CHAPTER 2

Identification of the Anatomically Difficult Airway

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INTRODUCTION

An anatomically difficult airway is one in which identifiable anatomic attributes predict technical difficulty with securing the airway. One can think about airway difficulty in two categories: an anatomically difficult airway and a physiologically difficult airway. The former presents anatomic barriers to successful airway management, whereas the latter requires the operator to optimize overall patient physiology in the context of critically low oxygen saturation, hemodynamic instability, or severe metabolic acidosis (discussed in Chapter 3). This chapter focuses on the anatomic issues related to airway management.

An anatomically difficult airway exists on a spectrum and is one in which a preintubation examination identifies physical attributes that are likely to make laryngoscopy, intubation, bag-mask ventilation (BMV), the use of an extraglottic device (EGD; eg, laryngeal mask airway [LMA] or King laryngeal tube [King-LT]), or surgical airway management more difficult than would be the case in an ordinary patient without those attributes. Some patients may have a single anatomic reason for airway difficulty, whereas others may have numerous difficult airway characteristics. Identification of an anatomically 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 5). The key reason for this is that, depending on the degree of predicted difficulty, induction of anesthesia and use of neuromuscular blocking medications would be avoided in the face of severe anatomic limitation (ie, obstructing oropharyngeal pathology) unless one has a measure of confidence that gas exchange can be maintained if laryngoscopy and intubation fail, or a forced-to-act scenario existed (see Chapter 5). Accordingly, if an anatomically difficult airway is identified, the difficult airway algorithm is used.

Airways that are difficult to manage because of anatomic challenges are common in emergency medicine practice. Difficult direct laryngoscopy (DL), defined as a grade III or grade IV laryngoscopic view, occurs in approximately 10% of all adult emergency intubations. The incidence is dramatically lower when a video laryngoscope is used (see Chapter 16). Recognizing the anatomically difficult airway in advance and executing an appropriate and thoughtful plan, guided by the difficult airway algorithm, will minimize the likelihood that airway management will fail.

THE DIFFICULT AIRWAY

According to the main emergency airway management algorithm, rapid sequence intubation (RSI) is the method of choice for any airway when significant 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 anatomically difficult airway has four dimensions:

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

A distinct evaluation is required for difficult DL, difficult BMV, difficult EGD, and difficult surgical airway management, and each evaluation must be applied to each patient, when time allows, 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 DL, is still relevant even in the era of video laryngoscopy (VL). Nearly all research relating specific patient characteristics to difficult or impossible intubation is based on studies of DL. VL is much less affected than DL by the presence or number of difficult airway attributes; however, extreme abnormalities of some elements of LEMON will affect both DL and VL alike. Severely reduced mouth opening, for example, makes it impossible for any laryngoscope blade to be inserted. So, although abnormal LEMON findings will differentially impact DL more, we recommend performing a difficult laryngoscopy assessment, using the LEMON mnemonic, on all patients for whom intubation is planned, including for planned VL. When able to be inserted, it is rare for VL, particularly hyperangulated VL (HA-VL), to yield a Cormack and Lehane (C-L) grade III (or worse) glottic view. VL accomplishes this independently of the need to align the various airway axes, as must occur during DL (see Chapters 15 and 16). It follows that evidence-based guidelines for prediction of difficult VL may be challenging, or even impossible, to create. A mnemonic for difficult VL, CRANE (see "Evidence" section), has been developed, based on limited evidence from the anesthesia literature, but its utility in emergency airway management is unclear. If orotracheal intubation is planned and the airway is not overwhelmingly soiled or obliterated by large obstructing airway pathology, then VL provides the best opportunity for intubation success despite the presence of other "CRANE" abnormalities. Providers should proceed with using VL unless patient characteristics are present that would make both

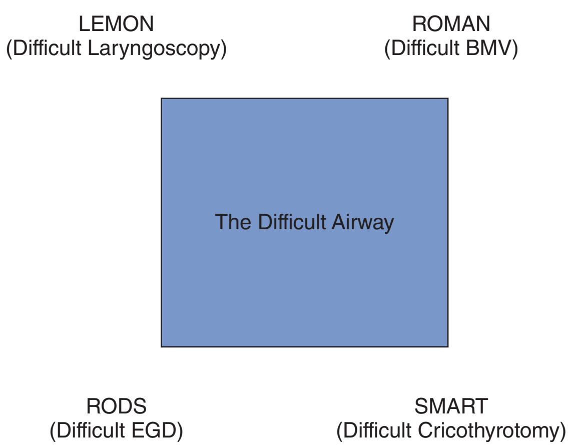

Figure 2.1: Difficult airway box. Note that the *four corners* represent the four dimensions of difficulty.

