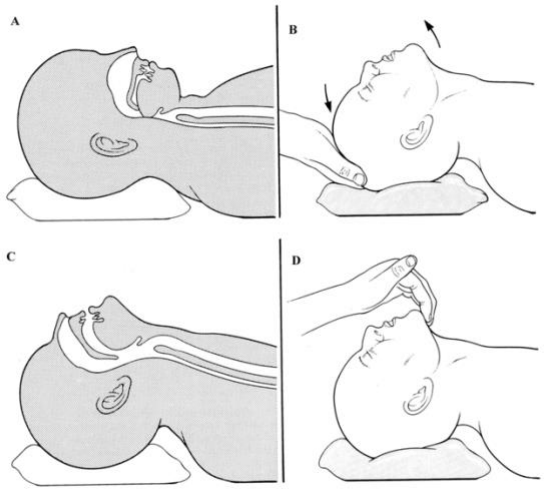
Table: Formulas for selecting the correct size of endotracheal tubes

A laryngoscope with a lighted Miller blade. This blade is designed to retract the epiglottis directly. Memory trick: The scope handle and MiLLer blade together are shaped like the letter "L."

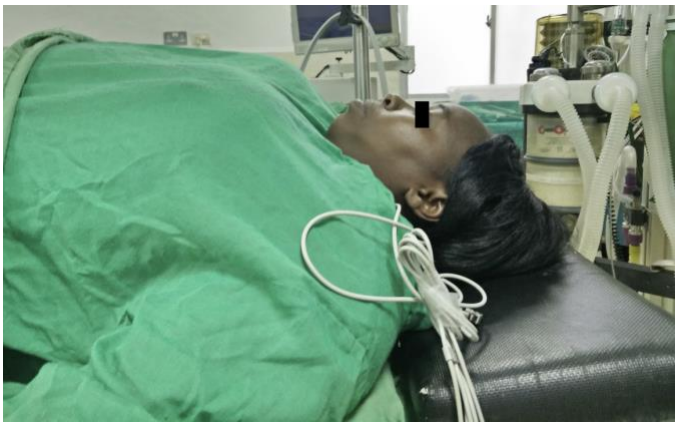
A laryngoscope with a lighted Macintosh blade. This blade is designed to retract the epiglottis indirectly, when its tip is placed in the vallecula, the space between the base of the tongue and the epiglottis. This maneuver is shown further in the diagrams below. Memory trick: The blade of the MaCintosh is shaped like the letter "C"

Positioning the patient before attempting endotracheal intubation will greatly improve your chances of success. The ideal positioning is the "sniffing position." The goal of this position is to align the patient's head and neck in such a way as to allow direct visualization of the vocal cords. This is especially important in obese patients. Using folded blankets to create a "ramp" behind the patient's back

will allow you to successfully position obese patients in the sniffing position.



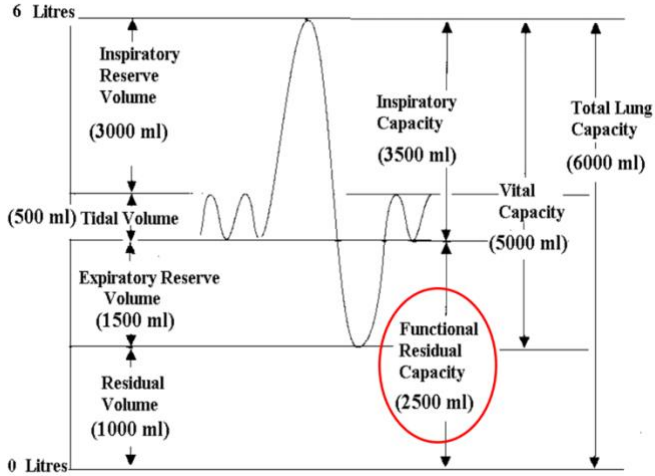
The "sniffing position" to improve visualization of vocal cords during direct laryngoscopy



In obese patients, the excess tissue of the chest and abdomen make accessing the airway more difficult.

