SECTION 1 Foundations of Difficult and Failed Airway Management

1. Evaluation of the Airway
2. The Algorithms
3. Preparation for Awake Intubation
4. Pharmacology of Intubation
5. Aspiration: Risks and Prevention
1.1 INTRODUCTION

“Airway management” may be defined as the application of therapeutic interventions that are intended to affect gas exchange in patients. Gas exchange is the fundamental feature of this definition.\(^1\) A number of devices and techniques are commonly employed in health-care settings to achieve this goal, for example, bag-mask ventilation (BMV), extraglottic devices (EGDs), oral or nasal endotracheal intubation, and surgical airway management techniques.

The failure to adequately manage the airway has been identified as a major factor leading to poor outcomes in anesthesia, critical care, emergency medicine, and emergency medical services (EMS).\(^2,3\) In fact, adverse respiratory events constituted the largest single cause of injury in the ASA Closed Claims Project.\(^4\) Furthermore, it has been repeatedly shown that the single most important factor leading to a failed airway is the failure to predict the difficult airway.\(^3,5\)

Screening tests designed to predict difficult laryngoscopic intubation in otherwise normal patients have proven to be so unreliable that airway practitioners need to be prepared to manage a failed airway every time they are faced with a patient in need of airway management.\(^6,7\)

This chapter deals with the identification of the difficult and failed airway, particularly in an emergency, in which evaluation and management must be done concurrently in a compressed time frame and canceling the case or delaying management is not an option.

Successful airway management is generally governed by four intertwined factors:

- A clinical situation of varying urgency, venue, and resources
- Patient factors including airway anatomy and vital organ system reserve
- Available airway resources
- Skills of the airway practitioner

Because one must choose a method of airway management from an array of techniques, some degree of precision of language is essential. For example, a difficult oral laryngoscopy and intubation may not necessarily constitute a difficult airway if BMV is easily performed. Furthermore, a difficult laryngoscopic intubation does not mean a difficult intubation using a lightwand or using a video laryngoscope. In the same way, a failed intubation does not necessarily constitute a failed airway. A failed intubation, defined narrowly as the failure to intubate the trachea on three attempts,\(^6,8\) may not constitute a failed airway if one is able to affect gas exchange with BMV or with an EGD. However, intubation failure ought to conjure a sense of urgency and mandates the airway practitioner to rapidly switch to a failed airway management sequence because such a situation may become life-threatening if gas exchange cannot be provided expeditiously and adequately by other means. Furthermore, the alternative airway technique employed must have the highest degree of success in the practitioner’s skill set. It is inappropriate to make random disorganized attempts to manage the airway in the hope that one of the airway techniques might work. Rather, one should have a planned strategy (See the Algorithms in Chapter 2) including invasive techniques such as cricothyrotomy.\(^2-5\)

Caveat:

Failure to Evaluate the Airway and Predict Difficulty is the Single Most Important Factor Leading to a Failed Airway.

(ASA Close Claims Database)\(^6\)
1.2 INCIDENCE OF DIFFICULT AND FAILED AIRWAY

1.2.1 How common are the difficult and failed airway?

Bag-mask-ventilation (BMV), the use of EGDs, endotracheal intubation, and surgical airway management constitute the four primary avenues by which gas exchange is provided in the event patients are unable to do so adequately for themselves. In each category, difficulty and failure may be encountered. Failure of all four, ordinarily, leads to the demise of the patient.

Until recently, the success or failure of airway management has been defined in terms of BMV and orotracheal intubation. The introduction of EGDs and the heightened profile of cricothyrotomy have broadened such concepts. Fortunately, tracheal intubation is usually straightforward, particularly in the elective setting of the operating room (OR). The same cannot be said for other venues.

Airways that are difficult to manage are fairly common in anesthesia and emergency medicine practice, with some estimates as high as 20% of all emergency intubations. However, the incidence of intubation failure is quite uncommon (ranging 0.5%-2.5%), and the disastrous situation of being unable to intubate or ventilate rarely occurs (0.1%-0.05%). This translates to a “can’t intubate, can’t ventilate” failure rate of about 1:1000 to 1:2000 patients in a general surgical population. The incidence is strikingly higher in the parturient undergoing cesarean section (1:280), an almost tenfold increase. In fact, half of the excess mortality (28 times) seen with general anesthesia for cesarean section (1:2000 patients in a general surgical population) is attributable to airway management failure.

1.2.2 How do we avoid airway management failure?

Although circumstances can vary widely, the expectation is the same: timely, effective airway management executed without patient injury. In circumstances of multiple trauma, facial or airway swelling, abnormal upper airway anatomy, upper airway hemorrhage, or a myriad of other difficult airway scenarios, intubation may be difficult, or even impossible, and even BMV can fail. Nevertheless, the expectation remains that the patient’s airway be promptly secured and oxygenation be maintained.