VL and DL virtually impossible, in which case, another approach may be required (ie, nasotracheal flexible VL for advanced angioedema of the tongue).

C-L introduced the most widely used system of categorizing the degree of visualization of the larynx during DL, in which a complete laryngoscopic view is designated grade 1 and the worst possible view, grade 4 (**Fig. 2.2**). C-L grade 3 view (only the epiglottis is visible) and grade 4 view (no glottic structures are 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 if only the arytenoids are visible. This led to adoption of a grade 2a/2b system, wherein a 2a shows any portion of the cords and a 2b shows only the arytenoids. Grade 2a airways perform comparably to those scored as grade 1, whereas grade 2b airways behave more like grade 3 airways. When DL is used, 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 nearly universal intubation success.

Despite scores of clinical studies, no evidence to date has identified a foolproof set of patient attributes that, when absent, always predicts successful intubation and, when present, predicts certain intubation failure. In the absence of a proven and validated system that can predict 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 (ie, identifying all those who might be difficult) more than specificity (ie, always being correct when identifying a patient as difficult).

The mnemonic LEMON is a useful guide to identify as many of the anatomic risks of difficulty 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, which we developed for The Difficult Airway Course and the first edition of this book, has been externally validated in emergency department (ED) patients. The modified LEMON (all aspects of LEMON except the Mallampati score and thyromental distance) has undergone additional external validation and been found to have very high negative predictive value for both conventional laryngoscopy and

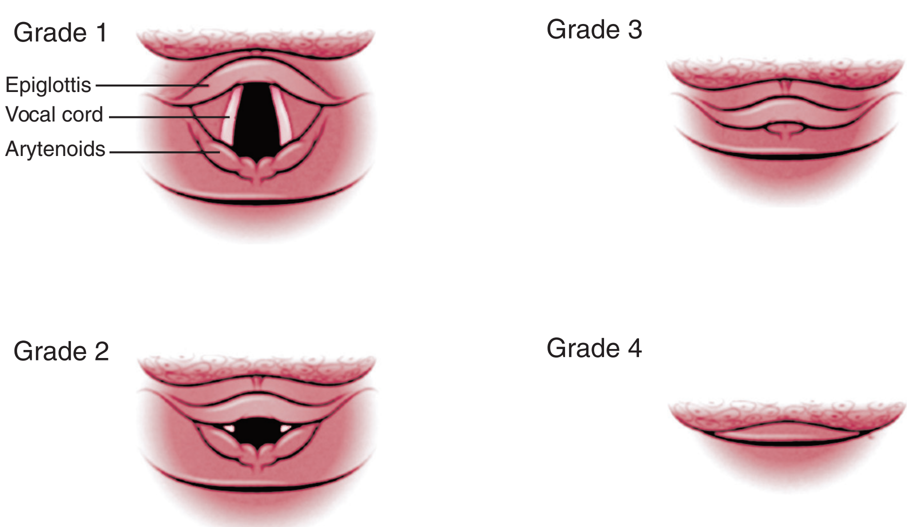

Figure 2.2: Cormack-Lehane laryngeal view grading system.

VL. LEMON has now been adopted as a recommended airway assessment tool in the Advanced Trauma Life Support (ATLS) manual. When a complete or near-complete LEMON assessment is not possible because of patient acuity or obtundation, a single thyromental height (TMH) can be measured and, if <5 cm, identifies patients with challenging laryngoscopy with decent sensitivity and specificity (see "Evidence" section that follows).

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 (eg, 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 VL as for DL.

