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Airway Techniques

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Abstract

Airway management is a fundamental practice of vital importance in numerous clinical specialties, including anesthesiology, emergency medicine, and intensive care. In this review, commonly used techniques in clinical practice —bag-mask ventilation, endotracheal intubation methods (direct laryngoscopy, video laryngoscopy, and flexible bronchoscopic intubation), extraglottic airway devices (LMA, Combitube), and surgical airway techniques (cricothyrotomy and tracheotomy)— have been evaluated in light of the most current evidence. The advantages, limitations, clinical indications, and procedural details of each technique have been discussed in depth. The available data demonstrate that the choice of airway method varies according to the patient's profile and the urgency of the clinical situation. Advanced technological approaches improve success rates in difficult airway scenarios, while extraglottic and surgical interventions offer life-saving solutions during emergencies. Airway management should be approached holistically, encompassing not only technical execution but also accurate assessment, appropriate equipment selection, and sound clinical decision-making. Consequently, it is critically important for healthcare professionals to be proficient in all airway techniques and to continuously update their skills in order to ensure patient safety.

Keywords
airway management, bag mask ventilation, intubation, extraglottic airway techniques, surgical airway techniques

Introduction

Airway management is a fundamental skill required in various medical specialties, including emergency medicine, anesthesiology, and intensive care. Ensuring airway patency and maintaining adequate oxygenation and ventilation are critical for preserving the patient's vital functions. Properly applied airway techniques can prevent life-threatening complications such as aspiration, hypoxia, and hypercapnia [1].

The techniques used for airway management vary depending on several factors, including the patient's clinical condition, anatomical features, and the available equipment. With the advancement of modern technology, airway management encompasses a broad range of techniques, and their appropriate application has a direct impact on patient outcomes [2].

This review aims to discuss the fundamental techniques used in airway management. It will first examine basic airway maintenance methods such as bag-mask ventilation, followed by an evaluation of advanced airway techniques including direct laryngoscopy, video laryngoscopy, and flexible bronchoscopic intubation. Additionally, extraglottic airway devices and surgical airway management options will also be discussed.

Bag-Mask Ventilation

Bag-mask ventilation (BMV) is one of the most fundamental and frequently employed techniques in airway management. It is primarily used to ensure oxygenation and ventilation in patients who are apneic or exhibit inadequate spontaneous breathing. BMV plays a vital role in emergency situations, anesthesia induction, and resuscitation procedures [3].

The indications for BMV are presented in **Table 1**. Difficult BMV is encountered in approximately 5–9% of the population. Predictors of difficult BMV and intubation include increased body weight and neck circumference, snoring, obstructive sleep apnea, advanced age, edentulism, and a Mallampati score of class III or IV [4]. In certain conditions—such as severe airway obstruction, facial trauma, or anatomical deformities—BMV may prove insufficient. In patients at high risk of gastric regurgitation, BMV is often avoided due to the potential for aspiration of gastric contents. The risk of pulmonary aspiration is notably increased in patients with a full stomach, hiatal hernia, pharyngeal diverticulum, or esophageal motility disorders. Prolonged suboptimal BMV involving high peak inspiratory flows and pressures can lead to gastric insufflation, which increases intragastric pressure, elevates the diaphragm, restricts lung movement, reduces respiratory system compliance, and consequently raises the peak airway pressures required for effective ventilation [5,6].

Table 1: Indications for Bag-Mask Ventilation

• As part of basic life support in patients experiencing cardiac or respiratory arrest
• For preoxygenation prior to endotracheal intubation
• To provide alternative ventilatory support in cases of failed or delayed intubation
• For temporary ventilatory support in patients with respiratory depression not requiring a surgical airway

The face mask was introduced in 1847 by British physician John Snow for the administration of inhalational anesthesia and remains the oldest airway management device still in use today [7]. Proper placement of the mask on the face is essential to ensure optimal airway patency and to prevent air leakage. The generic left-hand 'E-C' technique is performed with the thumb and index finger resting on the dome (the 'C'), the third and fourth on the mandible and the fifth at the mandibular angle (the 'E') [8]. In two-handed mask ventilation techniques, an optimal seal is achieved, and airway patency is maintained through a bilateral jaw thrust maneuver. However, a second provider is required to operate the ventilation bag [9]. To evaluate the effectiveness of ventilation, it is essential to observe chest rise, utilize capnography, and monitor oxygen saturation [10].

