Airway Management in Anesthesia

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Airway management challenges are the common causes of morbidity and mortality of patients acquiring anesthesia during the operation. Airway management is an integral part of general anesthesia that allows ventilation and oxygenation in the patient. The prime purpose of airway management is to stabilize and secure the patient during an emergency or operation. Pre-operative assessment of respiratory tract should be done through the identification of patient’s relevant factors via standard diagnostic measures prior to anesthesia. This help to evaluate the 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 may be mechanically ventilated. A prior assessment of respiratory conditions, the decision of 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 (3 or more attempts to secure the airway that take more than 10 minutes) results in high anesthesia morbidity.

Airway Assessment

To be able to detect difficult intubation conditions before the induction of anesthesia, the attending anesthetist must examine a patient’s airway during the pre-medication visit.
This is important as it will help with planning ventilation and equipment choice (a video laryngoscope); thus, the following parameters should be enquired and analyzed under a fixed scheme:

- Medical history to establish any prior difficulty in intubation.
- Mallampati score where the size of the interincisor distance is estimated in the wide opened mount into:
  - 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 the medical history, we may initially gather information on any difficult intubation in the past. At the same time, a pre-medical doctor should inquire about and examine malformations and tumors in the mouth and throat area: everything which 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. We judge with the Mallampati score which pharynx 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 choose a Mallampati classification (Class I-IV) score. The goal is to determine whether the laryngeal inlet is visible with direct laryngoscopy.
Mallampati score:

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
<th>Visibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Uvula completely visible</td>
<td>Total glottis is visible</td>
</tr>
<tr>
<td>II</td>
<td>Uvula partially visible</td>
<td>Glottis is usually fully adjustable with a laryngoscope</td>
</tr>
<tr>
<td>III</td>
<td>Soft and hard palate visible</td>
<td>Varying good glottal adjustability</td>
</tr>
<tr>
<td>IV</td>
<td>Only hard palate visible</td>
<td>Usually only epiglottis or the base of the tongue</td>
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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 classification by **Cormack and Lehane**. It divides the invisible portion of the larynx in **Class I, II, III and IV**. The higher the class, the more difficult the intubation is.

**Cormack and Lehane:**

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Total glottis is visible</td>
</tr>
<tr>
<td>II</td>
<td>Glottis is only partially visible  (at the rear commissure)</td>
</tr>
<tr>
<td>III</td>
<td>Glottis is not adjustable. Only epiglottis is visible.</td>
</tr>
<tr>
<td>IV</td>
<td>Larynx structures and epiglottis cannot be adjusted. Only soft palate visible.</td>
</tr>
</tbody>
</table>
Mandibular space

The size of the **mandibular space** is another object of examination. The mandibular space includes the oral cavity and upper throat; thus, focusing on the space in front of the larynx. We estimate the distance between the chin and jawline. 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**, i.e. when intubation is not possible (e.g. in the case of the cervical spine stiffness in the context of ankylosing spondylitis), or it is only possible to a limited extent (for instance, due to 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 and 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 blood during the application of instruments.

Masks have an **elbow** with which **inspiration and expiration tubes** are connected.
Mask ventilation techniques

When carrying out the mask ventilation, you need to consider a few things: as a rule, the mask must be firmly fixed on the patient’s face with the left hand. While the mask is kept 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 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 the mask ventilation. This is an important disadvantage compared to intubation!
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 over-inflate the patient’s stomach. Additionally, even more important, 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 offers the possibility 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 laryngoscope. If the laryngeal mask is in its place, it cannot be further advanced, and the funnel is located at the entrance of the larynx, the bead is inflated which seals the larynx.

If air escapes during respiration despite adaptation attempts, 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 an adhesive tape in order to prevent an intraoperative slipping after successful placement.

Contraindications

Contraindications for a laryngeal mask include pharyngeal abscess or obstructions and restrictive lung diseases that require a high inspiratory pressure (> 30 cm H2O). A non-fasting patient also represents a contraindication, as the laryngeal mask closes the entrance to the esophagus and trachea not against each other, and therefore does not protect against aspiration in regurgitation.

