Management of Unanticipated Difficult Intubation

ABSTRACT

Airway management, ensuring uninterrupted oxygenation and ventilation, is a fundamental part of the practice of anesthesia and of emergency and critical care medicine. Endotracheal intubation is an airway management technique indicated in a variety of clinical situations, most commonly for the maintenance of the upper airway during general anesthesia, but also in any situation involving the maintenance and protection of the upper airway when the airway may be compromised or positive pressure ventilation is necessary. A difficult intubation is defined by the American Society of Anesthesiologists as tracheal intubation requiring more than three attempts, in the presence or absence of tracheal pathology. Unanticipated difficulty with endotracheal intubation may result in catastrophic outcomes, including cerebral anoxia and death. Of the anesthesia events involving complications reported to the Pennsylvania Patient Safety Authority in 2009, 36 reports involved a difficult intubation. In 23 reports, difficult intubation was described as unanticipated. Even the most thorough assessment of the airway may not detect the possibility of a difficult intubation, and every anesthetist should have a predetermined strategy for dealing with this situation. Alternative methods of managing the airway should be initiated after two or three unsuccessful attempts at intubation. This article discusses assessment of the airway, identification of patients at risk for a difficult intubation, and risk reduction strategies, including plans for dealing with an unexpected difficult intubation. Recent advances in airway management techniques and devices will be summarized. (Pa Patient Saf Advis 2010 Dec;7[4]:113-22.)

Introduction

Airway management, specifically ensuring uninterrupted oxygenation and ventilation, is a fundamental part of the practice of anesthesia and of emergency and critical care medicine. Difficulty in airway management can be categorized as difficult mask ventilation and/or difficult tracheal intubation, which is defined by the American Society of Anesthesiologists (ASA) as tracheal intubation requiring multiple attempts in the presence or absence of tracheal pathology.[1] Of the anesthesia events involving complications reported to the Pennsylvania Patient Safety Authority in 2009, 36 involved difficult preoperative tracheal intubation. These will be the focus of this article, although the information may also be of value in other settings.

Endotracheal intubation (ETI) meets the following goals of airway management: the maintenance of airway patency, protection of the lungs from aspiration, and creation of a conduit for ventilation. Indications for ETI vary with clinical scenarios. In the operating room (OR) setting, ETI is used to ensure airway patency and protection for the unconscious patient. ETI is based on the need for reliable oxygenation or ventilation. Difficulty with ETI may occur unexpectedly even under controlled situations such as during induction of anesthesia in the OR.

Airway management difficulty is an important factor in mortality and morbidity related to anesthesia.[2-4] The ASA Closed Claim Project involves analysis of closed anesthesia malpractice claims files. Cheney et al. analyzed 6,750 claims in the database for events that occurred between 1975 and 2000 and found that 39% were claims for death or permanent brain damage. Respiratory-related damaging events were responsible for 50% or more of those claims. In the respiratory events category, the most frequent events were difficult intubation (23% of the respiratory events) and inadequate ventilation/oxygenation (22%).[4] Although some difficult airways can be predicted, even the most thorough assessment of the airway may not detect the possibility of a difficult intubation and associated problems with ventilation of the patient. Every clinician should have a predetermined strategy for dealing with this situation. This article will discuss the assessment of the airway, identification of patients at risk for a difficult intubation, and risk reduction strategies designed to maintain oxygenation and ventilation of the patient, including predetermined and rehearsed plans for dealing with an unexpected difficult intubation.

Authority Reports

In 2009, the Authority received 448 event reports involving complications related to anesthesia. Of these reports, 36 involved a difficult intubation. Six events were reported as an anticipated difficult airway involving patients with the following risk factors:

- Known history of difficult intubation (two patients)
- Anterior larynx (one patient)
- Small mouth (one patient)
- Kyphosis resulting in difficult positioning (one patient)
- Severe neck swelling due to bleeding (one patient)

For 23 events, difficult intubation was reported as unanticipated. In the seven remaining reports, it was indeterminable whether the difficult intubation was

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anticipated. Nine events involving a difficult intubation resulted in harm to the patient.

Reports of difficult intubation in which the patient was harmed include the following:

> *Intubation took three attempts. The larynx was anterior and made for difficult intubation. The patient had difficulty swallowing postoperatively and was found to have an esophageal perforation.*
>
> *The anesthesiologist was attempting to insert the [endotracheal] tube using a GlideScope®. The patient's mouth was small, and the size of the tube prevented direct visual placement. Several attempts were made; then, copious amounts of blood were noted in the oropharynx. A laceration of the tonsil occurred.*
>
> *A patient was admitted for shoulder surgery under general anesthesia. [It was a] difficult intubation. During intubation, an approximate 1 cm laceration of the soft palate occurred.*

Evaluation of the Airway

A published analysis of 4,000 incidents reported to the Australian Incident Monitoring System emphasizes the importance of preoperative assessment of the airway.[5] In 76 (52%) of 147 reports of difficult intubation, the difficulty with intubation was unanticipated. The most frequently reported complications included oxygen desaturation, unrecognized esophageal intubation, and pulmonary reflux with aspiration. The most common remediable cause of unpredicted difficult intubation was inadequate preoperative assessment. The components of preoperative airway evaluation include taking patient history and performing a physical examination to identify clinical risk factors that might predict difficult intubation.

