

# 2

## Identification of the Difficult and Failed Airway

Ron M. Walls • Michael F. Murphy

## DEFINITION OF THE DIFFICULT AND FAILED AIRWAY

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Although both difficult and failed airways are discussed in this chapter, the two concepts are distinct. A difficult airway is one for which a preintubation examination identifies attributes that are likely to make laryngoscopy, intubation, bag-mask ventilation (BMV), the use of an extraglottic device (EGD; e.g., Combitube and laryngeal mask airway [LMA]), or surgical airway management more difficult than would be the case in an ordinary patient without those attributes. Identification of a difficult airway is a key component of the approach to airway management for any patient and is a key branch point on the main airway algorithm (see Chapter 3). The key reason for this is that, in general, one should not administer a neuromuscular blocking medication to a patient unless one has a measure of certainty that oxygenation can be maintained if laryngoscopy and intubation fail. Accordingly, if a difficult airway is identified, the difficult airway algorithm is used.

A failed airway situation occurs when a provider has embarked on a certain course of airway management (e.g., rapid sequence intubation [RSI]) and has identified that intubation by that method is not going to succeed, requiring the immediate initiation of a rescue sequence (the failed airway algorithm, see Chapter 3). Certainly, in retrospect, a failed airway can be called a difficult airway because it has proven to be difficult or impossible to intubate, but the terms “failed airway” and “difficult airway” must be kept distinct because they represent different situations, require different approaches, and arise at different points in the airway management sequence. One way of thinking about this is that the difficult airway is something one anticipates and plans for; the failed airway is something one experiences.

Airways that are difficult to manage are fairly common in emergency practice, with some estimates being as high as 20% of all emergency intubations. However, the incidence of overall intubation failure is quite low, generally approximately 1% or less. Intubation failure can occur in a setting where the patient can be oxygenated by an alternative method, such as by BMV or using an EGD, or in a setting where the patient neither can be intubated nor oxygenated. The true incidence of the “*can’t* intubate, *can’t* oxygenate” (CICO) situation is unknown in emergency intubations but is estimated to represent between 1 in 5,000 and 1 in 20,000 operating room intubations.

This chapter explores the concepts of the failed and the difficult airway in the setting of emergency intubation. Recognizing the difficult airway in advance and executing an appropriate and thoughtful plan, guided by the difficult airway algorithm (see Chapter 3) will minimize the likelihood that airway management will fail. Furthermore, recognizing the failed airway promptly allows use of the failed airway algorithm to guide selection of a rescue approach.

## THE FAILED AIRWAY

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A failed airway exists when any of the following conditions is met:

1. Failure to maintain acceptable oxygen saturation during or after one or more failed laryngoscopic attempts (CICO) *or*
2. Three failed attempts at orotracheal intubation by an experienced intubator, even when oxygen saturation can be maintained *or*
3. The single “best attempt” at intubation fails in the “Forced to Act” situation (see below).

Clinically, the failed airway presents itself in two ways, dictating the urgency created by the situation:

1. ***Can’t Intubate, Can’t Oxygenate:*** There is not sufficient time to evaluate or attempt a series of rescue options, and the airway must be secured immediately because of an inability to maintain oxygen saturation by BMV or with an EGD.
2. ***Can’t Intubate, Can Oxygenate:*** There is time to evaluate and execute various options because the patient is oxygenated.

The most important way to avoid airway management failure is to identify in advance those patients for whom difficulty can be anticipated with intubation, BMV, insertion of an EGD, or cricothyrotomy. In the “Forced to Act” scenario, airway difficulty is apparent, but the clinical conditions (e.g., combative, hypoxic, and deteriorating patient) force the operator’s hand, requiring administration of RSI drugs in an attempt to create the best possible circumstances for tracheal intubation, with immediate progression to failed airway management if that one best attempt is not successful (see Chapter 3).

## THE DIFFICULT AIRWAY

The emergency airway algorithms are discussed in Chapter 3. According to the main emergency airway management algorithm, RSI is the method of choice for any non-crash airway when airway management difficulty is not anticipated. This requires a reliable and reproducible method for identifying the difficult airway. This evaluation must be expeditious, easy to remember, and complete.

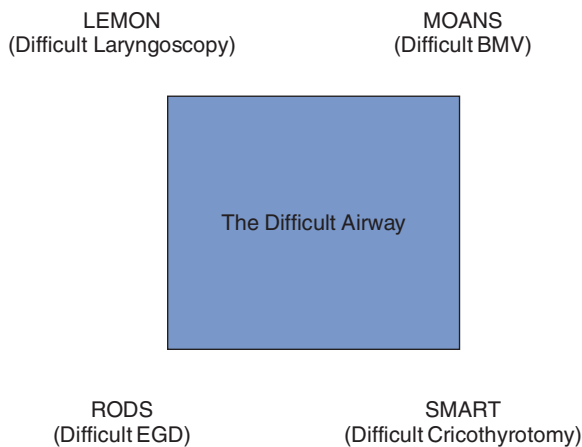
In clinical practice, the difficult airway has four dimensions:

1. Difficult laryngoscopy
2. Difficult BMV
3. Difficult EGD
4. Difficult cricothyrotomy

A distinct evaluation is required for difficult laryngoscopy, difficult BMV, difficult EGD, and difficult surgical airway management, and each evaluation must be applied to each patient before airway management is undertaken (Fig. 2-1).

