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Airway Management: A Review and Update

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Abstract

In following the 'ABCs' of resuscitation, (airway, breathing, and circulation) airway management is the first priority for patients in the emergency department, for evaluation of patients by the anesthesiologist for surgery, and for patients decompensating in the critical care setting. The goal is to ventilate adequately enough to meet the patient's oxygen demands and eliminate carbon dioxide. Over the past 20 years, changes in airway management techniques have led to decreased morbidity and mortality in both the acute care and surgical setting. With difficult intubation being reported as up to 3% of airway emergencies in the emergency department1, and the incidence of failed intubation in the operating room approximately 1 to 3 per 1000 patients2, the skillful use of both traditional and alternate techniques are necessary to provide adequate care. This review covers airway anatomy, assessment of the airway, indications for intubation, techniques, and some of the pharmacological issues in airway management.

ANATOMY

Knowledge of the anatomy of the hypopharynx is essential for airway management. When viewing the hypopharynx using a laryngoscope, the epiglottis is visualized. The epiglottis is the structure that overlies the laryngeal inlet arising from the vallecula (Figure 1).

Figure 1

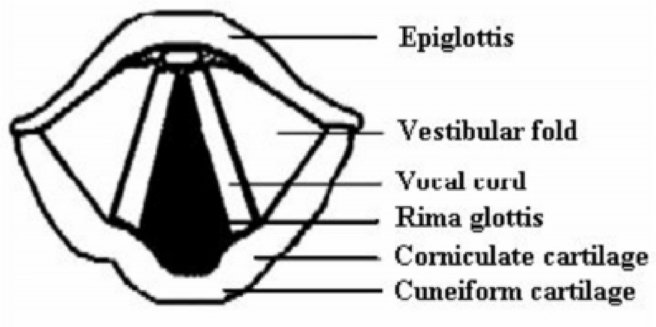


Figure 1 - Laryngoscopic view of the larynx

Using a curved laryngoscope (Macintosh), pressure applied to the vallecula lifts the epiglottis for visualization, utilizing a laryngoscope with a straight blade (Miller), the epiglottis is directly lifted for visualization of the laryngeal inlet. The true vocal cords are the gray-white colored structures located medially to the vestibular folds. The space seen between the relaxed vocal cords, called the rima glottidis is entered with an endotracheal tube during intubation. Anteriorly, the true vocal cords attach to the thyroid cartilage (Figure 2), which may be externally manipulated to improve visualization of the larynx.

Figure 2

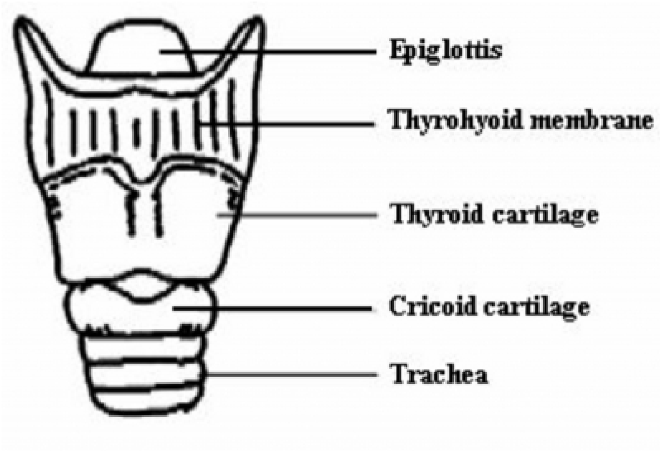


Figure 2 - Anterior view of laryngeal anatomy.