Clinical Risk Factors

Clinical risk factors that may be associated with difficult intubation in adult patients include increased age, male gender, high body mass index, and history of obstructive sleep apnea (OSA).[6-8] Obesity (i.e., a body mass index above 30 kg/m^2) is an increasingly important risk factor to consider.[9] In a prospective observational controlled study of 204 patients, the authors compared intubation difficulty among obese and nonobese patients using an intubation difficulty score, intubation duration, and lowest oxygenation saturation levels during intubation. Scores were found to be higher among obese patients due to poor glottis exposure, increasing lifting force needed during laryngoscopy, and the need to apply external laryngeal pressure to improve glottis exposure. The results concurred with an earlier study comparing scores between obese patients and lean patients.[10] Chung et al. showed an association between OSA and unexpected difficult intubation.[11] Thirty-three patients classified as a difficult intubation cases were referred to a sleep clinic for polysomnography. Of these, 66% were diagnosed as having OSA. The authors suggest that patients with difficult intubation are at high risk for OSA and should be screened for signs and symptoms of sleep apnea. Although it was not evaluated, the study also suggests that thorough screening for signs and symptoms of OSA, including a short thick neck, limited head extension, and reduced thyromental distance, is an important aspect of predicting difficult intubation. Clinical signs and symptoms associated with sleep apnea include snoring, excessive daytime sleepiness, falling asleep while driving, frequent nighttime awakenings, difficulty falling asleep, and a neck circumference greater than 16 inches in a woman or greater than 17 inches in a man.

Clinical risk factors for difficult intubation in pediatric patients are related to the anatomic differences between pediatric patients and adults, including the relative position of the larynx in the neck, a less rigid airway, the size of the occipital bones, tongue size, decreased functional pulmonary reserve, less developed accessory muscles of respiration, and smaller airway diameter.[12,13] Most cases of acute airway compromise in children are the result of infections, the presence of foreign bodies, or trauma. Additional predictors of a difficult intubation in pediatric patients include the following:[12]

- Small mouth opening
- Mental-hyoid distance (a measure to evaluate the submandibular space) of 1.5 cm or less in a newborn or infant and 3 cm or less in a child
- Impaired head and neck mobility
- Micrognathia (small lower jaw)
- Retrognathia (receding mandible or maxilla)
- Mandibular dysplasia or hypoplasia
- Macroglossia (enlargement of the tongue)
- Space-occupying airway lesions
- Supralaryngeal inflammatory pathology
- Nasal airway obstruction
- Pathologic obesity
- Craniofacial abnormalities

In the obstetric patient, anatomic and physiological changes may place the patient at increased risk for difficulty with intubation.[14] The effects of estrogen and increased blood volume may contribute to edema and friability of the upper airway mucosa. This change may result in nasal congestion and in increased risk of mucosal bleeding with airway manipulation. Hormonal changes induced by pregnancy increase the subcostal angle of the ribs and, combined with displacement of the diaphragm by the gravid uterus, result in a decreased functional residual capacity in the lungs. These changes will accelerate the onset of oxygenation desaturation during hypoventilation and apnea.

History and Physical Examination

According to the ASA Task Force on Management of the Difficult Airway, an airway history should be conducted, when feasible, before the initiation of

anesthetic care and airway management when some features of a patient's medical history or medical records may be related to the risk of encountering a difficult airway. The ASA task force recommends a focused bedside medical history and a focused review of the medical records.[1] A thorough history addresses any difficulty with previous general anesthesia, OSA or snoring, head and neck abnormalities, and diseases that might impair the airway and prevent tracheal intubation.[13] For an adult patient, the examination assesses facial and neck masses and deformities, scars, the quality of dentition, maxillary and mandibular position, pharyngeal structures, neck mobility, and facial hair.[13] Parents of pediatric patients are asked about noisy breathing at play, rest, or feeding; previous surgeries or intubations; neck pain, fever, or recent upper respiratory infections; birth trauma; and congenital abnormalities.[13] The physical exam includes examination of the respiratory rate, nasal flaring, and accessory muscles.

