Airway Management in Anesthesia

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Airway management challenges are common causes of morbidity and mortality in patients requiring anesthesia during surgical procedures. Airway management is an integral part of general anesthesia that allows ventilation and oxygenation of the patient. The prime purpose of airway management is to stabilize and secure the patient during an emergency or operation. Pre-operative assessment of the respiratory tract should be done to assess risk factors. Standard diagnostic measures are used to evaluate the anticipated degree of difficulty with mask ventilation and endotracheal intubation.

The purpose of airway management is to secure a patient's airway so that he/she can breathe spontaneously during an emergency case or an operation, or be mechanically ventilated. A prior **assessment** of respiratory conditions, the decision for which **technique** should be applied, and the professional handling and use of **instruments** are all important elements in the management of the respiratory tract. A difficult airway (three or more attempts to secure the airway that take more than 10 minutes) results in high anesthesia morbidity.

Airway Assessment

To detect difficult intubation conditions before the induction of anesthesia, the attending anesthetist must examine the patient's airway during the pre-medication visit. This is important as it will help with planning ventilation and equipment choice (e.g., whether to use a video laryngoscope); thus, the following parameters should be recorded and

analyzed for the anesthesia plan:

- Medical history to establish any prior difficulty in intubation
- Mallampati score: the size of the interincisor distance is estimated in the wide-open mouth:
    - Mallampati I
    - Mallampati II
    - Mallampati III
    - Mallampati IV
- Mandibular space
- Reclination of the head and dental status

Patient features play a vital role in determining the ease or difficulty of a laryngoscopy.

Medical history

In **medical history**, one initially gathers information on any difficult intubation in the past. The clinician should inquire about and examine malformations and tumors in the **mouth and throat area.** Anything that could constrict or constrain airways must be recorded. In addition, it is important to note how wide the mouth can be opened. The wider it opens, the more “space” remains for the anesthetist to do his/her work. A **restricted mouth opening** makes it difficult to view the larynx with the laryngoscope during intubation.

Mallampati score

Clinical scores help to assess the airways. The Mallampati score is used to assess which pharyngeal structures are visible when a patient opens his/her mouth wide and sticks his/her tongue out as far as possible. The patient sits upright, with a neutral head position. Depending on the visible structures, we assign a **Mallampati classification (Class I-IV) score**. The goal is to determine whether the laryngeal inlet is visible with direct laryngoscopy.

