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Intubation: Difficult Airway

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<http://dx.doi.org/10.5772/intechopen.75512>

Abstract

This chapter focuses on the difficult airway algorithm during the intubation process. The current published recommendations will address the definition of the difficult airway, steps by which to secure the airway, and when to employ a surgical airway in the form of tracheotomy or cricothyrotomy. Finally, the role of the Otolaryngologist-Head and Neck Surgeon will be highlighted in the difficult airway team which should be multidisciplinary when handling airway concerns in a hospital. Overall, the goals of this chapter are to educate the reader on how to critically analyze and decide on the means to adopt a difficult airway algorithm in their own institution(s).

Keywords: difficult airway guidelines, tracheotomy, cricothyroidotomy, surgical airway

1. Introduction

Intubation is the mechanism to artificially secure the airway. When assessment of the airway yields concerns of poor oxygenation and ventilation through traditional technique, then a difficult airway algorithm should be considered. The difficult airway algorithm is described in multiple practice guidelines, amongst many specialties [1, 2]. This chapter reviews the definition of a difficult airway, anatomical and physiological considerations of a difficult airway, and the tools that are utilized when attempting a difficult airway intubation. Lastly, from a head and neck surgical perspective, the chapter will discuss the options for surgical airway, when to consider placement of a surgical airway, and what is required from a multidisciplinary approach when left with placing a surgical airway.

2. Definition of a difficult airway

The definition of a difficult airway has been described multiple ways in the literature. There is no single definition of a difficult airway. According to the 2003 revised American Anesthesiology Task Force guidelines, a difficult airway is when a trained anesthesiologist experiences difficulty with face mask ventilation of the upper airway, difficulty with tracheal intubation, or both [2, 3]. Other definitions incorporate a broader definition whereby there is problematic ventilation using a facemask, incomplete laryngoscopic visualization, or as a difficult intubation with standard airway equipment [4]. Difficult ventilation is the inability to deliver the necessary tidal volume via the facemask even when using an oral or nasal airway and necessitating another device such as the laryngeal mask airway. Difficult laryngoscopy is impaired visualization of the true vocal cords despite elaborate external laryngeal repositioning. Difficult intubation requires external laryngeal manipulation, difficult laryngoscopy requiring greater than three attempts at intubation, intubation requiring nonstandard equipment or approaches, or the inability to intubate using all available methods [5].

The importance of identifying a difficult airway is not in a single definition—it is in the recognition by a team in charge of the airway to institute an algorithm to secure the airway appropriately, in order to prevent morbidity and mortality. The incidence of difficult intubation in the operating room ranges between 1.15 and 3.80% [6], with failed attempts in 0.05–0.35% of cases [7, 8]. In the emergency department, difficult intubation occurs in 3.0–5.3% [7, 8] of cases with failure rates ranging from 0.5 to 1.1% [7, 8]. The most common complication related to a difficult airway is mistakes in the algorithm, mainly caused by unpreparedness [4]. This chapter aims to describe ways to prepare and secure the difficult airway.

2.1. Early clinical considerations of a difficult airway

In order to prepare and implement a difficult airway algorithm, it is important to assess the clinical scenarios or patient factors that can help determine the airway plan. Both the environment and patient stability dictate the scope of evaluation and management. The pace at which the assessment, approach and intervention is made is vital to securing the airway.

The initial history and physical examination are crucial in the assessment of the airway. The history is most accessible in an elective scenario or controlled setting where the patient is stable. Patient's age, mental status and cooperativeness is also important [5]. Pertinent history includes prior history difficult intubation, obstructive sleep apnea (OSA), head and neck irradiation, obesity, congenital malformations, cervical spine disability, and thyroid goiters [4]. Each of these factors can be important when deciding electively to secure a potentially difficult airway. In an emergency situation when a patient is not stable, having a history of difficult intubations can be the most important. Lundstrom et al. found that 24% of the patients with a documented history of difficult prior intubation subsequently experienced a difficult tracheal intubation. Amongst the patients with no history of difficult intubation, 95% of them subsequently underwent an intubation with no difficulty [9].