Laterally, the aryepiglottic folds attach the epiglottis to the cuneiform tubercles. Medial to these structures are the corniculate tubercles that are connected by the interarytendoid notch. The cricoid cartilage located beneath the true vocal cords completely encircles the trachea. The external application of pressure to the cricoid cartilage (Sellick's maneuver) is a technique used to make aspiration less likely by compression of the esophagus.3

Knowledge of the innervation of the larynx, particularly the left recurrent laryngeal nerve (RLN) and the superior laryngeal nerve (SLN), is important with regards to airway management. The left RLN courses around the arch of the aorta at the ligamentum arteriosum making it prone to surgical injury. Unilateral injury to the RLN results in adduction of the ipsilateral vocal cord and a hoarse voice. Bilateral injury to the RLN can cause adduction of both the vocal cords leading to complete airway obstruction.3,4 The external branch of the superior laryngeal nerve supplies the cricothyroid muscle after transversing the thyrohyoid membrane. Injury to the SLN will not result in airway obstruction, but may lead to hoarse vocalization by tensing the vocal cords.4 In an awake patient, bilateral SLN blocks along with topicalization of the airway may be used, allowing the patient to better tolerate manipulation of the oropharynx and intubation. To perform this block, locate the greater cornu of the hyoid bone and inject 3ml of lidocaine approximately 1cm caudal to this point.5 Caution should be taken when using this type of block because cough reflexes may be depressed leading to an increase risk of aspiration.5

ASSESSING THE AIRWAY

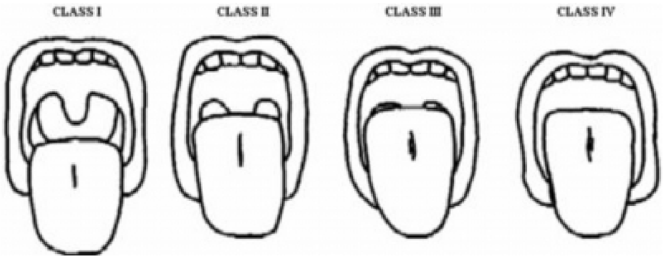
With an understanding of airway anatomy, a thorough patient evaluation is essential in airway management. Evaluation involves obtaining a history and performing a physical exam.

HISTORY AND PHYSICAL EXAM

Taking an adequate history is necessary to anticipate possible complications. With regards to airway management, the history should focus on prior intubations, anesthetic history, drug allergies, and confounding illnesses that may hinder airway access. A history of difficult intubation has the highest positive and negative predictive value in predicting a difficult intubation.6 The examination of the airway involves inspection of the state of dentition; especially loose teeth, upper incisors as well as protuberant incisors. Visualization of the oropharynx is classified most commonly by the Modified Mallampati classification system. This system is based on the visualization of the oropharynx (Figure 3) when a seated patient opens his or her mouth and protrudes the tongue.7,8

Figure 3

FIGURE 3: Views of the pharynx as classified by Mallampati et al.7 (Modified from Samsoon GLT, Young JRB8: Difficult tracheal intubation: a retrospective study. Anaesthesia. 1987;42:487)



In this classification system, Class I and II airways are generally predicted easy to intubate, while Class III and IV are sometimes difficult (Table1).8 Though this system lacks specificity,8 it does allow for preparation of possible complications and improves communication between medical personnel with regards to a patient's airway.

Figure 4

TABLE 1 - Mallampati Airway Classifications (Modified from Mallampati RS, Gatt SP, Gugino LD: A clinical sign to predict difficult tracheal intubation: A prospective study. *Can Anaesth Soc J.* 1985;32:429)[7]	
Class I:	visualize the soft palate, uvula, fauces, anterior and posterior tonsillar pillars
Class II:	soft palate, fauces, uvula
Class III:	soft palate, base of uvula
Class IV:	no structures are visible

In addition to the Mallampati classification system, other physical findings have been shown to be good predictors of a difficult airway. Wilson et al. using linear discriminant analysis incorporated five variables: body weight, head and neck movement, jaw movement, receding mandible, and buckteeth into a scoring system that predicted 75% of difficult intubations at a risk criterion =2 (Table 2).9 Other factors used to predict a difficult intubation include:

- Large tongue
- Less than 6 cm distance from mandible to thyroid notch
- Inability to place patient in “sniff” position
- Short neck4,10,11,12,13

INDICATIONS FOR INTUBATION

Establishing indication for intubation is a primary step in airway management. In general, indications for intubation include:

1. Protection of the airway from obstruction or aspiration
2. Facilitation of positive pressure ventilation
3. Airway control for diagnostic and therapeutic measures14

Multiple situations lead to one of these three indications. For example, unconscious patients with poor ventilatory drive, patients with suspected epiglottitis, patients with severe laryngeal angioedema, and patients with possible foreign body obstruction require intubation for airway management. After patient evaluation and if intubation is indicated, an airway management technique is selected.