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 DL. 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 geometric requirements for successful DL, that is, the ability of the operator to create a direct line of sight from outside the mouth to the glottis. It is unlikely it has any value in predicting difficult HA-VL, 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 during DL.
- 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**). This is an approximate measurement as it would be unusual to ask an acutely ill or injured patient to stick three fingers in his or her mouth. If a patient can comply, ask if he or she can open the mouth as wide as possible. This will give a meaningful sense of whether the patient is able to open fully, partially, or not at all. 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 (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 DL. The ability to accommodate fewer 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

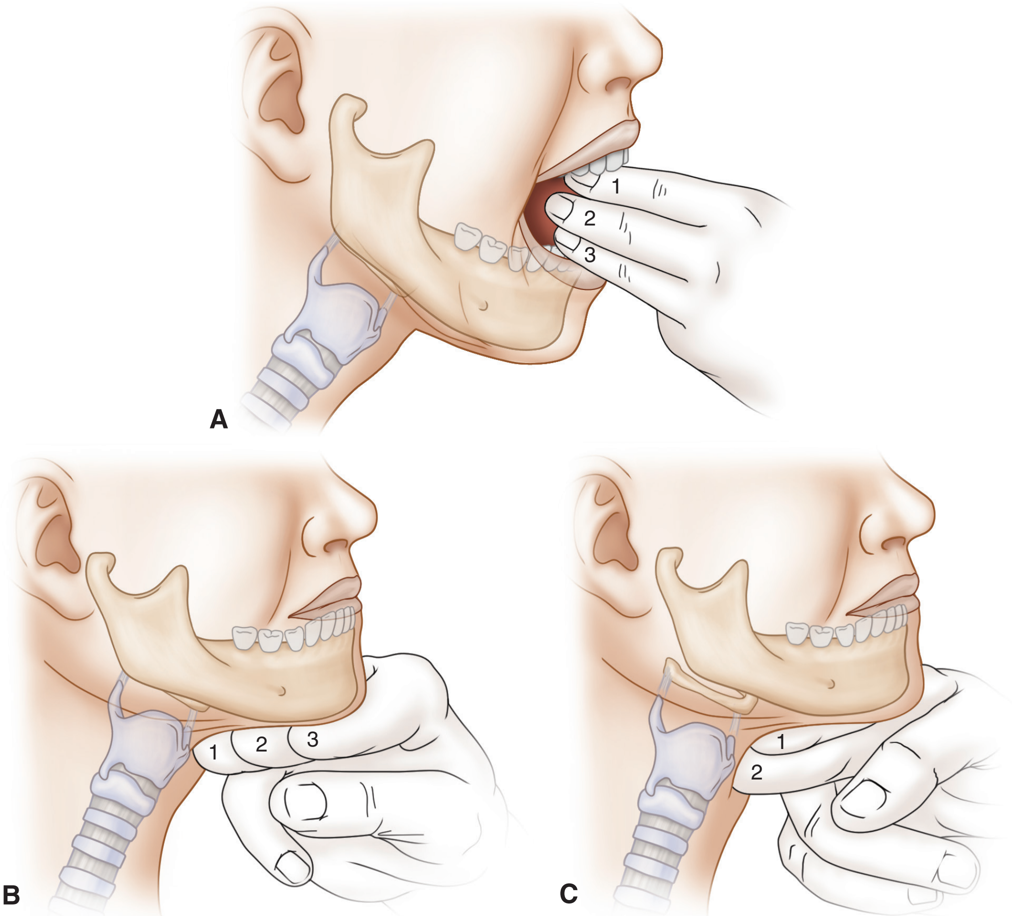

Figure 2.3: **A:** The first 3 of the 3-3-2 rule. **B:** The second 3 of the 3-3-2 rule. **C:** The 2 of the 3-3-2 rule.

cavity or move posteriorly, obscuring the view of the glottis. Encroachment on the submandibular space by infiltrative conditions (eg, 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 DL, particularly if a smaller blade size is used initially. 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 an "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 cavity 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. Classes I and 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 and not meant to be used as a stand-alone assessment; 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