When this problem exists, the "sniffing position" can be supplemented by using folded blankets to create a "ramp." This position allows gravity to pull the tissue of the patient's neck and upper chest towards the patient's feet and out of your way.

Whenever possible, prior to attempting endotracheal intubation, the patient should be pre-oxygenated. This involves the administration of 100% oxygen for 3 to 5 minutes, with a good mask seal, while the patient is spontaneously breathing. This will fill the functional residual capacity (FRC) of the patient's lungs with a high concentration of oxygen and prolong the period of apnea before oxygen desaturation occurs. This can be critical in patients who are difficult to intubate, or must be allowed to emerge from the effects of the induction drug because they cannot be intubated.



Functional Residual Capacity (Red circle) can be conceived as the air remaining inside a patient's lungs at the end of a normal respiratory cycle. In an adult male, this can be as much as 2-2.5L. Preoxygenation fills this space with 100% oxygen, allowing more time without breathing before the oxygen level starts to drop.

A 70 kg adult man has an FRC of approximately 2.5 L, and consumes 250 mL of oxygen each minute while producing 200 mL of CO2. Theoretically you should have 8 - 10 minutes (2,500 divided by 250) to control this patient's airway but in reality it is 3 to 4 minutes. It is important to have that time available should difficulties with intubation arise.

After pre-oxygenation, induction drugs with or without paralytics are administered. While patients can be intubated without paralysis, use of depolarizing or non-depolarizing muscle relaxants

will make laryngoscopy and intubation significantly easier, especially in adult patients.

Agent	Dose	Induction Time	BP Effect	ICP Effect
Thiopental	3-5mg/kg	15-20 Seconds	Lowers	Lowers
Propofol	1-2mg/kg	15-20 Seconds	Lowers	Lowers
Ketamine	1-2mg/kg	30-45 Seconds	Raises	Raises
Midazolam	0.1-0.3mg/kg	120-180 Seconds	Neutral/Lowers	Neutral

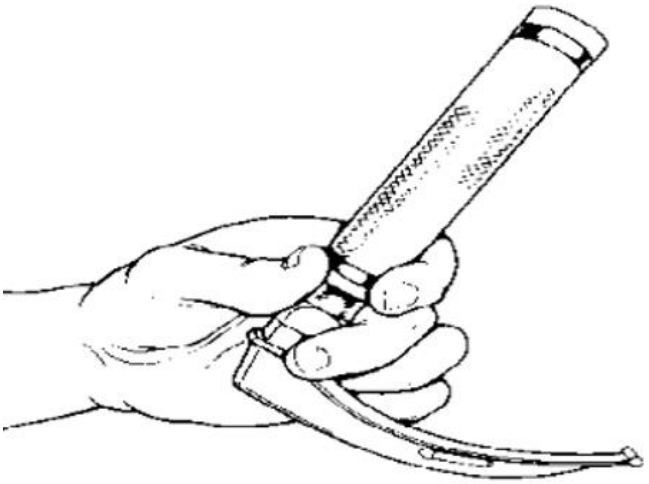
Table: commonly used sedation agents for intubation and some of their side effects

Agent	Dose	Onset
Succinylcholine	1.5mg/kg	30-60 Seconds
Rocuronium	1-1.2mg/kg	60-90 Seconds
Vecuronium	0.15-0.25mg/kg	2-3 Minutes
Pancuronium	0.1mg/kg	3 Minutes

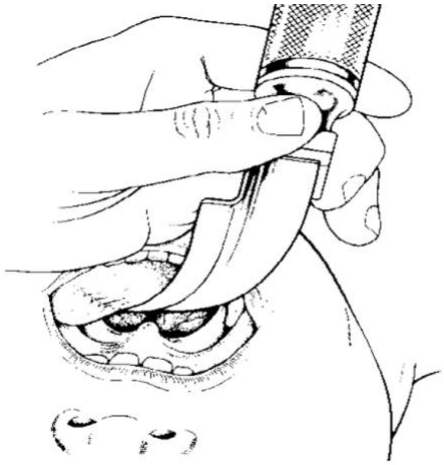
Table: commonly used paralytics and their duration of onset. Recall that during the time of onset, the patient may not be able to breathe but may not be paralyzed enough to intubate, so a shorter onset is almost always preferable.

