Elective Intubation

Charles G Durbin Jr MD FAARC, Christopher T Bell MD, and Ashley M Shilling MD

Endotracheal intubation is a commonly performed operating room (OR) procedure that provides safe delivery of anesthetic gases and airway protection during surgery. The most common intubation technique in the perioperative environment is direct laryngoscopy with orotracheal tube insertion. Infrequently, difficulties that require an alternative intubation technique are encountered due to patient anatomy, equipment limitations, or patient pathophysiology. Careful patient evaluation, advanced planning, equipment preparation, system redundancy, use of checklists, familiarity with airway algorithms, and availability of additional help when needed during OR intubations have resulted in exceptional success and safety. Airway difficulties during intubation outside the controlled environment of the OR are more frequent and more serious. Translating the intubation processes practiced in the OR to intubations outside the perioperative setting should improve patient safety. This paper considers each step in the OR intubation process in detail and proposes ways of incorporating perioperative procedures into intubations outside the OR. Management of the physiologic impact of intubation, lack of readily available specialized equipment and experienced help, and planning for transfer of care following intubation are all challenges during these intubations. *Key words: tracheal intubation; manual ventilation; artificial airway; endotracheal tube; difficult airway; difficult intubation; airway emergency; direct laryngoscopy; fiberoptic intubation.* [Respir Care 2014;59(6):825–849. © 2014 Daedalus Enterprises]

Introduction

Endotracheal intubation is a commonly performed procedure. It was calculated by the Centers for Disease Control and Prevention that over 51 million surgeries were performed in the United States in 2010.[1] An estimated 15 million (30%) of these included insertion of an endotracheal tube (ETT). During this same time period, at least 650,000 intubations were performed in hospitals outside the operating room (OR) and procedure areas. In addition, almost 300,000 additional intubations were performed in the emergency room in 2010.[2] This does not include those ETT placements performed during resuscitation attempts outside the hospital setting. The number of ETT intubations performed to facilitate surgery or procedural interventions continues to rise in the United States and throughout the world.

Airway management is often complex and can be a source of patient morbidity and mortality. The American Society of Anesthesiologists Closed Claims Project database allows structured analyses of adverse anesthetic outcomes obtained from reviewing closed claims files of 35 professional liability insurance companies representing anesthesiologists in the United States. While this database is biased toward the worst outcomes, it can be used to identify areas and practices in which improvements can be made. Remarkably, the most common serious outcomes occurred during airway management and intubation. Of the first 1,540 cases reported in 1990, 522 (34%) were related to airway problems.[3] Death or severe brain injury occurred in 83% of these cases. As many as 72% of these were judged preventable with improved clinical care. Airway issues were not confined to the time of anesthesia induction. Over 6% of the complications occurred outside the OR at the time of extubation, and these carried a higher risk of death or severe injury than those occurring during anesthesia induction and intubation. With the development of algorithms and new devices to deal with expected and unexpected difficulties, airway safety has improved markedly in the OR environment.

Preparing for and executing a safe and successful elective intubation require completion of a complex series of activities that should occur in a prescribed order. While the correct placement and securing of the artificial airway in a patient's trachea are the ultimate goals and hallmarks of success, each individual step leading to this goal must be carefully considered and accomplished to be effective. Unlike an emergency situation requiring an expeditious airway insertion to preserve life, performing an elective intubation allows time for a systematic evaluation and optimization of environmental and patient factors that will influence ultimate success in intubation with a minimum of physiologic trespass. In this discussion, a systematic approach used for intubation as part of the provision of anesthetic care during surgery will be developed and proposed as a model to approach intubations being performed outside the OR. While scientific evidence is available in support of many components of contemporary anesthesia airway practice, some of the routine approaches and safety measures have not been (and likely will never be) evaluated in randomized prospective trials. Published data, when available, will be cited to support recommendations. By analyzing the intubation process in the OR, the critical components, preparations, and actions that are associated with safety and success can be identified and adapted for intubations performed outside the OR.

Intubation: Perioperative Versus Outside the Operating Room

As listed in detail in Table 1, airway management and intubation in the operative setting include the following sequential activities: examination and identification of specific patient issues, development of an airway plan, environmental preparation, managing the actual airway and performing intubation, confirming and maintaining correct tube placement, and managing the patient's physiologic response to intubation. When intubation is performed outside the OR, an additional step is transitioning care of the patient with the artificial airway to another clinician. Transfer of care also occurs following a surgical procedure when extubation is not immediately appropriate. This is true for transfers to ICUs and when an intubated patient is placed in the post-anesthesia care unit. It is important to note that extubation is also a time of increased airway risk, and knowledge of any issues encountered during intubation is a priority for the team responsible for removing the artificial airway. Timely and accurate communications between teams are essential for patient safety at extubation. Consistent methods for documenting and conveying details of airway management to the next and future clinicians have received considerable attention.

The authors are affiliated with the Department of Anesthesiology, University of Virginia Health Science System, Charlottesville, Virginia.

Dr Durbin is on the board of medical advisors of the Masimo Foundation and has consulted on airway products for Kimberly-Clark. The other authors have disclosed no conflicts of interest.

Dr Durbin presented a version of this paper at the 52nd RESPIRATORY CARE Journal Conference, "Adult Artificial Airways and Airway Adjuncts," held June 14 and 15, 2013, in St Petersburg, Florida.

Correspondence: Charles G Durbin Jr MD FAARC, Department of Anesthesiology, University of Virginia Health Science System, Box 800710, Charlottesville, VA 22908. E-mail: cgd8v@virginia.edu.

DOI: 10.4187/respcare.02802

Table 1. Steps in Preparing for and Managing an Intubation Under Anesthesia for Surgery in the Operating Room

Activity	Details	Objectives
Patient and airway evaluation	Pay particular attention to airway history and examination.	Predict airway difficulty.
	Assess existing patient medical issues.	Identify patient physiologic tolerance.
	Identify potentially modifiable patient medical risks.	
Intubation plan development	Choose a primary intubation plan based on the patient evaluation.	Define an initial plan and alternative plans for intubation.
	Include additional options to deal with anticipated or unanticipated difficulties that may be encountered.	
	Consider airway algorithms and protocols.	
	Confirm all equipment that may be needed.	
Environment analysis and preparation	Use a checklist.	Prepare equipment and assistants for intubation.
	Locate, prepare, and test all essential and emergency equipment.	Guarantee that all essential equipment is present and working.
	• Oxygen source and backup	Provide intravenous access.
	• Suction	Record vital signs.
	• Manual ventilation devices	Review airway plans with the team.
	• CPR equipment	Confirm availability of help in an emergency.
	• Defibrillator	
	Establish patient monitoring.	
	Identify and confirm function of communication system to get help.	
	Plan for obtaining additional intubation equipment if needed.	
	Establish or confirm function of intravenous access.	
	Prepare drugs for sedation and intubation.	
	Locate and prepare drugs and fluids to modify patient physiologic responses to intubation.	
	Organize assistants and assign tasks.	
	Communicate plans for intubation and emergencies.	
Actual intubation	Call a time-out, check-in, or pause.	Focus the team.
	• Identify the patient, procedure, and correct surgical site.	Safely perform the intubation.
	• Confirm presence of critical equipment and personnel.	
	• Review intubation and surgical plans.	
	• Identify potential and actual risks.	
	• Discuss what will be needed and by whom if difficulties are encountered.	
	Begin and complete intubation.	
	Anticipate and respond to undesired responses in hemodynamics.	
Postintubation tasks	Confirm correct ETT placement.	Confirm tracheal placement.
	• Physical examination	Prevent accidental extubation.
	• Auscultation	Normalize vital signs after intubation.
	• CO_2 measurement	
	• Pulse oximetry monitoring	
	Secure the ETT and provide appropriate ventilation.	
	Monitor vital signs and gas exchange.	
	Continue management of expected and unanticipated changes in hemodynamics and respiratory function.	
Airway issue communication	Record details of the intubation.	Document airway difficulties in medical record.
	Convey methods used to resolve airway problems.	Provide the patient with information.
	Inform the patient and family members of all issues.	Guarantee essential information is available when needed in future.
	Communicate with the team and future caregivers of airway risks and their successful management.	

CPR = cardiopulmonary resuscitation
ETT = endotracheal tube

Difficulties during airway management outside the OR are encountered more frequently than during intubations performed in the controlled OR setting. In one study, urgent intubation in ICU patients by airway experts (individuals with > 6 months of anesthesiology training) resulted in a difficult intubation rate (defined as requiring

> 2 attempts at ETT placement) of 8%.[4] In addition, death within 30 min of intubation occurred in 3% of patients. Although the authors speculated that insufficient environmental preparations, inadequate equipment, fewer experienced staff members assisting, and intubator deficiencies may contribute to the increased incidence of complications, no definitive conclusions implicating any of these factors were presented in this paper. Published data support the assertion that patients undergoing intubations outside the OR are 10–30 times more likely to experience airway complications. A poor laryngeal view on direct laryngoscopy is encountered in the OR in 0.13–0.3% of cases; however, failure to intubate is much lower.[5] While poor glottic views are seen more frequently in intubations occurring outside the OR, intubation can typically still be successful with simple interventions.[6] Having a faculty anesthesiologist present during ICU intubations was associated with fewer complications: 21.7 versus 6.1%. Overall, there were no intubation-related deaths during any of the 322 intubations.[7] Applying the systematic operational model used in the OR to intubations performed outside the OR may improve the outcome from unanticipated airway events during these higher risk situations.[8] Each of these tasks involved in a successful intubation in the OR will be considered as it could apply to intubations performed outside the OR.

Patient Examination and Airway Evaluation

Perioperative airway evaluation begins by obtaining a history of previous airway problems and performing a patient examination specifically directed at identifying patient characteristics known to correlate with airway difficulties. The steps in this airway evaluation process are reviewed and summarized in Table 2.

During an elective surgical procedure, patients are typically seen and the airway is evaluated prior to entering the OR suite.[9] An important part of this evaluation includes previous surgeries and intubations in order to predict the likelihood of airway difficulties during the intubation process. One of the most important predictors of difficult-airway management is a history of difficult intubation. The clinician may be alerted to this by a patient or a family member. A very sore throat after surgery and dental damage after an intubation are clues that the patient was difficult to intubate. It is critical to obtain as many details of the event as possible and, most importantly, to identify the intubation method that was finally successful. With current anesthesia practice and the expanding use of electronic records, a detailed contemporaneous record of the events may be available. However, many patients will be told it was difficult to place their ETT, but none of the details will be available. Because of this, there is growing sentiment in the anesthesia community to standardize coding for airway events and to create a consistent method for conveying difficult intubation details to patients and future caregivers. One such proposal, shown in Figure 1, was created by the Anesthesia Patient Safety Foundation.[10] To this point, no consensus of how to standardize this documentation has been established. Within hospital systems, patients experiencing a difficult intubation event may be labeled as such, much in the way an allergy will be identified. Arm bands can be placed on the patient, a sticker may be placed in the record, a tag may be attached to the ETT, or a sign may be placed on the patient's door identifying the event. At a minimum, a note in the medical record should detail the events and their resolution.

Predictors of a Difficult Airway. There are many conditions that can lead to problems managing a patient's airway. Difficulty with airway management is typically divided into difficult mask ventilation and difficult intubation. These are different situations that demand different approaches and pose markedly different patient risks. An airway emergency is defined as the situation in which the clinician is unable to ventilate AND unable to intubate a patient. This may result in a fall in P_{aO_2}, leading to cardiac arrest and brain injury or death. Prevention of lethal hypoxemia by applying extraordinary airway techniques, including surgical airway access, is mandatory and must be a part of all elective airway management plans.[11]

Physical examination of patients and their airways should help identify predictors of difficult ventilation or intubation. In a large study of over 53,000 general anesthetics, 77 (0.15%) patients could not be ventilated by mask or with a simple airway adjuvant.[12] Of those who failed ventilation, 74% were able to be intubated with 3 or less attempts employing conventional and specialized intubation techniques; 25% were found to have a difficult intubation as well. Two of these required an urgent surgical airway, whereas 2 were awakened and electively intubated awake. None suffered adverse neurologic events during care. Even with careful preparation, the situation of cannot ventilate/cannot intubate will occur. For the group of patients discussed above, predictors for impossible ventilation are shown in Table 3. With the exception of head and neck radiation and addition of obesity, these are generally recognized as predictors for difficult ventilation.

