Recent Advances in Airway Management

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Abstract

Airway management is a critical component of modern anesthetic care. Advances in airway management, as well as the recent history of airway management teaching at The Mount Sinai Hospital, are reviewed.

Key Words: Airway management, Bullard laryngoscope, cuffed oropharyngeal airway, esophageal-tracheal Combitube, flexible fiberoptic laryngoscope, laryngeal mask airway, unanticipated difficult airways, Wu laryngoscope.

Approximately one-third of all adverse anesthetic outcomes are related to respiratory problems (1), and almost one-third of all anesthetic-related deaths result from an inability to manage the difficult airway (2). Airway patency for oxygenation and ventilation remains a pivotal point in modern anesthesia practice. Failure to provide the patient with an adequately patent airway leads to cerebral hypoxia, rapid deterioration and, possibly, death.

In an effort to help prevent airway-related morbidity and mortality, the American Society of Anesthesiologists published practice guidelines in 1993. An algorithm is provided to facilitate handling of the difficult airway (3). The first portion of the algorithm addresses the anticipated difficult airway. Unfortunately, despite all the information currently available, no single factor reliably predicts difficulties; consequently, many difficult airways are not recognized until after induction of general anesthesia (4). These airways are termed the "unanticipated difficult airways." Care of patients presenting with unanticipated difficult airways relies on both invasive and noninvasive techniques. Noninvasive techniques are discussed below.

Masks

Facemask ventilation is the most frequently applied of all modern techniques. This method is generally the first one learned and the first one applied. Unfortunately, facemask ventilation is frequently difficult to achieve. Successful facemask ventilation depends on airway patency. Commonly, when the patient is in the supine position, the base of tongue falls posteriorly and obstructs the airway. Chin lift, jaw thrust, and oral or nasal airways generally overcome this impediment. Facemask ventilation is fraught with potential complications. One of the most frequent and serious complications is gastric insufflation. Forcing gas into the stomach predisposes the patient to two important problems: aspiration pneumonitis and ventilatory embarrassment. Maintaining airway patency and utilizing inspiratory pressures of less than 20 cm of water help prevent introducing gas into the stomach.

In 1983, Brain (5) first described a new mask (Figure), the laryngeal mask airway (LMA). LMAs have been commercially available in the United States since 1992 and have met with great success. As the name implies, laryngeal mask airways are masks that fit around the larynx. In contrast to endotracheal tubes, LMAs do not enter the larynx, vocal

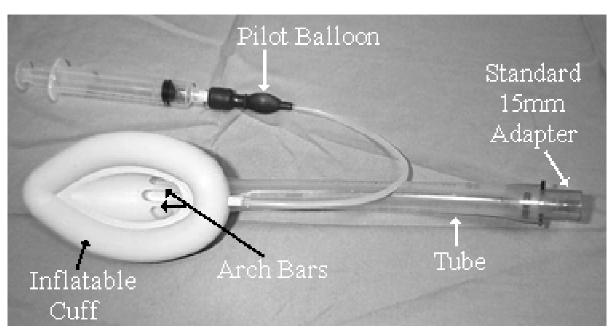

Figure. Classic laryngeal mask airway.

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cords, or trachea. As with the face mask, gas leaks are common around the LMA. Current models are constructed from silicon, thereby removing the potential for latex allergies, and are available in a variety of sizes designed to fit everyone, from the smallest to the largest. Various LMA models provide reinforced tubes to prevent kinking, are nonmetallic for use with magnetic resonance imaging, facilitate endotracheal intubation, or divert regurgitated gastric content away from the trachea.

LMA insertion requires ablation of gag reflexes. Those who would otherwise not tolerate airway manipulation are poor candidates for LMA placement. With the patient's head in the sniffing position, the operator opens the patient's mouth. The convex portion of the LMA is placed against the hard palate, and the device is inserted around the base of the tongue until it abuts the upper esophageal sphincter residing at the bifurcation of the digestive and respiratory tracts. The balloon is inflated, and the airway's 15-mm adapter is connected to a source of oxygen. Signs of proper placement include chest wall motion, breath sounds over both lung fields, absence of sounds over the epigastrium, and a capnogram which measures the concentration of CO_2 in the end-tidal gas. Ideal placement excludes the epiglottis from the anterior (concave) mask surface; nevertheless, the epiglottis sometimes flips into the bowl of the mask without producing significant airway obstruction. At other times airway obstruction is considerable. Correct placement does not affect vocal cord movement, so patients may vocalize while an LMA is in place.

