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Introduction

One of the greatest challenges in the emergency situation is the acquisition of the airway. In the algorithm for any emergency situation, airway is the first step. When acquiring or establishing the airway becomes difficult, it is often called a "difficult airway." When the situation where a difficult airway occurs in an emergency, the challenges are much greater for the physicians involved. Otolaryngologists play a vital role in the management of the emergent airway as they can provide a surgical airway. This is often the last choice in management of difficult airways.

The Difficult Airway

There is no standard definition for what is constituted a difficult airway by any group. Many authors believe that the difficult airway is defined as an airway where there is problematic ventilation using a face mask. This is further classified as the inability to deliver necessary tidal volumes through the face mask utilizing a nasal or oral airway. It is also described as a Cormack and Lehane grade 3 or 4 view on laryngoscopic visualization. A difficult airway is also where intubation is difficult with standard airway equipment. During routine intubation, the airway is also defined as difficult when the airway requires external laryngeal manipulation, there are greater than 3 attempts at intubation, or when it requires nonstandard equipment. Unfortunately, the evaluation of the airway cannot always occur, especially during emergencies. However, when the time is available, a thorough evaluation of the airway can be essential to the proper management of the airway.

Evaluation of the Airway

Each hospital has a team of airway specialists. This team is made of experts in airway management. This often includes an Anesthesiologist, Otolaryngologist, Emergency Physician

and Respiratory Therapist. There are several important factors when evaluating the airway. First of all, an elective procedure allows for more time in evaluation of the airway. It also allows for acquisition of necessary tools to have available. In an urgent airway, often the evaluation of the airway is either forgotten or dismissed. The situation can be and is often less than ideal as adjuvant equipment is not available. In the evaluation, understanding the differences in the adult and pediatric airway is also vital. Finally, the status of the patient during the evaluation is critical.

There are several predictors for a significantly difficult or impossible intubation in adults. An interincisor distance of 3 cm or less, a thyro-mental distance of 6 cm or less, maxillary dentition interfering with jaw thrust, a neck in fixed flexion, or extreme head and neck radiation, scarring or large neck masses. Often times, the patients that an Otolaryngologist deals with have one or more of these associated predictors. In intubations, the setting can have a significant role in the success of establishing the airway. In the OR, often the rate of difficult intubations is 1.15% to 3.80%. Failed attempts at intubation occur in only 0.05% to 0.35%. In the emergency department, the incidences of difficult intubations occur in 3.0% to 5.3%. Failure rates in the ER range from 0.5% to 1.1%. There is a 10 fold increase in failure rates in the ER.

Wong et al examined the difficult airway in the emergency department. They studied 2,343 patients undergoing advanced airway management in the ER. This study was dated over a 6 year period from 2000 to 2006. Of the 2,343, 93 patients were deemed difficult intubations. In the study, a difficult airway was defined as difficulty with mask ventilation or at least three attempts at orotracheal intubation, failed intubation, or cricothyroidotomy. A failed airway was defined as tracheal intubation that could not be achieved after multiple attempts at orotracheal, nasotracheal or transtracheal intubation. Also, a failed airway was defined as one that was abandoned. The three most common diagnoses encountered during a difficult airway were cardiac arrest, trauma, and congestive heart failure. The authors then analyzed the records and found that the most common reasons for difficult intubation included an anterior larynx, neck immobility, secretions and blood in the airway, and a small mouth opening of less than 3 fingerbreadths. For patients with a difficult intubation, the mean number of attempts was 3.6 compared to 1.2 for all patients. For the entire group, the rate of airways requiring a surgical procedure was 0.3% and the overall rate of difficult intubations was 4%.

In the evaluation of the airway, the Mallampati classification is often used to help evaluate and predict the ease at viewing the patient's glottis. It is a four grade system that requires the patient to open his mouth and extend his tongue. By evaluating the amount of oropharynx visible, the examiner grades the airway. The Mallampati classification is often used in conjunction and as a predictor of the Cormack Lehane scale. The Cormack Lehane scale is also a four grade system which grades on the view seen of the glottis with a Macintosh blade.

There are several very important questions one needs to ask prior to attempting to secure the airway. First off, Can I perform effective mask ventilation? As described previously, this is defined as the inability to maintain oxygen saturation greater than 90% with 100%

inspired oxygen to prevent severe signs of hypoventilation with positive-pressure mask ventilation. Literature review states an incidence of 1.4-5% of difficult mask ventilation in patients in the OR. Second, one must ask whether the patient can be safely intubated. Again, trauma, secretions, and bleeding can make intubation difficult if not impossible to perform. Although tracheal intubation is the ultimate goal in airway management, the ability to provide effective mask-ventilation is life saving.