Quantitative Evaluation of Difficult Intubations

Tracheal intubation is most commonly performed using a direct laryngoscopy technique. When a patient is prepared for intubation, a laryngoscope is used to visualize the airway and the tracheal tube is inserted. Visibility of the glottis is often documented to describe predicted ease of intubation.[15] The Cormack-Lehane (CL) classification is a grading system commonly used to describe the view of the larynx during direct laryngoscopy.[16] Grades 3 and 4, in which the glottis is not visualized, are considered difficult intubations. Despite widespread use of the CL classification, researchers have questioned its reliability. Krage et al. evaluated knowledge of the CL classification among anesthesiologists and its reliability in a simulated clinical setting.[15] A survey of 120 anesthesiologists showed that 3 out of 4 anesthesiologists claimed to know the CL classification, yet only 1 out of 4 was able to define all grades correctly. Intra- and interobserver reliabilities were tested with a patient simulator. The CL classification showed fair interobserver reliability and poor intraobserver reliability.

Another commonly used predictor of difficult intubation, the Mallampati score, estimates the size of the tongue relative to the oral cavity and the ability to open the mouth. Originally, this system graded the patient (grades 1 to 3) based on the structures visible in the oropharynx with maximal mouth opening; a fourth grade was subsequently added. Grade 3 or 4 suggests a significant chance that the patient will be difficult to intubate.[17,18] In a series of 1,956 patients undergoing elective general anesthesia, Cattano et al. demonstrated a good correlation between the Mallampati scale and the CL classification, although the Mallampati scale lacked the sensitivity to be predictive when used alone. The Mallampati score is also not specific since there may also be a high incidence of false positives.[19]

Another common approach to predicting difficult intubation is an evaluation guided by the mnemonic LEMON (see "LEMON Airway Assessment Method").

Other bedside tests that assess for anatomic indicators of a potentially difficult intubation include measurement of thyromental, sternomental, hyomental, and interincisor distances. Thyromental distance (TMD) is a measurement taken from the thyroid notch to the tip of the chin with the head extended. Determination of TMD can be difficult in patients who are overweight, patients who are immobilized, and patients with goiters or other neck diseases.[20] Sternomental distance (SMD) is the distance from the tip of the chin to the sternal notch with the mouth closed and head in full extension.[21] Hyomental distance is the distance from the hyoid bone to the mentum (chin).[22] Interincisor distance (IID) measures the distance between the patient's incisor teeth. The upper lip bite test assesses the patient's ability to bite the upper lip with the lower teeth.[22]

Risk indexes have been developed based on quantitative evaluations. Wilson et al. developed a risk scoring system based on body weight, head and neck movement, jaw movement, and the presence or absence of mandibular recession and protruding teeth.[22] The Naguib model considers TMD, Mallampati score, IID, and height.[23] The El-Ganzouri risk index was devised from prospective evaluation of 10,507 patients.[24] The multivariate risk index combined and stratified seven variables derived from parameters and observations individually associated with difficult intubation.

LEMON Airway Assessment Method

L = Look externally for anatomic feature that may make intubation difficult.

E = Evaluate the 3-3-2 rule.

- Mouth opening (3 finger-breadths)
- Hyoid-chin distance (3 finger-breadths)
- Thyroid cartilage-floor of mouth distance (2 finger-breadths)

M = Mallampati score.

- Class 1: soft palate, uvula, pillars visible
- Class II: soft palate, uvula visible
- Class III: soft palate, base of uvula visible
- Class IV: hard palate visible

O = Obstruction: examine for partial or complete upper airway obstruction.

N = Neck mobility.

Source: Reed MJ, Dunn MJMJ, McKeown DW. Can an airway assessment score predict difficulty at intubation in the emergency department? *Emerg Med J* 2005 Feb;22(2):99-102.

Arne et al. prospectively evaluated 1,200 patients and, using univariate and multivariate analysis, identified 7 criteria as independent predictors of difficult tracheal intubation. Risk factors were assigned a point value; a score of less than 11 indicated that a difficult intubation could be excluded, with a risk of false prediction of 1% to 2%.[25] Recently, Eberhart et al. prospectively evaluated 3,763 patients for potential risk factors of difficult intubation.[26] A random sample was subjected to mulitvariate logistic regression analysis, and the most powerful independent risk factors were used to develop a simplified multivariate risk score. The presence of the upper front teeth, a history of difficult intubation, Mallampati classification between 2 and 4, and mouth opening of less than 4 cm are independent risk factors for difficult tracheal intubation. With each risk factor, the likelihood of difficult intubation increases from 0% (no risk factors) to 17% when 4 or 5 factors are present.