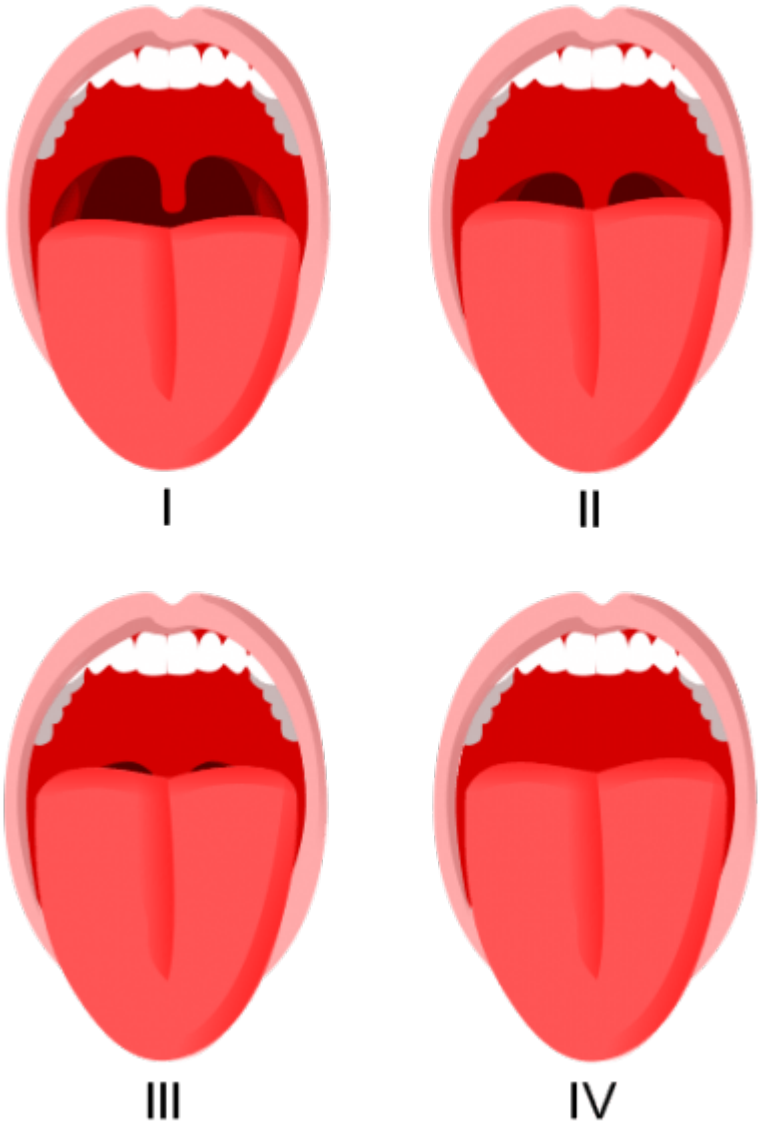

Image: “Mallampati Score” by Jmarchn. License: CC BY-SA 3.0

Mallampati score:

Class I	Uvula completely visible	The glottis is usually fully adjustable with a laryngoscope
Class II	Uvula partially visible	Varying good glottal adjustability
Class III	Soft and hard palate visible	Varying good glottal adjustability
Class IV	Only hard palate visible	Usually only epiglottis or the base of the tongue

Cormack and Lehane

During the intubation procedure, the glottis is adjusted and its visible structures are directly evaluated using the laryngoscope. This index is called the **Cormack and Lehane classification**. It describes the laryngeal view by direct laryngoscopy as **Class I, II, III, or IV**. The higher the class, the more difficult the intubation.

Cormack and Lehane:

Class I	Total glottis is visible.
Class II	Glottis is only partially visible (at the rear commissure).
Class III	Glottis is not adjustable. Only epiglottis is visible.
Class IV	Larynx structures and epiglottis cannot be adjusted. Only soft palate is visible.

Mandibular space

The size of the **mandibular space** is another component of the examination. The mandibular space includes the oral cavity and upper throat; thus, it focuses on the space in front of the larynx. The distance between the chin and jawline is estimated. The throat is usually clearly visible at a distance of **> 9 cm (adults). Pharyngeal space is limited by micrognathia.**

Neck extension

How far the patient's head can be extended is important in the introduction of the laryngoscope. The patient's head is hyperextended in order to reach a common axis of the mouth, the pharynx, and the larynx. Certain **measures** must be taken for **dealing with difficult airways.** A difficult airway is a situation in which intubation either is not possible (e.g., cervical spine stiffness in a patient with ankylosing spondylitis) or is only possible to a limited extent (e.g., in a patient with cervical spine injuries). Normal extension of the head is approximately **35 degrees.**

Dental status

Dental status also plays an important role in airway management. Are there prostheses which must be removed before the procedure? Are any of the teeth loose? Caution should be exercised when intubating. A loose tooth poses a **risk of aspiration or swallowing**.

At a glance*:* Assessment of the respiratory tract

If these criteria, which are easy to comprehend, are considered, intubation difficulties are expected to be relatively simple to assess:

- Medical history and examination
- Mallampati score
- Size of mandibular space
- Neck extension
- Dental status

Securing the patient's airways can be carried out via **supraglottic procedures,** such as a face mask and a laryngeal mask, or through endotracheal intubation using **infraglottic techniques**.

Mask Ventilation

In all anesthesia cases, the patient is first manually ventilated with a face mask until intubated, or a laryngeal mask is introduced to obtain sufficient oxygen saturation of the blood during the application of instruments.

Masks have an **elbow** to which **inspiration and expiration tubes** are connected.

Image: “Bag Valve Mask (AMBU-bag). Used for manual ventilation of the patient in case of a respiratory emergency.” by Hospital. License: CC BY-SA 3.0

Mask ventilation techniques

When carrying out the mask ventilation, you must consider the following: as a rule, the mask must be firmly fixed on the patient’s face with the left hand. While the mask is held on top and in the bottom part of its elbow with a thumb and a forefinger, a middle finger, a ring finger, and a little finger should embrace the patient’s lower jaw and stretch his/her head posteriorly, extending the neck. Using the so-called **C-grip**, named after the position of the thumb and the forefinger during this procedure, the mask can be fixed so that no air can escape. The physician can now use the **ventilation bag** with a free hand. The operator of a mask needs to be fully trained and experienced to perform mask ventilation adequately. The equipment (face mask and respiratory bag) need to be of the right design and size.