Responding to an identified need to reduce the incidence of airway management failure, the American Society of Anesthesiologists (ASA) issued guidelines and an algorithm for management of the difficult airway in 1993, with a revision in 2003. The guidelines stressed the importance of performing an airway evaluation for difficulty prior to inducing anesthesia and paralyzing the patient. Planned awake intubation, awakening the patient in the presence of a failed airway, and acquiring skills in alternative airway-management techniques are hallmarks of the 1993 guidelines. The 2003 guidelines reemphasize the importance of the airway evaluation and incorporate the laryngeal mask airway (LMA) as a discrete step in the algorithm, should failure occur. Unfortunately, the guidelines are less useful outside the operating room (OR), especially in circumstances in which tracheal intubation must be accomplished quickly and awakening the patient is not an option. Even in the OR setting, explicit guidelines for the rapid evaluation of an airway for occult difficulty and the prioritization of rescue maneuvers in the event of a mandated immediate intubation are not well handled by the ASA guidelines and algorithm (see Chapter 2). Furthermore, the ASA guidelines do not take into consideration patients who are uncooperative (eg, young children or mentally challenged patients) or different patient populations (eg, partrients).

Further complicating this issue are the many new, effective, and safe airway devices that have been introduced to assist with difficult and failed airway management. Flexible endoscopic and video-intubating bronchoscopes have become more portable and easier to use and have been joined by a collection of rigid fiberoptic scopes (Bullard Laryngoscope™, Upsher Laryngoscope™, etc), rigid fiberoptic stylets (eg, Shikani Optical Stylet™, Bonfils Stylet™, Levitan FPS Scope™, etc), and hybrid devices employing cameras or fiberoptics, such as video laryngoscopy (eg, Glidescope™ and McGrath™ video laryngoscope, see Chapter 10). The laryngeal mask airway (LMA) and intubating laryngeal mask airway (ILMA or LMA Fastrach™) have taken on a distinct role in the management of both the difficult and the failed airway. The Combitube™ has often been used as a lifesaving rescue device. Lighted stylet methods (eg, Trachlight™) may permit light-guided (transillumination) intubation in situations in which the vocal cords cannot be visualized. Certain airways are impossible to manage by any means other than surgical cricothyrotomy, a procedure of increasing importance for all airway practitioners.

The challenge for any airway practitioner is to be able to accurately predict when a difficult airway is present, to immediately recognize when an intubation failure has occurred, and to reliably and reproducibly secure continuous gas exchange in both of these unnerving circumstances.

1.3 STANDARD OF CARE

1.3.1 Is there a prevailing standard of care in managing the difficult and failed airway? How is it defined?

The growth in knowledge and evidence related to the practice of airway management is relentless. The challenge for the practitioner is to keep abreast of new information, new techniques, and the changing expectations by our colleagues and patients. Advances in airway management over the past decade have significantly improved patient outcome with a reduction in the incidence of death and disability. Therefore, it is important for practitioners to keep abreast of these advances in airway management in their clinical practice.
Black's Law Dictionary\(^3\) defines the "Standard of Care" as:

The average degree of skill, care and diligence exercised by members of the same profession, practicing in the same or similar locality in light of the present state of medical and surgical science.

This definition incorporates several important features:

- **Average degree of skill**
- **Same or similar locality**
- **Present state of knowledge**

Taking these into consideration, the Standard of Care is the conduct and skill of an average and prudent practitioner that can be expected by a reasonable patient. A bad result due to a failure to meet the standard of care is generally considered to be malpractice. There are two main sources of information as to exactly what is the expected standard of care:

- **The beliefs and opinions of experts in the field.**
- **The published scientific evidence, standards of care, practice guidelines, protocols.**

Ultimately the standard of care is what a jury says it is!

Driven by the complex nature of this clinical dilemma and the need for successful solutions that are easily learned and maintained (and cost-effective), the standard of care in airway management is exceedingly dynamic. Continuing evolution of new devices and techniques, or ways of thinking, modify the existing standard of care on an ongoing basis. It is incumbent on practitioners to keep abreast of new devices and techniques and remain facile with existing rescue techniques. They can do so by continually perusing the literature and attending educational programs related to airway management.

### 1.3.2 What is the role of professional organizations in establishing the standard of care?

International, national, regional, and local professional organizations generally address issues relevant to airway management in a variety of ways. Most national societies, such as the American Society of Anesthesiologists (ASA), the Difficult Airway Society (UK), the American Association of Nurse Anesthetists (AANA), the American College of Emergency Physicians (ACEP), the Canadian Anesthesiologists’ Society (CAS), and others, engage in crafting practice guidelines.\(^6\,21\,24\,25\)

In the event of an untoward outcome, the reasonable patient expects the published guidelines to be observed by the prudent practitioner. Organizations that craft and publish such practice guidelines are careful to stipulate that such guidelines do not constitute the Standard of Care.\(^6\) Unfortunately, guidelines are often perceived as the standard of care, particularly in a medical–legal context.