In many patients, no concrete information about previous airway problems is available from the record or from the patient at the time it is sought. Self-reported airway difficulties should serve as a red flag to perform a careful airway exam in an attempt to understand what the problems might have been, develop plans, have appropriate equipment, and anticipate a difficult-airway situation. Typical questions and physical findings that are helpful in identifying a high risk of airway problems during elective intubation are listed in Table 2.

Table 2. Important Details of the History and Physical Exam That May Help Predict a Difficult Airway or Intubation

Factor	Important Questions	Implications
History of a difficult intubation	What were the details of the difficulty? When did it occur? During what kind of surgery or procedure did it occur? How was it managed? Were there any sequelae?	Increased risk of intubation difficulties Known successful management plan
History of an airway problem	What were the details of the difficulty? When did it occur? During what kind of surgery or procedure did it occur? How was it managed? Were there any sequelae?	Increased risk of ventilation difficulties Anticipation of other problems
History of a previous tracheostomy	Why was it performed? When was it performed? When was it removed? Were there any complications? Are there any symptoms of airway narrowing now?	Possible need for smaller ETT Possible need for repeat surgical airway
Mouth opening	Is the mouth opening small? Is the mouth distance (upper to lower incisor) < 3 cm? Is pain a limiting factor to opening?	Laryngoscope may not fit. Supraglottic airway (LMA) may not fit through oral opening. Possible dental damage Anesthesia may improve oral access. Nasal or retrograde intubation may be necessary.
Teeth	Is the patient edentulous? Are the teeth in poor condition? Does the patient have prominent upper incisors (overbite)?	More difficulty with manual ventilation Easy DL and intubation Increased loss risk, aspiration risk Increased tooth damage risk Increased DL difficulty
Oral view	What is the Mallampati score?	Increasing score predicts poorer laryngeal view and possible difficult intubation.
Neck mobility	Does the patient have limited extension? Does the patient have no extension? Does the patient have symptoms of neurologic compromise? Is the neck in orthopedic fixation or a rigid collar?	Ventilation and DL intubation may be difficult. Difficult ventilation: early use of airway adjuncts may be needed. Low probability of DL intubation Need to use other means for placement of ETT (ie, FOI or indirect laryngoscope) Surgical airway may not be possible. Dangerous ventilation: early use of airway adjuncts may be needed. Neck immobility during ventilation and intubation required Dangerous ventilation: early use of airway adjuncts may be needed. Neck immobility during ventilation and intubation required Awake intubation (FOI) preferred to evaluate neurologic function after intubation
Jaw	Is the jaw short? Is the jaw thick: < 3 finger tips between inside of jaw and hyoid bone?	Creates anterior larynx phenomenon Difficult intubation likely Difficult to displace tongue and intubate
Submental tissues	Are they stiff? Are they solid?	Radiation therapy or healed burns can make tongue displacement impossible and intubation difficult. It may be impossible to intubate with DL; FOI may be only successful approach.
Body size	Is the patient morbidly obese?	Difficult ventilation but usually normal DL intubation May require device to elevate head and shoulders (ramp) to improve ventilation and intubation May have OSA syndrome Will desaturate quickly during intubation attempts

LMA = laryngeal mask airway
DL = direct laryngoscopy
FOI = flexible fiberoptic intubation
OSA = obstructive sleep apnea

Appendix

Date: (00/00/0000) RE:________________________ has a difficult airway, DOB: (00/00/0000)
(Patient Name)

During your recent anesthetic and surgery, your anesthesia providers noted that you have a difficult airway.

Specifically: ______ difficult mask ventilation, ______difficult laryngoscopy, ______difficult intubation, or ______failed intubation.

An unexpected difficult airway is a known potential concern with general anesthesia and can be dangerous. If you should need anesthesia or mechanical ventilation in the future, it is important that you inform your anesthesiologist and surgeon of the potential for a difficult airway. Ideally you would give them this letter to review.

Physical Exam:

Body mass index (BMI < 25_____ 25 - 30______ > 30_____

Mallampati airway classification: ______I- soft palate, uvula, pillars ______ II- soft palate, pillars ______ III-soft palate ______IV-hard palate

Mouth opening: ______ cm

Dentition: Native ______ prominent incisors ______edentulous
______ Jaw protrusion (can protrude lower incisors beyond upper incisors)

Thyromental distance: ______> 6 cm ______< 6 cm

Neck extension: ______ full (35°) ______limited (<15°O)

Details of what actually took place during airway management:

Intubation: ______ emergency ______elective

Bag and mask ventilation was ______Easy ______Difficult ______Not possible

Muscle relaxants were ______administered ______not administered

Cormack/Lehane Laryngoscopic view:
______I - full view of the glottis opening ______II - epiglottis and arytenoids
______III - tip of epiglottis ______IV - only soft palate

Intubation ______Successful ______Not successful

______An LMA was placed and anesthesia proceeded without further difficulties
______Intubation was performed ______through a Fast track laryngeal mask airway
______with video assisted laryngoscopy
______with fiberoptic bronchoscope guidance
______An emergency tracheostomy was performed
______Your surgery and anesthetic were rescheduled
______Decadron was administered to prevent swelling postoperatively
______You were admitted postoperatively for____________________
______Other____

Extubation was ______routine ______over a stylet

Complications

Although a minor sore throat is common after general anesthesia, if you experience a persistent severe sore throat, difficulty swallowing or fever, immediately contact your surgeon and the anesthesiologist on call at the facility.

Sincerely,
Your Anesthesiologist (sign and print your name)

Fig. 1. Suggested letter to be given to a patient with a difficulty airway experience to be shared with future caregivers, who then can use this information to prepare for and prevent future tragedies. DOB = date of birth. LMA = laryngeal mask airway. Courtesy the Anesthesia Patient Safety Foundation.

Table 3. Patient Factors Found to Be Associated With Impossible Ventilation Identified in > 50,000 Subjects Cared for in the Operating Room

Predictor	P	Odds Ratio (95% CI)
Radiation changes to neck	.002	7.1 (2.1–24.4)
Male sex	< .001	3.3 (1.8–6.3)
OSA syndrome	.005	2.4 (1.3–4.3)
Mallampati III or IV	.01	2.0 (1.1–3.4)
Beard	.02	1.9 (1.1–3.3)

Data from Reference 12.
OSA = obstructive sleep apnea

Elective intubation is usually performed under direct vision using a laryngoscope. This technique is referred to as direct laryngoscopy (DL). The laryngoscope will have either a straight or a curved blade and a light source near its tip to illuminate the airway structures. After inserting the blade through the mouth, the laryngoscope is used to move and control the tongue and upper airway structures. By lifting the tongue and jaw, the larynx is seen. A direct line of vision from the mouth to the glottis is used when inserting an ETT. The directed airway examination is used to identify obstacles to establishing a direct line of vision to the larynx. If the physical examination suggests that DL will be difficult, an alternative intubation technique should be considered. Some of the many techniques that can be used for intubation are listed in Table 4.

Mouth Opening and Dentition. Inserting a standard laryngoscope blade into the mouth and passing a tube into the trachea of an adult requires a reasonably sized mouth opening. A normal size mouth opening is demonstrated in Figure 2. Patients with a < 1.5-cm mouth opening between the upper and lower front teeth (or gums if edentulous) may be impossible to intubate with conventional DL since the blade flange is often larger than this size. If a small mouth opening is identified during airway examination, the cause of the restriction should be determined. If pain from temporomandibular joint disease or an acute mandibular fracture is the cause, use of analgesics or anesthesia with or without a muscle relaxant may increase the mouth opening and allow a conventional intubation technique. If the mouth opening is fixed and severely limited, then an alternative intubation technique such as oral

Table 4. Selected Intubation Techniques That May Be Useful Under a Variety of Circumstances

Intubation Techniques	Comments
Direct laryngoscopy and intubation	Best known skill with most practice
Curved blade	Tongue control and working space best
Straight blade	Best laryngeal view, less easy tube placement
Sedation/anesthesia with muscle relaxant	Best view, no patient cooperation
Sedation with topical local anesthesia	Continued spontaneous ventilation, less pain with curved blade
Awake with topical local anesthesia	Cooperative patient, good success without burning bridges
Indirect laryngoscopic intubation	Visual view excellent and seen by all
Sedation/anesthesia with muscle relaxant	Best success
Sedation with topical local anesthesia	Not well tolerated by patients unless deeply sedated
Fiberoptic lighted stylet	Dark room needed, blinded technique
Sedation/anesthesia with muscle relaxant	Best success, but a problem if it fails
Sedation/anesthesia with spontaneous ventilation	Safest approach as spontaneous ventilation is maintained
Flexible fiberoptic intubation	Accepted standard for difficult-airway management
Sedation/anesthesia with muscle relaxant	Secretions and blood can greatly reduce success
Oral	Difficulty greater than nasal, but adjuncts can help
Nasal	Direct intubation route, bleeding risk
Sedation with spontaneous ventilation	Improved safety, as no bridge is burnt
Awake with topical local anesthesia	Standard for known or anticipated difficult airway
Retrograde intubation	Minimally invasive blind technique, technical details difficult to execute
Cricothyrotomy	Emergency airway when all else fails, and death is imminent
Percutaneous tracheostomy	Preferred technique for long-term artificial airway Almost as fast as cricothyrotomy for emergency surgical airway with less potential for airway damage Requires special equipment and skill
Transtracheal jet ventilation	Needle or catheter for entry Least invasive surgical emergency airway Must have high pressure gas source and jet device Complications frequent

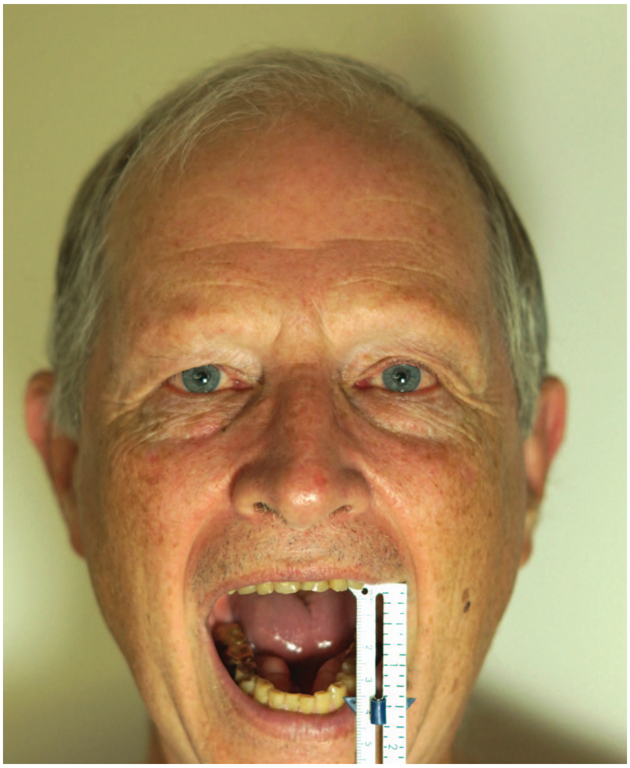

Fig. 2. This subject demonstrates an wide oral opening and stable dentition.

Fig. 3. The normal profile of this subject suggests that his mandibular length is adequate and that manual ventilation and intubation should not be difficult.

or nasal flexible fiberoptic intubation should be chosen for the first intubation attempt. Prominent or misaligned upper incisors may also present a challenge to intubation by DL. This can be subjectively evaluated by viewing the subject in profile. A normal mandibular profile is seen in Figure 3. The tip of the chin is in line with or in front of the upper lip. An abnormal profile suggesting intubation difficulties would show a jaw tip that is substantially behind the upper lip.