Guedel and spiral tube

The additional use of **nasopharyngeal tubes** or **oropharyngeal tubes** prevents the falling back of the tongue to the epiglottis, keeping the airway open during mask ventilation. In this case, the **Guedel tube** is the method of choice. The **Wendl tube**, which is introduced through the nose, triggers a gag reflex, and it is generally used in the case of non-tolerance of the Guedel tube. Although both tubes keep the airway free, they offer no protection against aspiration as the laryngeal inlet remains open with mask ventilation. This is an important disadvantage of mask ventilation compared to intubation.

Image: “Intersurgical One-piece Guedel Airways.” by Intersurgical Ltd. License: CC BY-SA 3.0

When performing mask ventilation, it is important to keep the lowest possible **ventilation pressure**. At a pressure of more than 20 mbar, the closing pressure of the **esophageal sphincter** is exceeded, and the air volume compresses into the stomach. On the one hand, you should avoid it, because it can overinflate the patient’s stomach. Even more importantly, the air should get into the lungs in order to provide the patient with oxygen. This fact is often asked during exams.

Laryngeal Mask

The use of a laryngeal mask is more invasive than the face mask, but there are some advantages. The **laryngeal mask** makes it possible to keep the upper respiratory tract free without the risks of tracheal intubation. It consists of a **silicone tube** with a connector. An elliptically-shaped **mask** is attached at its distal end. Its **beaded-edge** can be inflated via a supply line and, thus, block the airstream. The empty mask is introduced into the hypopharynx blindly, without a laryngoscope. If the laryngeal mask is in the proper position, it cannot be further advanced. The funnel is located at the entrance of the larynx, and the bead is inflated, which seals the larynx.

Image: “Laryngeal Mask Airway” by ignis. License: CC BY-SA 3.0

If air escapes during respiration despite attempts to adjust, you may try again with a

mask of a **different size**. The shaft of the laryngeal mask can be fixed on the patient's face with adhesive tape to prevent intraoperative slipping after successful placement.

Contraindications

Contraindications for use of a laryngeal mask include **pharyngeal abscess** or **obstructions** and **restrictive lung diseases** that require high inspiratory pressure (> 30 cm H2O). A **nonfasting patient** also represents a contraindication because the laryngeal mask closes the entrance to the esophagus and trachea, but it does not isolate them from each other; therefore, it **does not protect against aspiration** in case of regurgitation.

Advantages and disadvantages

Advantages of the laryngeal mask compared with the **face mask** include the reduced trauma risk of facial structures, such as the facial nerve and the eyes. The **airway** is easier to keep open, and this method is best suited for bearded patients because a mask would often **not be completely airtight**. The placement requires **deeper anesthesia** than the face mask to minimize the gag and cough reflex.

Compared to intubation, the laryngeal mask is less invasive. It causes fewer **teeth** and **larynx traumas**. No **muscle relaxant** is required, and the risk of **laryngeal and bronchial spasm** is lower. At the same time, there is no risk of accidental **esophageal or endobronchial intubation**.

In patients with difficult airways, especially in the "cannot ventilate, cannot intubate situation", the laryngeal mask can be a lifesaving temporary measure for securing the airway due to its relatively easy placement. Generally, the laryngeal mask is used during small, uncomplicated operations. With nonfasting patients, it offers **no adequate aspiration protection**. In these patients, endotracheal intubation is preferred.

Endotracheal Intubation

Endotracheal intubation is one of the most essential topics of anesthesia and an indispensable tool. You should familiarize yourself with the instruments, their clinical implementation, and their advantages and disadvantages, as well as the indications for their application. Endotracheal intubation describes the insertion of a **tube** through the glottis into the trachea, which allows the patient either to breathe by himself/herself or to receive artificial ventilation.

The introduction of a tube through the nose, called nasotracheal intubation, is also possible. By sealing with a **balloon (cuff)**, airways are protected against the ingress of liquids, such as gastric fluid or blood. In addition to this aspiration protection, the **suction of endobronchial secretion** via the tube, and the **secure aspiration of all anesthetic gases** is possible, which consequently allows medical staff to be less burdened with escaping gases.