### Difficult Laryngoscopy: LEMON

The concept of difficult laryngoscopy and intubation is inextricably linked to poor glottic view; the less adequate the glottic view, the more challenging the intubation. This concept, developed during an era when almost all intubations were done by direct laryngoscopy, appears to hold true even in the era of video laryngoscopy. Almost all research relating certain patient characteristics

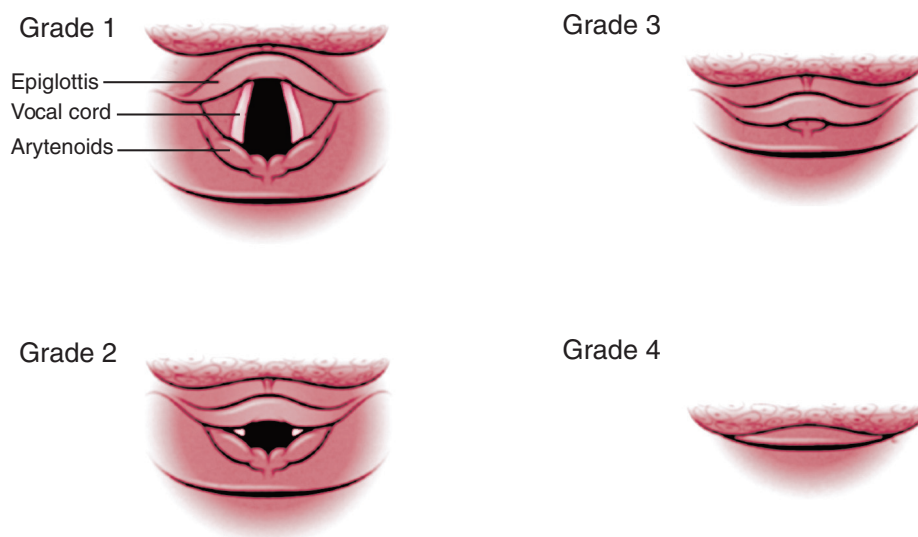


**Figure 2-1 ● Difficult Airway Box.** Note that the *four corners* represent the four dimensions of difficulty.

to difficult or impossible intubation is based on studies of direct laryngoscopy. It is not possible to determine, based on current information, whether these same characteristics predict difficult video laryngoscopy, and, if so, to what degree. Video laryngoscopy almost invariably produces an excellent glottic view, independently of the need to align the various airway axes, as must occur during direct laryngoscopy (see Chapters 12 and 13.) Difficult laryngoscopy and intubation are uncommon, even rare, when certain video laryngoscopes are used. It follows that evidence-based guidelines for prediction of difficult video laryngoscopy may be challenging, or even impossible, to develop. Pending further information, however, we recommend performing a difficult laryngoscopy assessment, using the LEMON mnemonic, on all patients for whom intubation is planned.

Cormack and Lehane introduced the most widely used system of categorizing the degree of visualization of the larynx during laryngoscopy, in which an ideal laryngoscopic view is designated grade 1 and the worst possible view grade 4 (Fig. 2-2). Cormack–Lehane (C–L) view grade 3 (epiglottis only visible) and grade 4 (no glottic structures at all visible) are highly correlated with difficult or failed intubation. C–L grade 1 (visualization of virtually the entire glottic aperture) and grade 2 (visualization of the posterior portion of the cords or the arytenoids) are not typically associated with difficult intubation. The C–L grading system does not differentiate precisely the degree to which the laryngeal aperture is visible during laryngoscopy: a grade 2 view may reveal little of the vocal cords, or none at all if only the arytenoids are visible. This has led some authors to propose a 2a/2b system, wherein a 2a shows any portion of the cords and a 2b shows only the arytenoids. Grade 2b accounts for only about 20% of grade 2 views. However, when a grade 2b view occurs, two-thirds of patients are difficult to intubate, whereas only about 4% of patients with grade 2a views are characterized as difficult intubations. A grade 1 view reveals virtually the entire glottis and is associated with almost universal intubation success.

Despite scores of clinical studies, no evidence to date reliably identifies which patient attributes predict successful laryngoscopy and intubation and which predict failure. Lists of anatomical features, radiologic findings, and complex scoring systems have been explored with only limited success. In the absence of a proven and validated system that is capable of predicting intubation difficulty with 100% sensitivity and specificity, it is important to develop an approach that will enable a clinician to quickly and simply identify those patients who *might* be difficult to intubate so an appropriate plan can be made using the difficult airway algorithm. In other words, when asking the question, “Does this patient’s airway warrant using the difficult airway algorithm, or is it appropriate and safe to proceed directly to RSI?” we value sensitivity (i.e., identifying all those



**Figure 2-2 ● C–L laryngeal view grade system.**

who might be difficult) more than specificity (i.e., always being correct when identifying a patient as difficult).