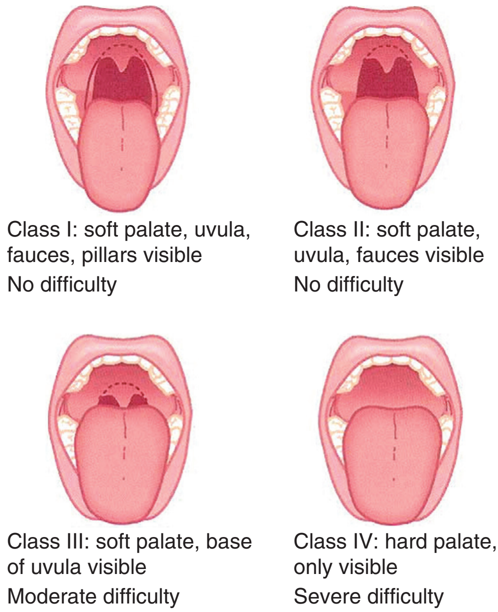

Figure 2.4: The Mallampati scale. In class I, the oropharynx, tonsillar pillars, and entire uvula are visible. In class II, the pillars are not visible. In class III, only a minimal portion of the oropharyngeal wall is visible, and in class IV, the tongue is pressed against the hard palate.

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 on the anterior half of the tongue to gain an appreciation of how much mouth opening is present (at least in the preparalyzed 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. The laryngoscope or tongue blade should not be inserted too deeply because this may incite a gag reflex and can place a supine and compromised patient at risk for vomiting and aspiration.

O—*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 caliber, or to a diameter of 4.5 mm or less. The management of patients with upper airway obstruction is discussed in Chapter 37. 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 DL or VL, and obesity 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 DL. 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, as in cases of ankylosing spondylitis or rheumatoid arthritis, can make intubation by DL extremely difficult or impossible and should be considered a much more serious issue than the ubiquitous cervical collar (which mandates inline manual immobilization). VL requires much less (or no) head extension, depending on blade shape, and provides a glottic view superior to that by DL when head extension or neck flexion is restricted, particularly when HA-VL is used. Other angulated devices, such as the King Vision VL or Airtraq, discussed elsewhere in this manual, also may require less cervical spine movement than DL although image size and clarity are far inferior to that obtained with traditional VL units such as the GlideScope or C-MAC.

Difficult BMV: ROMAN

Chapter 12 highlights the importance of BMV in airway management, particularly as a rescue maneuver when orotracheal intubation has failed. The airway manager must be confident that oxygenation with a BMV or EGD is feasible before induction agents or neuromuscular blockers are administered, whether or not laryngoscopy and intubation are thought to be successful.

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 ROMAN.

R—*Radiation/Restriction:* Evidence suggests that radiation treatment to the neck is one of the strongest predictors of difficult and failed mask ventilation. Restriction refers to patients whose lungs and thoraces are resistant to ventilation and require high-ventilation pressures. These patients are primarily suffering from 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.

O—*Obesity/Obstruction/Obstructive sleep apnea:* We refer to this as the "triple O" because all three attributes are important, and they are often linked (eg, obesity with obstructive sleep apnea [OSA]). Patients who are obese (body mass index [BMI] >26 kg/m^2) are often difficult to ventilate adequately by BMV. Women in third-trimester gestation are also challenging to mask ventilate 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 38 and 43). Difficulty bagging the obese patient is not caused solely by the weight of the chest and abdominal walls but also the resistance by the abdominal contents to diaphragmatic excursion. Obese patients also have redundant tissues, creating resistance to airflow in the upper airway. This explains the recent association with OSA and difficult mask ventilation. Similarly, obstruction caused by angioedema, Ludwig angina, upper airway abscesses, epiglottitis, and other similar conditions will make BMV more difficult. In general, soft tissue lesions (eg, angioedema, croup, and epiglottis) 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.

M—*Mask seal/Mallampati/Male sex:* 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 water based lubricant 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 airway also appear to be independent predictors of difficult BMV.

A—*Age:* Age greater than 55 years is associated with a higher risk of difficult BMV, perhaps because of a loss of muscle tone and tissue fullness in the face. 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 to improve the seal. Another technique for limiting mask leak involves rolling the lower lip down toward the chin and using the inner mucosal surface as a contact point for the bottom of the mask (see Chapter 12).