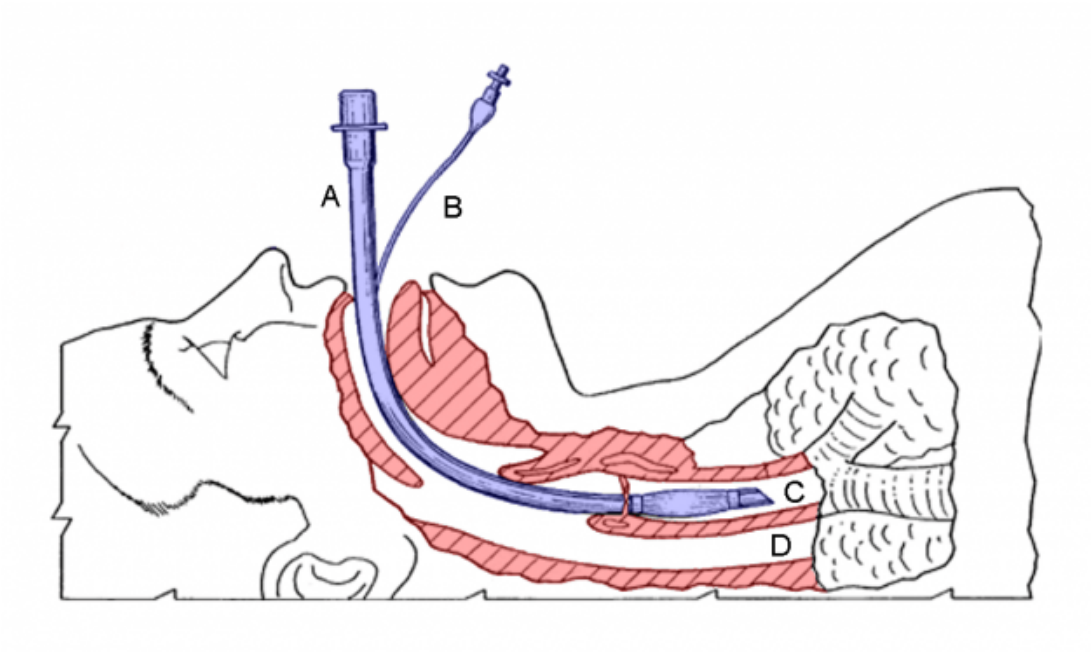

Image: “Diagram of an inserted endotracheal tube” by PhilippN. License: Public Domain

The ease or difficulty of intubation is highly dependent on oral opening, neck extension, the structure of the soft oropharyngeal tissues, neck movement, mandibular joints, and the upper body weight of the patient. Pre-existing medical conditions, such as rheumatoid arthritis, must be identified to determine whether palpation of the larynx and trachea is indicated.

Indication

Endotracheal intubation is indicated during **operations in the neck and facial area**, where supraglottic airway aids, such as a facial or laryngeal mask, are unfavorable.

This method is also indicated for nonfasting patients, like **emergency patients** whose fasting status is unknown, or for **pregnant women** from the 14th week of pregnancy due to the increased intra-abdominal pressure.

There is also an indication for tracheal intubation in the case of **abdominal and thoracic surgery, overweight** patients, and in surgeries with patients in positions that make anesthesia more difficult, such as sitting, lateral, or prone position.

Implementation

To insert the tube under direct vision, the laryngeal aperture is revealed with a **laryngoscope**. Since the glottis is the narrowest point of the larynx, the **tube size** and its diameter are dependent on the glottis size. With children, the narrowest point is located just below the glottis in the area of the cricoid cartilage. If you meet resistance when pushing the tube through the glottis, it must be replaced by a model with a smaller diameter. Under no circumstances should the tube be forcefully pressed forward.

Image: “Laryngoscope with Macintosh type curved blades.” by Sasata (talk). License: CC BY 3.0

Tube types

Tube types are a favorite topic in exams. There is the Magill tube, the Murphy tube, and the Woodbridge tube.

The **Magill tube** is made of plastic (PVC) and represents the **standard tube**. The slightly curved tubes with a normalized radius of curvature are generally intended for single use only.

The **Murphy tube** has an additional hole, the so-called “**Murphy eye,**” just in front of the tube tip. The ventilation can be performed via this lateral Murphy eye if the main lumen of the tracheal mucous membrane sits closely, or if an atypically arising right main bronchus is to be ventilated.

The **Woodbridge tube** is particularly suitable for operations in the prone position and other operative positions where the tube has to be bent much. The latex spiral tube reinforced with metal is extremely flexible and cannot be bent; thus, a stylet is used to

stabilize it during insertion.