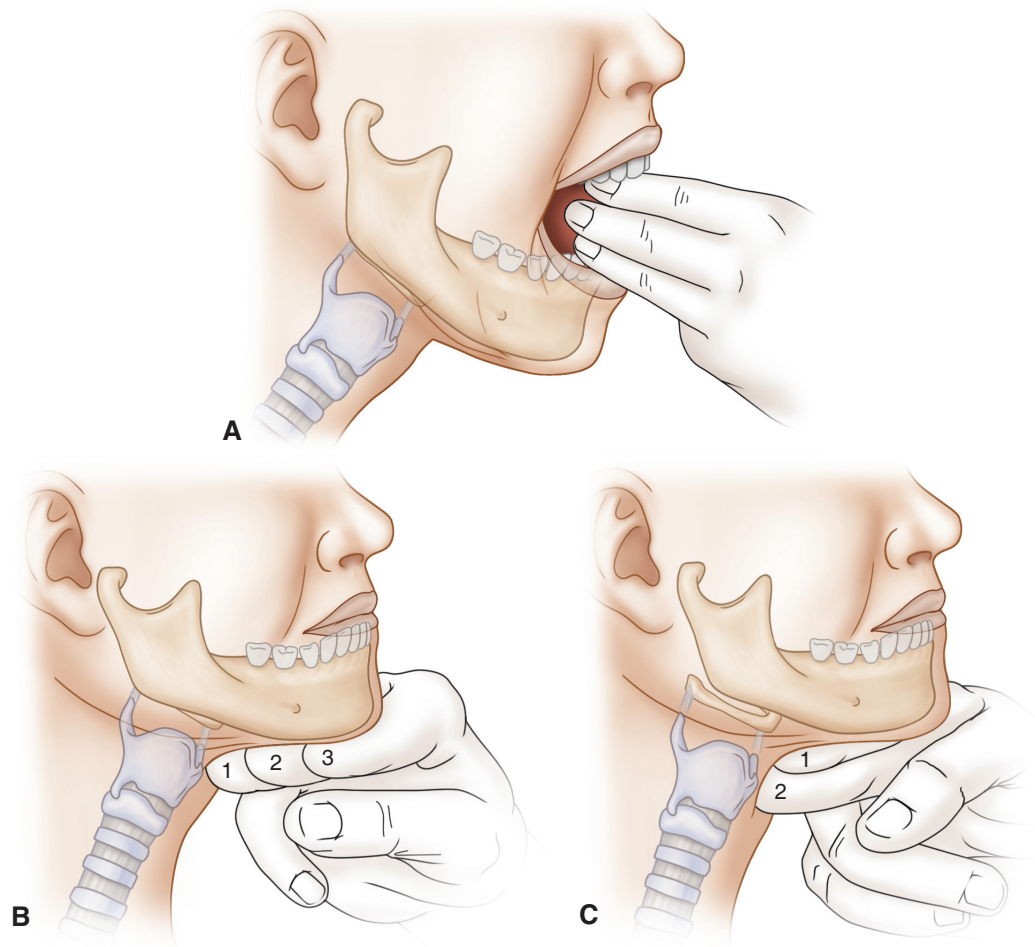
The mnemonic LEMON is a useful guide to identify as many of the risks as possible as quickly and reliably as possible to meet the demands of an emergency situation. The elements of the mnemonic are assembled from an analysis of the difficult airway prediction instruments in the anesthesia, emergency medicine, and critical care literature. The mnemonic, developed for The Difficult Airway Course™ and the first edition of this book, has been externally validated and has been adopted as a recommended airway assessment tool in Advanced Trauma Life Support (ATLS). The mnemonic is as follows:

**L—Look externally:** Although a gestalt of difficult intubation is not particularly sensitive (meaning that many difficult airways are not readily apparent externally), it is quite specific, meaning that if the airway looks difficult, it probably is. Most of the litany of physical features associated with difficult laryngoscopy and intubation (e.g., small mandible, large tongue, large teeth, and short neck) are accounted for by the remaining elements of LEMON and so do not need to be specifically recalled or sought, which can be a difficult memory challenge in a critical situation. The external look specified here is for the “feeling” that the airway will be difficult. This feeling may be driven by a specific finding, such as external evidence of lower facial disruption and bleeding that might make intubation difficult, or it might be the ill-defined composite impression of the patient, such as the obese, agitated patient with a short neck and small mouth, whose airway appears formidable even before any formal evaluation (the rest of the LEMON attributes) is undertaken. This “gestalt” of the patient is influenced by patient attributes, the setting, and clinician expertise and experience, and likely is as valid for video laryngoscopy as for direct laryngoscopy.

**E—Evaluate 3-3-2:** This step is an amalgamation of the much-studied geometric considerations that relate mouth opening and the size of the mandible to the position of the larynx in the neck in terms of likelihood of successful visualization of the glottis by direct laryngoscopy. This concept originally was identified with “thyromental distance,” but has become more sophisticated over time. The thyromental distance is the hypotenuse of a right triangle, the two legs being the anteroposterior dimension of the mandibular space, and the interval between the chin–neck junction (roughly the position of the hyoid bone indicating the posterior limit of the tongue) and the top of the larynx, indicated by the thyroid notch. The 3-3-2 evaluation is derived from studies of the geometrical requirements for successful direct laryngoscopy, that is, the ability of the operator to create a direct line of sight from outside the mouth to the glottis. It is not known whether it has any value in predicting difficult video laryngoscopy, for which no straight line of sight is required. The premises of the 3-3-2 evaluation are as follows:

- The mouth must open adequately to permit visualization past the tongue when both the laryngoscope blade and the endotracheal tube are within the oral cavity.
- The mandible must be of sufficient size (length) to allow the tongue to be displaced fully into the submandibular space.
- The glottis must be located a sufficient distance caudad to the base of the tongue that a direct line of sight can be created from outside the mouth to the vocal cords as the tongue is displaced inferiorly into the submandibular space.