Kheterpal et al reviewed 50,000 patients undergoing airway management in the operating room. They found that they encountered impossible mask ventilation in 0.15% of cases. In the review, the authors found predictors for impossible mask ventilation including previous neck radiation, male sex, OSA, a Mallampati class III or IV, and presence of a beard. Only 25% (19/77) of patients with impossible mask ventilation were difficult to intubate. Of the study group, only 2 patients required a surgical airway.

Causes of a Difficult Airway

There are many causes of a difficult airway and recognition of each situation is important in helping to safely and securely acquire the airway. Forms of trauma can create difficult airways. Midface and mandible trauma can create soft tissue collapse, bleeding and secretions into the airway, and instability of the facial skeleton. Neck trauma can make orotracheal intubation difficult and sometimes impossible. One must be aware, especially, of blunt neck trauma and cricotracheal separation that would necessitate a surgical airway. Other causes of a difficult airway include bleeding into the airway, caustic injury, and thermal burns. Obstructive sleep apnea can cause a difficult airway as often the patient has difficult upper airway anatomy and redundant upper airway tissue. Mucosal malignancies can create difficult and challenging airways that often necessitate a surgical airway. Extrinsic malignancies, especially of the neck can create mass effect. Thyroid masses, lymphomas, and esophageal malignancies can distort and compress the upper airway.

Other causes of a difficult airway include: foreign body, cervical spine disease, deep neck space abscesses, trismus, anaphylaxis, angioedema, previous head and neck surgery, and vocal cord paralysis. Covered later in the chapter, congenital factors and pediatric syndromes can create situations for a difficult airway.

Intubation

An important initial step in the intubation process is pre-oxygenating the patient. In most healthy adults breathing room air, oxygen desaturation (SpO₂ less than 90%) will develop within a 2 minute time span. By pre-oxygenating patients with 100% oxygen, patients can maintain minimum oxygen saturation above 90% for more than 6 minutes. In order to properly get the patient pre-oxygenated, it is recommended to have the patient take 4 vital-capacity breaths in 30 seconds or 8 vital capacity breaths in 60 seconds by using a tight-fitting face mask with 100% oxygen. Pre-oxygenation is a crucial step in initiating intubation as it can provide

extra time in securing the airway.

In 1986, the American Society of Anesthesiology set out the American Society of Anesthesiology Standards for Basic Anesthetic Monitoring. Prior to this standard, there were no specifics in the monitoring of anesthesia. The society found that implementing technology that was already in existence as standard practice drastically improved anesthesia outcomes. The recommendations included continued monitoring of oxygen, ventilation, circulation, and temperature. Also, the standards include requirements for intermittent measurement of arterial blood pressure and heart rate. These standards have led to the safer administration of anesthetics and decreased complications.

The initiation of anesthesia starts with the administration of induction agents. It is important that the otolaryngologist has a working understanding of the various induction agents, their effects on the cardiovascular system, and their side effects. The current induction agents are administered intravenously. They have a quick onset and produce unconsciousness within 1-2 minutes. There are 4 induction agents that are commonly used. They include Thiopental, Propofol, Etomidate, and Ketamine. Thiopental and Propofol have negative inotropic effects causing hypotension. They produce apnea along with unconsciousness. Etomidate is often used in emergency situations. It has less of an effect on hemodynamics while producing apnea with unconsciousness. Etomidate has been found to be a potential suppressor of adrenal activity and can cause myoclonic activity. Ketamine has gained favor in many emergencies as it does not produce apnea. Ketamine can be given IM or IV. It can cause tachycardia and hypertension. Ketamine can also exaggerate secretions. It is often beneficial to administer glycopyrrolate to decrease secretions.