Other important clinical considerations include obstructing upper airway disorders. Amongst these clinical diagnoses include a more progressive process like a glottis or supraglottic tumor, subglottic stenosis, history of longstanding vocal fold paralyzes either unilateral or bilateral [4]. The presentation of patients with significant obstructing airway disorders is variable depending on the cause of the obstruction as well as the acuity or long-term progression. With a gathered history in a stable patient, what is important is the decision to consider a fiberoptic laryngoscopy prior to intubation. Flexible laryngoscopy and bronchoscopy is advisable before airway management [10]. Flexible laryngoscopy is necessary to indicate the extent, location, and nature of the obstructing disorder, and can lead to a more informed and successful airway management communication and plan. Bronchoscopy is good for visualization distal to the vocal folds in cases of subglottic or tracheal stenosis that would impede intubation.

What is important in any difficult airway is the adoption of an algorithm that begins with tracheal intubation. When tracheal intubation is not successful, an algorithm can direct the next steps to securing the airway. The risk of repeated unsuccessful trachea intubations leads to increased morbidity and mortality [11]. As soon as one method is deemed impracticable, practitioners must quickly advance through the algorithm rather than persist in futile attempts.

2.2. Difficult airway algorithm

The difficult airway algorithm is published annually by the American Society of Anesthesiologists (ASA) (**Figure 1**) to reinforce the guidelines and be utilized by anesthesiologists nationwide [2, 3]. It standardizes how to secure a difficult airway. The initiation of the airway algorithm is dependent upon assessing the likelihood and clinical impact of basic management problems such (1) difficult ventilation, (2) difficult intubation, (3) uncooperative patient, (4) difficult tracheotomy. It then proceeds to break down the algorithm into different basic management choices such as awake intubation, non-invasive techniques and spontaneous ventilation compared to intubation after general anesthesia delivery and invasive methods for intubation. Within the branched algorithm, each method is described in a step-wise fashion, and the algorithm offers steps depending on success or failure of each method. Conservative non-invasive methods only become invasive and/or require help and surgical expertise when ventilation is not successful. Caveats for invasive airway techniques are listed at the bottom of the diagram in footnote fashion.