Positive pressure ventilation may be impaired by improper placement of the LMA (6). If oxygenation and ventilation are unacceptable, the device should be removed and replaced. Variations in placement techniques are useful when difficult insertions are experienced. Alternative techniques include slight inflation of the cuff prior to insertion (7), jaw thrust (8), tube rotation (9), and elevation of the base of the tongue with a laryngoscope blade (10). When inspiratory pressures exceed 20 cm of water, gas tends to leak around the inflatable cuff. However, an audible leak does not contraindicate use of LMA if adequate oxygenation and ventilation can be achieved without dilating the stomach. LMAs have been used successfully in anesthetized patients for 7 hours (11), but this author is reluctant to recommend such a practice. Studies on anesthetized patients reveal successful insertions on the first attempt in 88–90% of patients and on the second attempt in 95–98% of patients (12). Hypertension and tachycardia associated with LMA insertion are minimal (12) and compare favorably to tracheal intubation (13).

Contraindications to the LMA are relative and include poor pulmonary compliance and limited interincisor distance, as well as increased risk of aspiration pneumonia. Contraindications to its use must be weighed against its potential benefit during a particular clinical situation. Inability to achieve sniffing position may complicate insertion, but does not contraindicate LMA use. Small mouth openings complicate placement, but theoretically interincisor distances of 1.5 cm or greater allow for insertion. Pharyngeal abnormalities such as tonsillar hypertrophy, hematoma, abscess, or mucosal lesions may hamper advancement of the LMA into the retropharyngeal space. When correctly placed, an LMA approximates the upper esophageal sphincter, but does not occlude the esophagus. The inflatable balloon around the mask does not reliably exclude vomitus from entering the trachea (14). Many malpositions that allow oxygenation and ventilation can incorporate the esophagus into the LMA; consequently, patients at increased risk for aspiration pneumonitis are not good candidates for LMA use (15). Although cricoid pressure may be used to occlude the esophagus and prevent gastric contents from reaching the pharynx and trachea, its application may impair LMA insertion. If LMA use is deemed to be the method of choice in a patient at risk for aspiration pneumonitis, ventilation may be continued with simultaneous application of cricoid pressure. However, if cricoid pressure interferes with oxygenation and ventilation, it must be released. Any one of multiple malpositions of the LMA can result in gastric distention, increasing the risk of regurgitation and vomiting. The insertion of a gastric tube prior to using an LMA often treats gastric distention and prevents its recurrence. In 1999, a new LMA model was released that provides an esophageal port for evacuation of esophageal contents.

In an emergency, oxygenation and ventilation must receive top priority. LMA should be employed despite its relative contraindications, since its placement is the fastest and most efficient technique of establishing airway patency. Examples of such emergency situations theoretically include cardiac arrest and rapid cardiopulmonary decompensation in patients with difficult airways. Alternative methods can be substituted on an elective basis.

Since 1983, LMAs have been the only means of providing laryngeal mask ventilation. In 1998 Benumof described the Glottic Aperture Seal (GAS) airway (16). The GAS airway provides a firm glottic pad that is pressed up against laryngeal cartilages, forming a tight seal between the device and the larynx, thereby allowing both greater inspiratory pressures in patients with poor pulmonary compliance and the exclusion of vomitus from the trachea. At this time, it is not commercially available.

The pharyngeal airway (PA) is a mask-like device, which became commercially available in October 2000. The PA provides an inflatable pharyngeal cuff to prevent gas from escaping through the nose and mouth. It also offers a gilled tip that is designed to seal the esophagus.

Retraction Laryngoscopy Blades

Tracheal intubation is frequently accomplished utilizing a curved Macintosh (17) or straight Miller (18) laryngoscope blade. Sometimes, one or both of these blades fail to provide adequate visualization of the larynx. Recent advances in retractable-blade design include the Bullard (19) and Wu (20) laryngoscopes. Both systems combine the advantages of fiberoptics with the durability of traditional steel blades. The fiberoptic system directs light around anatomic structures; therefore, use of these blades does not require that the patient be in the sniffing position. These systems may be particularly helpful for patients with ankylosing spondylitis, cervical vertebral instability, prior cervical fusions, or severe arthritis. As with all fiberoptic devices, they offer a limited field of view that is further restricted by blood or secretions.

The Bullard laryngoscope (Circon Corp., Santa Barbara, CA) offers a broad but thin retraction blade with a fiberoptic system running along its back portion. A tracheal tube is loaded onto its stylette, and the device is inserted blindly into the mouth, around the base of tongue, and underneath the epiglottis. After positioning, the laryngoscope is lifted anteriorly to expose the vocal cords, and the tracheal tube is advanced over the stylette into the trachea. If the blade lodges in the vallecula, the epiglottis is not lifted and glottic visualization is impeded. Sometimes it is difficult to advance the tracheal tube over the stylette between the vocal cords.