A case-controlled, double-blind study examined three multivariate risk indexes, the Wilson, Arne, and Naguib risk models, to determine the most sensitive model in the prediction of difficult intubations.[23] The Naguib model demonstrated the highest sensitivity (82.5%) and specificity (86.5%).[23]

A meta-analysis by Shiga et al. evaluated bedside tests for predicting difficult intubation, including the Mallampati classification, TMD, SMD, mouth opening, and the Wilson risk score.[17] These tests had poor-to-moderate discriminative power when used alone. Combinations of tests add incremental diagnostic value; the most useful combination of tests for prediction of difficult intubation was the Mallampati classification and TMD. Similarly, a systematic review of the accuracy of the original and modified Mallampati score concluded that when used alone, the Mallampati test is insufficient to predict a difficult intubation.[27] Forty-two studies enrolling 34,513 patients were included.

Accurate preoperative prediction of difficulty with intubation can help reduce the risk of catastrophic outcomes but may not always be possible using available quantitative tests, which lack in sensitivity and specificity, resulting in false positives and a low positive predictive value for any single test.[28] Despite the limitations of predictive tests, overestimation of the difficulty of airway management might result in "much ado about nothing," while underestimation may result in brain damage or death.[29] Moreover, the prediction of airway difficulty is useful in focusing on the identification of potential airway strategies.[28]

Risk Reduction Strategies

Airway Management

In the event that intubation unexpectedly becomes difficult or impossible, a predetermined plan will allow anesthesia providers to manage the airway and ensure uninterrupted oxygenation and ventilation of the patient. An unanticipated difficult intubation, if associated with difficult mask ventilation, allows only a short period of time to solve the problem before hypoxemia, hypercarbia, and hemodynamic instability occur.[30] Early skilled assistance is critical, followed by advancement through a series of predetermined and rehearsed strategies. The ASA task force has recommended, based on consensus opinion, limiting intubation attempts to three, with subsequent use of accessory airway devices or alternative techniques to secure the airway when difficulty with intubation is encountered.[1] Analysis of a large quality-improvement database has confirmed the recommendations of the ASA task force. Mort analyzed 283 questionnaires following conventional laryngoscopic-intubation to determine the incidence of airway and hemodynamic complications during emergency tracheal intubation outside the OR and to determine any relationship between the number of conventional intubation attempts and the incidence of complications. The rate of airway-related complications significantly increased as the number of laryngoscopic attempts increased (from 2 or fewer attempts to 2 or more attempts: hypoxemia (11.8% versus 70%), regurgitation of gastric contents (1.95% versus 22%), aspiration of gastric contents (0.8% versus 13%), bradycardia (1.6% versus 21%), and cardiac arrest (0.7% versus 11%).[31]

The following methods of securing the airway form the basis of a structured approach and are presented, in general, from the least to most invasive method.[5,13,30]

Mask Ventilation

Mask ventilation is used during induction of anesthesia before intubation and as a rescue technique during an unsuccessful intubation attempt. Hyperoxygenation of the patient by mask ventilation provides time for intubation and consideration of the next approach. However, a mask does not protect against aspiration, and air may be forced into the esophagus or stomach.[13]

Tracheal Intubation

While the patient is being prepared for intubation, if the vocal cords are not observed during laryngoscopy, different maneuvers can be tried to help visualize the glottis. The following steps may provide adequate exposure for direct visualization of the true vocal cords:

- Modified Jackson position.[13,30] Position the head into a "sniffing" or "drinking" position.
- External laryngeal manipulation.[5,13,30] Direct an assistant to apply backward pressure on the cricoid cartilage (BURP maneuver: *b*ackward, *u*pward, *r*ightward *p*ressure). Compress the cricoid cartilage against the cervical spine with three fingers of the opposite hand (Sellick maneuver).
- Laryngoscope blade.[30] Use a larger blade. In patients with a large lower jaw or deep pharynx, use of a larger, size 4 Macintosh blade rather than the more common size 3 (for consistency) can facilitate the tip of the blade reaching the vallecula for

optimal elevation of the epiglottis. Alternatively, using a straight blade such as a Miller 2 or 3 may facilitate intubation.