Professional organizations often provide educational initiatives to ensure that their members practice at the prevailing standard. The ASA, ACEP, and the Society for Airway Management (SAM) are good examples. SAM is an organization committed to advancing knowledge and improving the quality of airway care to our patients. This international society blends the expertise of anesthesia, otolaryngology, head and neck surgery, critical care, and emergency medicine to debate issues related to airway management. The SAM serves as a sounding board, not only for new devices and techniques but also for those wishing to challenge traditional dogma and advance new frontiers. Those with a specific interest in airway management are well advised to become involved in this organization.

### 1.3.3 How can we integrate the standard of care into our clinical practice?

Despite all these initiatives, the Standard of Care remains elusive, particularly when applied to the management of the difficult and failed airway. It means different things to different practitioners and is situation dependent. For example,

- To the plaintiff’s attorney, it must be precisely defined in the most minute of detail
- To the practitioner, it is what they do every day
- To the defendant practitioner, it is consistent with their actions

It is perhaps easier to articulate what it is not:

- It is not so low as to consistently lead to bad outcomes.
- It is neither much better nor much worse care than that delivered on average by one’s peers.
- It is not the same as the care provided by experts managing difficult and failed airways every day.
- It is not what ivory tower academic experts think it ought to be.
- It is not a single study published in a reputable journal last week, or a position advocated by experts in an editorial in a similarly reputable journal.

We do know that the Standard of Care is dynamic and our patients expect to receive it at a minimum. Perhaps the best test with respect to difficult and failed airway management is to ask a specific question: “Should the average, reasonable, and prudent practitioner…”

- Be able to recognize and manage an anticipated difficult airway?
- Be able to manage an unanticipated difficult airway?
- Be able to use a flexible bronchoscope to intubate the trachea of a patient?
- Be able to recognize and manage the failed airway?
- Be facile with one or two rescue devices or techniques in the face of a failed airway?
- Be able to perform a surgical airway? Or at the least, transtracheal ventilation?

It is reasonable to expect that most practitioners charged with managing airways would answer yes to all of these questions and thereby define the standard of care.
1.4 DEVELOPMENT OF LARYNGOSCOPIC INTUBATION

1.4.1 How did the design of laryngoscopes and the basic technique of oral laryngoscopy evolve?

Herholdt and Rafn are generally credited with first describing blind oral intubation in 1796. Subsequently, Desault described blind nasal intubation in 1814. Although Sir William Macewen described direct vision oral intubation in 1880, it is generally accepted that the first description of laryngoscopy-aided oral intubation was by Kirsten in 1895. By 1907, Chevalier Jackson, an ENT surgeon of considerable renown, introduced distal lighting to the laryngoscope, and Janeway in 1913, innovated the insertion of electric batteries into the handle of a laryngoscope to facilitate the procedure. Magill and Rowbotham engineered the straight Magill blade in the 1920s by cutting a wedge out of the side of the blade of the ENT surgeon’s anterior commissure laryngoscope to facilitate intubation (Figure 1-1). Across the Atlantic, this design (with minor modifications) became known as the Miller blade in the 1940s. The Macintosh blade was also introduced in the 1940s by Sir Robert Macintosh.26

Magill is credited with introducing the “retro-molar” or “paraglossal” approach, reasoning that placing the blade as far to the corner of the mouth as possible when attempting to bring the glottis into view (as opposed to being in the midline) ought to minimize the distance to the glottis and enhance the degree to which it is visible. This technique has recently been resurrected by Henderson.27

1.4.2 How did the design of endotracheal tubes evolve?

It was also Sir Ivan Magill (circa 1914) who recommended a left-sided bevel (Magill bevel) be created on the distal tip of an endotracheal tube (ETT) (Figure 1-2). At that time, blind nasal intubation using a non-beveled, gum-elastic tube was popular. Magill observed that, as the right nostril is usually largest and most anesthesia practitioners are right handed, nasotracheal intubation was usually first attempted through the right nostril. The natural tendency for a tube introduced through the right nostril was to deviate leftward as it transited the nasopharynx and oropharynx and to deflect off the left glottic structures into the left pyriform recess. Magill reasoned that the left-sided bevel would deflect the ETT into the glottis.28 Left-side bevel ETTs continue to be the most commonly used tubes to this day.

Curare and succinylcholine were introduced into anesthetic practice during the 1940s. These drugs led to the need for positive pressure ventilation, a tracheal seal being achieved by packing gauze (at times oil soaked) around the glottic opening. A more effective seal could be obtained by incorporating a balloon (initially rubber, thick walled, high pressure, and removable) onto the ETT. However, the possibility that the beveled orifice of the distal tip could rest against the wall of the bronchus in the event of a right mainstem intubation permitting positive pressure inspiration but not passive expiration was noted. This led to the creation of the Murphy eye opposite the bevel orifice (ie, facing the right side).

The bulk of the ETT and balloon hindered its passage through the channel of laryngoscope blades, and this led the Eschmann Corporation to introduce the intubating stylet to facilitate a Seldinger-type intubation over the stylet in 1949.29
1.4.3 How has our understanding of how the difficult airway might be predicted developed over the years?