The first “3,” therefore, assesses mouth opening. A normal patient can open his or her mouth sufficiently to accommodate three of his or her own fingers between the upper and lower incisors (Fig. 2-3A). The second “3” evaluates the length of the mandibular space by ensuring the patient’s ability to accommodate three of his or her own fingers between the tip of the mentum and chin–neck junction (hyoid bone) (Fig. 2-3B). The “2” assesses the position of the glottis in relation to the base of the tongue. The space between the chin–neck junction



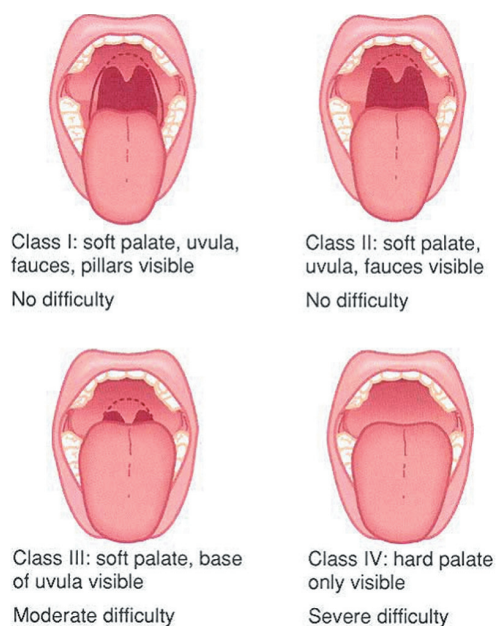
**Figure 2-3** ● A: The first 3 of the 3-3-2 rule. B: The second 3 of the 3-3-2 rule. C: The 2 of the 3-3-2 rule.

(hyoid bone) and the thyroid notch should accommodate two of the patient's fingers (Fig. 2-3C). Thus, in the 3-3-2 rule, the first 3 assesses the adequacy of oral access, and the second 3 addresses the dimensions of the mandibular space to accommodate the tongue on laryngoscopy. The ability to accommodate significantly more than or less than three fingers is associated with greater degrees of difficulty in visualizing the larynx at laryngoscopy: the former because the length of the oral axis is elongated and the latter because the mandibular space may be too small to accommodate the tongue, requiring it to remain in the oral cavity or move posteriorly, obscuring the view of the glottis. Encroachment on the submandibular space by infiltrative conditions (e.g., Ludwig angina) is identified during this evaluation. The final 2 identifies the location of the larynx in relation to the base of the tongue. If significantly more than two fingers are accommodated, meaning the larynx is distant from the base of the tongue, it may be difficult to reach or visualize the glottis on direct laryngoscopy. 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 imprecisely called "anterior larynx."

**M—Mallampati score:** Mallampati determined that the degree to which the posterior oropharyngeal structures are visible when the mouth is fully open and the tongue is extruded reflects the

relationships among mouth opening, the size of the tongue, and the size of the oral pharynx, which defines access through the oral cavity for intubation, and that these relationships are associated with intubation difficulty. Mallampati's classic assessment requires that the patient sit upright, open the mouth as widely as possible, and protrude the tongue as far as possible without phonating. Figure 2-4 depicts how the scale is constructed. Class I and class II patients have low intubation failure rates, so the importance with respect to the decision whether to use neuromuscular blockade rests with those in classes III and IV, particularly class IV where intubation failure rates may exceed 10%. By itself, the scale is neither sensitive nor specific; however, when used in conjunction with the other difficult airway assessments, it provides valuable information about access to the glottis through the oral cavity. In the emergency situation, it frequently is not possible to have the patient sit up or to follow instructions. Therefore, often only a crude Mallampati measure is possible, obtained by examining the supine, obtunded patient's mouth with a tongue blade and light, or by using a lighted laryngoscope blade as a tongue depressor to gain an appreciation of how much mouth opening is present (at least in the paralyzed state) and the relationship between the size of the tongue and that of the oral cavity. Although not validated in the supine position using this approach, there is no reason to expect that the assessment would be significantly less reliable than the original method with the patient sitting and performing the maneuver actively.

- **Obstruction/obesity:** Upper airway obstruction is a marker for difficult laryngoscopy. The four cardinal signs of upper airway obstruction are muffled voice (hot potato voice), difficulty swallowing secretions (because of either pain or obstruction), stridor, and a sensation of dyspnea. The first two signs do not ordinarily herald imminent total upper airway obstruction in adults, but critical obstruction is much more imminent when the sensation of dyspnea occurs. Stridor is a particularly ominous sign. The presence of stridor is generally considered to indicate that the airway has been reduced to <50% of its normal calibre, or to a diameter of 4.5 mm or less. The management of patients with upper airway obstruction is discussed in Chapter 34.