Poor dental hygiene and periodontal disease may result in loose or broken teeth and may increase the risk for tooth damage or loss during intubation. Care to prevent pulmonary aspiration of a dislodged tooth or crown is essential. If native dentition or prostheses are at risk of damage due to disease or mouth anatomy, the patient should be made aware of this risk. Cost of dental repairs necessitated by tooth injury during elective intubation are usually borne by the patient and rarely covered by health insurance.

Oral Cavity and Neck Mobility Evaluation. After examining the mouth opening and dentition, the oral cavity should be examined. One of the most frequently used tools to quantitate the risk of a difficult intubation is the Mallampati (MP) score.[13] Prospectively tested and reported in 1985, the clinical sign of concealment of the faucial pillars (palatoglossal and palatopharyngeal arches) and uvula by the base of the tongue predicts difficulty with visualization of the laryngeal opening during DL. With maximal tongue protrusion in the upright sitting position and without phonation, the degree of visual obstruction of the posterior mouth and palate is graded from MP I (the entire faucial pillars and uvula are seen) to MP III (only the soft palate and the base of the uvula are visualized). As the MP score increases, the risk of visualization difficulty during DL also increases. In the original report, there were no laryngeal view or intubation difficulties with any the 155 patients with an MP I oral view. Of the 40 patients with an MP II oral view, 26 patients had a good laryngeal grade view, and all 40 were successfully intubated. Of the 15 patients with an MP III airway, only one had a good glottic view. In 9 of these patients, only the arytenoids were seen, and in 5 patients, no identified laryngeal structure could be seen. Also noted in this initial report, in the 4 patients with limited neck extension, 2 patients had poor glottic views despite an MP I or II oral view. Since this original report, an MP IV airway score has been added, in which only the hard palate can be visualized. The MP system is widely used and easy to apply. An MP score of I or II is reassuring but, by itself, does not guarantee good visualization or easy intubation by DL. A higher MP score is associated with less optimal visualization of the glottis but does not necessarily predict a difficult intubation.

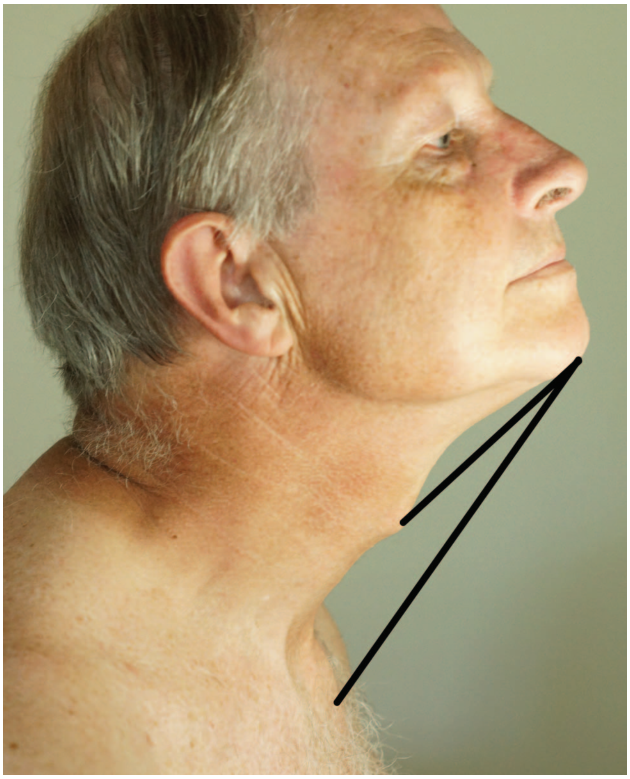

Fig. 4. Thyromental and sternomental distances are measured with the subject performing maximal head extension.

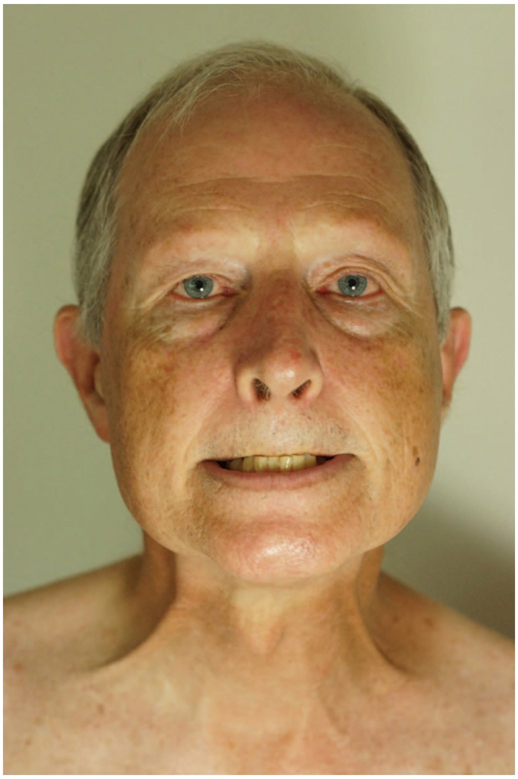

Fig. 5. Lip bite test is demonstrated. Since the subject can place his lower teeth at or above the upper vermilion line, adequate jaw movement should permit intubation using direct laryngoscopy.

Adding other patient factors to the airway evaluation improves prediction of ease or difficulty of intubation. Jaw size and mobility of the neck and jaw are very important. Systems for quantitating neck and jaw mobility and using this information to predict a difficult glottic view have been proposed. Measurements of thyromental and sternomental distances on maximal extension have been suggested as criteria for prediction of neck mobility and ease of laryngoscopy (Fig. 4). The simple upper lip bite test has been suggested as a qualitative combined measure of abnormal dentition and mandible mobility. The patient is asked to bite his upper lip with his lower teeth. An adult with normal jaw mobility can place the lower teeth up to or above the vermilion line (Fig. 5). Failure to bite the upper lip at all predicts a poor glottal view on DL only ~40% of the time.[14] When combined with other measures, improved accuracy is possible.

During DL, the axes of the mouth, pharynx, and larynx need alignment to establish a view of the glottis. The classic sniffing position (Fig. 6) is recommended as an effective way of head positioning to achieve this goal. As a starting point, this is a reasonable recommendation, as it also provides an effective head position to facilitate manual face mask ventilation. This position is achieved by placing a non-compressible cushion under the occiput to flex the lower cervical spine and lifting the chin to extend the head on the upper cervical spine. Ability to extend the upper cervical spine is most important for optimizing laryngeal view during DL. Evaluation of neck mobility can be assessed during patient examination by having the patient demonstrate maximal voluntary neck movement with particular attention to extension. A sternomental distance of > 9 cm predicts adequate extension. Correction for patient height may improve positive prediction of a difficult laryngoscopic view on DL (short sternomental measurement), but use of even this corrected measurement is < 50% accurate.[15]

If neck extension is limited, the reason should be assessed. If pain is the reason for limitation, the quality of pain and whether there is radiation suggesting spinal cord or nerve root compression should be noted. If pain is not associated with radiation, the degree of extension will likely be greater with sedation and/or analgesia and is less concerning for spinal injury risk. If there is significant limitation of extension and no pain, this represents a fixed bony issue that is unlikely to improve with medications. The presence of a known instability of the spine prohibits extension and makes safe intubation with DL difficult, and an alternative approach is mandated, eg, fiberoptic intubation. Additional intubation techniques are listed in Table 4.

Fig. 6. This subject illustrates the classic sniffing head position, which is optimal for intubation. It also allows for more effective manual ventilation in most situations.

For optimal intubating conditions during DL, the tongue must be controlled and displaced from the line of sight by the laryngoscope blade. Conventionally, this is achieved by inserting the blade into the right side of the mouth and sweeping the tongue toward the left. To achieve a good view, the tongue is displaced between the rami of the mandible. Short jaw length and increased ramus thickness are factors that may make this difficult or impossible. A submental space of < 1.5 cm (distance of 2 finger tips) between the hyoid bone and the inner surface of the mandible predicts difficulty in obtaining a good view with DL. In addition to displacing the tongue, the jaw must be lifted to provide good visualization during DL, and therefore, limited jaw movement or a short jaw can make this movement difficult and reduce glottic visibility. As mentioned above, asking the patient to bite his upper lip will allow a clinical assessment of mandibular mobility. While not subjected to large studies, a 1–2-mm protrusion of the lower teeth in front of the upper teeth predicts adequate jaw movement during DL.

Physiologic Risks of Intubation

Prior to intubation, the plan typically involves the induction of general anesthesia with an intravenous injection of a short-acting sedative/hypnotic and sometimes also a narcotic. Neuromuscular relaxants are often used as well to facilitate intubation. A list of drugs that may be used for anesthesia induction is provided in Table 5. After physical examination and assessment of the airway, an informed judgment is made regarding the likelihood of a difficult intubation, and the next step is to evaluate and manage the patient's medical conditions that may be impacted by intubation choices.[16,17] Conditions that may be affected by intubation include cardiovascular disease, cerebrovascular issues, pulmonary disease, bleeding disorders, neuromuscular disorders, hypovolemia, hypoxia, shock, or impending shock. It is expected that even during moderately deep levels of general anesthesia, tracheal intubation results in sympathetic stimulation, which can provoke tachycardia, hypertension, and bronchospasm.[18,19] This is due both to the irritation and discomfort of the process of placing and using a laryngoscope and to the direct tracheal stimulation by the ETT. These hemodynamic and bronchoconstriction responses are exaggerated but are normal protective reflexes of the larynx and airway to heighten awareness, prevent pulmonary aspiration, and expel foreign materials from the trachea (cough reflex). An awake patient has intact cortical control over the magnitude of these responses, but this modulation is lost with unconsciousness. If these physiologic responses pose undue risk to the patient (eg, a patient known to be at risk for rupture of an intracerebral aneurysm or for cardiac ischemia due to critical coronary artery disease, history of bronchospasm, etc), alternative approaches to minimize hemodynamic stress during intubation should be applied.[20,21]

Topical analgesia using a local anesthetic applied to the upper airway, larynx, and trachea is one of the most effective ways to block the hypertensive and bronchoconstriction response to intubation during DL.[22,23] Specific airway and nerve block techniques are easy to perform and are effective but require considerable experience to use safely (Table 6). Topical local anesthesia of the airway can be administered during light general anesthesia, or it can be introduced under light sedation and analgesia in a cooperative patient with good modification of the ensuing intubation-stimulating effects of DL. Intubation using an awake technique is a reasonable way to reduce or eliminate the profound changes in blood pressure as cortical modification and suppression of these reflexes is maintained. Patient cooperation and protection from aspiration are other desirable outcomes of an awake intubation.[24]

Patients requiring intubation who are in impending or actual shock pose significant problems during and following intubation.[25] Opiate analgesics and other sedatives can blunt the hypertensive response to intubation; however, if the patient is hypovolemic or in acute shock, severe hypotension or cardiac arrest may result from even small doses of sedating drugs. Hemodynamic stability and risk should be assessed prior to an elective (or emergent) intubation, and plans for treating the consequences need to be developed before proceeding to intubation. These must include reliable intravenous access for drugs and fluids, as well as availability of all necessary drugs, including those specific to the patient conditions and those needed for resuscitation should deterioration occur. The impact of positive-pressure ventilation on lowering venous return and contributing to hypotension should be anticipated and may

Table 5. Drugs That May Be Used for Sedation and/or Anesthesia Induction Before Intubation