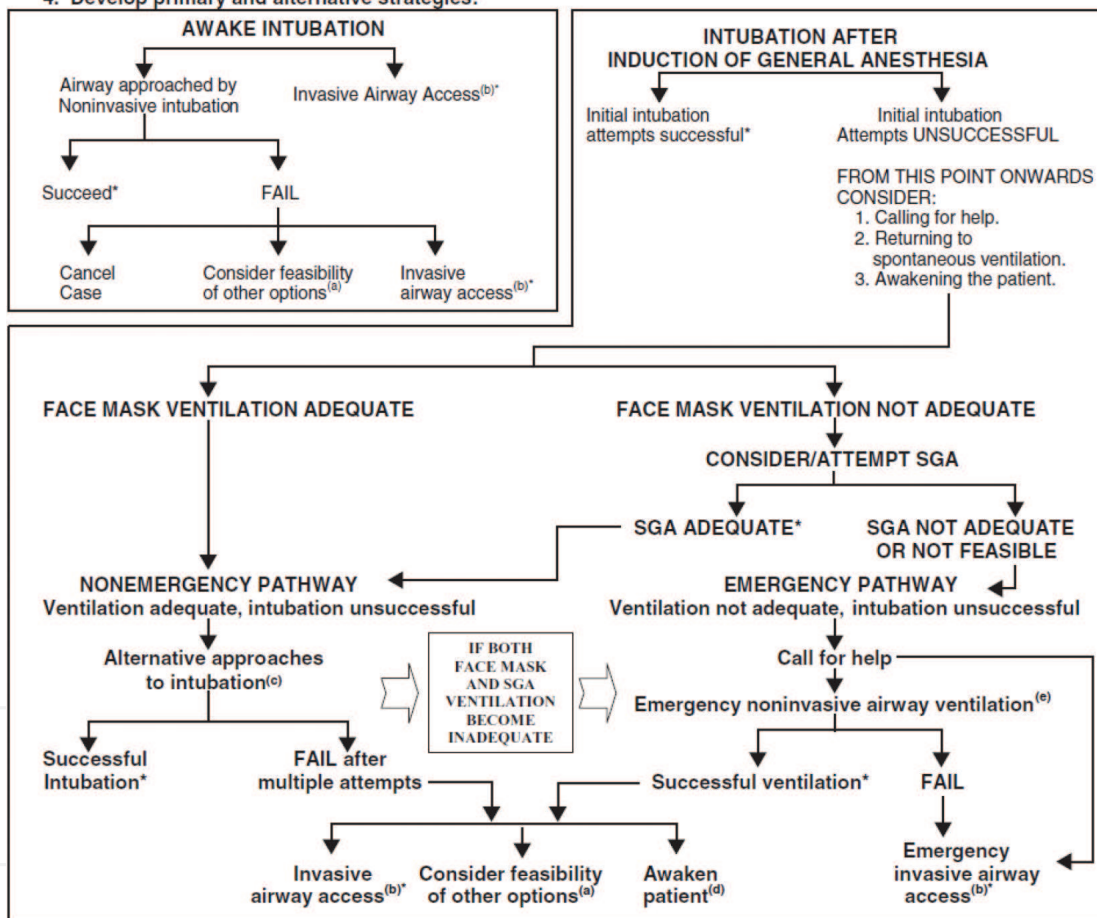
The importance of a multidisciplinary team, the presence of an acting lead in securing the difficult airway, and the timing and number of intubation attempts are all critical components of a difficult airway algorithm.

2.3. Tools to secure the difficult airway

As described in the difficult airway algorithm, alternative approaches to intubation are only possible if the toolbox available has both the basic and the alternative instrumentation for securing the airway. The difficult airway 'cart' should be established and secure in an area in any hospital setting, whether it be in the operating room, the emergency room and/or a

American Society of
Anesthesiologists[®] 
DIFFICULT AIRWAY ALGORITHM

1. Assess the likelihood and clinical impact of basic management problems:
 - Difficulty with patient cooperation or consent
 - Difficult mask ventilation
 - Difficult supraglottic airway placement
 - Difficult laryngoscopy
 - Difficult intubation
 - Difficult surgical airway access
2. Actively pursue opportunities to deliver supplemental oxygen throughout the process of difficult airway management.
3. Consider the relative merits and feasibility of basic management choices:
 - Awake intubation vs. intubation after induction of general anesthesia
 - Non-invasive technique vs. invasive techniques for the initial approach to intubation
 - Video-assisted laryngoscopy as an initial approach to intubation
 - Preservation vs. ablation of spontaneous ventilation
4. Develop primary and alternative strategies:



*Confirm ventilation, tracheal intubation, or SGA placement with exhaled CO₂.

a. Other options include (but are not limited to): surgery utilizing face mask or supraglottic airway (SGA) anesthesia (e.g., LMA, ILMA, laryngeal tube), local anesthesia infiltration or regional nerve blockade. Pursuit of these options usually implies that mask ventilation will not be problematic. Therefore, these options may be of limited value if this step in the algorithm has been reached via the Emergency Pathway.

b. Invasive airway access includes surgical or percutaneous airway, jet ventilation, and retrograde intubation.

c. Alternative difficult intubation approaches include (but are not limited to): video-assisted laryngoscopy, alternative laryngoscope blades, SGA (e.g., LMA or ILMA) as an intubation conduit (with or without fiberoptic guidance), fiberoptic intubation, intubating stylet or tube changer, light wand, and blind oral or nasal intubation.

d. Consider re-preparation of the patient for awake intubation or canceling surgery.

e. Emergency non-invasive airway ventilation consists of a SGA.