Volatile anesthetic agents are used in maintenance of anesthesia. There are several volatile anesthetics in use. Halothane is a nonflammable alkane gas. It does not cause bronchospasm. Halothane is highly soluble in the blood and fatty tissues. It can take time for the effects to wear off as the gas must be released from the fatty tissues. Halothane has negative inotropic effects on cardiac muscle. Enflurane and Isoflurane are nonflammable gases. Each possesses a pungent odor making them less ideal for mask ventilation. They generally cause intrinsic respiratory depression but have less cardiac effects than Halothane. Enflurane is now rarely used due to an increased risk of renal toxicity and seizures. Sevoflurane and Desflurane are gases with low lipid solubility allowing for quicker arousal than other volatile agents. These gases generally cause little myocardial depression. Desflurane is known to have bronchospasm properties. Nitrous oxide is another gas frequently used in anesthesia. It is generally not a potent enough agent to be used on its own. However, it is often used in conjunction with other volatile agents during general anesthesia. When used in conjunction, nitrous oxide can decrease the requirements of volatile agents. One must be aware that nitrous oxide can support combustion with oxygen. Interestingly, nitrous oxide quickly diffuses into closed, air-filled body cavities. Contraindications toward using nitrous oxide include obstructive ileus, pulmonary bullae, and unrelieved pneumothorax. In otolaryngology, nitrous oxide can be useful in minor ear cases. In myringotomy with PE tube placement, nitrous oxide can inflate the middle ear space. This however, can cause adverse events during procedures

such as tympanoplasties where the nitrous oxide can knock the graft off its location.

The other important groups of agents an Otolaryngologist must be familiar with are the neuromuscular blocking agents. There are two basic classes of neuromuscular agents. Competitive inhibitors require a reversal agent after administration while non-competitive inhibitors will stop. Pancuronium is a competitive inhibitor that lasts 60-90 minutes with an onset of less than 3 minutes. It is metabolized in the liver and excreted by the kidneys. Administration can cause tachycardia. Vecuronium is another competitive inhibitor that lasts 45-60 minutes with an onset of less than 3 minutes. It is also metabolized by the liver and excreted in the kidneys. Vecuronium does not have cardiovascular effects. Rocuronium is newer agent that is also metabolized in the liver and excreted by the kidneys. It is a quicker onset, generally less than 1 minute, and lasts 45-60 minutes. Rocuronium also does not have any cardiovascular effects. The only non-competitive inhibitor is Succinylcholine. Succinylcholine is metabolized by plasma cholinesterase and is then excreted by the kidneys. When administered, Succinylcholine can cause bradycardia in children or after repetitive boluses in adults. Its onset is generally less than 1 minute during which the patient will undergo fasciculations. Succinylcholine has a duration of less than 10 minutes. Succinylcholine is advantageous often in airway emergencies due to its onset and duration. Paralysis can create more problems during securing the airway as voluntary respirations will be lost. While mask ventilation can improve after neuromuscular agent administration, upper airway obstruction can occur.

Rapid sequence intubation is the most common approach to securing the airway in the ER, ICU and OR when there are concerns for aspiration such as a history of GERD or recent ingestion of foods. Intubation occurs first with pre-oxygenation after which induction agents and muscle relaxants are administered in rapid succession. After administration, one waits 45-60 seconds without mask ventilation. Mask ventilation can increase risk of aspiration. Intubation then occurs with cricoid pressure. However, there is controversy over the use of cricoid pressure during rapid sequence intubation. Studies have shown that during intubation the cricoid cartilage lies over the hypopharynx. When cricoid pressure is applied, the diameter of the esophagus is only compressed by 35%. Smith et al utilized MRI to investigate the role of cricoid pressure. They found that greater than 50% of patients have their esophagus displaced laterally during cricoid pressure. They also found that the esophagus is not compressible.

As discussed earlier, evaluation of the patient requires a good history and physical examination. There are differences between the adult and the pediatric evaluation. When evaluating the adult prior to intubation, one must evaluate for facial or neck masses. Also, one must evaluate for deformities, scars, quality of dentition, maxillary and mandibular position, pharyngeal structures, and neck mobility. Despite all of these factors, the best evaluation of the airway is through a flexible fiber-optic endoscopy. It can assess the entire upper airway and potential obstructive areas. There is controversy whether risk factors such as increased age, male sex, OSA, high BMI, and pretracheal soft tissue cause for difficult intubations. In the pediatric patient, history is the most important factor in evaluating the airway. Often, physical examination is difficult to properly perform. One should assess for noisy breathing during

exercise, at rest, or when feeding. A thorough history of previous surgeries and intubations is helpful as well. One should know about neck pain, recent fever, and recent upper respiratory infections that can increase the risk of laryngospasm and tracheospasm. Birth trauma and congenital anomalies should also be discussed prior to intubation. A good thorough evaluation can help avert disasters during intubation and allow for extra tools to be available.