Drug	Class	Comments
Thiopental, amobarbital, methohexital	Barbiturate	Short-acting, causing unconsciousness; offset in minutes by redistribution; hypotension due to depression of cardiac function
Propofol	Unique sedative/ hypnotic	Painful on intravenous injection, has amnestic effects in lower doses, can be used for anesthesia with continuous infusion, lowers blood pressure by vasodilation
Midazolam (lorazepam, diazepam)	GABA receptor antagonist	Profound effect on memory, amnesia; little respiratory depression by itself, but synergistic depression with opiates
Dexmedetomidine	Central α_2 agonist	No depression of ventilation, predictable bradycardia
Fentanyl, sufentanil, alfentanil	Opioid	Potent analgesics, medium duration of action; respiratory depression
Remifentanil	Opioid	Very short-acting narcotic analgesic, unique metabolism accounts for short half-life (10 min); profound respiratory depression; mild bradycardia
Ketamine	NMDA antagonist	Sedation and analgesia, opioid effect without respiratory depression, bronchodilator, hypertension, hallucinations

GABA = gamma-aminobutyric acid
NMDA = N-methyl-D-aspartate

Table 6. Techniques to Provide Upper and Lower Airway Local Analgesia

Inhalation of nebulized local anesthetic	Causes analgesia of entire upper airway, including larynx, vocal cords, and upper trachea; requires 20–30 min of inhalation; systemic toxicity risk
Oral topical spraying of local anesthetic	Rapid onset of numbness, mucosal absorption creates high blood levels that can cause toxicity, larynx and vocal cords not numb
Transtracheal injection of local anesthetic	Small dose of drug needed (1–2 mL), good laryngeal analgesia, little or no upper airway analgesia
Superior laryngeal nerve blocks	Small amount locally injected (<1 mL), analgesia of the cords and part of the larynx, slightly painful injection
Glossopharyngeal nerve blocks	Special long needle needed for intraoral injection, excellent analgesia of posterior tongue, little pain on injection

be averted with medications, rapid infusion of fluids, patient positioning in a head-down position, and manually assisted gentle ventilation.[26] Awake intubation using only topical anesthesia and maintenance of spontaneous ventilation is the least disruptive way to gain airway control in unstable patients undergoing elective or urgent intubation.[27]

Environmental Assessment and Preparation

When intubation is performed as part of an anesthetic plan for surgery, equipment and appropriate personnel for the planned procedures are confirmed to be available in the OR. Because the environment is familiar, reproducible, and maintained in some degree of readiness for emergencies, needs for a particular patient can be rapidly assembled. As part of OR preparations, a checklist (explicit, written, or memorized) is used to ensure that routine and necessary equipment, monitors, drugs, and supplies are available and ready for use before bringing the patient into the OR. A proposed anesthesia preinduction checklist developed by the Anesthesia Patient Safety Foundation is shown in Figure 7. Even though the OR preparation for anesthesia is repetitive and relatively routine, necessary components are not infrequently missing or found to fail at the moment when they are most needed. This has led to the redundancy of essential equipment and a time-out for confirming that essential issues are addressed before beginning anesthesia induction.[28] Preliminary studies and anecdotal reports support the belief that the formal confirmation process and focused attention of the entire team during a pause before induction of anesthesia (including the participation of the patient) are associated with fewer errors and greater safety.[29] During intubation, experienced anesthesia assistants or OR circulating nurses are attentive and actively assist with the intubation process. If unexpected difficulties are encountered or if essential equipment fails, experienced personnel are readily available to assist in providing equipment, solve problems, and assist with airway issues. The components of teamwork, including role definition, resource allocation, and communication, help with the expectations and competencies of the OR team members and allow them to deal with unexpected issues.

In summary, safe airway management requires a thorough physical exam, a prepared environment, redundancy of essential equipment, appropriate assistant personnel with airway management understanding and/or skills, attention

- ☐ Suction is working.
- ☐ Anesthesia workstation can provide ventilation with 100% oxygen under positive pressure.
- ☐ Upper airway status has been evaluated.
- ☐ Backup airway devices are immediately available.
- ☐ Patient's significant drug allergies and possible drug interactions noted.
- ☐ NPO status and aspiration risk confirmed.
- ☐ Monitors are functioning with appropriate waveforms.
- ☐ Audible and visual alarms are set appropriately.
- ☐ Appropriate medications including resuscitation drugs are available.
- ☐ Intravenous access (if indicated) is appropriate and functioning.
- ☐ Special considerations for this patient confirmed (may include but not limited to):
  - ☐ Increased risk for operating room fire.
  - ☐ Surgical positioning requirements.
  - ☐ Goals for blood pressure and/or heart rate management.
  - ☐ ______________________
  - ☐ ______________________
  - ☐ ______________________

Fig. 7. Pre-anesthesia checklist. NPO = nil per os (nothing by mouth). Courtesy the Anesthesia Patient Safety Foundation.

Table 7. Analysis of Factors Recorded in 1,000 ICU Intubations and Used for Development of a Predictive Index for Difficult ICU Intubation

Observation*	All Intubations (%)	Difficult Intubations (%)	Easy Intubations (%)	Univariate *P*†
Preoxygenation used	946 (95)	106 (94)	840 (95)	.69
NIV O_2 used	407 (40)	37 (33)	370 (42)	.07
Oral airway used	94 (9)	17 (15)	77 (9)	.03
Difficult to ventilate	73/392 (19)	20/64 (31)	56/328 (16)	
Mallampati ≥ 3	93/766 (12)	64/107 (60)	40/682 (6)	< .001
Previous difficult intubation	23 (2)	9 (8)	92 (10)	.005
Small mouth opening	120 (9)	25 (22)	67 (8)	< .001
Short thyromental distance	107 (11)	15 (13)	92 (10)	.35
Large neck	141 (14)	33 (29)	108 (12)	< .001
Cervical rigidity	83 (8)	23 (20)	60 (7)	< .001
OSA syndrome	78 (8)	33 (29)	45 (5)	< .001
Full beard	78 (8)	12 (11)	66 (7)	.24
Edentulous	283 (28)	21 (19)	262 (30)	.01

Data from Reference 32.
* Not all observations were available before or during intubation in each patient, so the sizes of groups for each variable are different.
† Comparison of the frequency of the observed factor between the easy and difficult intubation groups
NIV = noninvasive ventilation
OSA = obstructive sleep apnea

of the team before and during critical steps, and the ability to quickly find additional help, equipment, and drugs if needed. Most of this preparation and support is provided as a normal procedure in the OR environment; however, achieving these essential elements outside the OR, where airway difficulties are at least 10-fold more likely and outcomes are worse, is more challenging.[30,31]

Managing Airway Risks Outside the Operating Room. Intubation difficulties have been studied in the ICU environment. As in the OR, prediction of intubation difficulties prior to intubation is essential. In a prospective multicenter study of 1,000 consecutive intubations from 42 ICUs, a score predictive of a difficult intubation was developed.[32] Problems were encountered in 11.3% of these intubations. Thirty-eight percent of these patients suffered serious complications, including profound hypoxia, cardiac collapse, cardiac arrest, and death. The predictive factors identified are listed in Table 7. A weighted factor composite index score was then validated externally in 400 consecutive intubation procedures from 18 other ICUs. The components and weighting values for the risk factors are shown in Table 8. Patients intubated with a score of 0 or 1 rarely experienced difficulty, whereas those with a score of 12 suffered major complications. However, only 2 patients had a score of > 10, thus reducing the usefulness of the high scores. The utility and accuracy of this composite score remain to be established, but a low score appears to be reassuring when intubation outside the OR is needed. As the score rises from 2 to 9, the percentage of patients experiencing problems during ICU intubation rises from ~10% to > 80%.

When performing an elective intubation outside the OR, nothing should be taken for granted. Airway equipment

Table 8. Factors and Weighting Used to Derive a Composite Score Predictive of Problems or Difficulties During Intubation Performed in an ICU

Factors	Points
Factors related to patient	
Mallampati III or IV	5
Obstructive sleep apnea syndrome	2
Reduced mobility of cervical spine	1
Limited mouth opening < 3 cm	1
Factors related to pathology	
Coma	1
Severe hypoxemia (S_{pO_2} < 80%)	1
Factor related to intubator	
Non-anesthesiologist	1

From Reference 32, with permission. The score can range from 0 to 12.

and monitors may be different and unfamiliar to the clinician. There are often no trained assistants who can be expected to anticipate critical needs. Therefore, a comprehensive explicit environmental checklist should be carried out, and staff should be made familiar with how to retrieve emergency assistance. Each of the aspects listed in Table 9 should be specifically identified and confirmed. Missing elements need to be addressed, and alternative plans should be developed. A physical checklist can be used and reviewed, item by item. This is not too basic an approach, especially in an area where intubations are rarely performed. While oversights and missing items in the OR can generally be quickly remedied, outside the OR, this is rarely possible; these environments are much more hostile. Local staff may know where things are kept in their area but will not be able to anticipate what is needed without specific direction from the intubation team.

Intubating devices are best brought to the intubation location. At a minimum, the institution should provide a standardized fully stocked airway cart that contains all usual and special devices and equipment, including those for emergency surgical airway access. The organization of the cart and location of critical components should be familiar to the intubation team, allowing necessary but missing components to be quickly identified and acquired before attempting intubation. At least 2 experienced airway experts should be present at elective intubations. This degree of preparation and support is less than that provided routinely in the OR. During an emergent intubation, there is likely to be less time for preparation and less support. However, in the case of an elective intubation outside the OR, even if urgent, appropriate preparations and equipment must be available even if a delay in the procedure is necessary.

Table 9. Essential Requirements for Safety and Success When Performing an Elective Intubation Outside of the Operating Room

Oxygen source and backup source
Airway equipment
Assorted clear plastic ventilation masks
Self-inflating manual ventilation device
Non-self-inflating airway ventilation device
Oral, nasal, upper airway devices
Assorted sizes and types of supraglottic ventilating airways
Esophageal blocking and lung ventilation device
Suction system with tracheal and oral aspirating devices
Intubating equipment
Laryngoscope handles (at least 2 working)
Laryngoscope blades (assortment of different sizes and shapes)
Appropriate assortment of cuffed ETTs
Malleable stylets
Gum elastic bougie or tracheal identifying stylet
Head-and-shoulder positioning devices
Surgical emergency airway device
Difficult airway or difficult intubation expected
Indirect laryngoscope and stylet
Supraglottic intubating airway devices and tubes
Flexible fiberoptic intubating scope and light source
Designated staff to help
Method to get additional and appropriate help quickly
Functioning intravenous access
Drugs for intravenous injection and qualified person to administer them

ETT = endotracheal tube

Monitoring

Minimal acceptable monitoring standards have been adopted for all patients undergoing anesthesia. These include a dedicated monitor (a person not performing surgery) able to observe the patient and electronic monitoring devices. The intubating team should be able to respond to changes in vital signs, administer fluids and drugs, and manage the patient's airway. Minimal patient monitoring includes continuous visual electrocardiogram display of at least 2 leads, continuous pulse oximetry, and intermittent (at least every 3 min) arterial blood pressure measurements. In the OR, capnography, F_{IO_2}, and anesthetic gas monitoring are also routine. Outside the OR, either CO_2 measurement devices or capnography for intubation confirmation should be available.[33] In addition, the patient's clinical status may mandate additional needs such as monitoring of intra-arterial pressure, central venous pressure, cardiac output, and intracranial pressure.

Intubation: Plans A, B, and C

After the environment is optimized, equipment confirmed present and working, and appropriate help available, a primary intubation sequence is chosen and discussed with the team. If the airway examination is reassuring, the patient's physiologic risks are low, and the patient is not an aspiration risk, intubation using DL after induction of deep sedation or general anesthesia with or without a muscle relaxant is a reasonable first choice. If the intubation is predicted to be difficult, a different approach, such as use of an indirect laryngoscope, may be chosen for the initial intubation attempt. If the patient is at high risk of vomiting (eg, bowel obstruction) and aspirating (eg, altered mental status), this must be taken into account in determining the first choice of an intubation technique. The so-called rapid-sequence intubation, which includes induction with immediate paralysis, may be preferable in some of these cases.[34] The risk of an adverse physiologic response or inability to intubate with DL must be weighed when choosing to perform a rapid-sequence intubation. Direct posterior cricoid ring pressure during rapid-sequence intubation (Sellick's maneuver) is often used to prevent passive regurgitation; however, its effectiveness in this regard has been questioned.[35] Additionally, intubation with cricoid pressure is more difficult and may delay insertion of the tube and inflation of the tube cuff, which protects the airway.[36] Other approaches, including methods for awake intubation (discussed above), can be successful in preventing aspiration in patients at high risk.