Endotracheal Intubation Techniques

1. Direct Laryngoscopy

Direct laryngoscopy is a fundamental technique in airway management that allows for visual guidance of the endotracheal tube during intubation. This method is widely used to establish a secure and effective airway in patients with respiratory failure or those requiring surgical anesthesia [11]. The indications for endotracheal intubation are listed in **Table 2**; these also represent contraindications for noninvasive ventilation [12].

Table 2: Indications for Endotracheal Intubation (and Contraindications for Noninvasive Ventilation)

• Respiratory arrest
• Unable to fit mask
• Medically unstable condition
• Agitated and uncooperative patient
• Inability to maintain airway patency
• Absence of swallowing (protective) reflexes
• Multiple organ failure
• Failed noninvasive ventilation

In adults, the Macintosh Laryngoscope Blade is most commonly used for direct laryngoscopy. The blade is inserted along the floor of the mouth, directed to the right side of the tongue. By displacing the tongue to the left and elevating the mandible, the soft tissues within the submandibular space are compressed. This allows the operator to visualize the vocal cords and insert the endotracheal tube into the trachea. When using a Miller blade, the tip is placed posterior to the epiglottis and is used to lift it directly. Anatomical causes of difficult direct laryngoscopy may be summarized within the three-column model of difficult airways **(Table 3)** [13].

Preoxygenation is recommended for patients undergoing endotracheal intubation. This increases the oxygen reserve in the lungs and helps prevent desaturation during the intubation process [14]. Patients should be positioned appropriately and intubated using an endotracheal tube whose cuff has been checked in advance. Placing the patient in the "sniffing position"—a combination of lower cervical flexion and upper cervical extension, first described by Kirstein in the late 1800s—helps align the oropharyngeal and laryngotracheal curves. This alignment facilitates airway manipulation and improves the likelihood of successful direct laryngoscopy [15]. In intubated patients, it is essential to confirm correct placement of the endotracheal tube within the trachea.

Table 3: The three-column model of difficult airways

Anterior column (formed by the mandible and submandibular tissues)	Middle column (formed by the airspace)	Posterior column (formed by the cervical spine)
Reduced volume (e.g. short mandible or short thyromental distance) that limits the space into which tissues can be compressed	Laryngeal tumours	Ankylosing spondylitis
Reduced compliance of soft tissues (e.g. haematoma, infection, mass or previous radiotherapy to submandibular tissues) making compression more difficult	Lingual tonsillar hypertrophy	Manual in-line neck stabilisation
		Obesity, especially patients with enlarged dorsocervical fat pads ('buffalo humps') which prevent the head extending backwards

Chest auscultation (five-point auscultation: lung apices, axillae, and epigastrium) and capnography are the most commonly used verification methods in clinical practice [16].

When direct laryngoscopy is inadequate or unsuccessful, alternative methods such as video laryngoscopy and flexible bronchoscopic intubation can be utilized to achieve endotracheal intubation.

2. Video Laryngoscopy

Video laryngoscopy is a technique that enhances visualization during airway management and facilitates the intubation process. A high-resolution camera is mounted on the laryngoscope blade, and the image is displayed on a screen. Compared to traditional direct laryngoscopy, it provides a wider viewing angle of the vocal cords and significantly increases the success rate, particularly in difficult intubation cases [17,18].

Video laryngoscopes can be classified into three main types based on the blade design:

- Macintosh-like blade,
- Hyperangulated blade,
- Blade with an integrated tracheal tube-guiding channel (i.e. a conduit) [19].