Difficult EGD: RODS

In the emergency setting, extraglottic airway devices are excellent 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 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—*Restriction:* The restriction referred to here is like that for the ROMAN mnemonic, that is, "restricted" lung compliance or intrinsic resistance to ventilation from primary lung or tracheal/bronchial pathology. Ventilation with an EGD may be difficult or impossible in the face of substantial increases in airway resistance (eg, asthma) or decreases in pulmonary compliance (eg, pulmonary edema), although often the EGD is more effective at ventilation than is a bag and mask. In addition, restricted mouth opening will affect EGD insertion or make it impossible. Adequate mouth opening is required for insertion of the EGD. This requirement varies, depending on the EGD to be used. Recent operating room (OR) data have also identified restricted cervical spine mobility as a risk for difficult EGD use, likely because placement can be more challenging in these patients.

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 in order to achieve ventilation and oxygenation. In some circumstances, it will not bypass the obstruction at all. 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 Trendelenburg position), ventilation resistance may exceed the ability of the EGD to seal and deliver the necessary pressures. More information on leak pressures for the variety of EGDs in circulation can be found in Chapter 13.

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 peri-laryngeal abscess each may distort the anatomy sufficiently to prevent proper positioning of the device.

S—*Short thyromental distance:* A small mandibular space, as assessed by the patient's thyromental distance, may indicate that the tongue resides less in the mandibular fossa and more in the oral cavity. This can obstruct and complicate EGD insertion and has been strongly associated with difficult EGD use.

Difficult Cricothyrotomy: SMART

There are no absolute contraindications to performing an emergency cricothyrotomy in adults (see Chapter 19). However, some conditions may make it difficult or impossible to perform the procedure, making it important to identify those conditions in advance and allow consideration of alternatives rather than assuming that cricothyrotomy, if necessary, will be successful as a rescue technique. The mnemonic SMART is used to quickly assess the patient for features that 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 subtlety 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 excess soft tissue makes it more difficult to identify landmarks. Additionally, the extra tissue forces the operator to work in a deep hole. Similar challenges are presented by subcutaneous emphysema, soft tissue infection, or edema. A patient with a short neck or overlying mandibular pannus presents challenges with both identification of landmarks and access to perform the procedure. External immobilization devices, such as a cervical immobilization collar, or a halo-thoracic brace also may impede access.

R—*Radiation (and other deformity or scarring):* Previous radiation therapy may distort and scar tissues, making the procedure difficult and often causing tissues that are normally 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.

TIPS AND PEARLS

- When intubation is indicated, the most important question is "Is this airway difficult?" The decision to perform RSI, for example, is based, in part, on a thorough assessment of anatomic difficulty (LEMON, ROMAN, RODS, and SMART) and appropriate use of the main or difficult airway algorithms. Most ED patients will have some degree of difficulty after a bedside assessment. The decision to perform RSI is a complex one that takes into account the degree of difficulty, the urgency for tube placement, the availability of difficult airway devices, especially VL, and one's own skill and experience. Basically, to use neuromuscular blocking agents (NMBAs), the operator must be confident that oxygenation can be maintained, and that intubation is likely to be successful, using the planned approach.
- LEMON is a relevant screening tool for both difficult DL and VL. Even when elements of LEMON are found to be abnormal on bedside exam (ie, reduced cervical mobility secondary to a cervical collar), VL is still likely to succeed if the oral cavity is adequately accessible and not obliterated by massive soilage, significant anatomic distortion, or an obstructing mass.
- If LEMON and ROMAN are assessed first, in order, then each component of RODS also has been assessed, aside from the D: distorted anatomy. In other words, if LEMON and ROMAN 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 "can't intubate, can't oxygenate" situation requiring urgent cricothyrotomy into a "can't intubate, *can* oxygenate" situation, in which many rescue options can be considered. The ability to

(*continued*)

TIPS AND PEARLS (*continued*)

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 NMBAs.

- 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 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 converse.

EVIDENCE

What is the incidence of poor glottic view during emergency department intubation?

A poor glottic view is associated with low intubation success. The highest first-attempt success has historically been seen with a C-L grade I and II airways and is largely dependent on device. Recent data from the National Emergency Airway Registry (NEAR) have provided insight into the expected C-L view during ED intubation. In an analysis of nearly 12 000 patients intubated with either HA-VL or SG-VL, a C-L grade I or II view was obtained in 94.1% and 87.4%, respectively.[1] A second NEAR study, assessing the intubating conditions during RSI with either DL or VL observed a C-L grade I or II view in approximately 89% of all encounters. In this same study the first-attempt success rate was 87% to 88% with an ultimate success rate >99%.[2] In a single-center prospective evaluation of 750 ED intubations over a 2-year period, during which 255 intubations were performed with a C-MAC and the rest with a conventional laryngoscope, the C-MAC yielded grade I/II views in 94% of cases compared with 83% for DL.[3] On balance, emergency physicians can expect to obtain a C-L grade I or II view in 80% to 90% of patients when using DL but 90% to 95% with VL. The latter exhibits some variability depending on whether a SG or HA video laryngoscope is used.