Airway management failures, including intubation issues, are a cause of patient morbidity in and out of the OR. Delay in recognizing a problem and failing to change course result in worsening patient outcomes. This has led to the development and promotion of difficult-airway management algorithms by various professional societies. One such guideline is the difficult-airway algorithm[37] created and revised by the American Society of Anesthesiologists (Fig. 8).[38] This guide can serve as a road map for choosing the next option to establish a patent airway when the first or subsequent attempted airway technique has failed. The starting point of this and other guidelines is to establish effective manual ventilation with optimal head position using simple supraglottic airway devices (eg, oral and nasal pharyngeal airways). An important addition to ensuring gas exchange was provided with the invention of the laryngeal mask airway (LMA). Designed by Dr Brain in the late 1980s, this device bypasses the tongue and upper airway structures, seats in the lower pharynx, and conforms to the opening of the larynx. A seal is formed by inflation of the mask cuff pressing against the pharyngeal walls, and manual ventilation can be provided through a standard ETT connector. Once in place, the LMA is remarkably well tolerated even without deep anesthesia. LMA insertion and confirmation techniques are easily taught and quickly mastered. Use of this device has been added to the airway algorithm as a rescue airway and when other approaches have failed. Of note, an LMA does not protect a patient from aspiration and, although an excellent temporizing technique, is not a safe or definitive airway when aspiration is a concern.

No matter which primary intubation technique is chosen, explicit plans must be made in advance for the next steps if intubation fails or unexpected difficulties occur once the primary intubation sequence is begun. This planning should be done before beginning the intubation, and these alternative plans should be shared with the clinicians present and assisting. If the patient is able to understand and cooperate, the intubation plan (as well as plans for comfort measures after intubation) should be discussed with the patient, and verbal or written consent should be obtained.

Preparing for Intubation

After the primary and additional contingency plans for intubation are developed, all indicated and backup airway tools are available and working, and necessary drugs are available and prepared, patient preparation can then begin. Often overlooked, a functioning and adequate source of suction is imperative in case the patient vomits or has significant secretions or blood in the airway. This should include suction tips capable of removing massive quantities of gastric material from the upper airway and mouth if the patient vomits before or during intubation, as well as lower airway catheters if aspiration occurs. During an elective intubation, routine and indicated additional monitors should be placed and functioning. Frequent blood pressure measurements are needed to detect and correct the expected physiologic changes that occur with sedation/anesthesia, intubation, and initiation of mechanical ventilation. Monitoring should begin prior to starting the intubation sequence so that baseline values and variability can be noted. As mentioned before, a means of measuring exhaled carbon dioxide is needed for confirmation of intubation. Continuous CO_2 monitoring during the intubation process and with mechanical ventilation is recommended to detect airway problems before tragedy occurs.[39] Depending on individual patient risk factors and concern for the response to intubation, continuous intra-arterial pressure measurements may be needed to provide safe care and to avoid cardiovascular collapse. In situations in which changes in intracranial pressure are of concern, direct pressure monitoring with an intracranial device is useful. Drugs that can modify intracranial pressure changes should be available, as well as the expertise to order and administer them. A peripheral nerve stimulator can be used to detect maximal paralysis following administration of a neuromuscular blocker.

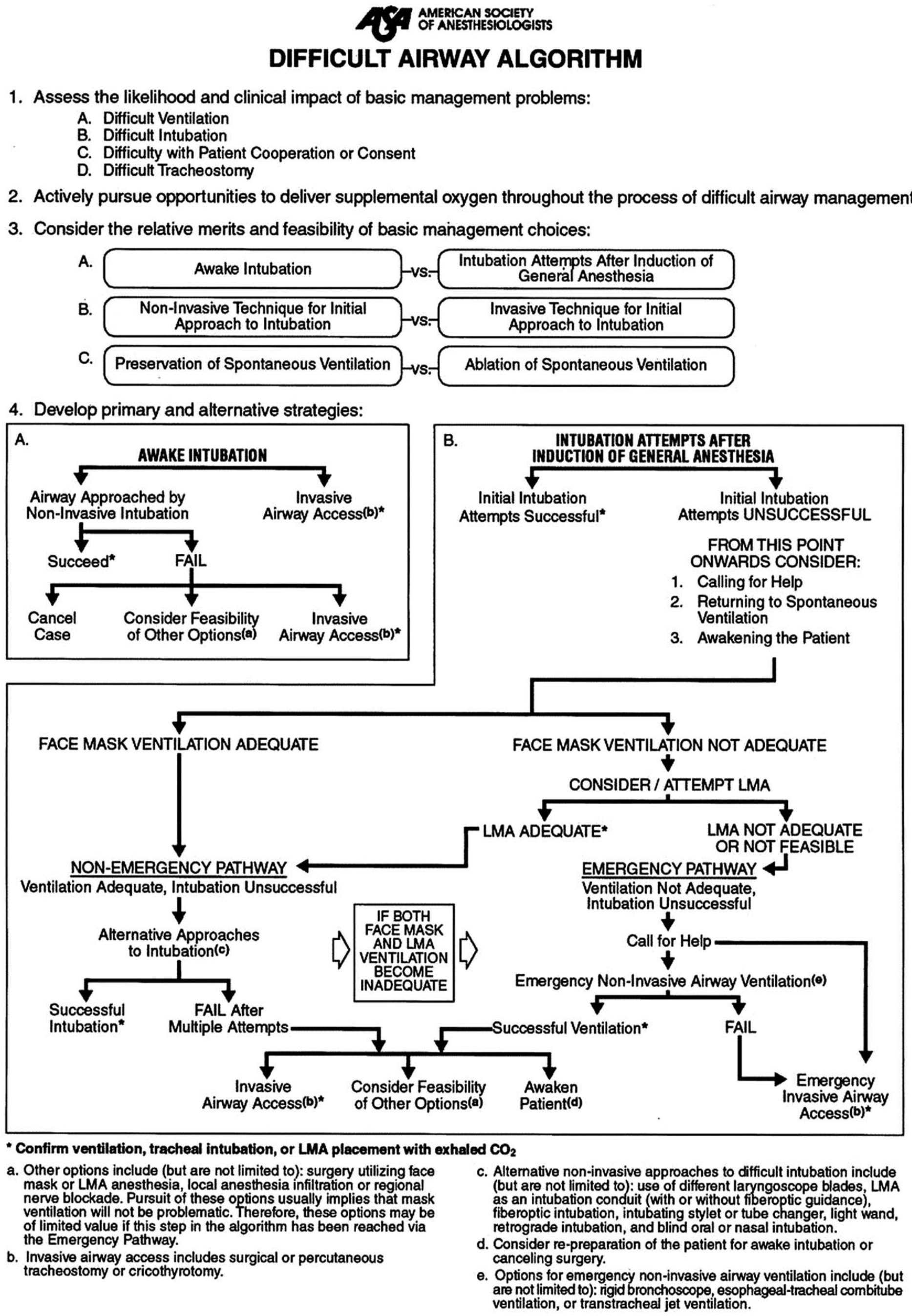

Fig. 8. Difficult airway algorithm developed and modified by the American Society of Anesthesiologists. LMA = laryngeal mask airway. From Reference 38, with permission.

Physical Considerations and Time-Out

During intubation, the patient should be on a bed or stretcher with the ability to provide head-up tilt (to help with intubation) and rapid head-down tilt (to prevent pulmonary aspiration if vomiting or regurgitation occurs). A hard surface for chest compressions (if needed) should be placed under the patient's back prior to beginning the intubation sequence. The patient should be positioned with his head at the very top of the bed, the headboard (if there is one) removed, and the bed height adjusted to suit the intubator's height and chosen technique. The bed controls that make changes in bed tilt and height should be tested, and an assistant should be assigned this task if needed after the intubation process begins. Because intubations occurring outside the OR are unscheduled and the staff involved is usually unfamiliar with the intubation process and sequence, a formal time-out is useful to bring the team together. During this pause, immediately before beginning the intubation sequence, the patient is identified, the status and plan are reviewed, critical points are identified, equipment is confirmed to be present, and tasks are assigned. Alternative plans should be discussed at this time. The patient should be explicitly identified, the initial intubation plan should be verbalized, and the team members should be identified by name and assignment. Medications, allergies, intravenous access, oxygen source, suction, monitors, manual ventilatory devices, simple airway devices, intubating equipment, the selected and tested ETT, and adjuncts to be used if intubation fails should be verbally confirmed as present and functional. As these are confirmed, the individual responding should identify themselves by name, professional role, and tasks they will be assuming. If someone or something that is needed is missing, this situation must be remedied before starting the intubation process. During a pause after reviewing the checklist (see Table 9), the group should be asked, "Does anyone have a question or a safety concern?" If there are no concerns from the group, the beginning of the intubation sequence should be announced, and patient preparation should begin with oxygen administration.

Denitrogenation or Preoxygenation

Prevention of hypoxemia and its deleterious effects on patients is the paramount consideration in airway management situations. The term preoxygenation is commonly but wrongly applied to a patient inhaling a high concentration (usually 100%) of oxygen immediately before beginning medication administration for intubation. The actual process is effected by removal of nitrogen from the lungs and body storage spaces and should more accurately be called denitrogenation. Clinically effective denitrogenation can be achieved during a short period of spontaneous or assisted ventilation with a very high oxygen concentration. This provides a margin of safety for periods of apnea of at least 5–10 min without critical oxygen desaturation (Fig. 9). With prolonged oxygen breathing ($\geq$ 45 min of 100%), duration of apnea without hypoxemia for as long as 30–45 min can be achieved.[41] Of course, P_{aCO_2} will rise during apnea, and levels exceeding 150 mm Hg have been reported.[42] This degree of hypercarbic acidosis is remarkably well tolerated since hypoxemia is prevented. Several methods have been suggested to achieve a margin of safety in a brief period, and these include 3 min of spontaneous breathing with 100% O_2, 4–5 maximal inhalations and exhalations with a high-flow non-rebreathing circuit,[43] breathing with face mask CPAP or noninvasive

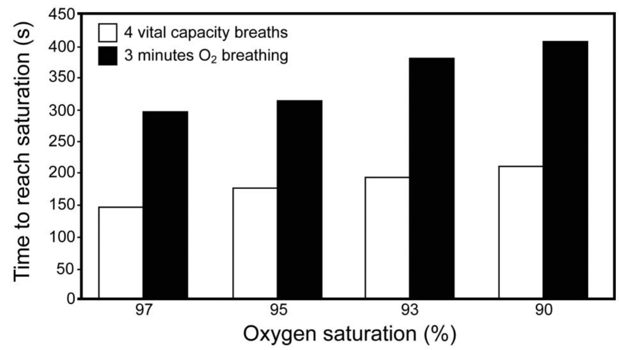

Fig. 9. Comparison of 2 methods of preoxygenation. Data from Reference 40.

mechanical ventilation, and 100% O_2 for a longer period of time.[44] While any of these are generally effective if intubation is rapidly successful, in compromised patients or during prolonged unsuccessful attempts at intubation, saturation may fall to unacceptable levels. Successive intubation attempts should be interrupted with periods of mask ventilation to restore baseline oxygenation. Before beginning intubation, the ability to provide positive-pressure ventilation with a mask should be confirmed. If manual mask ventilation is difficult or unsuccessful, use of an LMA should be considered, and avoidance of neuromuscular blockers should also be considered. If failed ventilation continues despite maximal efforts, desaturation occurs to dangerous levels (as indicated by a falling heart rate), and one or two attempts at intubation have failed, then a surgical airway should be rapidly placed, and adequate oxygenation should be restored. Surgical airways are listed in Table 4. Transtracheal jet ventilation through a large-bore intravenous catheter is a reasonable alternative to other surgical airways and offers a low risk of complications and reasonable success if equipment is close at hand and if undue delay is avoided.[45]