Safe and unsafe intubation signs

Immediate control of the airway is important for each intubation. First, check to confirm whether the tube is correctly placed in the trachea. Due to anatomical proximity to the larynx, the tube may land in the esophagus (**esophageal intubation**). In this case, the air arrives in the stomach instead of the lungs. If the tube is too far advanced, it may be ventilating only one lung. Anatomically, due to the steeper angle mostly to the right, the tube may land in one of the main bronchi (**endobronchial intubation**).

Image: “A Carlens double-lumen endotracheal tube for selective bronchial intubation” by bigomar2. License: CC BY-SA 3.0

Secure intubation signs include the **direct visualization of the tube passing** through the vocal cords, a **bronchoscopic view** of the intra-tracheal position of the tube, and **CO2 detection** in the exhaled air with the capnometer (tidal volume 4–5% = 35–40 mm Hg). **Insecure (less reliable) intubation signs** are **chest rise**, **fogging of the tube inner walls** with breath moisture, **auscultatory breathing sounds** (particularly in children), as well as **constant readings for oxygen saturation with pulse oximetry** over extended periods of time.

Even if the intubation seems successful, a **chest x-ray is always done** to confirm the proper placement of the endotracheal tube.

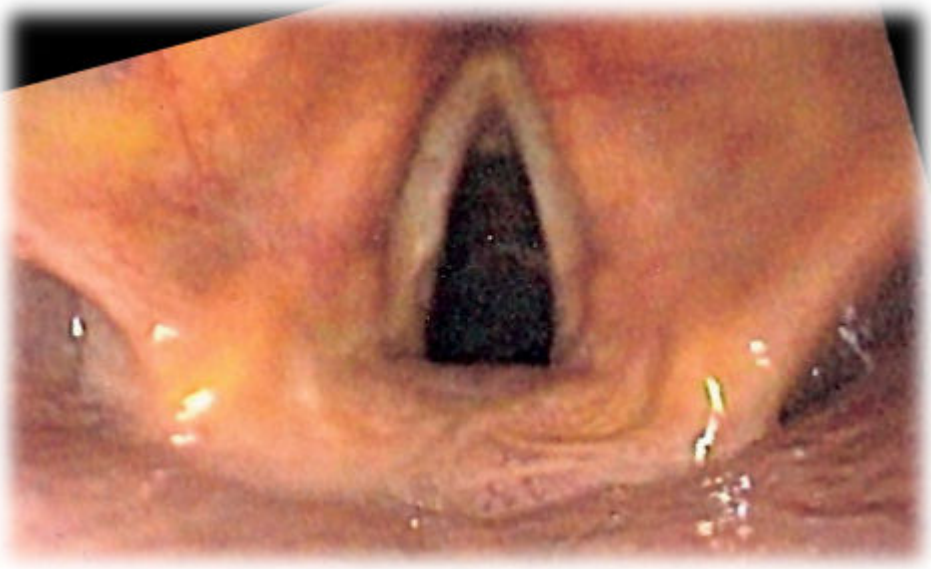

Image: “Endoscopic image of larynx seen at the time of intubation of the esophagus during gastroscopy.” by Samir. License: CC BY-SA 3.0

At a glance: Endotracheal intubation

Advantages

- Lower risk of aspiration
- Endobronchial suction via the tube is possible
- Secure aspiration of all anesthetic gases

Indication

- Operations in the face, neck, and chest area
- Regurgitation threat
- Surgical positions: sitting position, lateral position, prone position

Important tube types

- Magill tube – standard tube
- Murphy tube – “Murphy’s eye“
- Woodbridge tube – very flexible

Airway Difficulties

Problems during ventilation, such as keeping the airway open or providing sufficient ventilation of the respiratory tract, account for approximately 50% of **anesthesia-related complications**. Expected airway difficulties, such as poor visualization, can be overcome by using **video laryngoscope** or conducting **awake fiberoptic intubation**. Both methods allow the anesthesiologist to conduct a visual inspection of the tube position with a camera.

Note: Failure to secure the airway can lead to death from cardiac arrest or permanent brain damage from cerebral hypoxemia. This is the single most important aspect of the anesthesiologist´s responsibilities.

Some warning signs:

- Poor mouth opening (< 2–3 cm)
- Poor neck mobility (limitation of extension)

- Small or deformed mandible
- Mento-thyroid distance < 4 cm
- Short, thick neck
- Fixed flexion deformity to the neck
- Airway tumors, abscesses, or hematomata

Note: Always adopt the most conservative approach when there is any doubt about the ability to maintain the patient's airway.