The use of neuromuscular blockade to facilitate orotracheal intubation followed the introduction of curare into anesthetic practice in the early 1940s and succinylcholine in the late 1940s. Up until that time, orotracheal intubation was largely performed with the patient ventilating spontaneously under inhalational anesthesia. The consequence of a failed intubation was mitigated by the fact that the patient continued to breathe spontaneously. The threat of failure to intubate in the face of neuromuscular blockade and apnea required anesthesia practitioners to evaluate the airway for difficulty, leading to a landmark publication by Cass in 1956. This study identified those anatomical features that might predict difficult laryngoscopic intubation. Thus, the clinical use of neuromuscular blocking agents became inseparable from the ability to perform an airway evaluation and the ability to rescue the airway in the event of failure. Many practitioners still fail to recognize a difficult airway when one exists or they overlook the evaluation altogether.

The literature regarding the difficult airway was relatively quiet until the mid-1980s when Patil offered the proposition that a thyromental distance of less than 6 cm was associated with orotracheal intubation difficulty. During the 1990s, Savva did the same by using the sternomental distance. The importance of Patil’s dimension rests not in the distance described, or in its lack of sensitivity, specificity, or positive predictive value with respect to airway management difficulty, but in the fact that it alludes to the geometry of the airway. The thyromental line constitutes the hypotenuse of a right angle triangle (Figure 1-3). The axis is length of the floor of the mouth (a dimension of the mandibular space), and the abscissa locates the larynx in relation to the base of the tongue. The length of the oral axis affects the ease with which the glottis is exposed during conventional laryngoscopy: the glottis cannot be visualized beyond the horizon of visibility if it is too long; the larynx is shielded by the base of the tongue (anterior larynx) if it is too short. Likewise for the location of the larynx in relation to the base of the tongue: it is beyond the visible horizon if it is too far down the neck; it is tucked up under the base of the tongue if it is too high in the neck. Furthermore, the dimensions of the mandibular space (length, width, and depth; or volume) have important implications. The volume of the mandibular space must accommodate the tongue, a fluid-filled noncompressible structure, as it is displaced into this space during laryngoscopy to bring the glottis into view.

Mallampati in 1983 and 1985 created a scoring system, modified by Samsoon in 1987, that identified oral and pharyngeal access as an issue of importance in airway management (Figure 1-4). Although the score by itself had poor sensitivity, specificity, and positive predictive value, the notion that access is important became cemented.

By the late 1980s, it had become apparent that airway management failure was the most important contributor to poor patient outcome in anesthesia practice, lawsuits, and financial settlements. The question facing airway practitioners became: Who should you not paralyze? A variety of investigators pursued univariate and multivariate systems of analysis that attempted to answer this question, but none with reliable success; in an effort to provide some structure to the discussion of difficult laryngoscopy (Figure 1-5). Although found to be subject to considerable interobserver variability, the scale has been embraced as a valid measure of difficulty; with Grade 3 and 4 views being equated with difficult laryngoscopy. By the late 1990s, other models with more reproducible scoring systems, such as Levitan’s Percentage of Glottic Opening (POGO) visible, were proposed. However, widespread adoption of these systems over the Cormack/Lehane (C/L) system has yet to occur (Figure 1-6).
• Wilson, 1988 (Wilson Risk Sum): Employed a weighted scoring system 0 to 2 incorporating body weight, head and neck movement, jaw movement, receding mandible, and prominent (buck) teeth.41
• Bellhouse, 1988: Used x-rays to evaluate for difficulty.42–46
• Rocke, 1992: Evaluated 1500 parturients using a combination of Mallampati, short neck, receding mandible, and buck teeth.47
• Savva, 1994: Identified a sternomental distance less than 12 cm as a risk for difficulty.32
• Tse, 1995: Combined Mallampati, head extension, and thyromental distance.48

- El-Ganzouri, 1996: In a large study of 10,507 patients looked at mouth opening, Mallampati, neck movement, mandibular protrusion, body weight, and a positive history of airway management difficulty.49
- Karkouri, 2000: Evaluated 461 patients (38 difficult)—correlated mouth opening, chin protrusion, atlanto-occipital extension.50

Hot on the heels of the “Who should you not paralyze?” question is the dilemma: How is the airway best rescued in the event that intubation and/or ventilation is impossible, that is, a failed airway? In the past, BMV was viewed as the most commonly performed fallback technique. This technique, difficult to teach, learn, and perform, is being supplanted by more user friendly and easily performed EGDs. This has led to a reframing of the way we think about airway management: In the event laryngoscopy and intubation fails, is it likely that gas exchange can be maintained by BMV or one of these EGD devices? Furthermore, the recognition that while aspiration is undesirable, it is not usually a deadly occurrence, serves to emphasize the primacy of gas exchange over intubation and airway protection.

1.5 DEFINITIONS OF DIFFICULT AND FAILED AIRWAYS

The Difficult Airway is something you anticipate; the Failed Airway is something you experience.