**Figure 2-4 ● The Mallampati Scale.** In class I, the oropharynx, tonsillar pillars, and entire uvula are visible. In class II, the pillars are not visible. In class III, only a minimal portion of the oropharyngeal wall is visible, and in class IV, the tongue is pressed against the hard palate.

Although it is controversial whether obesity per se is an independent marker for difficult laryngoscopy or whether obesity simply is associated with various difficult airway attributes, such as high Mallampati score or failure of the 3-3-2 rule, obese patients frequently have poor glottic views by direct or video laryngoscopy, and obesity, in itself, should be considered to portend difficult laryngoscopy.

**N**—*Neck mobility*: The ability to position the head and neck is one of the key factors in achieving the best possible view of the larynx by direct laryngoscopy. Cervical spine immobilization for trauma, by itself, may not create a degree of difficulty that ultimately leads one to avoid RSI after applying the thought processes of the difficult airway algorithm. However, cervical spine immobilization will make intubation more difficult and will compound the effects of other identified difficult airway markers. In addition, intrinsic cervical spine immobility, such as in cases of ankylosing spondylitis or rheumatoid arthritis, can make intubation by direct laryngoscopy extremely difficult or impossible and should be considered as a much more serious issue than the ubiquitous cervical collar (which mandates inline manual immobilization). Video laryngoscopy requires much less (or no) head extension, and provides a glottic view superior to that by direct laryngoscopy when head extension or neck flexion is restricted. Other devices, such as the Airtraq or the Shikani optical stylet, also may require less cervical spine movement than direct laryngoscopy.

## Difficult BMV: MOANS

Chapter 9 highlights the importance of BMV in airway management, particularly as a rescue maneuver when orotracheal intubation has failed. If the airway manager is uncertain that neuromuscular blockade–facilitated orotracheal intubation (RSI) will be successful, he or she must be confident that BMV is possible, oxygenation using an EGD is possible, or, at the very least, a cricothyrotomy can rapidly be performed.

The validated indicators of difficult BMV from various clinical studies can be easily recalled for rapid use in the emergency setting by using the mnemonic MOANS.

**M**—*Mask seal/male sex/Mallampati*: Bushy beards, blood or debris on the face, or a disruption of lower facial continuity are the most common examples of conditions that may make an adequate mask seal difficult. Some experts recommend smearing a substance, such as KY jelly, on the beard as a remedy to this problem, although this action may simply make a bad situation worse in that the entire face may become too slippery to hold the mask in place. Both male sex and a Mallampati class 3 or 4 (see earlier) airway appear also to be independent predictors of difficult BMV.

**O**—*Obesity/obstruction*: Patients who are obese (body mass index  $>26$  kg per  $m^2$ ) are often difficult to ventilate adequately by bag and mask. Women in third-trimester gestation are also a prototype for this problem because of their increased body mass, and the resistance to diaphragmatic excursion caused by the gravid uterus. Pregnant or obese patients also desaturate more quickly, making the bag ventilation difficulty of even greater import (see Chapters 36 and 39). The difficulty bagging the obese patient is not caused solely by the weight of the chest and abdominal walls and the resistance by the abdominal contents to diaphragmatic excursion. Obese patients also have redundant tissues, creating resistance to airflow in the upper airway. Similarly, obstruction caused by angioedema, Ludwig angina, upper airway abscesses (e.g., peritonsillar), epiglottitis, and other similar conditions will make BMV more difficult. In general, soft tissue lesions (e.g., angioedema, croup, and epiglottitis) are amenable to bag and mask rescue if obstruction occurs, but not with 100% certainty. Similarly, laryngospasm can usually be overcome with good bag and mask technique. In contrast, firm, immobile lesions such as hematomas, cancers, and foreign bodies are less amenable to rescue by BMV, which is unlikely to provide adequate ventilation or oxygenation if total obstruction arises in this context.

**A**—*Age*: Age older than 55 to 57 years is associated with a higher risk of difficult BMV, perhaps because of a loss of muscle and tissue tone in the upper airway. The age is not a precise cutoff,



and some judgment can be applied with respect to whether the patient has relatively elastic (young) or inelastic (aged) tissue.

- N**—*No teeth*: An adequate mask seal may be difficult in the edentulous patient because the face may not adequately support the mask. An option is to leave dentures (if available) in situ for BMV and remove them for intubation. Alternatively, gauze dressings may be inserted into the cheek areas through the mouth to puff them out in an attempt to improve the seal.
- S**—*Stiff/snoring*: This refers to patients whose lungs and thoraces are resistant to ventilation and require high-ventilation pressures. These patients are primarily those with reactive airways disease with medium and small airways obstruction (asthma and chronic obstructive pulmonary disease [COPD]) and those with pulmonary edema, acute respiratory distress syndrome (ARDS), advanced pneumonia, or any other condition that reduces pulmonary compliance or increases airway resistance to BMV. Also, a history of snoring (or of sleep apnea) predicts more difficult BMV. This risk factor may not be detectable in the setting of an emergency intubation, though, as it requires historical information.

### Difficult EGD: RODS

In the emergency setting, extraglottic airway devices have emerged as credible first line devices for ventilation and oxygenation, instead of the traditional bag and mask; as alternatives to tracheal intubation in some patient circumstances (especially out of hospital), and as valuable airway rescue devices.