- Lighted stylet.[13,30] The lighted stylet (i.e., a malleable metal or plastic rod with a fiberoptic light source that is passed through the endotracheal tube to adjust its curvature) helps facilitate blind intubation (i.e., when the glottis is poorly visualized or not observed). Greater intensity of light visible through the soft tissue of the anterior neck as the light passes beyond the vocal cords helps distinguish the tracheal lumen from the esophagus.
- Gum elastic bougie.[13,30] Use a semirigid gum elastic bougie (i.e., a blunt-ended malleable rod that may be passed through the nonvisualized larynx by bending a J-shape at the tip and passing it blindly in the midline beyond the base of the epiglottis). The endotracheal tube can be guided along the bougie, which is then withdrawn. Another technique involves inserting the gum elastic bougie into the trachea under direct visualization and then inserting the tube over the bougie.
- Fiberoptic intubation.[13,30] Pass a flexible fiberoptic bronchoscope through the endotracheal tube and then through an anesthetized naris or through the oral cavity of an awake patient. Pull the mandible and tongue anterior to expose the larynx. The bronchoscope serves as a visual guide and as a stylet for the endotracheal tube. The technique may also be used if the patient has been anesthetized; however, loss of muscle tone will allow the epiglottis and tongue to fall back against the posterior pharynx. Pulling the jaw forward is likely to be required.
- Laryngeal mask airway (LMA).[13,30] Place an LMA (i.e., a small latex mask mounted on a hollow plastic tube) blindly in the lower pharynx overlying the glottis. The inflatable cuff on the mask wedges the mask in the hypopharynx and helps seal the gastrointestinal tract from the airway. Use a modification of the LMA, an intubating LMA (ILMA), which has a more rigid, wider tube with a handle for insertion. A modified tracheal tube can then be passed through the ILMA into the trachea either blindly or with the aid of a fiberoptic scope.[32]
- Esophageal-tracheal double-lumen airway.[32] Use a Combitube®, a combined esophageal obturator and tracheal tube. This twin-lumen device is inserted without the need for visualization into the oropharynx and usually into the esophagus. It has a low-volume inflatable distal cuff and a much larger proximal cuff designed to occlude the oro- and nasopharynx. If the tube has entered the trachea, ventilation is achieved through the distal lumen as with a standard endotracheal tube. More commonly, the device enters the esophagus and ventilation is achieved through multiple openings in the tube situated above the distal cuff. In the latter case, the proximal and distal cuffs must be inflated to prevent air from escaping through the esophagus or back out of the oro- and nasopharynx.[32]
- Retrograde guidewire.[33] A Seldinger guidewire is inserted by needle through the cricothyroid membrane and bounced toward the mouth off the back wall of the trachea. It is then retrieved in the mouth. The endotracheal tube is introduced through the vocal cords over the guidewire, which is removed as the tube passes down the trachea.

Surgical Intervention

When the aforementioned methods are unsuccessful, the inability to intubate and ventilate the patient, commonly referred to as the "can't intubate, can't ventilate" scenario, typically requires rapid surgical access to the trachea for adequate ventilation and oxygenation. Rapid access is usually achieved through a cricothyroidotomy.[30] Cricothyroidotomies may be performed using three techniques: needle, wire-guided percutaneous, and surgical. Needle cricothyroidotomy entails insertion of a catheter (e.g., an intravenous catheter) through the cricothyroid membrane. In a wire-guided percutaneous approach (i.e., the Seldinger technique), a needle punctures the cricothyroid membrane and a wire is advanced into the airway through the needle, which is then removed. The wire becomes the guide for a series of dilators and a tracheostomy tube. The cricothyroid membrane may also be accessed by a surgical cutdown and the insertion of a tube directly into the trachea. The surgical technique has been shown to be quicker and produce more effective ventilation. A tracheotomy may be performed when the airway can be maintained and the patient can be ventilated and is not hypoxic.[33]

New Devices

Optical and video laryngoscope devices allow intubation to be performed under indirect visualization, overcoming the restrictions in patient anatomy that may make direct laryngoscopy difficult or impossible. Using fiberoptic and video technology, semirigid or rigid devices have been designed for intubation: they may be stylet-like (e.g., the Shikani optical stylet), flat (e.g., the Bullard laryngoscope), or hollow (e.g., the WuScope System) or they may resemble a conventional laryngoscope (e.g., the Karl Storz Video Macintosh, GlideScope).[34] Lighted stylets rely on transillumination of the tissues of the anterior neck to demonstrate the location of the tip of the endotracheal tube.[35] Video laryngoscopes use fiberoptic or digital imagery and allow indirect visualization of the airway on a monitor.[35] Although the devices vary with respect to diameter, image resolution, and flexibility, most are similar in structure and function. They are all inserted within an endotracheal tube and, through an eyepiece or video monitor, allow the practitioner to view the device's advancement. The main advantage of these devices is that they may not be affected by many of the anatomic factors that may lead to difficult direct laryngoscopy and intubation.[35] While it is beyond the scope of this article to discuss all available devices, a review of recently

developed airway management devices is available at http://www.anesthesiologynews.com/download/AirwayMgmt_AN0509_WM.pdf.