Whether video laryngoscopy should be used routinely in place of direct laryngoscopy or reserved for patients with anticipated or identified difficult airways remains a topic of ongoing debate. However, it is well established that the experience level of non-physician providers can often overcome many of the technical challenges associated with video laryngoscopy [20,21].

3. Flexible Bronchoscopic Intubation

Flexible bronchoscopic intubation (FBI) is an advanced intubation technique used in the management of difficult airways. It is performed using fiberoptic bronchoscopes and is particularly preferred for securing the airway in patients with anatomical abnormalities or cervical spine instability. One of the key advantages of FBI is its ability to be performed not only under general anesthesia in an unconscious patient, but also in an awake patient [22].

Prior to performing FBI, it is essential to ensure that the device has been properly cleaned. After positioning the patient in a semi-recumbent or supine position, the bronchoscope is advanced either orally or nasally. The epiglottis, vocal cords, and trachea are visualized as the bronchoscope is directed into the trachea. Once the trachea is reached, the endotracheal tube is advanced over the bronchoscope under direct visualization, and the bronchoscope is then withdrawn [23].
Despite its widespread use today, complications such as airway bleeding—particularly during awake fiberoptic intubation—as well as obstruction and regurgitation, can still occur. These issues may occasionally lead to failure of the technique and necessitate the use of surgical airway interventions [24].

Extraglottic Airway Techniques

1. Laryngeal Mask Airways

The laryngeal mask airway (LMA), developed in the 1980s, is a supraglottic device widely used in both surgical anesthesia and emergency airway management. Originally designed as an alternative to endotracheal intubation, it provides an effective solution particularly in short-duration surgeries and in cases where intubation is difficult [25,26].

The LMA consists of a soft mask that is positioned in the pharynx and covers the laryngeal inlet, along with

The LMA consists of a soft mask that is positioned in the pharynx and covers the laryngeal inlet, along with an attached airway tube. The mask component is surrounded by an inflatable cuff, which creates a seal in the hypopharynx, allowing for effective ventilation. For insertion, the patient is positioned supine with the head extended. The LMA is advanced along the hard palate into the hypopharynx. Once the cuff is properly inflated, it seals the glottic opening, enabling ventilation [27]. **Table 4** outlines the advantages and disadvantages of the laryngeal mask airway [28-30].

Table 4: Advantages and disadvantages of LMA

Advantages	Disadvantages
• Less invasive compared to endotracheal intubation.	• Does not provide adequate protection against aspiration.
• Easy to use and requires less clinical experience.	• Ventilation may be compromised if the device becomes displaced.
• Short insertion time allows for rapid airway establishment.	• Air leakage may occur in certain patient positions.
• Does not require neck or head movement; advantageous in trauma patients.	• Not suitable for long-term ventilation.
• Minimal hemodynamic responses.	• May cause complications such as hypopharyngeal trauma and tongue edema.

Over time, various models of the LMA have been developed [30-33]:

Classic LMA™: The original model, primarily used in routine surgical procedures.

LMA ProSeal™: Contains a gastric drainage tube to reduce the risk of aspiration.

LMA Supreme™: A single-use device with a rigid structure designed for easier insertion and gastric drainage.

LMA Fastrach™: Also known as the "intubating LMA," it facilitates fiberoptic intubation.

2. I-gel

The i-gel is an extraglottic airway device with a supraglottic placement that has gained widespread use over the past two decades. It is anatomically shaped and made of a gel-like thermoplastic elastomer, from which it derives its name—reflecting both its "i"-shaped anatomical design and its soft, gel-like composition. This structure allows the device to conform anatomically to the pharyngeal and laryngeal structures without the need for cuff inflation. Developed as an alternative to balloon-inflated laryngeal masks, the i-gel provides an effective airway solution in both emergency and elective settings [34,35].