Studies have identified factors that predict difficulty in placing an EGD and providing adequate gas exchange. These can be assessed using the mnemonic RODS.

- R**—*Restricted mouth opening*: Adequate mouth opening is required for insertion of the EGD. This requirement varies, depending on the particular EGD to be used.
- O**—*Obstruction/obesity*: If there is upper airway obstruction in the pharynx, at the level of the larynx or glottis, or below the vocal cords, an EGD may be impossible to insert or seat properly and will not bypass the obstruction to achieve ventilation and oxygenation. Obesity creates two challenges to oxygenation using an EGD. First, redundant tissues in the pharynx may make placement and seating of the device more difficult. Usually, this is not a significant problem. More importantly, obese patients require higher ventilation pressures, largely because of the weight of the chest wall and abdominal contents. The former causes resistance to ventilation by increasing the pressures required to expand the chest, and the latter causes resistance to ventilation by increasing the pressures required to cause the diaphragm to descend. Depending on the EGD chosen, and positioning of the patient (it is better to attempt ventilation with the patient 30° head up or in reverse Trendelenberg position), ventilation resistance may exceed the ability of the EGD to seal and deliver the necessary pressures.
- D**—*Disrupted or distorted airway*: The key question here is, “If I insert this EGD into the pharynx of this patient, will the device be able to seat itself and seal properly within relatively normal anatomy?” For example, fixed flexion deformity of the spine, penetrating neck injury with hematoma, epiglottitis, and pharyngeal abscess each may distort the anatomy sufficiently to prevent proper positioning of the device.
- S**—*Stiff*: The stiffness referred to here is as for the MOANS mnemonic, that is, intrinsic resistance to ventilation. Ventilation with an EGD may be difficult or impossible in the face of substantial increases in airway resistance (e.g., asthma) or decreases in pulmonary compliance (e.g., pulmonary edema).

### Difficult Cricothyrotomy: SMART

There are no absolute contraindications to performing an emergency cricothyrotomy (see Chapter 18). However, some conditions may make it difficult or impossible to perform the

procedure, making it important to identify those conditions in advance and allowing consideration of alternatives rather than assuming or hoping that cricothyrotomy, if necessary, will be successful as a rescue technique. The mnemonic SMART is a modernization of our former algorithm, SHORT, and is used to quickly assess the patient for features that may indicate that a cricothyrotomy might be difficult. A part of patient assessment using this mnemonic, which occurs during the “A” step, is to perform a physical examination of the neck, identifying the landmarks and any barriers to the procedure. The SMART mnemonic is applied as follows:

- S**—*Surgery (recent or remote)*: The anatomy may be subtly or obviously distorted, making the airway landmarks difficult to identify. Scarring may fuse tissue planes and make the procedure more difficult. Recent surgery may have associated edema or bleeding, complicating performance of the procedure.
- M**—*Mass*: A hematoma (postoperative or traumatic), abscess, or any other mass in the pathway of the cricothyrotomy may make the procedure technically difficult, and requires the operator to meticulously locate the landmarks, which may be out of the midline, or obscured.
- A**—*Access/anatomy*: Obesity makes surgical access challenging, as it often is difficult to identify landmarks. Similar challenges are presented by subcutaneous emphysema, soft tissue infection, or edema. A patient with a short neck or overlying mandibular pannus presents challenges both with identification of landmarks and access to perform the procedure. Extraneous devices, such as a cervical immobilization collar, or a halo-thoracic brace also may impede access.
- R**—*Radiation (and other deformity or scarring)*: Past radiation therapy may distort and scar tissues making the procedure difficult, often causing tissues that normally are discrete to bond together, distorting tissue planes and relationships.
- T**—*Tumor*: Tumor, either inside the airway (beware of the chronically hoarse patient) or encroaching on the airway, may present difficulty, both from access and bleeding perspectives.

## SUMMARY

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- When intubation is indicated, the most important question is, “Is this airway difficult?” The decision to perform RSI, for example, is based on thorough assessment for difficulty (LEMON, MOANS, RODS, and SMART) and appropriate use of the main or difficult airway algorithms.
- If LEMON and MOANS are performed first, in order, then each component of RODS also has been assessed, with the exception of the D: distorted anatomy. In other words, if LEMON and MOANS have identified no difficulties, then all that remains for RODS is the question: “If I insert this EGD into the pharynx of this patient, will the device be able to seat itself and seal properly within relatively normal anatomy?”
- The ability to oxygenate a patient with a bag and mask or an EGD turns a potential CICO situation requiring urgent cricothyrotomy into a “*can’t* intubate, *can* oxygenate” situation, in which many rescue options can be considered. The ability to prospectively identify situations in which oxygenation using an EGD or a bag and mask will be difficult or impossible is critical to the decision whether to use neuromuscular blocking agents.
- No single indicator, combination of indicators, or even weighted scoring system of indicators can be relied on to guarantee success or predict inevitable failure for oral intubation. Application of a systematic method to identify the difficult airway and then analysis of the situation to identify the best approach, given the anticipated degree of difficulty and the skill, experience, and judgment of the individual performing the intubation, will lead to the best decisions regarding how to manage the particular clinical situation. In general, it is better to err by identifying an airway as potentially difficult, only to subsequently find this not to be the case, than the other way around.