(Walls, 2002)

As noted earlier, this chapter explores the concepts of the difficult and the failed airway. The premise is that the pre-procedure recognition and management of the difficult airway should minimize the occurrence of a failed airway. Furthermore, recognizing the failed airway promptly ought to optimize the chances that failing techniques will be abandoned and replaced by techniques reasonably anticipated to succeed.

1.5.1 The difficult airway

When one is presented with a patient that requires tracheal intubation, the first decision is whether or not this airway needs to be managed immediately (typically, the newly dead or the nearly dead crash airway, see Chapter 2) and one simply proceeds to intervene in the airway. If it is not a crash airway, one must ask, “Is this a difficult airway?” Asking the question presume that one has a framework to answer it!

As discussed above, and unlike the failed airway, the difficult airway is not so easily defined. Rather than a definition, in concept, the difficult airway has five dimensions:

- Difficult BMV
- Difficult laryngoscopy
- Difficult intubation
- Difficult placement of a EGD
- Difficult cricothyrotomy
These five dimensions can be reduced to four technical operations:

- Difficult BMV
- Difficult laryngoscopy and intubation
- Difficult EGD
- Difficult cricothyrotomy

The evaluation of the airway for difficulty may be leisurely or urgent. In the latter circumstance, it must be done quickly with care taken not to omit anything important. Like well-constructed algorithms, mnemonics are efficient memory-aid strategies that lead to a complete, yet rapid, evaluation. One for each technical operation has been crafted to permit a rapid and complete evaluation, no matter the clinical circumstance.

### 1.5.2 The failed airway

The failed airway has been defined as:

- Three failed attempts at orotracheal intubation by a skilled practitioner and/or
- Failure to maintain acceptable oxygen saturations, typically 90% or above, in otherwise normal individuals

The problem in everyday practice is not so much defining failure; it is recognizing failure once it has occurred, and then moving quickly to alternatives. Clinically, the failed airway presents itself in two ways:

1. You have time: "Can’t intubate/can ventilate and oxygenate.”
2. You have no time: “Can’t intubate/can’t ventilate or oxygenate” (CICV or CICO).

The intent is to minimize the chance of encountering a failed airway when one might have easily predicted a difficult intubation, difficult BMV, difficult EGD ventilation, or a difficult cricothyrotomy.

The adage in anesthesia practice with respect to neuromuscular blockade of a patient who has some effective spontaneous ventilation has always been “Don’t take anything away from the patient that you can’t replace.” While such a rigid principle is not always consistent with the realities of airway management, it is a useful one to remember!

### 1.6 Prediction of Difficult and Failed Airway

The most effective aids work well in all clinical situations, as everyday practice adjuncts. The following mnemonics fall into this category:

#### 1.6.1 Difficult bag-mask-ventilation: MOANS

The importance of BMV in airway management is not taken lightly by airway practitioners, particularly as a rescue maneuver when orotracheal intubation has failed. If the airway practitioner is uncertain that neuromuscular blockade facilitated tracheal intubation will be successful, they must be confident that BMV will be adequate, the use of an EGD will be successful, or at the very least, a successful cricothyrotomy can rapidly be performed.

The bag-mask devices most commonly used in resuscitation settings are capable of generating 50 to 100 cm of water pressure in the upper airway, provided that they do not have positive pressure relief valves, and an adequate mask seal can be obtained (Figure 1-7). Pediatric and neonatal devices often incorporate positive pressure relief valves that can be easily defeated if needed. This degree of positive pressure is often sufficient to overcome the moderate degree of upper airway obstruction offered by redundant tissue (eg, the obese) or edematous tissue (eg, angioedema, croup, or epiglottitis). Research has validated many of those anatomical features that over the years have been implicated in heralding difficult BMV (difficult mask ventilation or DMV). Those features can be grouped into five indicators that can be easily recalled by using the mnemonic MOANS:

- Mask seal, high Mallampatti grades, Minimal jaw protrusion, or Male gender: Bushy beards, crusted blood on the face, or a disruption of lower facial continuity are the commonest examples of conditions that may make an adequate mask seal difficult. Some recommend smearing a substance such as Vaseline or KY Jelly on a beard as a remedy to this problem. However, in the experience of the authors, it simply makes a bad situation worse in that the entire face becomes too slippery to hold the mask in place. Several studies have identified additional risk factors of difficult mask ventilation, including male sex, Mallampati III or IV airways, and limited jaw protrusion.
- Obese or Obstructing lesions: Patients who are obese (defined by Langeron et al as BMI >26 kg·m⁻² as opposed to the conventional definition of obese as 30-35 kg·m⁻²) are often difficult to ventilate adequately by bag and mask. BMV can also be difficult in parturients at term and in patients with upper-airway obstruction, angioedema, Ludwig angina, upper airway abscesses (eg, peritonsillar), and epiglottitis. There is a sense among experienced practitioners that edematous lesions (eg,
angioedema, croup, epiglottitis, etc) are more amenable to bag-mask rescue should sudden obstruction occur or be induced, although the authors would not rely on this opinion. On the other hand, firm, immobile lesions such as hematomas, cancers, and foreign bodies usually cannot be circumvented by BMV. Total airway obstruction must be avoided in these patients, and care must be taken with airway manipulation (positioning, avoidance of bleeding, sedative hypnotic medications, etc).