AIRWAY MANAGEMENT

Medical personnel should be knowledgeable in management devices and techniques. The approach to the patient in need of airway access begins with relief of possible obstruction. Since the tongue is the most common cause of airway obstruction, relief is attempted by tilting the head, chin lift, and or jaw thrust.3,15 This will decrease the amount of soft tissue obstruction around the airway. Supplemental oxygen may then be given via facemask or nasal canula.

Two easily implemented non-definitive techniques include the oral and nasal airway. The oral airway is designed to relieve obstruction caused by the tongue, and assist in mask ventilation.3,4,15 Possible complications of placement of an oral airway include initiation of gag reflex, vomiting, aspiration, laryngospasm, and damage to teeth and lips.3,16

The cuffed oropharyngeal airway (COPA) is a modified version of the oral airway with an inflatable cuff and distal port for attachment to an anesthetic circuit.17 When properly placed, the COPA is designed to displace the tongue, provide an airtight seal, and elevate the epiglottis.17 In addition to use as a non-definitive airway, this device has been used as an aid for tracheal intubation18, and as an airway during anesthesia in spontaneously breathing patients.17,19,20 When compared to the LMA, the COPA has been shown to provide similar results physiologically, but does require more manipulation for placement.17,19 The nasal airway may be preferable to the oral in cases such as in pharyngeal trauma or to facilitate nasotracheal intubation. Like the oral airway, the nasal airway will relieve some of the soft tissue obstruction of the posterior pharynx.3

Definitive airway techniques most commonly used include endotracheal and nasotracheal intubation. The use of a definitive airway allows for control of ventilation, protects the airway from aspiration, and allows for delivery of higher concentrations of supplemental oxygen.21 Before an airway is placed, the patient is placed in the optimal position for alignment of the three anatomic axes, the oral, pharyngeal, and laryngeal.21 The “sniffing” position best allows for this (Figure 4). Alternative techniques for obtaining an airway are discussed later.

Figure 5

Figure 4: The patient is lying in the sniffing position. In this position, the oropharynx, pharynx, and larynx are in alignment.

OROTRACHEAL INTUBATION

Orotracheal intubation is the most commonly accepted method for securing an airway. When performed by a skilled clinician, it has been shown to have a high rate of success with low rate of complication.22 However, similar to many procedures in medicine, orotracheal intubation is a skill that requires practice to become proficient. One study conducted by Konrad et al demonstrated a 90% success rate after 57 attempts in first year anesthesiology residents.23 Videotapes and anatomical models have been used to facilitate the learning of this skill in medical students, residents, and nurses.21

When intubation is planned, a pneumonic such as MSMAID

(Table 3) is a helpful tool for evaluating your preparedness. The patient is placed in sniffing position, and preoxygenated via facemask. First narcotics and then an induction agent is given. Prior to giving neuromuscular blocking agent, it is usually necessary to establish the ability to ventilate. After muscle relaxant takes effect, the patient is either mask ventilated before being intubated, or immediately intubated if the rapid sequence induction (RSI) technique is being used. Usually in RSI, short acting relaxants like succinylcholine are used.14

Figure 6

Table 3 - Pneumonic MSMAID   *For pre-intubation check*
Machine check including ventilatory settings
Suction is on with catheter in place
Monitors are on the patient (blood pressure cuff, pulse oxymeter, ECG, ETCO2 detector
Airway equipment (including oral/nasal airway, face mask, endotracheal tubes, stylets, laryngoscope with working bulb)
IV access for administering drugs and giving fluids
Drugs including induction agents, muscle relaxants, and drugs for resuscitation