Advantages and disadvantages

Advantages of the laryngeal mask against 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 a 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”, due to its relatively easy placement, the laryngeal mask can be a lifesaving temporary measure for securing the airway. Generally, the laryngeal mask is used during small, uncomplicated operations. With non-fasting patients, it offers no adequate aspiration protection. In these patients, endotracheal intubation is preferred.

Endotracheal Intubation

The endotracheal intubation is one of the most essential topics of anesthesia and is an indispensable tool. You should familiarize yourself with the instruments, the clinical implementation, 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 provides 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 gasses.
Intubation is highly reliant on oral opening, neck extension, and structure of the soft oropharyngeal tissues, neck movement, mandibular joints and the upper body weight of the patient. They determine the difficulty in intubation. Pre-existing medical conditions, such as rheumatoid arthritis, are necessary to identify so as to indicate larynx and trachea palpation if need be.

**Indication**

During **operations in the neck and facial area**, where supraglottic airway aids, such as a facial or laryngeal mask, are unfavorable.

With non-fasting patients, like **emergency patients** whose fasting is impossible to state, or with **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 difficult surgery positions, such as sitting, and operations in the lateral or prone position.

**Implementation**

To insert the tube under direct vision, the laryngeal aperture is presented 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 it be forcefully pressed inside.
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 OP 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 in order to
stabilize it during insertion.

**Safe and unsafe intubation signs**

Immediate control is important for each intubation. You should check if 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](image)

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 the CO2 detection in the exhaled air with the capnometer (tidal volume 4—5% = 35—40 mmHg). Insecure (less reliable) intubation signs are chest rise, fogging of the tube inner walls with breath moisture, auscultatory breathing sound (particularly in children), as well as a constant pulse oximetric saturation over longer periods of time.

Even if the intubation seems successful, a chest X-ray is always done to confirm the placement of the endotracheal tube.
At a glance: Endotracheal intubation

Advantages

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

Indication

- Operations in the face, neck and chest area
- Regurgitation threat
- Surgical positions: sitting, 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, describe 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
- Mentho-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 a previous difficulty in securing the airway.
2. If there is any concern, always have airway adjuvants available for immediate use (stylet, bougie, video-laryngoscope, 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 (ASA, CAS, Difficult Airway Society).
5. CALL FOR HELP EARLY!

“Can’t intubate“

Always remember to maintain the patient’s oxygenation by the bag and mask ventilation, and then utilize one or more of the airway adjuvants 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 (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 the priority.

The anesthetized patient is no longer able to breathe independently so oxygen saturation drops rapidly. Escalation of this situation may lead to a 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”) in order to re-open and secure the patient’s airway. If all attempts fail for an anesthetized patient, then suxamethonium is used to awaken the patient so that they 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

Can be unpleasant for the patient and 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.
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 fiber optic 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 a cough, keep advancing. If they do a 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 ETT to an end-tidal carbon oxide analyzer and if carbon dioxide is present, 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

**Review Questions**

The correct answers can be found below the references.

1. **What is determined by the Mallampati Score?**
   
   A. Dental status  
   B. Mouth opening  
   C. Reclination of the head in degrees  
   D. Visibility of pharynx structures with an open mouth and a protruded tongue  
   E. Complications of the previous anesthesia

2. **Which measure is NOT used in the “can’t intubate, can’t ventilate” situation?**
   
   A. Laryngeal mask  
   B. Cricothyrotomy  
   C. Transtracheal jet ventilation  
   D. Endotracheal intubation  
   E. Get experienced anesthesiologists to help

3. **Which one of the following belongs to secure intubation signs?**
   
   A. CO₂ detection in the exhaled air  
   B. Thorax excursion  
   C. Constant pulse oximetric saturation  
   D. Auscultatory breathing sound  
   E. Fogging of tube inner walls with respiratory moisture

**References**


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Correct answers: 1D, 2D, 3A

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