The Wu laryngoscope (Achi Corp., Fremont, CA) offers a bi-valved blade that allows visualization and manipulation of the tracheal tube through its hollow center. It is probably of most value for patients with large tongues, masses encroaching upon the airway, or redundant tissues; however, the blade is large and takes some practice to use comfortably.

Flexible Fiberoptic Laryngoscopes

It has been the author's personal experience that flexible fiberoptic laryngoscopes have been used successfully in many difficult intubations. Their unequaled flexibility allows for intubation of patients, without the need for head and neck manipulation. Fiberscopes may be used for both oral and nasal approaches to the larynx. They virtually eliminate laryngoscopy-associated dental damage and unrecognized esophageal intubation. They have been used successfully in patients with small mouth openings, provide cardiovascular stability during manipulation, and there has been excellent patient acceptance. Their major disadvantages are their limited field of view (which is exacerbated by blood and secretions in the airway) and the high cost of purchase and maintenance.

Recent advances in fiberscope technology have provided improved optics and greater portability. Modern optical systems offer a larger field of vision with wide-angle lenses. Most recently, battery-powered fiberscopes have become available, allowing for convenient transport to any area within the hospital. They obviate the need to carry heavy illuminators and do not require an outside alternating-current source.

Esophageal-Tracheal Combitubes

Over the years, numerous esophageal devices have been designed for airway management. Until recently, the best-known instrument was the esophageal obturator airway. Problems associated with the esophageal obturator airway include difficult mask fit, accidental tracheal intubation producing complete airway obstruction, vomiting, and esophageal rupture.

In 1988, the esophageal-tracheal Combitube (Tyco International-Kendall Health Care Products Company, Mansfield, MA) was approved for use in the United States. Combitubes are double lumen tubes that provide oxygenation and ventilation in the esophageal or tracheal position. Initially designed by Michael Frass, an intensivist in Vienna, Austria, the Combitube was intended as an airway patency device to be used by first responders to an emergency cardiac arrest when these responders lack traditional airway-maintenance skills (personal communication, October 1990). The Combitube's success in these emergency situations has expanded its applicability. It is now used as an alternative device for the management of difficult airways and has been used for elective surgery in patients who rely on their voices professionally, such as singers, lecturers, actors, and attorneys.

The Combitube has a few disadvantages. They currently come in two adult sizes, but no pediatric versions. Pulmonary toilet is not possible in the esophageal position. Esophageal rupture has been reported after its use (21).

Cuffed Oropharyngeal Airway

Guedel airways remain a classic airway management tool. In 1992, Greenberg and Toung (22) described modifications of Guedel's airway that may provide some advantages. The Cuffed Oropharyngeal Airway (COPA) (Mallinckrodt Corp., St. Louis, MO) consists of an inflatable balloon on the proximal end, with a 15-mm standard airway adapter affixed to the other end. The inflated balloon serves to displace the base of the tongue anteriorly, create an air-tight seal with the pharynx, and lift the epiglottis off the posterior pharyngeal wall. The 15-mm adapter allows direct connection to a standard respiratory circuit. COPAs are constructed of polyvinyl chloride and are disposable after a single use.

Advanced Airway Management Teaching at the Mount Sinai School of Medicine

In 1990, the Mount Sinai School of Medicine led the way in teaching new airway techniques. At that time, Mount Sinai was one of only two institutions worldwide to offer formal residency training in advanced airway management. By 1995, many training programs had followed this lead, but formal training in advanced airway management remained neglected by most other anesthesia residencies in the United States (23). In 1998, the program was discontinued due to the decreasing number of residents in the anesthesiology program. From 1990–1998 most residents developed fiberscope skills, well beyond those of residents who graduated prior to 1990 (personal observation). This program has placed 122 practicing physicians among the small cadre of anesthesiologists who are schooled and skilled in the use of advanced airway devices. In addition, some anesthesiologists have extended their expertise to devices other than flexible fiberoptic laryngoscopes.

Today, difficult airway management is commonly taught as clinical situations arise. Because these difficult clinical situations are infrequent and sporadic, opportunities to teach and practice the necessary skills are limited. Learning based on sporadic and occasional occurrences is usually incomplete and non-uniform. Lectures, "difficult- airway" workshops, manikin practice, and simulator sessions cannot replace actual clinical experience. All anesthesia residency programs are encouraged to institute formal training in advanced airway management.

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