ECRI Institute has evaluated the clinical literature on optical and video laryngoscopic devices and has identified 41 randomized control trials, 19 comparison studies, and 24 case series.[36] A 2008 quantitative review and meta-analysis by Mihai et al.[37] summarized studies of rigid fiberoptic laryngoscopy systems. The intubation success rate was greater than 90% in 6,622 "normal" patients using the BONFILS (a videolaryngoscope with a small video camera at the blade tip) and CTrach (an LMA with video-guidance) systems. In patients (n = 1,110) with predicted or diagnosed difficult intubation, first-time success rate was greater than 90%. However, data for comparative studies with the Macintosh direct laryngoscope was insufficient. The authors concluded that currently available information did not support the hypothesis that these devices should replace direct laryngoscopy for routine or difficult intubation. A technology assessment report by the Ontario Ministry of Health and Long-Term Care, Medical Advisory Secretariat, reviewed the effectiveness and cost-effectiveness of video-assisted laryngoscopy for tracheal intubation.[38] The report included two devices: (1) the Bullard and (2) the GlideScope. The authors concluded that compared to direct laryngoscopy, video-assisted systems provide a better view of the upper airway but are more expensive. A recent prospective study compared conventional blade laryngoscopy with direct-coupled interface (DCI) video-assisted blade laryngoscopy and the GlideScope.[39] One hundred twenty patients with at least one predictor for a difficult airway who were undergoing elective minor surgery requiring ETI underwent repeated laryngoscopy with the three devices. The GlideScope enabled significantly better laryngoscopic views than both direct and DCI video laryngoscopes.

Airway Management Guidelines

Preplanned strategies as described above have been linked to form airway management algorithms.[40] ASA developed its Difficult Airway Algorithm, last updated in 2003.[1] The algorithm first indicates assessment for basic airway management problems, if any. Next, the best approach to the patient's airway management should be evaluated. If the airway is predicted to be difficult to manage, a primary, preferred approach should be developed, followed by the identification of alternative approaches if the primary approach fails or is not feasible. In the event of difficulty that was not predicted in the surgical patient, an anesthesia provider should immediately call for help, take steps to ensure ongoing ventilation and oxygenation, and consider awakening the patient. Beyond this point, the decision-making algorithm depends on whether face-mask ventilation is effective after attempts at direct laryngoscopy fail. If face-mask ventilation is adequate (nonemergency pathway), then the next options include placing a supraglottic ventilation device, such as an LMA, or using alternative approaches to intubation (e.g., a different laryngoscopy blade, a stylet, fiberoptic intubation). If face-mask ventilation is inadequate, the emergency pathway indicates considering or attempting an LMA. If unsuccessful, attempting emergency, noninvasive airway ventilation is indicated, such as using rigid bronchoscope or esophageal-tracheal Combitube ventilation, followed by surgical techniques (e.g., cricothyroidotomy, tracheostomy).

The ASA task force recommends that intubation be attempted three times;[1] however, as previously noted, Mort has demonstrated that the rate of intubation-related complications increases beyond two intubation attempts. Mort suggests that the increase in the rates of complications may warrant further refinement of the ASA algorithm recommendations to fewer than three intubation attempts.[31] A refinement to the nonemergency pathway of the algorithm has been suggested. Noting that most anesthesiologists can identify a difficult intubation on the first laryngoscopy, Saxena describes the use of a video laryngoscope or a GlideScope if difficulty is encountered on the first attempt at intubation (assuming that good ventilation can be maintained using a face mask).[41] The ASA Difficult Airway Algorithm has been described as "limited" for emergent airway management in nonsurgical settings (e.g., emergency department, critical care units, hospital wards) due to several factors, including the limited time in the emergent setting to fully evaluate the patient and the presumption that the patient has a full stomach.[42] These differences require airway strategies beyond the scope of this article.

The Difficult Airway Society (DAS) guidelines for the management of unanticipated difficult tracheal intubation are based on a series of escalating management plans: if Plan A does not work, backup plans C, D, or E can be executed.[43] The plans are as follows:

Plan A. Initial tracheal intubation plan.

Plan B. Secondary tracheal intubation plan, when Plan A fails.

Plan C. Maintenance of oxygenation and ventilation, postponement of surgery, and awakening of the patient when earlier plans fail.

Plan D. Rescue techniques for "can't breathe, can't ventilate" situations.

Each plan describes a sequence of actions to be followed in the event of the following scenarios: (1) unanticipated difficult tracheal intubation during routine induction of anesthesia in an adult patient, (2) unanticipated difficult tracheal intubation during rapid sequence induction of anesthesia in a nonobstetric patient, and (3) failed intubation (i.e., "can't intubate, can't ventilate"). Two principles are emphasized in these guidelines: maintenance of oxygenation during the execution of each plan and seeking the best assistance available as soon as difficulty with laryngoscopy is experienced.