Difficult Airway Algorithm

The Difficult Airway Algorithm has been set up as a systematic approach during the intubation approach. There are 4 main steps in the process of developing the strategy for acquiring control of the airway. The first step in the algorithm is to assess the likelihood and clinical impact of basic management problems. One should assess the likelihood of difficult ventilation, difficult intubation, difficulty with patient cooperation or consent, or difficult tracheostomy. The second step is to actively pursue opportunities to deliver supplemental oxygen throughout the process of difficult airway management. Third, one should consider the relative merits and feasibility of basic managements. Considerations should be made between awake intubation versus intubation attempts after induction of general anesthesia. Also, one should assess whether non-invasive techniques for initial approaches to intubation are best or invasive techniques for initial approach are best. Finally, the decision between preserving spontaneous ventilation or ablation of spontaneous ventilation should be made. Finally, the fourth step is to develop primary and alternative strategies. One of the keys to the algorithm is the ability to mask ventilate the patient. A new innovation that has revolutionized the airway algorithm is the implementation of the LMA. The LMA can act as a primary airway or an adjunct toward securing the airway. There are alternative options toward intubation that include using different laryngoscope blades, the LMA as an intubation conduit, fiber optic intubation, intubating stylet or tube changer, light wand, retrograde intubation, or blind oral or nasal intubation. There are three non-invasive airway techniques that are mentioned during the algorithm. They include rigid bronchoscopy, esophageal-tracheal combitube, or transtracheal jet ventilation.

Non-Surgical Options

There are multiple non-surgical options available today during the management of the difficult or emergent airway. They include face mask ventilation, endotracheal intubation, LMA, Combitube, and fiber optic nasotracheal intubation. Face mask ventilation, as mentioned before, is an essential element to airway management. It is used during induction and as a rescue technique during failed attempts. The bearded patient presents a challenge as a proper seal can be very difficult. Often the use of a nasal trumpet or oral airway may assist in ventilation of the patient.

Endotracheal intubation has a long history, and the first accounts of endotracheal intubation were found in the works of Avicenna in 1000 AD. Generally, orotracheal intubation utilizes either a Macintosh or Miller blade. The Macintosh blade is a curved laryngoscope that slides under the vallecula and lifts the entire larynx anteriorly or ventrally to expose the glottis.

The Miller blade is a straight laryngoscope that is placed under the epiglottis where it sits in the petiole of the epiglottis lifting the larynx anteriorly to view the glottis. Three maneuvers can be beneficial if initial intubation is not successful. Placing the patient in the “sniff” or modified Jackson’s position, applying external laryngeal pressure and maneuvering the laryngoscope can assist in intubation. A general rule of thumb is that if there are three attempts, one should proceed with alternative procedures. Complications during endotracheal intubation include severe hypoxemia that can occur in 25% of cases or severe collapse that can also occur in 25% of cases. Difficult intubation occurs in 10-15% of cases.

The laryngeal mask airway or LMA was first introduced in the U.S. from Europe in the early 1990s. The LMA was initially utilized for elective face mask cases requiring general anesthesia. As mentioned previously, its utilization has revolutionized the algorithm for difficult airway management. The LMA is fast and easy to place and can be placed securely even by inexperienced personnel. However, it does not offer full protection of the airway from the potential for aspiration. Unique in its design, the LMA allows for patients to be intubated directly through the LMA either with a fiber optic endoscope or blindly.

The Combitube is a double lumen tube that has been designed for placement into the esophagus. It has been widely implemented by emergency personnel as an emergency airway device. The device has a closed distal end designed for passage into the esophagus with an inflatable seal. There is a proximal seal that is achieved either with a facemask or oropharyngeal cuff. There are multiple holes in the tube between the two seals that allows for delivery of gases into the laryngopharynx. There is a second open-ended tube that can function as a tracheal tube if the device is inserted into the trachea.

The semi-rigid gum elastic bougie is an adjunct to intubation. Generally it is best used in conjunction with an anterior commissure laryngoscope. The elastic bougie is able to pass into the larynx, sometimes blindly and act as a stylet for the endotracheal tube. One knows he is in the airway when tactile sensation of the tracheal rings is felt.