Intubation Using Direct Laryngoscopy

Initial Plan

If a difficult intubation is not anticipated and if the patient's risk for deterioration during or immediately after intubation is low, then an acceptable approach is a sedated/anesthetized intubation under direct vision with a standard straight or curved laryngoscope blade with laryngeal exposure facilitated by use of a neuromuscular blocker. This is a standard technique in most OR cases. After denitrogenation, unconsciousness is induced; manual ventilation may be attempted; and if manual mask ventilation is easy, the relaxant may be administered. The head should be in ideal intubating position before starting: flexed on the lower cervical spine and occiput slightly elevated on a

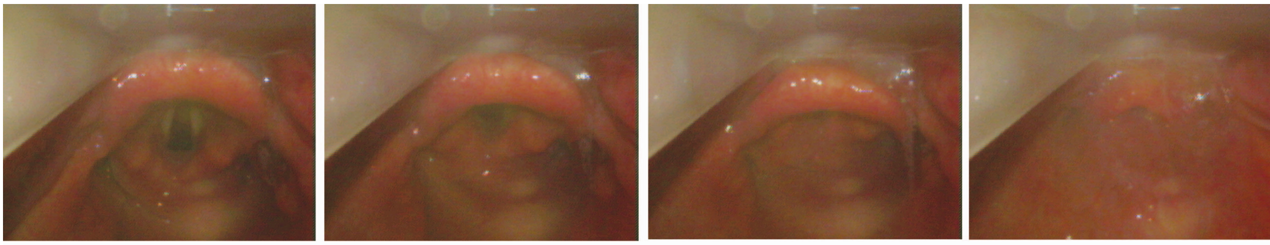

Fig. 10. Cormack-Lehane grades.

non-compressible head support, with extension of the upper cervical spine. To further improve the view of the larynx, some suggest placing the bed in a slight reverse Trendelenburg position. This also has the advantage of reducing airway pressures and lowering gastric reflux potential. Intubation using DL is the most frequently taught and mastered intubation technique and is therefore the first chosen and most often successful technique. Mastery of this intubation technique is achieved by anesthesia trainees after performing between 100 and 200 intubations.[46] Others with less experience or who intubate only rarely should have immediately available assistance from a more experienced person during an elective out-of-OR intubation, when conditions are less controlled, help is farther away, and complications are more frequent than in the OR.

Intubation is a risky and complex team process with specific actions requiring full attention of all members of the team. The ongoing activities of patient care create a degree of chaos as each individual performs his own task at the patient's bedside. Safe intubation requires a quiet and calm environment and the attention of all who are present to focus on this critical process. The person performing the intubation should assertively announce, "I am starting the intubation." This will get everyone's attention and allow the group to perform better as a team.

A functional and tested peripheral or central intravenous line should be used to deliver sedating and anesthetizing medications. The chosen medication is injected into the running intravenous line, usually by another team member at the direction of the person performing the intubation. The appropriate sterile technique is consistently applied to the injection process. Once the patient has lost consciousness and eyelash reflex is extinguished, airway patency and ability to ventilate are tested by performing one or more manual breaths. Success of manual ventilation is confirmed by observing the chest rise and fall, noting exhaled humidity in the mask, listening with a stethoscope to the trachea or lung fields, and/or observing the capnograph tracing. If a muscle relaxant is planned, it is then administered, and ventilation is provided until maximal relaxation is obtained.

DL begins by opening the patient's mouth and inserting the blade from the right side of the mouth, sweeping the tongue to the left. A crossed-finger technique to force the mouth open and to dislocate the jaw is recommended. Alternatively, use of the right hand to rotate the head backwards (neck extension) allows the mouth to fall open and accept the blade. The blade is moved from right to left, moving the tongue past the midline. As the blade is advanced, the oral anatomy comes into view, and any abnormalities are noted. With further advancement, the tip of the epiglottis should be seen. The larynx is visualized by catching the tip of the epiglottis if using a straight blade or by advancing into the vallecula (the space above the epiglottis) if using a curved blade. Lifting the blade (hanging the patient's jaw from the blade) brings the laryngeal structures into view.[47] The Cormack-Lehane system of grading the laryngeal view is often used to describe the best view obtained during laryngoscopy. Grade 1 is assigned if the entire larynx and both commissures are seen, grade 2 if half of the larynx and cords and only the posterior commissure are seen, grade 3 if none of the laryngeal opening is seen and only the posterior structures (the arytenoid cartilages) can be identified, and grade 4 if no identifiable laryngeal anatomy can be seen (Fig. 10).[6] Even when the glottic view is poor, blind intubation with a styleted ETT or over a bougie may not be difficult.

The selected ETT, which has been prepared and tested, is inserted from the right side of the mouth, out of the direct visual field, with the tube tip pointing upward. The ETT is then advanced upward through the laryngeal opening and into the trachea. This is best done with the intubator's head at least 2 feet from the patient's face, allowing binocular vision and depth perception to be maintained and facilitating controlled manipulation of the tip of the tube into the larynx. The tube should be placed so that the cuff is about 1 cm below the cords, but not farther to avoid endobronchial placement. If the best glottic view obtained is a grade 3 or 4 view, changing the head position or choosing a different length or shaped blade can be tried next. When an unexpected poor view of the larynx is encountered during DL, a malleable stylet is often helpful in directing the ETT up into the so-called anterior larynx. Experienced clinicians will use a stylet to stiffen and shape the flexible ETT, giving it a hockey stick curve to be used during any high-risk intubation. This advanced preparation allows a blind insertion when only a small or no part of the larynx is visible. After the tip is blindly inserted a short distance (enough to pass through the vocal cords), the stylet is pulled back in the tube to allow the ETT tip to bend downward and follow as the trachea descends into the thorax. If a malleable stylet is routinely placed before all intubations and if the tube is formed in an ideal shape, the ETT will always be ready when an unexpected poor-grade laryngeal view is encountered. After inflation of the ETT cuff, confirmation that the ETT is in the trachea and not the esophagus is necessary following all intubations and especially after a blind insertion.

Confirmation of Tracheal Intubation

Even if the ETT is placed by directly observing the tube enter the larynx and carefully advancing it an appropriate distance in the trachea, additional measures are used to confirm correct placement. The first sign of tracheal placement is humidity forming in the tube during gentle ventilation. Three or 4 breaths are delivered with a manual ventilatory device, and humidity is noted inside the tube, appearing and disappearing coincident with ventilation. A CO_2 monitor or detector is then attached to the tube, and appropriate levels of CO_2 should be detected in the next few breaths with tracheal placement. With esophageal placement, low levels of exhaled CO_2 can be seen with initial ventilation, but the CO_2 level will not be as high as expected from the trachea and will fall farther with each additional breath. Hyperventilation of the lungs can also reduce the measured CO_2 even if the ETT is correctly placed in the trachea. For this and other reasons, hyperventilation should be avoided. Next, both lung fields and the stomach area should be carefully auscultated. This can reliably identify an esophageal placement (loud ventilation sounds over the stomach and muted or no sounds over the lungs) and help avoid bronchial placement (no sounds over the stomach and asymmetric breath sounds over the lung fields). If bronchial intubation is suspected, the ETT can be withdrawn until lung breath sounds are equalized, and the tube can then be fixed in place. The distance marker on the tube at the teeth (or gums) should be noted when the breath sounds are equal and used as a reference point should the tube be moved in the future. There are many ways an ETT may be secured to the patient. Each has it advantages and disadvantages. The method chosen should be familiar to the caregivers who will manage the patient after the intubation team turns over care.

Table 10. Techniques and Drugs Useful for Managing Physiological Trespass Incurred by Tracheal Intubation and Positive-Pressure Ventilation

Topical airway anesthesia
Systemic treatment options
Deep sedation, opioids, general anesthesia
Cardiac drugs
β Blockers (esmolol)
Vascular drugs
Direct dilators (hydralazine, nitroprusside, nicardipine)
α Blockers (trimethaphan camsylate)
Combined effects (labetalol)
Central α_2 agents (dexmedetomidine)
Bronchodilators
β Agonists
Volatile anesthetics
Hypotension treatments
Fluids
Vasopressors (ephedrine, phenylephrine, vasopressin)
Inotropic agents (epinephrine, norepinephrine)
Inodilators (amrinone, milrinone)
CPR
Defibrillation

CPR = cardiopulmonary resuscitation

Physiologic Changes and Management Strategies

As mentioned earlier, blood pressure changes during and following intubation can be dramatic and life-threatening. If the patient is at risk of not tolerating these expected changes, plans to modify these responses are needed. These include choice of method for intubation, use of topical analgesia, and administration of cardiovascular medications. If drugs are needed, those that have rapid onset and are of short duration should be chosen. Hypertension and tachycardia during tracheal tube insertion are often followed by hypotension as reflex responses occur. Patients receiving active treatments for underlying hypertension or cardiac disease may have a paradoxical response to intubation, that is, hypotension. The application of positive-pressure ventilation after intubation will reduce venous return to the heart, resulting in reduced cardiac output and hypotension. This must be anticipated, and fluids and/or medications should be ready and administered in anticipation of this effect. Ventilation should be initiated with the lowest acceptable rate and tidal volume to minimize hypotension. In hypovolemia or patients with low cardiac reserve, intubation and ventilation can cause cardiac arrest. Resuscitation measures should be available and applied as needed without delay. While medication choices are not the domain of this paper, some useful drugs for managing the hemodynamic responses during airway management are listed in Table 10.

Alternative Airway Plans

With any intubation, changes in plans may be necessary depending on what happens during the initially chosen sequence. Major decision points are indicated in the airway algorithm in Figure 8. For instance, if manual ventilation (without a relaxant) is difficult, a short-acting relaxant rather than a longer acting one may be chosen. Also, the patient may be allowed to awaken, and an alternative intubation technique could be used. When the intubation is being performed outside the OR, explicit plans for dealing with the difficulties that may occur must be established prior to starting the intubation so that appropriate equipment and personnel are available. If a difficult intubation is predicted or known from previous intubations, all reasonable alternatives for achieving a successful intubation must be available. These must include, at a minimum, the airway equipment and the plan that was successful in the past but must also include a plan for a surgical airway if these fail. The patient's consent should include a discussion of this potential outcome. It may be prudent, if the situation allows, to move the patient to the OR when an extremely difficult airway or intubation is anticipated and to have a surgeon or other airway expert available.

The components of the difficult-airway algorithm are generally available in the OR suite. For intubations outside the OR, however, a lifesaving piece of equipment may not be available when problems occur. Having a dedicated difficult-airway cart that is mobile and stocked with all necessary devices and delivered on demand is one solution to this dangerous situation. A system solution should be developed in any health system where out-of-OR intubations are necessary on more than the occasional basis.