Figure 1. Difficult airway algorithm by the American Society of Anesthesiologist Task Force (2003).

designated area where it can be accessed by anyone who needs it [6, 12]. The tools for a difficult airway can be multiple.

One of the most pertinent tools in any intubation is the laryngoscope. Direct laryngoscopy is the paradigm of tracheal intubation, and has been a part of the armamentarium of any provider securing the airway. The role of videolaryngoscopy over direct laryngoscopy has been a topic of discussion and published research, in regards to providing improved benefit over the traditional direct laryngoscopic approach. The authors of a large meta-analysis of five randomized controlled studies with 1301 patients found no difference in first time success in endotracheal intubation between using videolaryngoscopy over direct laryngoscopy [13]. The caveat to this meta-analysis was that most endotracheal intubations were done in an ICU setting. Other reviews and case series demonstrate an improvement in first time intubations in an emergency room setting using videolaryngoscopy over direct laryngoscopy, although there is no large randomized control study that verifies this [14–17].

In the predicted difficult airway, when a patient is able to maintain spontaneous breathing, an awake intubation is an option. The tools for an awake intubation can be either non-invasive or invasive. LMA, supraglottic airways, and nasal-rays are examples of non-invasive tools. Fiberoptic laryngoscopy allowing for placement of a nasal-ray can be done awake. Invasive techniques include a surgical airway under local sedation- open versus percutaneous tracheostomy, or retrograde intubation [1].

Other tools that can be used for awake intubation include a fiberoptic bronchoscope. Apfelbaum et al. described bronchoscope success in 88–100% of these patients, although other tools such as intubation through supraglottic devices, glidescope, and other tools are also successful [3]. The fiberoptic bronchoscope is successful if someone with proficiency is able to perform it [3].

Other tools are also important in placement of endotracheal intubation. Intubating stylets or tube changers are also an option and can be used successfully for difficult intubations. Mild mucosal bleeding and sore throat are complications associated with stylets, and lung laceration and gastric perforation are associated with exchange catheters [3, 18]. This is a blind technique.

Supraglottic airways such as the LMA have shown to be rescue devices in patients who cannot be intubated or mask ventilated. The LMA can be used with a fiberoptic bronchoscope for intubation, and can maintain or restore ventilation in the difficult airway patient [5, 6, 18].

2.4. Surgical airway

In the algorithm of the difficulty airway, the surgical airway is the definitive step in securing the airway. The placement of a surgical airway does not necessitate it being the last step in the algorithm, when non-invasive methods are unsuccessful. It may be the first step in securing the airway dependent upon the clinical context and stability of the patient. A surgical airway may be planned such as an awake tracheostomy in a patient where intubation through the glottis is not possible, or it may be an emergency when a trauma patient initial assessment

is bypassed by airway compromise and a surgical airway is the most appropriate next step for airway security. An awake tracheostomy tube is performed with no sedation and local anesthesia is used. The patient maintains spontaneous ventilation while the tracheostomy is being performed. Plain lidocaine (1%) is injected into the trachea before entering the airway to minimize coughing. After return of CO₂ is confirmed, generalized anesthesia is immediately administered [4]. Difficulties with awake tracheostomy start with inability for the patient to be fully cooperative. Physical factors include fixed cervical spine flexion deformity, obesity and increased neck circumference that decreases ability to palpate laryngeal landmarks. Large thyroid goiters can also be a limitation. History of head and neck radiation also results in distorted anatomy and loss of palpable laryngeal structures that make it hard to complete an awake tracheostomy [4].

In the case of an airway emergency or acute destabilization of a patient requiring immediate airway protection, a surgical airway can take place in two forms: a cricothyroidotomy or a tracheostomy. The pros and cons of each approach are discussed in the next section.