Nasotracheal intubation is another non-invasive technique. The ability to drive the scope into the proper location can be very challenging. The fiber-optic scope allows the operator to see around corners. It is advantageous in patients with poor mouth opening, limited neck movement or other conditions that make direct laryngoscopy difficult. Bleeding and secretions can make its use difficult if not impossible. The fiber optic endoscope is passed transnasally after the endotracheal tube has been placed over the endoscope. The endoscope is passed into the subglottic trachea then the ETT is passed over the scope. There are several contraindications toward using nasotracheal intubation which include history of or possible basal skull fracture or epistaxis. Nasotracheal intubation can cause damage to nasal mucosa leading to epistaxis, or the scope can pass submucosally into the posterior nasopharynx.

Retrograde intubation is another alternative to orotracheal intubation. A narrow flexible guide is inserted percutaneously through the trachea below the vocal cords. It is then advanced out of the mouth or the nose. The endotracheal tube is then passed over the guide

into the upper part of the trachea. At this point, one can either perform an oral or nasal intubation. This technique can be performed when there is upper airway obstruction or severe trismus. However, retrograde intubation is invasive and takes time. Complications of retrograde intubation include minor bleeding, subcutaneous emphysema, pneumomediastinum, and infection. Important contraindications to retrograde intubation include coagulopathy, inability to identify landmarks, laryngeal disease, and local infection.

There are multiple options for non-invasive airway management. Many of these options can be time-consuming and must be under the right circumstances. When these options are not feasible, often airway management must turn to surgical management.

Surgical Management of the Difficult Airway

Awake Tracheostomy

Mentioned in the first scenario in the difficult airway algorithm, an awake tracheostomy is a safe and controlled method of surgically acquiring the airway. Awake tracheostomy is deemed appropriate when intubation is deemed impractical. It is best performed in a controlled environment under local anesthesia. The patient should get minimal sedation as to keep the patient comfortable but not enough to cause respiratory depression. Since the patient is awake and alert throughout the process, this procedure requires clear communication among the surgeon, anesthesiologist, nurses and technicians. Positioning the patient properly is very important during the procedure. The patient should be placed where anesthesiology can have ready access to the airway. Positioning the patient in a reverse trendelenburg position also allows for improved primary and accessory respiratory muscle function.

Emergency Cricothyroidotomy

The cricothyroidotomy is a relatively simple and fast procedure that can be life-saving in patients. The cricothyroidotomy has a low perioperative complication rate as the cricothyroid membrane is a relatively avascular membrane separated from the skin by only subcutaneous fat, anterior cervical fascia, and strap muscles laterally. Importantly, the vocal cords are approximately 1 cm above the cricothyroid membrane. There are several important contraindications to performing a cricothyroidotomy. Cricothyroidotomy should not be performed in patients less than 10 years of age. Any patients with severe neck trauma and loss of palpable landmarks or an expanding hematoma should not undergo cricothyroidotomy. Also, patients with obstructive lesions of the larynx with known subglottic extension should not undergo cricothyroidotomy. Ideally, these patients should undergo a planned urgent awake tracheostomy.

A surgeon should be able to quickly and safely perform a cricothyroidotomy. The procedure has six basic steps and requires good suction and lighting when it is performed. First, the surgeon should palpate airway landmarks including the thyroid notch, cricoid cartilage

and sternal notch. The upper airway, specifically the thyroid cartilage, should be stabilized by the nondominant hand. This is the single most important factor for a successful outcome. The airway will likely be a mobile target once the procedure starts. A vertical midline incision should then be performed until the membrane is identified. A horizontal incision over the lower edge of the cricothyroid membrane is then performed. Once the airway is entered, a Kelly or hemostat is used to dilate the membrane. Either a small (5.0) endotracheal tube or size 4 tracheostomy tube is then inserted into the airway. Once the proper placement is confirmed, the airway is secured.

Transtracheal Needle Ventilation

Transtracheal needle ventilation is an alternative surgical airway that can buy physicians valuable time until a more permanent airway solution is made. There are three basic tools necessary that can be found in any trauma bay or emergency department. They include an oxygen delivery device that can give 100% oxygen at 50 psi, a large-bore needle and cannula, and a luer-lok connector. The needle and cannula are connected to a saline syringe and then used to puncture the trachea or cricothyroid membrane. This maneuver is performed at the midline at a 30 degree caudal direction until air bubbles are seen in the syringe. Oxygen is then connected to the cannula through the luer-lok connector. A patient under this circumstance can be oxygenated for roughly 30 minutes to 2 hours while preparations are made for alternative strategies.