- Aged: Age more than 55 is associated with a higher risk of difficult BMV, perhaps because of a loss of muscle and tissue tone in the upper airway.\(^{52,57}\)

- No teeth or Neck radiation: An adequate mask seal may be difficult in the edentulous patient as the face tends to cave in. An option is to leave dentures in situ (if available) for BMV and remove them for intubation. Alternatively, gauze may be inserted in the cheeks to puff them out in an attempt to improve the seal (vigilance to prevent dislodgement into the airway is required). Radiation therapy in the past to the head and neck may hinder mask ventilation.\(^{55}\)

- Snore or Stiff: For the former, this mnemonic affords one a reminder to check for sleep apnea, an increasingly important consideration in anesthetic practice today. BMV may be difficult or impossible in the face of substantial increases in airways resistance (eg, deadly asthma) or decreases in pulmonary compliance (eg, pulmonary edema).

As discussed in Chapter 8, several studies involving large patient populations have validated the above findings.\(^{52,56,59}\) In a large study by Kheterpal et al involving over 53,000 adult patients receiving a general anesthetic at a tertiary care hospital, the reported incidence of impossible BMV (IMV) defined as “the inability to establish face-mask ventilation despite multiple airway adjuncts and two-hand mask ventilation” was 0.15%. Despite being a diverse clinician group (trainees; nurse and physician anesthetists), having a junior anesthesia provider was not found to be an independent predictor for IMV. The presence of three or more predictors (neck radiation, male, OSA, Mallampati III or IV, beard) significantly increased the risk of IMV with an odds ratio of 8.9 compared to patients without these risk factors. Another important finding from this study is that of the IMV group, 25% were also difficult to intubate. It should be remembered, however, that these studies did not examine the incidence of DMV in patients requiring emergency airway management.

### 1.6.2 Difficult laryngoscopy and intubation: LEMON

Difficult laryngoscopy and intubation ordinarily implies that the operator had a poor view of the glottis. Cormack and Lehane\(^{56}\) provided some clarity to the way we think of the difficult airway by parsing the act of intubation into its two subcomponents: laryngoscopy and intubation. They also introduced the most widely utilized system of categorizing the degree to which the glottis can be visualized during laryngoscopy (Figure 1-5). Cormack/Lehane view Grades 3 (epiglottis only visible) and 4 (no glottic structures at all visible) are often used as surrogates to define a difficult laryngoscopy and predict difficult intubation. View Grades 1 (visualization of the entire laryngeal aperture) and 2 (visualization of the posterior cords and arytenoids) are not typically associated with difficult intubation, though some Grade 2s may be difficult or impossible to intubate. Tough Grade 2s and 3s are tailor-made for intubating introducers such as the Eschmann Tracheal Introducer and Frova devices (see Sections 11.2.1 and 11.2.2).

As can be gleaned from the descriptions, the Cormack/Lehane grading system is insensitive to the degree to which the laryngeal aperture is visible during laryngoscopy: a little bit of it (Grade 2) or all of it (Grade 1). The question often asked is: How much of the cords must be viewed to assure intubation success? How much is enough? In attempting to provide a framework or an approach to answering this question, Levinan et al\(^{55,59}\) devised a scoring system to quantify the POGO visible. While attractive in many ways, this scale has yet to gain wide acceptance (Figure 1-6).

The Cormack/Lehane grading system is predicated upon grading during the best attempt at conventional laryngoscopy, and best attempt in turn requires definition. Benumof\(^{5}\) defines best attempt as being composed of six components:

1. Performance by a reasonably experienced practitioner
2. No significant muscle tone
3. The use of the optimal sniffing position
4. The use of external laryngeal manipulation (backward upward rightward pressure [BURP] or optimum external laryngeal manipulation [OELM])\(^{10}\)
5. Length of the blade
6. Type of blade

Most times, an intubation demands that the first attempt be the best attempt, particularly in an emergency, although some compromises may be necessary (eg, residency training). Should an orotracheal intubation attempt fail and an additional attempt be contemplated, it seems reasonable to change something on the subsequent attempt to enhance the chances of success. That something may be one, some, or all of these factors. Reminding oneself of the components of the optimum or best attempt provides a framework to address “what to change?”

Optimization of all six components may not be in the patient’s best interest in an emergency. For example, if difficulty is anticipated, it may not be advisable to paralyze the patient. Additionally, in the event the cervical spine is immobilized, it may not be possible to place them in the sniffing position. Most experts in airway management agree that positioning the head and neck is an important step in optimizing conventional laryngoscopy as a prelude to orotracheal intubation.\(^{51}\)

If it is possible to consistently and precisely predict intubation failure, the initial selection of laryngoscopic oral intubation could be eliminated as a strategy and alternative techniques employed (eg, flexible bronchoscopic intubation, cricothyrotomy). However, they may be technically more challenging, risky, and time consuming. During the last several decades, this has not proven to be possible. Lists of anatomical features, radiologic findings, and complex scoring systems have all been explored without consistent success.