After administration of an induction drug, the practitioner should ensure that the patient is unconscious before giving a paralytic or attempting intubation. This can be evaluated by gently brushing the eyelash with a finger; if no response is elicited you should proceed with intubation. Unless the patient is undergoing a rapid-sequence induction (see below), it is important to verify that you can provide effective bag-mask-ventilation before proceeding with paralysis. If it is not possible to ventilate, the patient can be allowed to emerge from the effect of the induction agent and other options for airway control can be considered.

If ventilation is possible, when the patient is adequately paralyzed the laryngoscope is gently inserted into the right side of the patient's mouth, and the tongue is swept to the left. As the laryngoscope is advanced, the epiglottis will be visualized. When using a Macintosh blade, the tip is inserted anterior to the epiglottis in the vallecula; if using a Miller blade the tip will actually lift the epiglottis. By exerting pressure in the same direction as the handle the laryngoscope blade will lift the epiglottis and soft tissues to allow visualization of the vocal cords at which point the endotracheal tube can be inserted into the trachea. It is important while elevating the tongue and mandible that there be NO pressure on the upper teeth, as this can dislodge a tooth and create a foreign body obstruction in an unconscious patient.



The laryngoscope is held gently in the left hand so that the tube can be inserted with the right hand.



The Macintosh laryngoscope is inserted on the right side of the patient's mouth so that the tongue can be swept towards the patient's left and the tube can be inserted along the right side of the scope.

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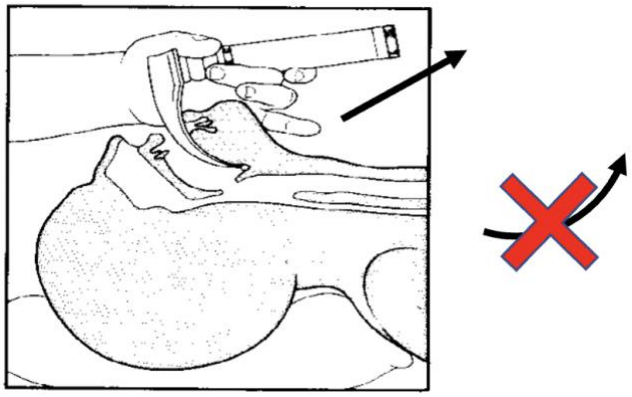
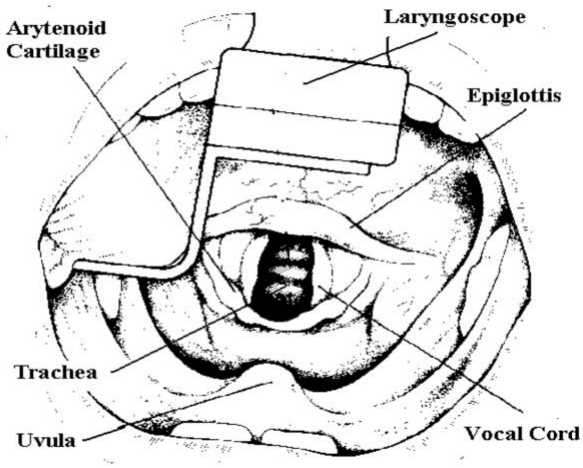


As the blade of the scope is inserted farther into the throat, be careful to apply force in the direction shown by the upper arrow, raising the tongue and mandible in an anterior and inferior direction. If you "pry" the scope by rotating the tip upwards, the upper part of the blade will press on the upper incisors and loosen, damage, or dislodge one or more upper teeth.