Emergency Tracheostomy

The emergency tracheostomy, or “slash” trach, as it is often referred to as, can be a very challenging situation for even the most experienced surgeons. Anoxia in a patient can cause death in 4-5 minutes necessitating that the tracheostomy be performed within 2 to 3 minutes. This procedure should always be performed through a vertical incision in the midline. Again, the non-dominant hand should stabilize the larynx. Rapid incisions should be made through the skin, subcutaneous tissues, platysma and thyroid isthmus until the trachea is reached. Using the index finger of the non-dominant hand during the procedure to help dissect and palpate can be very beneficial. Once the trachea is reached, a vertical incision through the second or third tracheal ring is then performed. The endotracheal or tracheostomy tube is then inserted into the airway. If available, a reinforced endotracheal tube should be placed. This tube has less chance of kinking in the airway. Once the airway is secured, the patient should be brought to a secured setting where the airway can be properly secured, bleeding can be controlled, and the surgical site inspected.

Outcomes of Emergency Surgical Airways

Gillespie et al examined chart records of patients from January 1, 1993 to December 31, 1998 and found 35 patients who underwent an emergency surgical procedure, either a cricothyroidotomy or a tracheotomy. In their study, the authors excluded patients who were found to have spontaneous ventilation or underwent an urgent airway procedure. Their study

found that 13 patients required a surgical airway for cardiac or pulmonary arrest, 12 patients for head and neck cancer, and 10 patients for trauma. These patients were found to be not amenable to mask ventilation or intubation. 40% of these patients had upper airway edema. 23% of the patients had difficult anatomy with inability to visualize the vocal cords. 20% of patients had an obstructing lesion in the oropharynx or larynx. 17% of patients had maxillofacial or neck trauma. The authors found that a surgical airway was established in 34 patients in 37 attempts for a 92% success rate. A cricothyroidotomy was successfully established in 20 of 23 attempts and a tracheostomy was performed successfully in all 14 patients.

Complication rates for both cricothyroidotomy and tracheostomy were similar with a total of 4 complications during cricothyroidotomy and 3 for tracheostomy. These complications included hemorrhage, cricoids cartilage injury, wound infection, operating room fire, and subglottic stenosis which occurred in one patient after cricothyroidotomy. The authors concluded that there is not much known about the role of tracheostomy in emergency situations. In their own review, tracheostomies were 100% successful with similar complication rates as cricothyroidotomies. Various literature estimates that elective tracheostomy has a complication rate of 15% which increases by 2 to 5 times higher in emergencies.

There is controversy over the emergency cricothyroidotomy surrounding the need to quickly convert to a standard tracheostomy. The principal long-term morbidity of a cricothyroidotomy is subglottic stenosis. In 1921 Chevalier Jackson submitted his publication on pediatric patients discouraging cricothyroidotomies due to the high rate of subglottic stenosis. At the time of his publication, most children had metal tracheostomy tubes which were placed for chronic inflammatory diseases of the larynx and trachea. As techniques and equipment have improved, incidence of subglottic stenosis has decreased dramatically. Most of the literature points to less than 1% rate of subglottic stenosis. These authors recommend avoiding this procedure in patients who have been intubated for more than 7 days. Often the stress and inflammation placed on the cricoids cartilage by the endotracheal tube is enough to cause subglottic stenosis. It is impossible to know the true incidence of subglottic and tracheal stenosis as many patients are asymptomatic or lost to follow-up after discharge.

Converting a cricothyroidotomy to a tracheostomy requires a second surgical operation, and there is controversy among surgeons. It is most often advocated to decrease the incidence of subglottic stenosis. DeLaurier et al questioned this need. They found that 0 out of the 11 patients they followed developed subglottic stenosis. In their group, however, they found 2 of the 9 patients who underwent conversion developed tracheal granulation tissue. Also, their one episode of subglottic stenosis was not prevented by conversion to tracheostomy. Several flaws in their study include the fact that their patients were mostly trauma victims who were successfully decannulated after an average of 3 days. Most otolaryngologists will agree that there are several instances in which conversion is necessary. This included patients who will require operative exploration for hemorrhage or other complications including suspected laryngeal cartilage injury. Also, patients who will require long-term airway maintenance or

mechanical ventilation should be converted from cricothyroidotomy to tracheostomy.