When attempting to intubate it is important to be careful not to use the patient's upper incisors as leverage for the laryngoscope. Damage to dentition is a preventable common side effect of intubation.24 After visualization of the vocal cords, the endotracheal tube is inserted. Correct placement of the endotracheal tube may be confirmed by:

- Direct visualization of the endotracheal tube cuff passing the vocal cords
- Presence of ETCO2 on three consecutive breaths
- Absence of stomach “gurgling” sound made by air entering the stomach. It is important to auscultate over the stomach before the lungs because the stomach may rapidly fill with gases in case of esophageal intubation
- Equal bilateral breath sounds over the lungs
- Fogging of the endotracheal tube
- Refilling of the ventilatory bag with expiration
- Rarely, a chest x-ray may be used to confirm placement of tube 14,25

NASOTRACHEAL INTUBATION

Nasotracheal intubation provides another definitive route of securing an airway. In cases such as oral surgery, this route of intubation is preferred. The choice of nostril does not appear to be a factor in the rate of peri-operative complications.26 The nostril that the patient breathes more easily through is usually chosen for intubation.21 After preparation of the nasal mucosa with vasocontricting nose drops and dilation of the nostril with progressively larger nasal trumpets, the tube is inserted into the nose until visualized in the oropharynx. With the aid of a laryngoscope and Magill forceps, the tube is then advanced into the trachea. Alternatively, the nasal tube may be inserted over a fiberoptic scope.21,27 Complications that can occur with this route of intubation include bleeding, infection, laryngospasm, and damage of the turbinates.28

RAPID SEQUENCE INDUCTION

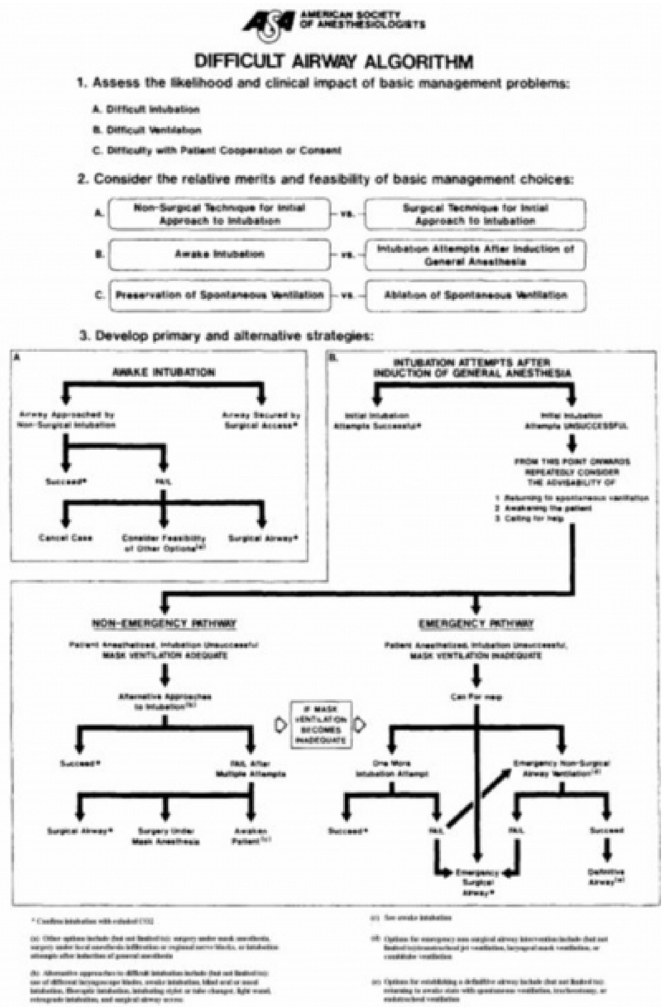
Rapid Sequence Induction (RSI) is a commonly used technique of intubation in emergent cases and in surgical patients at risk for aspiration.29 RSI consists of pretreatment, preoxygenation, administering of a short acting induction agent, and the administering of a neuromuscular blocker. Pretreatment also involves the administering of drugs to decrease the cardiovascular response to intubation. Lidocaine has been shown to blunt the cardiovascular response to the stimulation of the airway.30 Common induction agents are thiopental, propofol, and etomidate.29,31 Paralysis is commonly achieved with either succinylcholine or rocuronium.32,33 Many clinicians prefer to intubate without confirming the ability to mask ventilate the patient. Sellick's maneuver, continuous pressure on the cricothyroid cartilage, is employed to decrease aspiration related complications such as Mendelson's Syndrome.3 After placement of the endotracheal tube, confirmation of its placement is performed as in standard orotracheal intubation.