Postintubation Plans

Once intubation is successful, plans for continued maintenance of the ETT and patient comfort need to be initiated. As mentioned previously, manual ventilation or ventilation with a mechanical ventilator may induce the need for hemodynamic support due to the effects of positive-pressure ventilation affecting cardiac function. Vasopressors and fluids should be available and administered as needed. Use of sedation, analgesia, and neuromuscular blockade should be considered and may be part of the airway maintenance plan. Inadvertent extubation is a risk, and an effective method to secure an ETT should be applied. No one method is appropriate for all patients and situations. The consequences of tube displacement are more grave for more difficult intubations. Under these conditions, use of the most effective method of securing the tube is required. While placement of the tube may be the focus of the team initially, planning for its ultimate removal at a later time is essential. Next to intubation, extubation (either planned or accidental) is one of the most dangerous times in airway management. The risks at extubation of a patient after a difficult intubation are actually greater than those at intubation and are often underestimated by caregivers. Planning for extubation should be started at the time of intubation. Where and when to extubate should be influenced by the issues surrounding intubation.[48] Algorithms for stratification and management of airway risks at extubation have been proposed.[49]

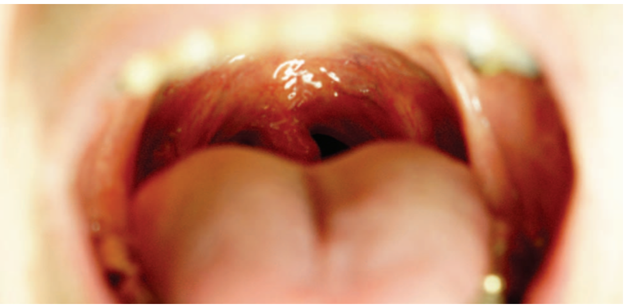

Fig. 11. Mallampati view of the patient discussed in the case study.

Transfer of Care

Often during intubations outside the OR environment, the person placing the ETT is not the one who will be caring for the patient and the airway during the subsequent period. Depending on the reason for intubation (eg, to allow a brief diagnostic or therapeutic procedure or a more persistent need such as progressive respiratory failure from COPD or congestive heart failure), complex medical care plans will be carried out that may impact airway stability. If the person performing the intubation is leaving the bedside, a change of care will occur. It is now well recognized that turnover of care carries significant risk. Transmission of critical patient information is frequently faulty. Ideal methods to summarize and pass on relevant and complete information at transfer points have not been established; however, checklists are often used to avoid omission of essential information and to delineate required activities.[50] In general, the transfer communications regarding airway management should include the medications administered; the patient's response to them; and the expected duration of those used to facilitate airway placement, to reduce consciousness, and to modify the physiologic changes during and following intubation.

Since the subsequent care is often not provided by an airway expert, explicit lists of drugs and doses used and whether the patient's response was normal, resistant, or sensitive should be conveyed. In addition, a description (verbal and written) of the intubation sequence, adjuncts used, and the ultimately successful technique should be [redacted] is a healthy [redacted] from the [redacted] who presented today for a [redacted]. His airway exam revealed a Mallampati I airway with adequate mandibular size, TMJ motion, mouth opening and neck mobility. After a smooth IV induction, he was found to be easily ventilated by mask. Direct laryngoscopy with a MAC 4, Miller 3 and Miller 4 was never successful in viewing the glottis; the epiglottis was always obstructing the view. An LMA 4 was easily placed and seated nicely. The epiglottis still obstructed the view of the glottic opening, however, so a LMA 5 was placed. The 5 LMA also seated easily and nicely and this allowed the fiberoptic scope to be maneuvered around the epiglottis and easily into the trachea. The oxygen saturation remained 99-100% throughout and [redacted] remained hemodynamically stable throughout the intubation. No trauma or edema was noted and the mask ventilation was always quite easy.

SIGNED BY: [redacted]
THIS DOCUMENT HAS BEEN ELECTRONICALLY SIGNED.

Fig. 12. Note dictated and entered into the medical record of the patient in the case study. LMA = laryngeal mask airway.

communicated to the next team. Any deviations from the initial plan and why they were invoked should be described. Additional information about the intubation and suggestions that could improve the process if re-intubation becomes necessary should be included. The method used to confirm correct tracheal placement (ie, expired CO_2, direct vision, breath sounds, and fiberoptic observation of the trachea through the ETT) should be conveyed and documented. The method used to secure the tube and the depth of the tube at the point it is secured to the patient are part of the transfer process and notes.

After the Difficult Intubation: A Case Review

Following an unexpected difficult-airway management issue, additional communication measures are required. A note in the medical record detailing the event should be entered as soon as possible so that the details are clearly recalled and accurately described.

The following is an actual case report of an unexpected difficult intubation in which one of the authors (CGD Jr) recently took part. The patient's preoperative airway evaluation is shown in Figures 2–6, and the MP view is shown in Figure 11. The patient was essentially normal by all usual measures, demonstrating no markers predictive of a difficult airway. Intubation was planned using DL after intravenous induction of general anesthesia. Figure 12 is the note entered into the medical record describing the airway events that ensued. After an uneventful anesthesia induction, mask ventilation was easily maintained. Several attempts at intubation were tried using DL and several different blades, but no laryngeal view was able to be obtained (Cormack-Lehane grade 4 view). An LMA was then inserted, and ventilation was easily maintained. The LMA was changed to a larger size and used as a conduit to facilitate a fiberoptic scope to enter the trachea. The scope was used to place a guide, and the LMA was removed. An ETT was advanced over the guide into the trachea. Successful tracheal placement was confirmed with capnography. The surgery proceeded uneventfully. Following the procedure, a discussion of the airway events was held with the patient and his wife.

Fig. 13. The cause of the intubation difficulty in the case study was massive mandibular tori.

The cause of the difficult intubation encountered in the patient above was subsequently identified as the presence of massive mandibular tori (Fig. 13). These benign bony outgrowths were not noted during the preoperative airway examination. Such tori are commonly seen by dental surgeons, as their presence is a challenge to providing dental

Fig. 14. A difficult-airway warning band was placed on the patient, alerting hospital caregivers of the potential airway problem.

prostheses and tooth repair. By functionally narrowing the submental space, these mandibular processes (when large) prevent displacement of the tongue during DL and lead to the difficult intubation that was encountered in this patient.[51]

To alert subsequent caregivers in the hospital that a significant airway event has occurred, a warning label can be placed on the ETT, the patient's chart or arm, the bed headboard, or the room door. An entry using the medical record critical alert system can also be used. In the case described above, an armband was placed and remained until hospital discharge (Fig. 14). Communication with future caregivers of the unexpected difficulties confronted during airway management begins with a discussion of the events with the patient and his family. This discussion should occur at an appropriate time before discharge. The note shown (Fig. 12) became a part of the medical record, and a copy of it was given to the patient. Some experts advise a patient experiencing a difficult intubation to acquire a MedicAlert bracelet or medallion to notify future clinicians of the airway problem at a time when the patient or family may not be able to supply necessary information. Many professional societies have advocated providing the patient with a standard difficult-intubation letter as described previously (Fig. 1), which can be included in the patient's medical record and given to the patient to be shared with future caregivers.

Conclusions

Management of elective intubations in the OR are frequently and safely performed daily throughout the world. The OR intubation forms a body of experience and information that can be used to improve the intubation process when performed elsewhere. Areas of highest risk that need attention are preintubation patient evaluation, intubating environment optimization, postintubation physiology management, and communication between caregivers. Documentation of airway difficulties needs consistent attention in the OR domain as well as when the intubation is performed elsewhere.

REFERENCES

1. Centers for Disease Control and Prevention. Inpatient surgery. http://www.cdc.gov/nchs/fastats/insurg.htm. *Accessed June 23, 2013*.
2. Centers for Disease Control and Prevention. NAMCS and NHAMCS Web Tables. http://www.cdc.gov/nchs/ahcd/web_tables.htm#2010. *Accessed June 23, 2013*.
3. Caplan RA, Posner KL, Ward RJ, Cheney FW. Adverse respiratory events in anesthesia: a closed claims analysis. Anesthesiology 1990;72(5):828-833.
4. Schwartz DE, Matthay MA, Cohen NH. Death and other complications of emergency airway management in critically ill adults. A prospective investigation of 297 tracheal intubations. Anesthesiology 1995;82(2):367-376.
5. Williams KN, Carli F, Cormack RS. Unexpected difficult laryngoscopy: a prospective survey in routine general surgery. Br J Anaesth 1991;66(1):38-44.
6. Cormack RS, Lehane J. Difficult tracheal intubation in obstetrics. Anaesthesia 1984;39(11):1105-1111.
7. Schmidt UH, Kumwilaisak K, Bittner E, George E, Hess D. Effects of supervision by attending anesthesiologists on complications of emergency tracheal intubation. Anesthesiology 2008;109(6):973-977.
8. Jaber S, Amraoui J, Lefrant JY, Arich C, Cohendy R, Landreau L, et al. Clinical practice and risk factors for immediate complications of endotracheal intubation in the intensive care unit: A prospective, multiple-center study. Crit Care Med 2006;34(9):2355-2361.
9. American Society of Anesthesiologists Task Force on Preanesthesia Evaluation. Practice advisory for preanesthesia evaluation: a report by the American Society of Anesthesiologists Task Force on Preanesthesia Evaluation. Anesthesiology 2002;96(2):485-496.
10. Koenig HM. No more difficult airway, again! Time for consistent standardized written patient notification of a difficult airway. Anesthesia Patient Safety Foundation Newsletter: Summer 2010. http://www.apsf.org/newsletters/html/2010/summer/06_diffairway.htm. *Accessed May 13, 2014.*
11. Hamaekers AE, Henderson JJ. Equipment and strategies for emergency tracheal access in the adult patient. Anaesthesia 2011;66 (Suppl 2):65-80.
12. Kheterpal S, Martin L, Shanks AM, Tremper KK. Prediction and outcomes of impossible mask ventilation: a review of 50,000 anesthetics. Anesthesiology 2009;110(4):891-897.
13. Mallampati SR, Gatt SP, Gugino LD, Desai SP, Waraksa B, Freiberger D, Liu PL. A clinical sign to predict difficult laryngoscopy: a prospective study. Can Anaesth Soc J 1985;32(4):429-434.
14. Khan ZH, Mohammadi M, Rasouli MR, Farrokhnia F, Khan RH. The diagnostic value of the upper lip bite test combined with sternomental distance, thyromental distance, and interincisor distance