Frova and Sorbello compared algorithms for difficult airway management from the United States (the ASA algorithm), the United Kingdom (the DAS algorithm), France, Italy, Germany, and Canada, explaining the primary differences, weaknesses, and strengths of concepts in the management of a difficult airway.[29] The following are mandatory points to include during guideline development based on their analysis:

- Importance of prediction
- Need for a preplanned high safety/low trauma strategy
- Importance of oxygenation/ventilation rather than intubation
- Familiarity with instruments and techniques
- Correct role of devices and techniques
- Skill development and maintenance

An optimal guideline is not proposed; however, the primary importance of the guidelines is attributed to the change in anesthetists' practice and effect on patient outcomes. The authors conclude that because no clear science-based evidence supports any of the proposed guidelines and because the documents are derived from expert opinion and experience, the ideal algorithm is the one that best conforms to an anesthesia provider's experience and to a facility's available devices and instruments.

Pediatric Difficult Airway Algorithm

The ASA Difficult Airway Algorithm is not specific to pediatric patients. Odnik et al. modified a simplified algorithm that specifically addresses the management of the difficult airway in the pediatric population.[44,45] See the accompanying materials for the pediatric airway algorithm.

Comprehensive Difficult Airway Program

Considering that the literature is replete with bedside tests, predictive models, and devices intended to assist in management of airway difficulties, a comprehensive approach requires a combination of best practices in preoperative evaluation, communication of prior experiences, availability of airway equipment, and training to avoid poor outcomes.[46] Berkow et al. describe how a comprehensive difficult airway program that was started in 1996 contributed to a significant reduction in emergency surgical airways, which represents the endpoint of the ASA and DAS algorithms.[47] In the four-year period before 1996, there were six to seven emergency surgical airways required per year due to a "can't intubate, can't ventilate" scenario. In the 11-year period following institution of the program, the number of emergency surgical airways required decreased to between 0 and 3 per year, even though the patient population had increased by 50%. Core components of the program include the following:[47]

- Communication
  - Patients were reported to a centralized database.
  - Patients with a known difficult airway were given a color-coded wristband.
  - After discharge, a letter was sent to the patient's home with details of the airway anatomy and techniques used to secure the airway.
  - Patients were encouraged to enroll in the MedicAlert® program.
  - The anesthesia preoperative evaluation form was redesigned to include documentation of an objective airway examination.
  - A difficult airway alert was placed on the OR schedule, alerting the OR coordinator to verify whether the anesthesia assignment was appropriate and necessary equipment was available in the OR before the start of the case.
- Equipment
  - Standardized difficult airway carts were designed to hold advanced airway management equipment (e.g., flexible fiberoptic bronchoscopes, light sources, LMAs, airway exchange catheters, cricothyroidotomy kits).
  - Difficult airway carts were made available in the obstetric and intensive care units.
  - A laminated card with the ASA Difficult Airway Algorithm was attached to each cart.
- Personnel
  - An interdisciplinary team was organized to assist in airway management when problems arose with intubation or face-mask ventilation. The team included an anesthesiologist, an otolaryngologist, and an equipment technician who would bring the difficult airway cart.
  - Anesthesia technical staff was trained to set up, clean, stock, and maintain the equipment and supplies.
- Education
  - Regularly scheduled training sessions were developed for staff and residents, including a "difficult airway" rotation for residents and twice yearly interdisciplinary grand rounds.

Patient education was found to be vitally important for future anesthetic planning. Knowledge of how a patient's airway was handled in the past was tremendously helpful to anesthesia staff. In a few difficult airway cases, patients were unaware that they had histories of difficult airways, but staff later learned that family members knew the patients' histories. According to the authors, anticipation and preparation for a difficult airway and intubation can potentially reduce surgery cancellation, adverse outcomes, malpractice claims, and loss of life.[47] See the accompanying materials for a sample airway alert letter that may be sent to a patient to alert subsequent anesthesia providers to potential airway difficulty and a difficult airway identification card that may be adapted for use by your institution.

Simulation Training

Kuduvalli et al. conducted a prospective controlled study on a medium-fidelity simulator,* designed to measure the effect of training on compliance with DAS guidelines for the management of unanticipated failed intubation and/or ventilation. It also assessed the effect of formal training on performance over time.[48] The study showed that adherence to the DAS guideline process was sustained for six to eight months for the aforementioned "can't intubate, can't ventilate" scenario, but only six to eight weeks for the "can't intubate" scenario. The result was thought to be partly because management of the "can't intubate" scenario involves more alternatives in a less critical situation compared with the "can't intubate, can't ventilate" scenario. The authors concluded that long-term retention of both technical and decision-making skills requires reinforcement, and they recommended conducting workshops at intervals of six months or less.