THE DIFFICULT AIRWAY

In many situations conventional methods of managing an airway may be inadequate and fail. Alternatives to these conventional techniques (oral and nasal intubation) must be practiced and well understood for optimum airway management. The American Society of Anesthesiologists Task Force on the Difficult Airway defines a difficult airway as a clinical situation in which a conventionally trained anesthesiologist experiences difficulty in mask ventilation, tracheal intubation or both.34 Management of a difficult airway has been reviewed extensively and is well summarized by the ASA Difficult Airway Algorithm (Figure 5).34

Figure 7

Figure 5: Difficult Airway Algorithm. Modified from Caplan RA, Benumof JL, Berry FA et al: Practice guidelines for management of the difficult airway: A report by the American Society of Anesthesiologists on Management of the Difficult Airway. Anesthesiology. 1993;78:578-59734



The algorithm begins with the recognition of a difficult airway by a clinician. The clinician will then consider the non-surgical vs surgical approach, awake intubation vs. intubation after induction, and the need for spontaneous vs. mechanical ventilation. Once these choices are considered, the algorithm is followed based on one of two strategies: awake intubation vs. intubation following induction. The choice to intubate must begin with the patient in proper position while maintaining oxygen saturation.4 Techniques available include oral and nasal intubation, retrograde intubation, fiberoptic intubation, cricothyroidotomy, and tracheostomy.34 Intubation after induction follows an emergent or non-emergent pathway. Both pathways for intubation have a common endpoint, to promptly and safely secure an airway. In addition, the availability of a difficult airway equipment cart is mandatory for these cases. Items to be included allow for alternative techniques to be implemented more readily (TABLE 4).34

ALTERNATIVE AIRWAY TECHNIQUES

LARYNGEAL MASK AIRWAY

When compared to orotracheal intubation, the LMA is considered easier and faster to place correctly.25,26 The lubricated LMA is inserted into the hypopharynx until the tip meets the upper esophageal sphincter.1,26,27 The cuff is then inflated. This low-pressure cuff increases the risk of aspiration if vomiting occurs during ventilation.2,27,35,36 When using the LMA in this manner the use of muscle relaxants do not necessarily improve the success rate of intubation, but decrease the incidence of coughing and movement.1 Therefore, muscle relaxants are generally given before LMA placement. Contraindications to the LMA include the need for peak pressure greater than 20cms H20, patients at risk for aspiration, and patients with low lung compliance necessitating the need for high-pressure ventilation.1

In the emergent situation, or in cases of a difficult airway, the intubating LMA-Fastrach can be used as a conduit for placement of an endotracheal tube.2,27,37,38 Ferson et al. demonstrated high success rates for blind and fiberoptically guided intubations (96.5% and 100% respectively) using the LMA-Fastrach in patients with difficult airways.39 The LMA-Fastrach is a modified version of the standard LMA with a large bore metal tube, a metal handle, and an epiglottis elevating bar. The LMA-Fastrach is placed inside the mouth and the endotracheal tube is passed through the device and blindly inserted into the trachea. It can accept up to an 9.0 mm endotracheal tube.2 Levitan et al found that after a 60-second instruction to experienced LMA users, a successful airway using an intubating LMA-Fastrach was established 97% of the time in a median time of 35s.2