What is the evidence basis of LEMON?

There is only one published external validation of the LEMON mnemonic and one for the modified LEMON.[4] The American College of Surgeons adopted the LEMON mnemonic for ATLS in 2008. In a multicenter prospective intubation registry in Japan, 3313 patients, for whom a difficult airway assessment was performed and who were intubated using DL, the modified LEMON had a sensitivity of 86% and a negative predictive value of 98% for difficult laryngoscopy.[5] Difficult intubation was defined as any encounter requiring two or more attempts. In other words, the LEMON assessment is most helpful when completely normal and indicates that nearly all patients would be candidates for RSI if truly LEMON-negative. Individual elements, taken in isolation, are less helpful and should not constitute the basis of a difficult airway assessment. However, in an uncooperative or obtunded patient in whom many of the elements of LEMON cannot be performed, a single measurement of the TMH performs well compared to other single bedside tests. It does not require head movement, patient cooperation, or sophisticated measuring tools. With the patient in neutral head position, a TMH of <5 cm identified challenging laryngoscopy with 77% sensitivity and 84% specificity, better than any other single bedside test.[6] The gestalt of difficulty provided by the patient is an intuitive notion and will vary greatly with the skills and experience of the intubator. There are no studies, of which we are aware, that assess the sensitivity or specificity of this first, quick look. 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 modified Mallampati score, the four-category method that is most familiar, is known to be reliable but while the test is important, it is not sufficient in fully evaluating the difficult airway and cannot be performed in roughly half of all ED patients requiring intubation. Interference with DL by upper airway obstruction is self-evident. Obesity is uniformly identified as a difficult airway marker controversy persists regarding whether 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.

What is the evidence basis of ROMAN?

The first well-designed study of difficult BMV reported a 5% incidence of difficult BMV in 1502 patients in the OR. 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.[7] 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, with neck radiation having the strongest association of failed mask ventilation.[8] These studies, combined with others, and with our collective experience, are the foundation for the ROMAN mnemonic.

What is the evidence basis of RODS?

Most EGDs have not been systematically studied for predictors of difficulty. Previous information came from case reports or small case series. A large OR-based registry of 14 480 adult patients managed with either an LMA or an i-gel showed that successful oxygenation and ventilation occurred in nearly all (99.8%) cases. Multivariable analysis identified four factors predictive of difficulty: short thyromental distance, male sex, limited neck movement, and age, with short thyromental distance having the highest odds of difficulty (adjusted odds ratio [aOR] 4.4).[9] Interestingly, obesity was not predictive. We hesitate to remove obesity from the RODS mnemonic, however, because this study had very few difficult cases and because it has been shown previously to affect rescue mask ventilation. As such, this mnemonic really represents our expert consensus and commonsense conclusions 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, particularly those with higher leak pressures, may be better suited for obese patients. Distorted anatomy is our own concept, because each of these devices is designed to "seat" into normal human anatomy, given that the right size of device is selected.

Does LEMON apply to VL and are there other difficult airway mnemonics in use?