The steps of the emergent surgical airway are:

1. Identifying surgical landmarks, including the laryngeal skeleton and midline trachea
2. Assessment of the patient's body habitus and any potential obstructions to entering the airway (such as obesity, enlarged thyroid goiter, neck irradiation)
3. Topical anesthetic to the skin for local anesthetic and less patient discomfort (if there is time)
4. Taking a large gauge needle and syringe and placing it directly into the airway, with confirmation of aspirated air back
5. Vertical incision with a 15 blade into the overlying soft tissue and through the trachea or a vertical stab incision into the cricothyroid membrane. Placement of an endotracheal tube into the lumen is important with end tidal CO₂ confirmation.
6. Securing the airway is important which may require transportation to an operating room setting if in the emergency department, with revision to a traditional tracheostomy, neckties and achievement of hemostasis.

2.5. Pros and cons of tracheotomy versus cricothyroidotomy

The American Society of Anesthesiologists difficult airway algorithm identifies two acceptable emergency surgical airways in the 'cannot intubate, cannot ventilate' scenario: cricothyrotomy and tracheotomy [2].

According to the guidelines of the American Trauma Life Support developed by the American College of Surgeons, cricothyrotomy is recommended in an emergent setting [19]. Cricothyroidotomy is perceived to be easier to perform as it is safer theoretically, has less bleeding, and requires less surgical time [20, 21]. The difference between a cricothyroidotomy and a tracheostomy is that a cricothyroidotomy is a temporizing measure only [20].

Furthermore, a needle cricothyroidotomy compared to a surgical cricothyroidotomy limits the time for ventilation before a more secure airway is designated [22]. A cricothyroidotomy should eventually be converted to tracheostomy as it is a more secure airway [23].

In a retrospective chart review conducted by Dillon et al. over a 6-year period at a level-one trauma center, there were 34 surgical airways, of which 10 were cricothyrotomies, whereas the remaining were emergent tracheotomies [24]. The authors concluded that the paucity of cricothyrotomies could not be accounted for and only that at their institution, tracheostomy was preferred in an emergent situation. Other studies have also found that the use of tracheotomy in the setting when intubation is not possible is considered a safe alternative [21, 25]. These studies suggested that although cricothyrotomies are the surgical airway of choice in an emergent setting, emergent tracheotomies are safe and maybe more commonly performed. Both can be performed on the field or an in hospital setting.

There are a few limitations for cricothyrotomy as demonstrated below in the table (**Figure 2**). Cricothyrotomy should not be performed in children less than 12 years of age, as the cricothyroid membrane is quite narrow resulting in an increased risk of permanent laryngeal injury [24]. Furthermore, patients with suspected laryngotracheal trauma should not undergo cricothyroidotomy [25].

Tracheostomy is a secure, permanent surgical airway. The indications and timing of placement has been reviewed extensively [26]. The complications associated with tracheostomy placement can be divided into early and late complications. Hemorrhage is the most common early complication. Any major bleeding, especially from an arterial source, may require operative exploration. Pneumothorax and/or subcutaneous emphysema are less common. Mucous plugging or obstruction due to blood clots can occur postoperatively and can be managed with the use of humidified air and regular gentle suctioning [25].

The part of a tracheostomy tube is important in patient teaching, for long-term use. Most tracheotomy tubes used commonly have an inner cannula which can be removed and cleaned on a routine basis, thus minimizing obstruction. In the early postoperative course, inadvertent displacement of the tracheotomy tube may result in a false passage, as the tract is not mature. Most of the later complications are secondary to constant pressure/irritation applied to the surrounding tracheal mucosa. This includes formation of granulomas, tracheal stenosis, and formation of fistulas in either the esophagus or the innominate artery [25]. An uncommon but

Indications	<ul style="list-style-type: none"> Facial fractures Blood or vomitus in airway Clenched teeth Traumatic airway obstruction Inability to maintain >90% oxygen saturation between intubation attempts or after 3 attempts Inability to ventilate the patient with a bag-valve-mask device between intubation attempts or after 3 attempts Multiple failed attempts at endotracheal intubation
Relative contraindications	<ul style="list-style-type: none"> Tracheal transection, fracture, or obstruction below the cricothyroid membrane Age <5 to 12 years, due to anatomic considerations (depending on reference)

Figure 2. Indications and contraindications for cricothyroidotomy according to the American College of Surgeons (2008).

life-threatening complication is a tracheo-innominate fistula. These are linked to low-placed tubes and patients with excessive movement of the head. This complication has a 25% mortality rate [27]. If it does occur, manual pressure over the tract or over inflation of the cuff when it is seated in this tract can help tamponade the bleed until the patient can be taken back to the operating room for further exploration.