## EVIDENCE

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- **What is the incidence of difficult and failed airway?** A poor glottic view is associated with low intubation success. In studies of intubation by direct laryngoscopy in elective anesthesia practice, various definitions of difficult intubation are used. C–L class III and IV glottic visualization occurs in up to 12.5% of elective anesthesia patients.<sup>1</sup> A meta-analysis of elective anesthesia studies found an incidence of difficult laryngoscopy ranging from 6% to 27% among nine studies totaling >14,000 patients.<sup>2</sup> For obese patients, the incidence of difficult intubation certainly is higher, but how much of this is caused by obesity alone, and how much is a product of the presence of various difficult airway markers, such as a poor Mallampati score, is not clear. The Intubation Difficulty Score (IDS) considers the numbers of operators, devices, attempts, the C–L score, vocal cord position (abducted or not), and whether excessive lifting force or external manipulation is required.<sup>3</sup> In one study of 129 lean and 134 obese patients, using an IDS of 5 or greater as the definition of difficult intubation (a relatively high bar), investigators identified difficult intubation in 2.2% of lean patients and 15.5% of obese patients.<sup>4</sup> Only 1% of 663 patients in one British study had grade III glottic views, but 6.5% had grade IIb views (only arytenoids visible) and 2/3 of these were difficult to intubate.<sup>5</sup> In Reed's validation study of the LEMON mnemonic, 11/156 (7%) of patients had C–L grade III glottic views and only 2/156 had grade IV views.<sup>6</sup> The largest emergency department series is from the National Emergency Airway Registry (NEAR) project. In phase 2 of NEAR, reporting on 8,937 intubations from 1997 to 2002, the first chosen method ultimately was not successful in approximately 5% of intubations. Overall airway management success was >99%, and surgical airways were performed on 1.7% of trauma patients and approximately 1% of all cases.<sup>7</sup> Analysis of a subset of almost 8,000 of the NEAR 2 patients showed that about 50% of rescues from failed attempts involved use of RSI after failure of intubation attempts without neuromuscular blockade.<sup>8</sup>
- **What is the evidence basis of LEMON?** Only one external validation of the LEMON mnemonic has been published.<sup>6</sup> The American College of Surgeons adopted the LEMON mnemonic for ATLS in 2008, but mistakenly attributed it to Reed. The gestalt of difficulty provided by the patient obviously is an intuitive notion and will vary greatly with the skills and experience of the intubator. Certainly, it is not a sufficient assessment for intubation difficulty, for many markers, such as limited neck mobility or limited mouth opening, may not be apparent on this first look. There are no studies, of which we are aware, that assess the sensitivity or specificity of this first, quick look. Of interest, in Langeron's study of difficult BMV, clinicians identified in advance only 13/75 difficult BMV patients, a sensitivity of only 17%.<sup>9</sup> We are not aware of the true origin of the 3-3-2 rule. It probably originated from a group of Canadian difficult airway experts, led by Edward Crosby, MD, but, to our knowledge, it was not published before we included it in the first edition of our book in 2000. The 3-3-2 rule has three components. The first is mouth opening, a long-identified and intuitively obvious marker of difficult direct laryngoscopy. The second and third have to do mandibular size and the distance from the floor of the mandible to the thyroid notch. Many studies suggest identifying decreased (and, to a lesser extent, increased) thyromental distance as a predictor of difficult direct laryngoscopy. One study identified that it is relative, but not absolute thyromental distance that matters; in other words, the relevant thyromental distance that predicts difficulty depends on the size of the patient.<sup>1</sup> This reinforces the notion of using the patient's own fingers as a size guide for thyromental distance, but also for the other two dimensions of the 3-3-2 rule. Hyomental distance also has been used, but seems less reliable, causing researchers to explore the value of repeated measurements and ratios involving different head and neck positions.<sup>10</sup> The eponymous Mallampati evaluation has been validated multiple times. The modified Mallampati score, the four-category method that is most familiar, was found highly reliable in a comprehensive meta-analysis of 42 studies, but the authors emphasize, as do we, that the

test is important, but not sufficient in evaluating the difficult airway.<sup>2</sup> One study suggested that the Mallampati evaluation gains specificity (from 70% to 80%) without loss of sensitivity if it is performed with the head in extension, but this study involved only 60 patients and performing the Mallampati, even in the neutral position, is challenging enough before emergency intubation, so we do not recommend head extension.<sup>11</sup> Interference with direct laryngoscopy by upper airway obstruction is self-evident. Obesity is uniformly identified as a difficult airway marker but, remarkably, controversy persists regarding obesity, *per se*, indicates difficult laryngoscopy, or whether obese patients simply have a greater incidence of having other difficult airway markers, such as higher Mallampati scores.<sup>12</sup> An opposing view suggests that, although a higher Mallampati score is associated with difficult intubation in obese patients, other traditional predictors of difficult intubation do not account for the high incidence and degree of difficulty in obese patients.<sup>4</sup> The only two studies to compare obese and lean patients head to head found a similar 5-fold increase in intubation difficulty for obese patients (about 15% vs. about 3% of lean patients), but one study concluded that body mass index (BMI) was important, the other concluded the opposite.<sup>13</sup>