Much of LEMON has to do with the need to see past the tongue, to the glottis, using a straight line of sight. VL, particularly HA-VL, does not require a straight line of sight, so, for example, we do not have any reason to believe that abnormalities discovered during a 3-3-2 assessment applies to hyperangulated video laryngoscopes. In one study comparing the C-MAC video laryngoscope with DL in ED intubations, the aggregate effect of multiple difficult airway markers had a significant impact on first-pass success with DL but not with VL. Comparing first-attempt success between patients without difficult airway markers with those that had three or more, the first-attempt success for DL decreased from 88% to 75% but decreased only by 5% for VL (99% - 93%).[3] Mallampati is not nearly as important, because the video viewer on most video laryngoscopes is positioned beyond the tongue, thus eliminating the tongue from consideration. Mallampati assesses mouth opening also, however, as does the first "3" of the 3-3-2 rule, and mouth opening remains important for VL, although much less so. The mnemonic "CRANE" (*C*ontamination and C-L 3 or 4 with DL, *R*adiation, *A*bnormal anatomy: mass; previous surgery; decreased mouth opening, *N*eck thick, *E*piglottitis or enlarged tongue) has been used by some to help identify potential challenges (in OR patients) with VL.[10] As previously mentioned above, the utility of this mnemonic for emergency airway management is questionable. In the OR, when VL is thought to be challenging, the threshold for performing an awake flexible intubation is much lower given patient stability, familiarity by anesthesiologists with awake techniques, and availability of flexible endoscopic tools. A more practical approach in ED patients is to first determine if orotracheal intubation is possible or doomed to fail because of overwhelming soilage, drastically reduced mouth opening, or large obstructing oral and upper airway pathology. If orotracheal intubation is planned and thought to be feasible, then VL should be used whenever possible and a LEMON assessment, if abnormal, will further support that decision. A second alternative mnemonic, "HEAVEN" (*H*ypoxemia, *E*xtremes of size, *A*natomic challenges, *V*omit/blood/fluid in the airway, *E*xsanguination, and *N*eck mobility) has been shown, in a retrospective review of aeromedical RSIs, to predict difficulty with both VL and DL. However, the components of HEAVEN are either excessively vague ("extremes of size" and "anatomic challenges") or self-evident (blood/vomit in the airway) and do not have sufficient detail or specificity to have utility at the bedside.[11]

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References

1. Driver BE, Prekker ME, Reardon RF, Fantegrossi A, Walls RM, Brown CA III. Comparing emergency department first-attempt intubation success with standard-geometry and hyperangulated video laryngoscopes. *Ann Emerg Med*. 2020;76(3):332-333.
2. April MD, Aran A, Pallin DJ, et al. Emergency department intubation success with succinylcholine versus rocuronium: a National Emergency Airway Registry Study. *Ann Emerg Med*. 2018;72(6):645-653.
3. Sakles JC, Mosier J, Chiu C, et al. A comparison of the C-MAC video laryngoscope to the Macintosh direct laryngoscope for intubation in the emergency department. *Ann Emerg Med*. 2012;60:739-748.
4. Reed MJ, Dunn MJ, McKeown DW. Can an airway assessment score predict difficulty at intubation in the emergency department? *Emerg Med J*. 2005;22(2):99-102.
5. Hagiwara Y, Watase H, Okamoto H, et al. Prospective validation of the modified LEMON criteria to predict difficult intubation in the ED. *Am J Emerg Med*. 2015;33(10):1492-1496.
6. Zimmerman B, Chason H, Schick A, Asselin N, Lindquist D, Musisca N. Assessment of the thyromental height test as an effective airway evaluation tool. *Ann Emerg Med*. 2021;77(3):305-314.
7. Kheterpal S, Han R, Tremper KK, et al. Incidence and predictors of difficult and impossible mask ventilation. *Anesthesiology*. 2006;105(5):885-891.
8. Kheterpal S, Martin L, Shanks AM, et al. Prediction and outcomes of impossible mask ventilation: a review of 50,000 anesthetics. *Anesthesiology*. 2009;110(4):891-897.
9. Saito T, Liu W, Chew ST, et al. Incidence of and risk factors for difficult ventilation via a supraglottic airway device in a population of 14,480 patients from South-East Asia. *Anaesthesia*. 2015;70(9):1079-1083.
10. Aziz MF, Bayman EO, Van Tienderen MM, Todd MM; StAGE Investigator Group, Brambrink AM. Predictors of difficult videolaryngoscopy with GlideScope® or C-MAC® with D-blade: secondary analysis from a large comparative videolaryngoscopy trial. *Br J Anaesth*. 2016;117(1):118-123.
11. Nausheen F, Niknafs NP, MacLean DJ, et al. The HEAVEN criteria predict laryngoscopic view and intubation success for both direct and video laryngoscopy: a cohort analysis. *Scand J Trauma Resusc Emerg Med*. 2019;27(1):50.