Tracheostomy placement in the form of an open versus percutaneous approach has been evaluated in many studies, to see if there is an advantage of one approach over the other. A Cochrane analysis of all randomized control and quasi-randomized control studies, evaluated approximately 20 trials that compared percutaneous to open technique [28]. The goal was to evaluate whether there was a higher complication profile amongst one technique over the other. The review looked at studies completed in an ICU over an emergency room setting. Overall, the systematic showed some benefits in terms of effectiveness and safety of the use of percutaneous techniques for tracheostomy, especially in regards to rates of late non-life threatening complications. However there is overall low quality evidence to suggest a difference in postoperative mortality or total mortality from life threatening complications like bleeding, between the two techniques. Generalizability of one technique over the other was not possible according to the Cochrane review [28].

The review concluded that open tracheostomy may still be indicated for selected patients, despite the continuing broader indications for use of percutaneous technique [28]. Again, this review did not evaluate studies that looked at the use of percutaneous tracheostomy in an emergent, difficult airway setting.

2.6. The role of the otolaryngologist-head and neck surgeon

The role of the otolaryngologist-head and neck surgeon is to be an important counterpart to the team involved in a difficult airway. O'dell describes the role of the otolaryngologist as involved in the preoperative evaluation of a difficult airway and the comprehensive algorithm in identifying and evaluating the airway prior or during induction of general anesthesia [4]. The fiberoptic laryngoscopy, used in evaluating the airway, is the trademark tool of the otolaryngologist. The technical expertise and familiarity with the upper airway and larynx allows an otolaryngologist to screen a difficult airway [5], as well as provide therapeutic means to fiberoptically intubate at the same time if needed. Nasotracheal intubations done with the use of a fiberoptic laryngoscope is a common practice, and can be done with the patient spontaneously breathing. The availability and expertise with certain equipment allows the otolaryngologist a more invasive approach to the airway, with determination of what branch of the difficult airway algorithm should be taken next based upon findings.

An otolaryngologist is also equipped to handle the placement of a surgical airway whether it is an awake tracheostomy in a controlled setting for a patient with known upper airway obstruction and difficult intubation [4, 26]. An otolaryngologist is also able to assist in placement of an emergency surgical airway, with most otolaryngologists placing an emergent tracheostomy over a cricothyroidotomy [23, 26].

Overall, the role of an otolaryngologist is both a consultant, and a surgeon. Ultimately, in any difficult airway scenario, the otolaryngologist is a member of a multi-disciplinary team that is involved in securing of the airway with an interdependent and algorithmic approach [2, 4, 5].

3. Conclusion

In conclusion, the definition of a difficult airway is not rigid, nor is it an over-arching diagnosis. A difficult airway can come in all shapes and sizes, keeping in mind that an airway is never stable without ability to oxygenate or ventilate. The importance of a difficult airway algorithm is crucial in organization of steps involved in securing the airway. A difficult airway does not necessarily have to be an emergency, but it does take require a team approach to initiate the appropriate steps in saving a life. Resources such as equipment available to secure a difficult airway, the steps involved in performing a surgical airway, and the pros and cons of a tracheostomy over a cricothyroidotomy, were summarized in this chapter. The goal of this chapter is to allow readers to identify the difficult airway and have a broad understanding of how to provide the appropriate care for these patients. For the otolaryngologist, this chapter aims to serve as a guideline by which to address the airway with the tools and resources available, both in a controlled and emergency situation.

Conflict of interest

Vaninder K. Dhillon declares no conflict of interest in the publication of this manuscript.

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