Therefore, we are left to assemble the known risks, match them to the skill, experience, and judgment of the practitioner, and
make a decision: Does this airway meet the threshold of being sufficiently difficult to warrant using a Difficult Airway Algorithm, or am I safe to proceed directly to induction, paralysis, and intubation (eg, rapid sequence intubation or rapid sequence induction, commonly known as RSI)?

So, how do we quickly identify as many of the risks as possible? The mnemonic LEMON is a useful guide:

- Look externally: If the airway looks difficult, it probably is (Figure 1-8). A litany of physical features have been associated with difficult laryngoscopy and intubation—a small mandible may indicate that the tongue is retro-fitted over the larynx; a large mandible elongates the pharyngeal axis serving to extend the distance to the larynx and perhaps move it beyond the horizon of view. Buck teeth block access to the oral cavity and elongate the length of the oral axis. A high, arched palate is often associated with a long, narrow oral cavity making access a problem. A short neck may mean the larynx is positioned higher in the neck relative to the base of the tongue making it more difficult to bring the glottis into view. Lower facial disruption is inconsistent with adequate mask seal and may make the glottis impossible to find. It is often said that when it comes to orotracheal intubation, the “tongue is your enemy” because it gets in your way and the “epiglottis is your friend” because once you find it, you ought to be able to find the glottic opening. In upper airway disruption, the tongue may actually be a friend as it leads to the epiglottis and the glottic opening.

- Evaluate 3-3-2: Although there is no scientific basis to support the 3-3-2 rule, it serves to ensure that the relevant geometry of the upper airway is assessed adequately. The first 3 assesses the adequacy of oral access (Figure 1-9). One ought to be able to open one’s mouth three of one’s own finger breadths (approximately 5 cm).

The second 3 and the 2 recognize the interplay of the geometric relationships among the various components of the upper airway as first articulated by Patil in 1983. A thyromental distance of less than 6 cm was associated with difficult intubation (Figure 1-3). As described earlier, the thyromental distance is the hypotenuse of Patil’s triangle (Figure 1-3), the base being the length of the mandible (Figure 1-10) and the third leg being the distance between the base of the tongue (neck–mandible junction at the level of the hyoid bone) and the top of the larynx (Figure 1-11). One ought to be able to accommodate three of one’s own fingers (approximately 5 cm) between the tip of mentum and the mandible–neck junction (Figure 1-10) and fit two fingers between the mandible–neck junction and the thyroid notch (Figure 1-11). The second 3 steers one in assessing the capacity or volume of the mandibular space to accommodate the tongue on laryngoscopy. More than, or less than, three fingers (approximately 5 cm) are associated with greater degrees of difficulty in visualizing the larynx. The length of the oral axis is elongated if it is longer than three fingers, and the mandibular space may be too small to accommodate the tongue during laryngoscopy if it is shorter than three fingers, leaving
it to obscure the view of the glottis. This volume is determined by three dimensions: its length, its width, and its depth. The 2 identifies the location of the larynx in relation to the base of the tongue. If more than two fingers are accommodated, meaning the larynx is further below the base of the tongue, it may be difficult to visualize the glottis on laryngoscopy because it is too far down the neck and beyond the visual horizon. Fewer than two fingers may mean that the larynx is tucked up under the base of the tongue and may be difficult to expose. This condition is often called “anterior larynx.”

- Mallampati class: Mallampati studied the relationship between the visibility of the posterior oropharyngeal structures and success rate of laryngoscopic intubation. He had patients sit on the side of the bed, open their mouth as widely as possible, and protrude their tongue as far as possible, without phonating. Figure 1-4 depicts how the scale is constructed. Although Class I and II patients are associated with low intubation failure rates, circumspection with respect to the wisdom of utilizing neuromuscular blockade to facilitate intubation rests with those in Classes III and IV, particularly Class IV in which intubation failure rates may exceed 10%. This scale, by itself, is neither sensitive nor specific. However, it is commonly used because it is easily performed, particularly in an emergency, and it may reveal important information about access to the oral cavity and potentially difficult glottic visualization.

- Obstruction: There are three cardinal signs of upper airway obstruction: muffled voice (‘hot potato voice’); difficulty in swallowing secretions, either because of pain or obstruction; and stridor. The first two signs do not ordinarily herald imminent total upper airway obstruction. The presence of stridor generally indicates that the diameter of the airway has been reduced to 4.0 mm or less. Upper airway obstruction should always be considered a difficult airway and managed with extreme care. The administration of small doses of opioids and benzodiazepines to manage anxiety may induce total upper airway obstruction. The presence of stridor generally indicates that the diameter of the airway has been reduced to 4.0 mm or less.

1.6.3 Difficult use of an extraglottic device: RODS

The insertion of an EGD may be a planned backup maneuver (Plan B) when faced with a failed conventional orotracheal intubation. It may also serve as a bridging technique to reestablish gas exchange in a CICV setting while one prepares to perform a cricothyrotomy (see Chapter 2). To minimize the wasting of valuable time, airway practitioners should place the EGD concurrently while setting up to perform a surgical airway.