The ProSeal LMA is a newer LMA model. Its modified cuff has been shown to provide a more effective seal than the standard LMA, and it comes with a drainage tube for gastric tube placement.36 Because of the better seal provided by the ProSeal LMA as compared to the standard LMA, the ProSeal LMA may be safer for use in patients at risk for aspiration and in the emergent difficult airway scenario.36

TRANSTRACHEAL JET VENTILATION

Transtracheal jet ventilation is performed by the placement of a large bore catheter (14-gauge) through the cricothyroid membrane into the trachea.4,14,35 The placement of the catheter is confirmed by aspiration of air before connecting to the ventilation system. This method can provide a temporary airway until an alternate airway is established.35 Complications with this technique include aspiration, bleeding, pneumothorax, subcutaneous emphysema, and inadequate ventilation.4,15

FIBEROPTIC INTUBATION

The use of a bronchoscope may facilitate the placement of an endotracheal tube both nasally and orally. The scope is passed through the glottis for direct visualization of the vocal cords, at which time the trachea is entered. An endotracheal tube may then be passed over the bronchoscope into the trachea.35 The bronchoscope may identify causes of acute hypoxia, and may help to remove secretions in the airway. Indications for fiberoptic tracheal intubation include a history of difficult intubation, a compromised airway, in cases as where extension of the neck is not possible, or for awake intubation with topical anesthesia.40 An Ovassapian intubating airway is an fiberoptic intubating airway used to facilitate passage of a flexible bronchoscope and placement of an endotracheal tube.40 Because of the time and skill needed to perform this procedure, this technique is not often used in an emergent situation.15 Limitations to this technique include secretions obstructing view, operator inexperience, and need for patient cooperation.35

RETROGRADE INTUBATION

This technique of intubation involves the placement of a guide wire through the cricothyroid membrane and into the pharynx in a retrograde fashion. The guide wire is then used to aid placement of an endotracheal tube.4,15

BULLARD LARYNGOSCOPE / WU SCOPE

The Bullard laryngoscope is a rigid fiberoptic device that has been used in patients with a difficult airway. Because visualization of the larynx is performed while the patient is in the neutral position, its use in the trauma setting has increased.15,35,41 Other advantages of this device include its easy portability and time to successful intubation.42 Like the Bullard laryngoscope, the Wu scope is also used with the patient in the neutral position.1 Unfortunately, the unfamiliarity and cost of these devices limit their use.

LIGHTWAND

The lightwand is a malleable stylet with a small light bulb on the end. An endotracheal tube is placed over the lightwand and is inserted into the mouth. Once at the tip of the larynx, the endotracheal tube is slipped into the larynx. If the endotracheal tube happens to enter the esophagus, the light dims. The endotracheal tube may then be withdrawn, and another attempt at placement is attempted. This technique must be practiced in a darkened room, limiting its use to a controlled setting.10,35