- **What is the evidence basis of MOANS?** Much of the clinical information about difficult bag-mask ventilation came from case reports and limited case series, so were subject to bias and misinterpretation. The first well-designed study of difficult BMV was that of Langeron et al.,<sup>9</sup> where a 5% incidence of difficult BMV occurred in 1,502 patients. They identified five independent predictors of difficult BMV: presence of a beard, high BMI, age >55 years, edentulousness, and a history of snoring. Subsequent studies by other investigators were much larger. Kheterpal et al. used a graded definition of difficult BMV in their study of >22,000 patients. They divided difficult BMV into four classes, ranging from routine and easy (class I) to impossible (class IV). Class III difficulty was defined as inadequate, “unstable,” or requiring two providers. They identified class III (difficult) BMV in 313/22,600 (1.4%) and class IV (impossible) in 37 (0.16%) patients. Multivariate analysis was used to identify independent predictors of difficult BMV: presence of a beard, high BMI, age >57 years, Mallampati class III or IV, limited jaw protrusion, and snoring. Snoring and thyromental distance <6 cm were independent predictors of impossible BMV.<sup>14</sup> Subsequently, the same researchers studied 53,041 patients over a 4-year period. Independent predictors of impossible BMV included the following: presence of a beard, male sex, neck radiation changes, Mallampati class III or IV, and sleep apnea.<sup>15</sup> These studies, combined with others, and with our collective experience, are the foundation for the MOANS mnemonic, which we have updated for this edition, reflecting the addition of male sex and Mallampati from the 2009 Kheterpal study. Interestingly, Mallampati class did not fare well as a predictor of difficult BMV in Lee’s meta-analysis of 42 studies with >34,000 patients, although it did quite well for difficult intubation.<sup>2</sup> Nevertheless, we feel that Mallampati is a worthy consideration with respect to difficult BMV, as it helps the operator to understand the extent to which the tongue might impede ventilation. Conditions that require increased ventilation pressures, such as reactive airways disease and COPD, and those associated with a decrease in pulmonary compliance, such as ARDS or pulmonary edema, understandably make ventilation with a bag and mask more difficult. Why were these attributes not identified in the elegant studies of predictors of difficult BMV? Likely, patients with these conditions were too ill to be included in any such studies. Nonetheless, we are confident in including this concept in the “S” of MOANS.
- **What is the evidence basis of RODS?** EGDs have not been systematically studied for predictors of difficulty. Original information came from case reports, and now more information is available, principally with respect to seal pressures for the various devices (the airway pressures beyond which leakage occurs, reducing the tidal volume). As such, this mnemonic really represents our expert consensus, rather than an assessment of high-quality evidence. The requirement for minimal mouth opening sufficient to insert the device is self-evident. Obesity and obstruction will interfere with EGD use in similar fashion to their interference with BMV. Devices vary in their utility in various patients, however, and some may be

better suited for obese patients than others. One study compared 50 morbidly obese patients to 50 lean patients and identified no increase in difficulty for either ventilation or intubation with the intubating LMA.<sup>16</sup> Distorted anatomy is our own concept, based on the fact that each of these devices is designed to “seat” into normal human anatomy, given that the right size of device is selected. The “S” for stiffness is exactly analogous to that for BMV, perhaps even more compelling here, because greater seal pressures often can be obtained using a bag and mask (with two operators) than with an EGD.

- **How reliable are the factors we evaluate in predicting difficult intubation?** Performing a preintubation assessment confers substantial protection against unexpectedly encountering a difficult intubation. Using a definition of difficult intubation as two failed attempts despite optimal laryngeal manipulation, one study found only 0.9% unexpected difficult intubations among >11,000 patients.<sup>17</sup> Investigators did not report C–L scores, though. In elective anesthesia practice, difficult airway patients often are “selected out” and managed by modified anesthetic technique, such as awake flexible endoscopic intubation. The safety of performing preintubation assessment is reinforced by this practice, however, as difficult and failed bag-mask ventilation and intubation in this population generally are unexpected because of the prescreening, and so probably reasonably predict unexpected (i.e., not detected by preintubation assessment of difficulty) similar events during emergency intubation. In one study of almost 23,000 patients, only about 1.6% had difficult bag-mask ventilation and only 0.37% or 1/300 had a combination of difficult BMV and difficult intubation.<sup>14</sup>
- **Does LEMON apply to video laryngoscopy also?** The short answer is no, or, at least, we do not know. Much of LEMON has to do with the need to see past the tongue, to the glottis, using a straight line of sight. Video laryngoscopy does not involve a straight line of sight, so, for example, we do not have any reason to believe that the 3-3-2 rule applies. Mallampati is not nearly as important, as the video viewer on most video laryngoscopes is positioned beyond the tongue, thus eliminating the tongue from consideration. Mallampati assesses mouth opening, also, though, as does the first “3” of the 3-3-2 rule, and mouth opening remains important for video laryngoscopy, although much less so. Only one study has attempted to identify attributes associated with difficult video laryngoscopy, in this case the GlideScope, and it is difficult to put much weight on any conclusions because 400/400 patients had C–L class I or II views.<sup>18</sup> The evidence for superiority of video laryngoscopy over conventional laryngoscopy is presented in Chapter 13.

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