1. Awake intubation is the safest technique when the patient's history indicates previous difficulty in securing the airway.
2. If there is any concern, always have airway adjuncts available for immediate use (stylet, bougie, video-laryngoscope, laryngeal mask airway (LMA), intubating LMA, cricothyrotomy kit).
3. Always keep a "difficult intubation" kit immediately available. Have a portable kit available for airway problems outside the OR (ICU, emergency room, wards, etc.).
4. Be knowledgeable in following a "difficult airway" algorithm (American Society of Anesthesiologists [ASA], Canadian Anesthesiologists' Society [CAS], Difficult Airway Society).
5. CALL FOR HELP EARLY!

Image: "Anesthesiologist using Glidescope video laryngoscope to intubate the trachea of a morbidly obese patient with challenging airway anatomy." by DiverDave. License: CC BY 3.0

"Can´t intubate"

Always remember to maintain the patient's oxygenation by bag-mask ventilation, and then utilize one or more of the airway adjuncts that you have available. DON'T PANIC!

The patient will be fine as long as you maintain oxygenation. If you fail after several attempts, consider waking the patient up and re-booking for an awake intubation at a later time.

“Can’t ventilate, can’t intubate situation”

Rarely (in less than 0.02% of patients), neither mask ventilation nor subsequent intubation is possible. When this situation arises, some call it the “can’t ventilate, can’t intubate” situation, and it is an absolute emergency. In this case, oxygenation becomes a priority.

The anesthetized patient is no longer able to breathe independently, so oxygen saturation drops rapidly. Escalation of this situation may lead to **hypoxic brain damage**. If the situation permits, anesthesia recovery with an evocation of the patient can bring him/her back to spontaneous breathing.

Often, as a first measure, you may successfully place a laryngeal mask, which can either be ventilated or fiber-optically intubated. If this fails, **cricothyrotomy or tracheotomy can be done** (you can read more about cricothyrotomy in our article “Anatomy of the Lower Respiratory Tract”) to re-open and secure the patient’s airway. If all attempts fail for an anesthetized patient, then a reversal agent is used to awaken the patient and let them breathe on their own to avoid hypoxia.

At a glance: Airway difficulties

Types

- Expected
- Unexpected

Procedures for the “can’t ventilate, can’t intubate situation”

- Place a laryngeal mask
- Ventilation or awake fiberoptic intubation
- Cricothyrotomy or tracheostomy (emergency)
- Transtracheal jet ventilation

Awake Intubation

Awake intubation can be unpleasant for the patient and the anesthesiologist, so practice on a simulator before trying on a patient. Watch a senior colleague do an awake intubation. Read and study textbook descriptions of awake intubation techniques. Understand the equipment and the procedure well, and prepare psychologically for your sake, as well as for the patient, who may show a variety of emotions. Consider doing superior laryngeal nerve block and/or transtracheal block to reduce discomfort to the patient.

Example: Technique of Dr. Brian Warriner

1. Ask the patient to gargle 2% lidocaine (5–10 mL) for as long as possible and then swallow any remaining solution.
2. Provide a small amount of sedation if the patient is anxious, but do not give enough to suppress breathing.
3. Grasp the tongue with gauze and pull it from the mouth as far as possible.
4. “Dribble” 1% lidocaine over the tongue and down the throat while the patient

breathes deeply.

5. When the gag reflex is lost, use fiberoptic bronchoscope through the mouth or nose (which has been prepared with drops of diluted phenylephrine to reduce bleeding).
6. When you see the vocal cords, stop advancing and inject 3 mL of 1% lidocaine through the bronchoscope. Slowly advance the bronchoscope. If the patient does not gag or cough, keep advancing. If they do cough or gag, inject another aliquot of lidocaine.
7. Do the same once the carina is seen. Advance the endotracheal tube over the bronchoscope and into the airway. Attach the endotracheal tube to an end-tidal carbon dioxide analyzer. If carbon dioxide is detected, inflate the cuff, and induce the patient.
8. Confirm that the tube has been placed and sedate.

Risk factors for difficult airway management:

- Issues with neck mobility
- Obesity
- Neck masses
- Pregnancy
- Burns
- Airway trauma
- Neck and oropharynx infections
- Angioedema
- Craniofacial deformity

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Notes