Surgical management of the airway requires a good knowledge of the upper airway anatomy. Keys to success include having the necessary tools to succeed and proper stabilization of the airway. The cricothyroidotomy is a safe, effective and simple procedure that can be life-saving. However, instances will occur where it is either unsafe or contraindicated. In these instances, a tracheostomy is the only option.

Management of the Pediatric Patient

The adult airway and pediatric airway differ greatly. In pediatric patients, the larynx is closer to the level of cervical C3 as opposed to the level of C5 in adults. This gives the pediatric patient a higher level of the tongue and an appearance of an anterior larynx. Pediatric patients, on average, have larger tongues. They generally have a larger, stiffer epiglottis. The angle of the thyroid is generally broader. In the pediatric airway, the narrowest part of the airway is at the level of the cricoids cartilage. In adults, the narrowest area is at the level of the true vocal cords. Also, children have large occiputs that make positioning more of a challenge. Relating to the airway, physics dictates that resistance to flow is inversely proportional to the radius of the lumen to the fourth power. This means that a similar change in edema between a pediatric patient and an adult patient means immensely more obstruction in a child. This point is best demonstrated by the incidence of airway emergencies in the pediatric population relating to viral and bacterial infections of the upper airway and larynx.

In the pediatric patient, proper selection of the endotracheal tube is best evaluated using a simple formula. The age is added to 16 then this sum is divided by four giving an accurate estimate of tube size. An LMA is a helpful device in children as well as adults. The LMA can easily be placed and removed while inflated. Proper sizing of the LMA should be based most on patient weight. During a difficult airway, the light wands can be used. It is a rigid fiber-optic stylet with a light at the tip. Using a blind technique for intubation, it is passed through the mouth into the trachea until a characteristic light pattern is observed. This technique does not depend on good mouth opening or extension of the neck. It can be simpler and faster than fiber optic intubation and can be performed even with bleeding. It does require the room lights to be dimmed and is difficult to perform in patients with distorted anatomy. Flexible fiber-optic bronchoscopy is a viable option in the pediatric patient. It has the same risks and complications as in adults. Children should be kept anesthetized but spontaneously breathing on 100% oxygen during the procedure. In these cases, often an LMA is a good adjunct to facilitate intubation.

Craniofacial Dysmorphologies

Craniofacial abnormalities, especially related to congenital syndromes, can be very difficult in airway management. There are a large number of different syndromes that can cause airway obstruction or difficulty with intubation. A few of these will be discussed.

Treacher-Collins Syndrome

Patients with Treacher-Collins syndrome have maxillary, mandibular, and zygomatic hypoplasia. These patients are often difficult to mask ventilate or intubation. In those patients with TMJ abnormalities, either is often impossible. Many of these patients require tracheostomy early in life, however, sedated fiber optic intubation or LMA placement can be helpful. Intubation, as a general rule, in these patients tends to improve as the patient grows older.

Cornelia de Lange Syndrome

Cornelia de Lange Syndrome is described in patients with microcephaly, confluent eyebrows with underdeveloped orbital arches. Often these patients have a long philtrum, high arched palate with an over or submucous cleft palate. Also these patients exhibit micrognathia. These patients require a similar approach in airway management as patients with Treacher-Collins syndrome.

Hallerman-Streif Syndrome

These patients exhibit microcephaly with malar hypoplasia. These patients have micrognathia with a “parrot-beak” nose secondary to hypoplasia of the nasal cartilage. They also have a narrow and high arched palate. Patients with this disorder exhibit thin, light hair with hypotrichosis which occurs most on the eyebrows and eyelashes. These patients also have low set ears. Often airway management is best with fiber optic intubation. These patients do not often require surgical airways.

Crouzon Syndrome

Crouzon disease is associated with craniosynostosis and midface hypoplasia, hypertelorism, and proptosis. These patients are primarily mouth breathers and many have obstructive sleep apnea. Neck extension can be limited due to vertebral anomalies, and tracheal abnormalities are often present. These patients can be hard to mask ventilate. They can be difficult to mask ventilate.

Freeman-Sheldon Syndrome

Freeman-Sheldon Syndrome is a rare myopathic disorder also known as Whistler’s disease. Often patients have a typical facial appearance with a mask-like facie. They have the appearance of whistling secondary to circumoral fibrosis and microstomia. This microstomia is sometimes so severe that direct laryngoscopy can be impossible to perform. It is important to note that inhalational agents are contraindicated in these patients as they are at an increased risk of malignant hyperthermia.