A full range of pediatric sizes is available, and the device consists of three main components. The mask portion does not require cuff inflation; it provides passive sealing through anatomical conformity. An integral bite block helps prevent airway occlusion during trismus or involuntary biting. The gastric drainage channel allows the insertion of an orogastric tube for gastric decompression, thereby reducing the risk of aspiration [35,36].

Insertion is performed in the sniffing position and requires that the i-gel is lubricated on all surfaces before insertion. Standard insertion mimics LMA insertion with the passage of the i-gel following the roof of the mouth and posterior pharynx until stopped by cricopharyngeus muscles [35,37].

The i-gel offers several advantages over the classic LMA, particularly due to its cuffless design and anatomical conformity. It facilitates more rapid airway establishment and reduces the risk of complications [37].

3. Combitube

The Combitube is a dual-lumen, dual-cuff extraglottic airway device developed for emergency airway management. It offers a rapid and effective alternative, particularly in prehospital and in-hospital emergency settings where intubation is difficult or not feasible. Its unique value lies in the ability to ventilate the lungs regardless of whether the device is positioned in the esophagus or the trachea. It was designed by Dr. Michael Frass in Austria in 1983 [38].

The device features two cuffs: a large oropharyngeal balloon located in the mid-portion of the tube and a smaller tracheoesophageal balloon situated distally. The two lumens are separated by a partition; one lumen is closed at the distal end and facilitates ventilation via eight side perforations located between the two cuffs, while the other lumen has an open distal tip. This design allows for ventilation through the perforated lumen when the Combitube is placed in the esophagus, and through the open-tip lumen when it is inserted into the trachea. The Combitube is designed for blind insertion with the patient's head in the neutral position, and it most commonly enters the esophagus when inserted blindly [39].

The advantages and disadvantages of the Combitube are summarized in **Table 5** [30,40].

Table 5: Advantages and disadvantages of Combitube

Advantages	Disadvantages
• Can be inserted blindly; does not require advanced skills. • Allows rapid insertion, saving time in emergencies. • Esophageal placement reduces the risk of pulmonary aspiration.	• Intended for short-term use; not suitable for prolonged ventilation. • Overinflation of cuffs may cause tissue damage. • Carries a risk of gastrointestinal complications (e.g., esophageal injury, gastric distension).
• Does not require head or neck manipulation, making it suitable for patients needing spinal stabilization.	• The rigid structure of the tube may cause oropharyngeal trauma.
• Serves as a bridge to endotracheal intubation.	• Not suitable for pediatric patients; only available in adult sizes.

Surgical Airway Techniques

1. Cricothyrotomy

Cricothyrotomy is one of the emergency airway management techniques and is considered the last resort in most airway management protocols. It is a life-saving intervention, particularly in “cannot intubate, cannot oxygenate” (CICO) scenarios [41].

Surgical cricothyrotomy has long been a standard of emergency invasive airway rescue; however, its use has declined, in part because of advances in noninvasive airway devices such as supraglottic airways and video laryngoscopes, the adoption of rapid sequence intubation in the emergency department, and increased requirements for trainee supervision [42].

The procedure is based on surgically opening the cricothyroid membrane to gain direct access to the trachea. This membrane is considered the most accessible part of the airway below the glottis [43]. Emergency cricothyrotomy may be performed in prehospital settings, emergency departments, intensive care units, or operating rooms. Elective cricothyrotomy is generally performed in the operating room prior to certain surgical procedures. It may also be performed bedside in critically ill ICU patients [44].

Cricothyrotomy can be performed via percutaneous or surgical techniques: In the percutaneous technique, a large-bore needle is inserted into the cricothyroid membrane under sterile conditions. Correct intratracheal positioning is confirmed by aspiration of air. A guidewire is then passed through the needle, followed by the insertion of a small-diameter cannula into the trachea over the wire. In the surgical technique, the patient is placed in the supine position with slight neck extension. The thyroid and cricoid cartilages are palpated, and the cricothyroid membrane between them is identified. A vertical skin incision is made over the membrane, followed by a horizontal incision through the membrane itself. A small-diameter endotracheal tube or tracheotomy cannula is then inserted into the trachea [45].