View of the vocal cords and trachea with the Macintosh laryngoscope in proper position. The tip of the blade is in the vallecula, between the base of the tongue and the epiglottis. Pressure in the right direction, as shown above, raises up the epiglottis and exposes the vocal cords. The Miller laryngoscope, in contrast, passes below the epiglottis and raises it directly.,

While applying traction in the right direction, and visualizing the cords, the operator then passes the tip of the endotracheal tube between the vocal cords. Note that a stylet, a thin stiff piece of metal, is inside the endotracheal tube to prevent it from flexing. Note also that the blade is close to the upper incisors: carelessness here, due to attention on the vocal cords only, could cause dental trauma.

Once the endotracheal tube is inserted to an appropriate depth (21 cm at the teeth in most adult women; 23 cm at the teeth in most adult men), the balloon should be inflated (3 – 5 mL of air injected through the pilot balloon) and the tube should be connected to the breathing circuit or Ambu bag and ventilation verified. As esophageal intubation is possible, even when the vocal cords are well visualized, it is important to verify endotracheal placement using multiple techniques, including visualization of chest rise, positive auscultation of breath sounds, fogging of the tube, and whenever possible, detection of end-tidal CO2 (capnography). If while auscultating, you hear breath sounds over the stomach but not in the chest, you have an esophageal intubation. Remove the endotracheal tube, mask ventilate, and consider repositioning the patient prior to your next attempt. If you hear breath sounds on the right, but not on the left you may have a right-mainstem intubation. Withdraw the tube slowly while checking breath sounds.

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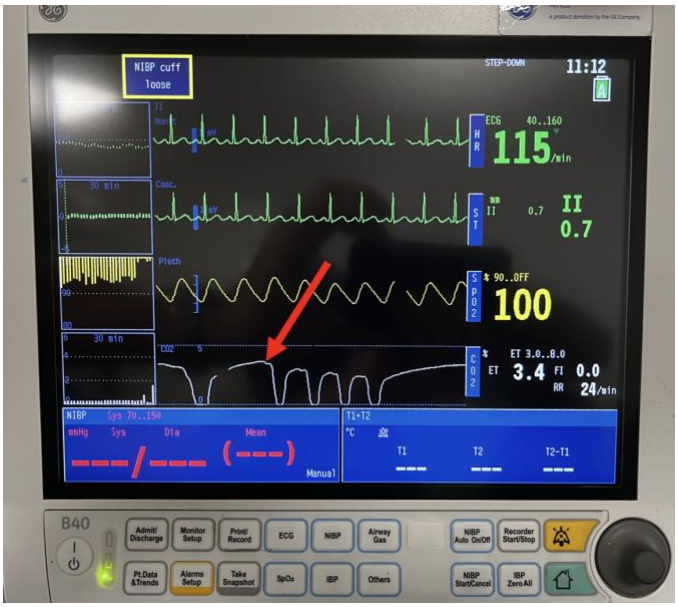


Capnography uses a sensor that is connected in-line to the ventilator tubing, just proximal to the endotracheal tube, to detect carbon dioxide. A rise and fall of CO2 with respiration, as shown here (Red arrow) confirms that the endotracheal tube is within the trachea.