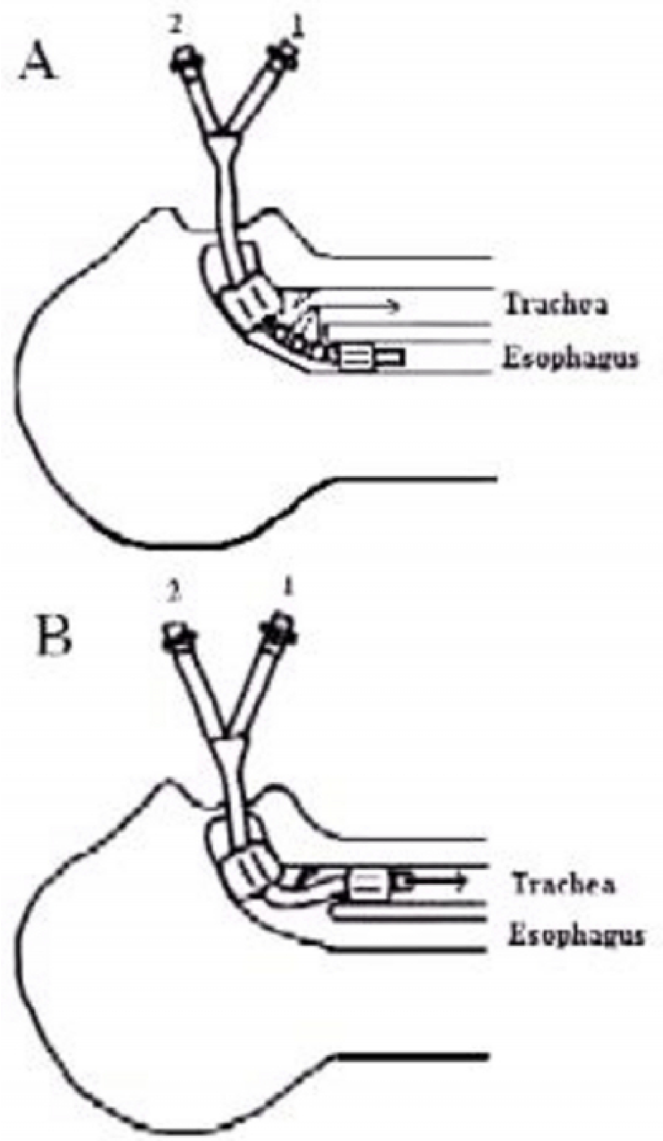
COMBITUBE

The combitube is a double lumen tube with one tube serving as an esophageal airway, and the other as a tracheal airway.35 Its blind placement into the hypopharynx makes it an important device in emergency airway management. After placement, the longer esophageal tube, tube 1, is ventilated. If no CO_2 is detected with ventilation, the tube is correctly placed in the esophagus. The ventilator is then attached to the other, tube 2, for ventilation into the trachea (Figure 6-A). Three percent of the blind combitube intubations lead to tracheal placement of the esophageal tube. When this is the case, tube 1 is ventilated instead of tube 2 (Figure 6-B).35 Placement of the combitube while the patient's neck is in the neutral position allows an advantage for use in the trauma patient.1 The major contraindication to use of the combitube is esophageal pathology.1,10,43,44

Check the article written by the inventor of the Combitube to read more about this device (http://www.ispub.com/ostia/index.php?xmlFilePath=journals/ija/vol5n2/combi.xml)

Figure 8

Figure 6: A The combitube is correctly placed in the esophagus. Tube#2 is used to ventilate the trachea. B. The combitube is placed in the trachea. Tube #1 is used to ventilate the trachea.



SURGICAL AIRWAY

A surgical airway is indicated when other means of establishing an airway fail, or in cases of laryngeal trauma, facial injuries, or long term need of ventilatory support.15,34 Cricothyroidotomy is the preferred method of a surgical airway. It involves the opening of the cricothyroid membrane for placement of a tracheal tube.45 Complications to this technique include bleeding infection, vocal cord damage, and tracheal stenosis.15 Cases in which a cricothyroidotomy is contraindicated include age <12 years, laryngotracheal disruption, or coagulopathy.15 When a cricothyroidotomy is contraindicated, a tracheostomy is the preferred approach.45 In these cases, Freidman et al demonstrated that a percutaneous dilational tracheostomy is a faster procedure with fewer complications than a surgical tracheostomy.45

AIRWAY PHARMACOLOGY

Many pharmacological agents are used in airway management. However two classes of drugs are used most commonly, induction agents and muscle relaxants. Readers are advised to consult other sources for review of other pharmacological agents.