Despite being a life-saving procedure, cricothyrotomy carries potential complications, including bleeding, subcutaneous emphysema, esophageal perforation, infection, and long-term tracheal stenosis [46,47].

2. Tracheo(s)tomy

“Tracheotomy” is the operation of ‘opening the trachea’, derived from the Greek words trachea arteria (rough artery) and tome (cut). “Tracheostomy” has an ending derived from the Greek word stoma (opening or mouth) [48]. These two terms are often used interchangeably in clinical practice. Throughout this manuscript, the procedure will be referred to as "tracheotomy."

Tracheotomy is the procedure by which access to the trachea is obtained via a surgical incision between the second and fourth tracheal rings, and the airway is maintained by placement of a tracheotomy cannula. It is generally performed in patients requiring prolonged ventilation or those with long-term upper airway obstruction. Although it can be performed emergently in cases of acute airway obstruction, tracheotomy is more commonly undertaken as an elective procedure. This intervention serves both to facilitate ventilation and to bypass the upper airway [49].
The four primary indications for tracheotomy are prolonged mechanical ventilation, failure to wean from the ventilator, upper airway obstruction, and copious secretions [48,50]. Similar to cricothyrotomy, tracheotomy may be performed using either a percutaneous or a surgical approach. The percutaneous technique is typically performed at the bedside in the intensive care unit, whereas the surgical approach is usually reserved for the operating room. In the percutaneous method, the Seldinger technique is employed: a needle and guidewire are used to access the trachea under sterile conditions, the tract is sequentially dilated with dilators, and finally a tracheotomy cannula is inserted.

In the surgical technique, the patient is placed supine with the neck in extension. A vertical incision is made through the skin and subcutaneous tissue. Because the thyroid isthmus often covers the lower tracheal rings, it is carefully retracted superiorly or inferiorly. A horizontal incision is then made between the second and third tracheal rings, after which the tracheotomy cannula is inserted and secured [48-50]. Proper fixation of the tracheotomy cannula and meticulous skin care are essential to minimize the risk of infection.

The cannula should be regularly cleaned and monitored for obstruction or secretion buildup. Use of a speaking valve or heat–moisture exchanger may be required to optimize humidification and enable phonation. The decannulation or tracheotomy closure process is planned based on the patient's respiratory adequacy and clinical status [51].

The fundamental differences between cricothyrotomy and tracheotomy are summarized in **Table 6**.

Table 6: Differences Between Cricothyrotomy and Tracheotomy

Feature	Cricothyrotomy	Tracheotomy
Purpose	Temporary airway in emergency situations	Elective or long-term airway management
Procedure time	Very rapid (1–3 minutes)	Longer duration (10–20 minutes)
Technical difficulty	Relatively easy	More complex
Complication rate	Lower in the short term	Lower in the long term
Age group	Applicable in adults only	Can be performed in all age groups

Conclusion

Timely and effective application of appropriate airway management techniques not only increases a patient's chance of survival but also significantly reduces the risk of complications. Therefore, it is vital that clinicians possess adequate knowledge and experience not only in primary methods but also in alternative and advanced airway techniques.

Today, airway management is not merely a set of technical procedures; it is a comprehensive process that requires pre-assessment, an algorithmic approach, appropriate equipment selection, and multidisciplinary collaboration. The success of this process is directly linked to the clinician's knowledge base, skill level, and decision-making capacity.

In conclusion, considering the wide range of airway techniques and their respective roles in various clinical contexts, physicians must act not only as practitioners but also as strategic decision-makers capable of selecting the most appropriate method for each situation. Mastery in airway management—achieved through education, simulation training, and continuous professional development—is essential for ensuring patient safety and successful outcomes.

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