Conclusion

Anesthesia providers always need to be prepared to manage an unanticipated difficult intubation. An assumption that the current method of securing the airway will not work will facilitate readiness to advance to the next method. In other words, the anesthesia provider can assume the possibility that anything may go wrong and plan accordingly. Poor outcomes can be avoided by implementing a comprehensive approach that includes thorough patient evaluation, multidisciplinary cooperation with a predetermined airway management strategy, skillful use of standardized equipment, frequent staff education, dissemination of important patient information, and a willingness to ask for assistance.

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(See Self-Assessment Questions on next page.)

Self-Assessment Questions

The following questions about this article may be useful for internal education and assessment. You may use the following examples or come up with your own.

> *A patient was scheduled to have a hysterectomy. During her preoperative anesthesia assessment, the patient told the anesthesiologist that she had surgery two years ago where they "put her under" and that she "didn't have any problems." Her preoperative assessment showed a class II Mallampati score. During induction of anesthesia, the resident anesthesiologist was unable to intubate after three attempts using direct laryngoscopy, before successfully using a different laryngoscopy blade, because a GlideScope® was unavailable to facilitate intubation. Adequate ventilation and oxygenation were maintained throughout the intubation attempts. Postoperatively, the patient experienced vocal cord paralysis that required surgery and prolonged her hospitalization. After the surgery, a family member mentioned to the surgeon that he remembered that the patient had some kind of anesthesia problem during her surgery two years ago.*

1. Which of the following statements is the *most accurate* about the prediction of this patient's difficult intubation?
   a. Intubation difficulty may have been most accurately predicted by measurement of the thyromental distance, inter-incisor distance, or the upper lip bite test.
   b. A combination of the Mallampati score and thyromental distance would have had incremental diagnostic value over any test used alone.
   c. Since tests to predict difficult intubation lack in sensitivity and specificity, the accurate way to predict a difficult intubation is by determining the presence of clinical risk factors.
   d. A focused bedside medical history and review of the medical records would have been sufficient to predict intubation difficulty, according to the American Society of Anesthesiologists (ASA) Task Force on difficult intubation.
2. Select the most effective strategy, according to the ASA Difficult Airway Algorithm, to manage the female patient's difficult airway.
   a. After failed attempts at direct laryngoscopy, the anesthesia provider should have called for help, taken steps to ensure adequate ventilation and oxygenation, and considered awakening the patient.
   b. After two intubation attempts, the next step to consider would have been a supraglottic airway device.
   c. After direct laryngoscopy attempts failed, a surgical technique to secure the airway would have been most appropriate.
   d. Since oxygenation and ventilation were sufficient throughout the intubation attempts, more than three intubation attempts would have been appropriate.
3. Components of a difficult airway program to decrease the likelihood of a similar patient's unanticipated difficult intubation include all of the following EXCEPT:
   a. A difficult airway alert form to be sent to the patient and primary care physician after the patient's previous surgery.
   b. An interdisciplinary team to assist in airway management when problems arise with intubation.
   c. Standardized difficult airway carts with advanced airway management equipment.
   d. Annual simulation training for residents on the management of unanticipated difficult intubation.

   > *A 36-year-old male undergoes anesthetic induction in preparation for a laparoscopic cholecystectomy. The anesthesia team has tried to intubate the patient three times (once by trainee, twice by staff).*

4. According to the Difficult Airway Society's unanticipated difficult tracheal intubation algorithm, which of the following interventions is the most appropriate?
   a. Check neck flexion, head extension, and laryngoscopic technique, and apply laryngeal manipulation.
   b. Request that another anesthesia provider assist with anesthesia.
   c. Use a fiberoptic intubation technique.
   d. Postpone surgery and awaken the patient.
5. All of the following are accurate statements about management of the male patient's unanticipated difficult intubation EXCEPT:
   a. Key points in managing an unanticipated difficult intubation include familiarity with instruments and techniques, the need for a preplanned strategy, and the importance of oxygenation/ventilation.
   b. Techniques that would help visualize the glottis include a modified Jackson's position and external laryngeal manipulation.
   c. If face-mask ventilation is inadequate to maintain oxygenation and ventilation, the next most appropriate intervention, according the ASA guidelines, is the placement of a supraglottic device, such as a laryngeal mask airway.
   d. An intubating laryngeal mask airway would assist in passing the endotracheal tube into the trachea either blindly or with the use of a fiberoptic scope.
6. Which of the following are clinical risk factors that, when present in this patient, may indicate the possibility of a difficult intubation?
   a. Male gender and smoking history
   b. Short thick neck, snoring, and a body mass index greater than 30kg/m^2
   c. Increased thyromental distance and limited head movement
   d. Poor dentition and a beard

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