Airway Management in Anesthesia

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Mask ventilation, intubation: these concepts immediately get in the head in terms of anesthesia. Airway management is one of the central tasks of the anesthetist in order to direct the patient safely through anesthesia. We explain basics, techniques, and instruments from Murphy tube to laryngeal mask.

The purpose of airway management is to secure a patient’s airways 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.

Airway Assessment

To be able to detect difficult intubation conditions before induction of anesthesia, the attending anesthetist must examine a patient’s airway during premedication 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, the Mallampati score, the size of mandibular space, reclamation of the head and dental status.
Medical history

In the **medical history**, we may initially gather information on any difficult intubation in the past. At the same time, a premedical 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. Whether it is 2, 3, 4 or 6 centimeters: the wider it opens, the more “space” remains for the anesthetist to do his/her work. A restricted **mouth opening** makes it difficult, for example, 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>Laryngoscopically Visible</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 only partially visible</td>
</tr>
<tr>
<td>III</td>
<td>Soft and hard palate visible</td>
<td>Glottis is not adjustable. Only epiglottis is visible.</td>
</tr>
<tr>
<td>IV</td>
<td>Only hard palate visible</td>
<td>Larynx structures and epiglottis cannot be adjusted. Only soft palate visible.</td>
</tr>
</tbody>
</table>

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 difficulty of intubation increases.

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 mandibular space is another object of examination. 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 jaw line. The throat is usually clearly visible at a distance of > 9 cm (adults) (the Mallampati score).

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. Measures for dealing with difficult airways must be taken (see below) if this 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, or loose front teeth? 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 initially ventilated with a face mask manually until intubated or until a laryngeal mask is introduced to obtain sufficient oxygen saturation of blood during the application of instruments.

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

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 the tubes keep the airway free but offer no protection against aspiration, 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. A laryngeal mask 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 entry 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 close not 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 and the increased risk of aspiration, it offers no adequate aspiration protection. In this case, 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 is possible via the tube. And the secure aspiration of all anesthetic gasses is possible, which consequently allows medical staff to be less burdened with escaping gasses.
Indication

During operations in the neck and facial area, where supraglottic airway aids such as 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 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 push the tube after passing through the glottis with resistance, it must be replaced by a model with a smaller diameter. Under no circumstances should it be forcefully pressed inside.
Tube types

Are important to know, because they 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. One-sided ventilation of only one lung is possible if the tube is too far advanced. Anatomically, due to the steeper angle mostly to the right, the tube may land in one of the main bronchi (endobronchial intubation).

![A Carlens double-lumen endotracheal tube for selective bronchial intubation](https://via.placeholder.com/150)

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 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 placement of the endotracheal tube.

![Endoscopic image of larynx seen at the time of intubation of the esophagus during gastroscopy.](https://via.placeholder.com/150)
At one glance - endotracheal intubation:

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

**Indication**
- Operations in 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 are not possible, 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 of 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 neck
- airway tumors, abscesses or hematoma

**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 the 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 patient’s oxygenation by bag and mask ventilation. 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 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.

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 be then ventilated or intubated fiberoptically. If this fails, cricothyrotomy or tracheostomy can be done (you can read more about cricothyrotomy in our article “Anatomy of the Lower Respiratory Tract“) or a transtracheal jet ventilation in emergency cases, in order to re-open and secure the patient’s airway.

At one 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 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. Consider doing superior laryngeal nerve block and/or transtracheal block to reduce discomfort to the patient.

Example: Technique of Dr. Brian Warriner

1. Ask patient to gargle 2% lidocaine (5—10 ml) for as long as possible and then swallow any remaining.
2. Provide small amount of sedation if patient is anxious but do not give enough to suppress breathing.
3. Grasp tongue with gauze and pull it from mouth as far as possible.
4. “Dribble” 1% lidocaine over the tongue and down the throat while the patient breathes deeply.
5. When gag reflex is lost, use fiber optic bronchoscope through mouth or nose (which has been prepared with drops of dilute 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 ETT to an end-tidal carbon dioxide analyzer and if carbon dioxide is present, inflate the cuff, and induce the patient.

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

Anästhesie, Intensivmedizin, Notfallmedizin (2012) - Schattauer Verlag  
Lernkarten Allgemeine Anästhesie via miamed.de  
Morgan & Mikhail’s Clinical Anesthesiology - Lange  

Correct answers: 1D, 2D, 3A

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