Instability or Inflexibility of the Larynx

It is important to know several conditions are related to problems with neck mobility. Patients with Down 's syndrome or Juvenile Rheumatoid Arthritis are at greater risk of laryngeal instability. Patients with Goldenhar or Klippel-Feil syndrome, commonly, have inflexibility of the larynx making positioning for intubation challenging.

Laryngeal Abnormalities

There are many syndromes associated with difficult upper airway abnormalities. Also, pediatric patients can have many abnormalities that are not evident externally. They include congenital lesions such as cricoids or subglottic stenosis, laryngeal webs and cysts, laryngoceles, subglottic hemangiomas, and bilateral true vocal cord paralysis. Infections can also cause laryngeal abnormalities including epiglottitis, recurrent respiratory papillomatosis, and group. Finally, traumatic injuries such as chemical or thermal burns and foreign bodies in the airway can pose potential problems during an airway event.

Conclusions

It has been shown that very few airway scenarios, even difficult airways, require a surgical airway. There are a large number of tools and procedures that are available to non-invasively acquire the airway. It is important to know the equipment and how to use it as these scenarios require quick thinking and quick action. The LMA is a wonderful tool and adjunct to the airway algorithm. It can help create time for more permanent solutions often. As discussed, pediatric patients have a differing anatomy and pose many challenges in airway management. One must be ready for multiple scenarios. Most importantly, one must always have back-up plans ready during airway management. Otolaryngologists have many special skills and tools that are invaluable in the management of the difficult and emergent airway.

Discussant's Remarks by Michael Underbrink, M.D. – Emergent Airway -- March 31, 2011

I'm going to make a few comments. First of all, that was a very good talk, Dr. Walton. I think the important thing, the reason to give this talk, is summed up in your summary, and basically I think that because we are so intimately involved with airway management that and being that an emergent or surgical airway is the last option that we are usually involved with, it is important for us to maintain communication during the whole process, at least to have an understanding of whether elective or emergent, how the anesthesiologist or the person that is intubating or getting beyond the basic airway thinks about their options, so it's nice to have that in the back of your mind that to have a deep understanding, a good depth of knowledge about how to prepare for the opportunity to gain access to the airway.

And you're right: the otolaryngologists do have an intimate involvement with how to obtain and maintain that airway and lots of clues to help along the way. So, very good talk in that respect. I also think it's important to know the adjuvant methods by which they do provide anesthesia for cases and so when you're having a case, whether it be elective or emergent or for cancer or for any number of cases I think that the important thing is to have communications especially when the airway is difficult or unstable or when you perceive that there will be difficulty with access to the airway and you do communicate effectively prior to the case, may not waiting until just before but maybe talking the night before. I generally talk with the anesthesiologist the night before if I'm considering that it may be a very difficult case and I think that's important too, at least in the preoperative planning phase, an hour before the case have a plan, and a backup plan, and a plan for the back up plan and a plan for the back up plan and generally when you're Plan B you should probably make sure you know what Plan A is.

So those are all good points. I had a specific comment with respect to the cricothyroidotomy because that was a very good point in that the complication rate for cricothyroidotomy is I believe is low insofar as subglottic stenosis with the caveat that you're not providing it for long term ventilation, and so my thought is and I usually do use the cricothyroidotomy if I'm doing an emergent airway first and then if I know that I'm going to ahead and convert it especially if you're doing it in the operating room in the first place, because the management of a tracheostomy in my opinion is a little bit easier if there if there are complications than the management of glottic stenosis. So, if you look at it from the perspective of whose managing the disease, I guess it's all relative to your experience with the complication and so if you are an emergency room physician or a surgeon, a trauma surgeon, and your experience is with trauma and three days of intubation via the cricothyroid membrane is different than someone who's going to be dealing with complications, so I convert those based on that knowledge that if there is a complication we're going to be...although I do agree with the literature that it's not going to be that likely.

The second thing about a cricothyroidotomy is that you did manage to hit on a key point that is to control with your off hand but it's not really that you're going to control movement, it's a moving target so when you're in that situation, don't try to keep them from swallowing because they'll be swallowing and you're going to be fighting them swallowing so you'll be hitting a moving target and you know where that is at all times because it elevates and depresses and is moving all the time so that's why you want to maintain control and palpate where you are so that when you're hitting that moving target it will probably move at least once or twice during the whole thing, so keep that in mind. A very good talk overall and I wonder if there are any other questions.

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