INDUCTION / HYPNOTIC AGENTS

Thiopental is a frequently studied short acting barbiturate. It produces rapid induction at an IV dose of 3-6 mg/kg making it favorable for use in the rapid sequence induction.46 Because of its cerebral protective effects, it is used often in trauma patients in place of other induction agents. However, thiopental is known for causing vasodilation and should be used cautiously in the hypovolemic patient.29 In addition, thiopental may precipitate acute intermittent porphyria in susceptible patients by the induction of aminolevulenic acid synthetase.46

Propofol, a phenol, is an ultrashort acting anesthetic used for induction at doses of 2-3 mg/kg, and used for maintenance of anesthesia.25 Its depressant effects on cardiovascular function are greater than that of the barbiturates making its use in the trauma department less than ideal.29 Because of its quick onset and rapid recovery time, propofol has however become a popular choice for induction in the operating room. Previously it was thought that patients allergic to eggs should not receive propofol because propofol is contained in a solution of 1.2% egg phosphotide. However, most egg allergies are to egg albumin, not egg phosphotide, and therefore may be used safely in patients with this allergy.25

Etomidate, an imidazole, is another commonly drug used for rapid induction. At an induction dose of 0.2 to 0.5 mg/kg, etomidate tends to preserve cardiovascular function.46 This property of etomidate makes it favorable for use in the trauma patient, RSI, and in patients with known heart conditions.5 Drawbacks to use of etomidate are the possibility of causing adrenocortical suppression with repeated use, laryngospasm, coughing, and hypertonus.46 Contraindications to the use of this drug include patients with pre-existing adrenocortical insufficiency, and patients with CHF.5

Ketamine, a phenycyclidine derivative, is regarded by many as the only “complete” anesthetic. Its properties include anesthesia, amnesia, and analgesia.29 By interrupting the association between the thalamocortical and limbic system, ketamine provides a “dissociative” type of anesthesia.29 At induction dose of 2mg/kg IV or 4-5mg/kg IM patients generally recover within 10-15 minutes if no other agents are added.14

By causing the increased release of catecholamines, ketamine has bronchodilator and dose related cardiovascular effect.47,48 Its bronchodilator properties and the preservation of airway reflexes make ketamine useful in patients with reactive airway disorders.3,14,41 Recovery from ketamine is associated with dysphoria and agitation making its use as a sole anesthetic agent limited.48 However, the concomitant use of a benzodiazepine, such as midazolam, may attenuate these effects.47

MUSCLE RELAXANTS

Use of muscle relaxation in patients to be intubated has shown to decrease the number of complications when compared to non-paralyzed patients. 49 Muscle relaxants may be depolarizing and non-depolarizing. Succinylcholine is the only depolarizing muscle relaxant in clinical use. At an induction dose of 1-1.5 mg/kg, it is used as the muscle relaxant of choice in RSI and regular tracheal intubation.29 Despite is usefulness in emergent and anesthetic care, succinylcholine has well documented side effects that must be considered prior to its use:

- Hyperkalemia
- malignant hyperthermia
- allergy to succinylcholine
- rhabdomyolysis 32

When a patient with potential contraindications to succinylcholine requires intubation, a fast acting non-depolarizing agent, such as rocuronium, can be substituted.33 Kirk-Nielson et al demonstrated that after induction with propofol or fentanyl, rocuronium 1.04 mg/kg gives a 95% success rate of intubation at 60 seconds.33

Cisatracurium is a newer non-depolarizing muscle relaxant. Its rapid onset and lack of significant hemodynamic side effects make it a good choice for rapid sequence induction, and normal intubation. An intubation dose of 0.1-0.15 mg/kg will result in paralysis within two minutes.46 Compared to rocuronium, cisatracurium has a slower time to relaxation, but has been shown to have similar times of recovery.50 Because cisatracurium is metabolized independently of renal and hepatic function by Hoffman elimination, it is used in patients with renal and hepatic disease.46,48,50,51 Cisatracurium has virtually no histamine release.46

SUMMARY

Securing an airway as quickly and safely as possible is the major issue in airway management. Many devices and techniques are available for this purpose. However, even the most experienced and skillfully trained anesthesiologist will encounter difficulties with the management of an airway. These situations require the ability to anticipate, recognize, and manage complications as they occur. Careful review and practice of assessment principles and techniques may tilt the balance between success and failure in airway management.

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