Rapid Sequence Induction

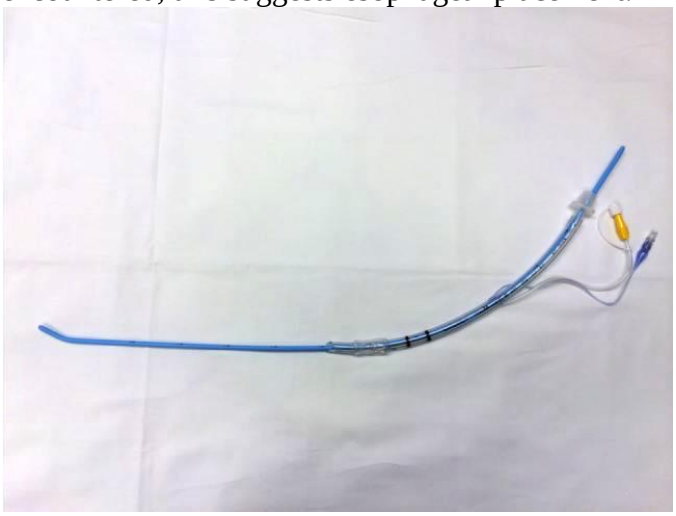
Patients who are at elevated risk for aspiration of gastric contents (recent meal, delayed gastric emptying, trauma, pregnancy) should undergo a rapid sequence induction (RSI) when endotracheal intubation is necessary. While the steps are similar to those described above, the patient should NOT be ventilated after loss of consciousness, but instead short-acting paralytics should be used (succinylcholine or rocuronium) and an assistant will need to place gentle pressure over the cricoid cartilage (Sellick's maneuver) in an attempt to occlude the esophagus and prevent regurgitation of gastric contents. This cricoid pressure should be light (300-400g,) should begin as the patient loses consciousness, and should not be released until the practitioner has verified endotracheal placement of the tube.

The Difficult Airway

Patients who will be difficult to ventilate and/or intubate can often, but not always, be identified during a pre-intubation airway evaluation. Therefore, it is vital to know what steps to take when one encounters an anticipated or unanticipated difficult intubation.

Whenever a difficult intubation is anticipated, it is always best to have all available airway equipment (including videolaryngoscopy or fiberoptic laryngoscopy if available) in the room. It is also wise to have a second operator who is skilled at intubation assist you, and whenever possible to have a surgeon who can provide a surgical airway present as well.

A bougie (Eschmann stylet) can be useful when only the posterior part of the vocal cords or the arytenoid cartilages are visualized. This stylet has a small "hook" on the end which can pass under the epiglottis and allow entry into the trachea. If the stylet passes successfully into the trachea, the operator will normally feel it passing along the tracheal rings and then resistance to forward movement as the carina is encountered. At this point an ETT can be passed over the stylet to an appropriate depth and the stylet withdrawn. If tracheal rings are not felt and no resistance is encountered, this suggests esophageal placement.



An intubating bougie with endotracheal tube loaded. The end on the left is passed through the vocal cords. As the tip passes over the tracheal rings, the operator feels this feedback and tracheal position is confirmed. The endotracheal tube is then advanced over the bougie into the trachea. Source: Baker JB et al, WestJEM 16:4;2015
DOI: 10.5811/WESTJEM.2015.4.22857

Videolaryngoscopy has become a widely available tool for patients who are difficult to intubate and has dramatically decreased the need for

awake fiberoptic intubations. The technique is similar to the technique described above. However, as a smaller mouth opening is needed to insert this unique videolaryngoscope blade,, many patients (especially those with anterior vocal cords) who are unable to be intubated with direct laryngoscopy will be able to be intubated using a videolaryngoscope.

Intubation using a fiberoptic glidescope. Note that the anesthetist is holding the blade with her left hand and an endotracheal tube with a stylet in the right hand, watching the screen preparing to insert the tip of the tube between the vocal cords as seen on the screen (Red arrow.)