In the former case, when Plan B is an EGD, one ought to have performed an evaluation for difficult EGD placement before it is relied on as a primary or backup plan. While there are no prospective studies to evaluate predictors of difficult use of EGDs, there are many clinical reports of difficult use of EGDs, such as the LMA. RODS is a mnemonic that is intended to identify problem patients when an EGD is contemplated:

- Restricted mouth opening: Depending on the EGD to be employed, more or less oral access may be needed. For instance, at least 2 cm of mouth opening is required to accommodate an LMA Fastrach™.
- Obstruction: Upper airway obstruction at the level of the larynx or below. An EGD will not bypass this obstruction. The use of an LMA can be potentially difficult in patients with lingual tonsillar hypertrophy.
- Disrupted or distorted airway: At least in as much as the seat and seal of the EGD may be compromised.
- Stiff lungs or Stiff cervical spine: Ventilation with an EGD may be difficult or impossible in the face of substantial increases in airway resistance (eg, deadly asthma) or decreases in pulmonary compliance (eg, pulmonary edema). Seal may be exceedingly difficult or impossible to achieve in the face of a fixed flexion deformity of the neck. In addition, there are reports of difficult LMA insertion in patients with limited neck movement (eg, ankylosing spondylitis).

1.6.4 Difficult cricothyrotomy: SHORT

There are no absolute contraindications to performing an emergency cricothyrotomy. However, some conditions may make it difficult or impossible to perform the procedure, making it imperative to identify those conditions upfront, particularly if one is relying on a rapidly performed cricothyrotomy as a rescue technique. Similarly, while there are no prospective trials to determine predictors of difficult cricothyrotomy, a number of clinical reports have identified situations associated with difficulties in performing a surgical airway. The mnemonic SHORT is used to quickly identify features that may indicate a difficult cricothyrotomy:
• Surgery/disrupted airway: The anatomy of the neck may be subtly or obviously distorted due to previous surgery, making the airway difficult to access. Patel reported a case of difficult surgical airway following a recent thyroidectomy.71

• Hematoma or infection: An infective process or hematoma in the pathway of the cricothyrotomy incision may make the procedure technically difficult but should never be considered a contraindication in a life-threatening situation.

• Obese/access problem: Obesity should be considered a surrogate for any problem that makes percutaneous access to the anterior neck problematic. A fixed flexion deformity of the cervical spine, halo traction, and other situations may also make access to the neck difficult. Patel reported a case of surgical airway failure in a patient with an obese and short neck.71

• Radiation: The tissue changes associated with past radiation therapy may alter tissues, making the procedure difficult.

• Tumor: Tumor either in or around the airway may present difficulty, both from an access perspective as well as bleeding.

1.7 SUMMARY

Failure to evaluate the airway and predict difficulty is the single most important factor leading to a failed airway. Despite decades of study, no system of evaluation is able to discern with certainty (100% reliability) those airways that can be managed with conventional laryngoscopic intubation and those where an alternative method is advisable. For this reason, each and every airway management episode must be approached with a view that some other device or technique may be necessary should the primary plan fail. Furthermore, the airway practitioner must evaluate the airway for difficulty relative to each of the alternatives contemplated. Once Plan A has failed, it is too late to suddenly realize that Plan B is also impossible because a factor which could have been detected had a prior evaluation for difficulty been conducted.

While not exhaustive in covering all of the features of a difficult airway, the mnemonics MOANS, LEMON, RODS, and SHORT provide guidance in evaluating all airways for difficulty, even though they are specifically designed to be employed rapidly in the face of an urgent or emergency clinical circumstance.

Finally, recognizing that one is in the midst of a failed airway is crucial in embarking on maneuvers that may rescue the airway. Persisting with a failing technique is a fundamental contributor to bad outcomes in airway management.

REFERENCES


71. Patel RG. Percutaneous transtracheal jet ventilation: a safe, quick, and temporary way to provide oxygenation and ventilation when conventional methods are unsuccessful. Chest. 1999;116:1089-1094.

SELF-EVALUATION QUESTIONS

1.1. The most common factor leading to a failed airway is
A. morbid obesity
B. distorted airway anatomy
C. upper airway obstruction
D. failure to predict a difficult airway
E. not knowing enough rescue techniques well

1.2. The standard of care in airway management is related to all of the following EXCEPT:
A. the skill of an average practitioner
B. similar localities
C. procedures that give the best results
D. the expectations of the reasonable patient
E. opinions offered by experts

1.3. The standard of care expects that the average, reasonable airway practitioner ought to be able to do all of the following EXCEPT:
A. be able to manage an unanticipated difficult airway
B. be an expert and be able to use a flexible bronchoscope to intubate immediately in the face of a CICV airway
C. be facile with one or two rescue devices or techniques in the face of a failed airway
D. be able to perform a surgical airway
E. be able to recognize and manage a failed airway