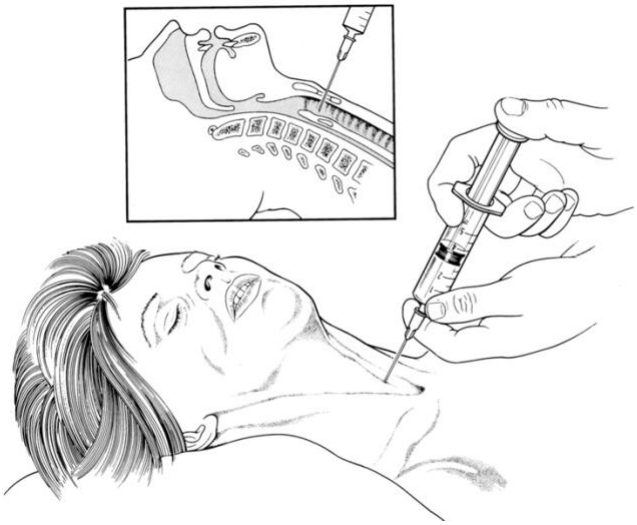
For patients with severely limited mouth opening or other anatomic abnormalities that preclude both direct and video-laryngoscopy, the operator may choose to perform fiberoptic laryngoscopy, if available. This can be performed with the patient anesthetized (if mask ventilation is possible) or with the patient conscious. The awake patient may benefit from light sedation and local topicalization of the airway. Giving small doses of midazolam, an opioid and/or ketamine will provide you with a more cooperative patient, however, these medications should be slowly and carefully titrated such that the patient continues to breathe spontaneously.

Draw 8-10 mL of 4% lignocaine into a syringe. Ask the patient to open his/her mouth and spray 4 to 5 mL of the solution onto and over the back of the tongue. If they are able to follow commands, ask them to gargle this solution prior to swallowing.

Ask the patient to close his/her eyes and breathe deeply. Reassure them, and then gently introduce a well-lubricated laryngoscope (use lignocaine jelly if available) over the tongue until you see the tip of his epiglottis. Then spray a further 1 to 1.5 mL of solution, through the scope itself, onto the epiglottis.

When you see his vocal cords, spray the remaining 2–3 mL into the upper larynx and between the vocal cords.

Optionally, you may wish to also use a 21 gauge needle attached to a 3 mL syringe, containing 4% lignocaine, to puncture the cricothyroid membrane. Upon aspiration of air inject the lignocaine. This will cause the patient to cough and will spread the lignocaine to the inferior surface of the vocal cords, the trachea and other areas of the glottic opening.



Injecting lidocaine into the airway through the cricothyroid membrane, which is located immediately beneath the thyroid cartilage ("Adam's apple.")

When his cords are widely abducted, pass the tracheal tube into his trachea and inflate the cuff. They may cough a little but will tolerate the tube. With his airway secured, you can, if necessary, induce the patient intravenously or by using inhalational agents.

A similar sequence of steps can be undertaken for NASAL fiberoptic intubation, when mouth opening is severely limited or there is a surgical indication to have the patient intubated

nasally. In this case, it is important to avoid traumatizing the nasal mucosa, which is fragile. Prior to inserting the fiberoptic scope, it is recommended that a topical vasoconstrictor such as oxymetazoline (Afrin) be sprayed into the nostril through which intubation will take place (usually the larger nostril). Also, 2% or 4% lidocaine can be sprayed into the nostril to improve patient tolerance to this procedure. Nasotracheal intubation can be performed with a regular oral endotracheal tube, however, if available, a nasal "RAE" endotracheal tube will be easier to position.

For patients with large head and neck tumors or other severe airway conditions which will prevent even awake fiberoptic intubation, the only other option may be an awake tracheostomy.

Finally, it is important to remember that patients with known or suspected cervical trauma should have their head and necks maintained in a neutral position, no matter which technique for intubation is chosen. This can be achieved by manual in-line stabilization (performed by an assistant) or by leaving the cervical collar in place, although this may make mouth opening difficult. See "Airway Management in Trauma."

Conclusion

Endotracheal intubation is a life-saving skill, but one which requires technical ability obtained through supervised practice, a thorough understanding of the indications and complications of this procedure, and how to appropriately prepare for routine as well as difficult intubations.

Note: all illustrations in this chapter are from Safe Anesthesia- A Training Manual Where Facilities are Limited by Lucille Bartholomeusz, 3rd Edition 2006 (Updated and Revised by Jean Lees.) Used with kind permission from HealthBooks International. https://healthbooksinternational.org

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