for prediction of easy laryngoscopy and intubation: a prospective study. Anesth Analg 2009;109(3):822-824.
15. Safavi M, Honarmand A, Zare N. A comparison of the ratio of patient's height to thyromental distance with the modified Mallampati and the upper lip bite test in predicting difficult laryngoscopy. Saudi J Anaesth 2011;5(3):258-263.
16. Pedersen T, Eliasen K, Henriksen E. A prospective study of risk factors in cardiopulmonary complications associated with anaesthesia and surgery: risk indicators of cardiopulmonary morbidity. Acta Anaesthesiol Scand 1990;34(2):144-155.
17. Pedersen T, Viby-Mogensen J, Ringsted C. Anaesthetic practice and postoperative pulmonary complications. Acta Anaesthesiol Scand 1992;36(8):812-818.
18. Perkins ZB, Gunning M, Crilly J, Lockey D, O'Brien B. The haemodynamic response to pre-hospital RSI in injured patients. Injury 2013;44(5):618-623.
19. Bedford RF, Feinstein B. Hospital admission blood pressure: a predictor for hypertension following endotracheal intubation. Anesth Analg 1980;59(5):367-370.
20. Pedersen T. Complications and death following anaesthesia. A prospective study with special reference to the influence of patient-, anaesthesia-, and surgery-related risk factors. Dan Med Bull 1994; 41(3):319-331.
21. Pedersen T, Johansen SH. Serious morbidity attributable to anaesthesia. Considerations for prevention. Anaesthesia 1989;44(6):504-508.
22. Stoelting RK. Circulatory changes during direct laryngoscopy and tracheal intubation: influence of duration of laryngoscopy with or without prior lidocaine. Anesthesiology 1977;47(4):381-384.
23. Hamill JF, Bedford RF, Weaver DC, Colohan AR. Lidocaine before endotracheal intubation: intravenous or laryngotracheal? Anesthesiology 1981;55(5):578-581.
24. Morris IR. Continuing medical education: fibreoptic intubation. Can J Anesth 1994;41(10):996-1007; discussion 1007-1008.
25. Heffner AC, Swords DS, Nussbaum ML, Kline JA, Jones AE. Predictors of the complication of postintubation hypotension during emergency airway management. J Crit Care 2012;27(6):587-593.
26. Murphy BA, Durbin CG Jr. Using ventilator and cardiovascular graphics in the patient who is hemodynamically unstable. Respir Care 2005;50(2):262-274; discussion 274.
27. Kopman AF, Wollman SB, Ross K, Surks SN. Awake endotracheal intubation: a review of 267 cases. Anesth Analg 1975;54(3):323-377.
28. DeMaria S Jr, Neustein SM. Production pressure, medical errors, and the pre-anesthesia checkout. Middle East J Anesthesiol 2010;20(5): 631-638.
29. Hart EM, Owen H. Errors and omissions in anesthesia: a pilot study using a pilot's checklist. Anesth Analg 2005;101(1):246-250.
30. Heuer JF, Barwing TA, Barwing J, Russo SG, Bleckmann E, Quintel M, Moerer O. Incidence of difficult intubation in intensive care patients: analysis of contributing factors. Anaesth Intensive Care 2012;40(1):120-127.
31. Robbertze R, Posner KL, Domino KB. Closed claims review of anesthesia for procedures outside the operating room. Curr Opin Anaesthesiol 2006;19(4):436-442.
32. De Jong A, Molinari N, Terzi N, Mongardon N, Arnal JM, Guitton C, et al. Early identification of patients at risk for difficult intubation in the intensive care unit: development and validation of the MACOCHA score in a multicenter cohort study. Am J Respir Crit Care Med 2013;187(8):832-839.
33. Goldhill DR, Cook TM, Waldmann CS. Airway incidents in critical care, the NPSA, medical training and capnography. Anaesthesia 2009; 64(4):354-357.
34. Ehrenfeld JM, Cassedy EA, Forbes VE, Mercaldo ND, Sandberg WS. Modified rapid sequence induction and intubation: a survey of United States current practice. Anesth Analg 2012;115(1):95-101.
35. Brimacombe JR, Berry AM. Cricoid pressure. Can J Anaesth 1997; 44(4):414-425.
36. Snider DD, Clarke D, Finucane BT. The 'BURP' maneuver worsens the glottic view when applied in combination with cricoid pressure. Can J Anaesth 2005;52(1):100-104.
37. Practice guidelines for management of the difficult airway: a report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Anesthesiology 1993;78(3):597-602.
38. American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Practice guidelines for management of difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Anesthesiology 2003;98(5):1269-1277.
39. Mort TC. The incidence and risk factors for cardiac arrest during emergency tracheal intubation: a justification for incorporating the ASA guidelines in the remote location. J Clin Anesth 2004;16(7):508-516.
40. Valentine SJ, Marjot R, Monk CR. Preoxygenation in the elderly: a comparison of the four-maximal-breath and three-minute techniques. Anesth Analg; 1990;71(5):516-519.
41. Teller LE, Alexander CM, Frumin MJ, Gross JB. Pharyngeal insufflation of oxygen prevents arterial desaturation during apnea. Anesthesiology 1988;69(6):980-982.
42. Frumin MJ, Epstein RM, Cohen G. Apneic oxygenation in man. Anesthesiology 1959;20(6):789-798.
43. Tanoubi I, Drolet P, Donati F. Optimizing preoxygenation in adults. Can J Anaesth 2009;56(6):449-466.
44. Weingart SD, Levitan RM. Preoxygenation and prevention of desaturation during emergency airway management. Ann Emerg Med 2012;59(3):165.e1-175.e1.
45. Ross-Anderson DJ, Ferguson C, Patel A. Transtracheal jet ventilation in 50 patients with severe airway compromise and stridor. Br J Anaesth 2011;106(1):140-144.
46. Clarke RC, Gardner AI. Anaesthesia trainees' exposure to airway management in an Australian tertiary adult teaching hospital. Anaesth Intensive Care 2008;36(4):513-515.
47. McIntyre JW. Laryngoscope design and the difficult adult tracheal intubation. Can J Anaesth 1989;36(1):94-98.
48. Cavallone LF, Vannucci A. Review article: extubation of the difficult airway and extubation failure. Anesth Analg 2013;116(2):368-383.
49. Difficult Airway Society Extubation Guidelines Group, Popat M, Mitchell V, Dravid R, Patel A, Swampillai C, Higgs A. Difficult Airway Society Guidelines for the management of tracheal extubation. Anaesthesia 2012;67(3):318-340.
50. Hales BM, Pronovost PJ. The checklist–a tool for error management and performance improvement. J Crit Care 2006;21(3):231-235.
51. Durrani MA, Barwise JA. Difficult endotracheal intubation associated with torus mandibularis. Anesth Analg 2000;90(3):757-759.

Discussion

Hurford: One of the problems with checklists is that you need to actually complete the checklist. In our electronic medical record, the process for completing the checklist can only be done after you've managed the airway. Bizarre. I was taught 30 years ago a mental checklist that's really simple called SOAP: S for suction, O for oxygen, A for airway, and P for pharmacy. Suction, as you mentioned is what you always forget, comes first. The oxygen (do I have a way of administering O_2 to the patient?) is next. All my airway equipment, as you mentioned, is included. Pharmacy is a functioning I.V. [intravenous line] and drugs to put into it. I've never seen it studied, but it works because it's a very simple mnemonic device that, even with me, 30 years later, I can remember, and I still use it every time I put an airway in.

Durbin: Bill, how would you modify something like that to take it outside the OR [operating room]?

Hurford: I use that everywhere I go, whether it's in the ICU or an emergent intubation anywhere. I'm always looking. Do we have suction? Do we have the bag and mask? Do we have oxygen hooked up? Is the Ambu bag [manual resuscitation bag] hooked up to the air rotameter? Do I have an airway to put in? Where's the cart? Are we going to use medications, and do I have an I.V.? Outside the OR, all four of those are often missing. You go to the patient, somebody's trying to manually ventilate, and nothing is prepared, but this enables me to ask for what I need very quickly and effectively.

Davies: Our therapists carry a pack or code bag, and it's arranged exactly the way you're describing. The first things accessed are the stabilization tools: oxygen equipment, resuscitation bag, and suction equipment. Once the stabilization equipment has been employed, another clinician can then access the laryngoscope, stylet, syringe, ET_{CO_2} [end-tidal carbon dioxide] detector, etc. The standardized code bag arrangement helps clinicians access the equipment faster than if they had to root around looking for something due to unfamiliarity.

Durbin: One of the things I included in my presentation but didn't promote strongly is a time-out to start the actual intubation sequence. This can be a time when everybody in the environment pays attention to the patient, the process, and the patient's upcoming needs. Do any of you use something like this as a way to focus attention during out-of-OR intubations? Do you say, "We're ready to intubate, the patient is X, we have the equipment and supplies, and now we're going to intubate?"

Davies: In an acute situation where intubation is considered imminent, it's not a time-out per se, but we have to make the announcement, "Do you want us to intubate?" Once we get this approval, we go ahead with the intubation. In the case of an elective intubation (where time is not as much of a priority), there will be a time-out performed to bring the focus to the patient.

Ramachandran: Let me go back to emergent intubations. With a 10% difficult intubation rate outside the OR versus about a 1% difficult intubation rate with DL [direct laryngoscopy], I think one of the challenges we face is who's going out to do these intubations with a 10 times increased risk. A Massachusetts General Hospital study showed that the presence of an attending anesthesiologist reduced the risk of failed intubation.[1] We didn't find that at our institution.[2] I wondered what your thoughts are about that and also about the use of advanced video laryngoscopy as first choice, which is increasingly en vogue, but not with very good evidence.

Durbin: The initial reports with every new device suggest that it is much better, easier to use, and always successful. Further reports identify failures, unexpected problems, and limitations. The reality is that every device or technique has advantages and disadvantages. This is not different with VL [video laryngoscopy]. As more experience is gained, the appropriate indications and limitations of this technique are becoming more clear. Individuals also have to have a significant amount of hands-on experience to appropriately use them. The initial learning curve with video laryngoscopic intubation is steep, and beginners quickly develop basic skills. However, knowing when to deviate from the normal plan takes more experience. In the case of emergent intubations, the first choice should the device with which you have the most experience; the second choice is the alternative technique with which you have the most experience. Traditionally, during anesthesia today, the first choice is DL with a straight or curved blade, and the second choice is a stylet or a tracheal bougie to facilitate a blind intubation. I believe that supraglottic airways are the solution for can't-ventilate patients, and an intubating LMA [laryngeal mask airway] has made a difference in patient outcomes. Since the incidence of ventilation failure is so low in the OR, data supporting this contention are anecdotal. The LMA takes a difficult-to-ventilate or failure-to-ventilate emergency situation and turns it into "I can now ventilate and think about what to do next" situation. The questions "Do I need more help?" and "Do I need a different device?" can now be entertained. Video laryngoscopes are not perfect; they have their own problems. The reassuring airway exam is different than with DL: more room between the teeth is needed, an anterior larynx is not as much of a problem, and neck mobility is less of a issue. A small mouth opening or large teeth can derail intubation with a video laryngoscope since both the scope and the stiffly styleted tube must be manipulated through the mouth. If individuals are now being trained with VL as their primary or backup technique, then using it during an emergent intubation makes good sense. You use the technique that you have the most experience with first; you recognize its limitations. When VL fails, you then use your secondary technique. The biggest problem with VL is that the device may not be available in emergency locations. These devices certainly should be available in elective intubations, which is where I think their primary role will be. They can be used either as a secondary device (DL being primary) because the airway suggests it would be easier to manage that way or as a primary device because you happen to have VL available at every intubating situation.

Collins: I would like to highlight my concern that new technologies like video laryngoscopy can be dangerous if new trainees are not learning and gaining firm skills in traditional methodologies such as direct laryngoscopy with straight or curved blades. This might be a problem if trainees consistently use such technology as a go-to device without a skill set in other more traditional techniques. This sentiment has been mentioned in at least one recent editorial[3] that I recall.

Napolitano: First, in the ICU for the unanticipated difficult airway, we've seen great benefit from the use of standardized airway carts that have our equipment in close proximity and allow us to train our health care providers about where the equipment is and then when to use it. There are not a lot of data to show that that actually works, but it seems reasonable. So, comments on whether that's useful or not useful?

Durbin: Yes, I agree there are little or no data on this, but it's certainly logical. If you can move what you're used to using to where you need it, that makes sense. The ASA [American Society of Anesthesiologists] difficult-airway algorithm includes various airway devices that should be available should an unexpected difficult airway occur.[4] Having these devices available and placing them together on a cart is one way to accomplish this task outside the OR. Having a restocking system and personnel to bring the cart to where it is needed is also necessary. Such a system works well in the hospital and maybe in rescue squads, but there are places where it doesn't work terribly well. I think you have to modify your process to suit the needs of the situations in which you're going to find yourself. I think that's what most people do. I saw a paper from the United Kingdom[5] where the availability of emergency airway carts, or trolleys as they call them, and their contents were limited. The authors commented that they did not meet the recommended standards in most of their institutions. They didn't have data on their patient outcomes, so we don't know whether the cart makes a difference, but it probably does.

Davies: One of the problems we run into with the airway carts in the ICUs and other areas is that neither the RTs [respiratory therapists] nor anesthesiologists stock them. When certain equipment is needed, there can be a delay due to unfamiliarity. In the majority of airway procedures, the RT code bag is used (if available) to limit this potential delay in establishing the airway.

Napolitano: We've had that issue of who is responsible for the airway carts in the ICU recently, and we had to revise who was going to be responsible, what the equipment was going to be, what needed to be there and particularly which pharmacologic options for induction and neuromuscular blockade, and how those drugs would be stocked as well. My second comment/question is that we struggle with the difficult-airway algorithm and teaching it to critical care fellows. Out of Melbourne, there's a new very simple approach called the Vortex approach[6] for management of the unanticipated difficult airway, where they basically have a circle for nonsurgical airway techniques, including face mask, ETT [endotracheal tube], and LMA, and in the center of the vortex is the surgical airway. So it's a very simplistic approach. We've been contemplating whether we should teach our fellows this approach, but we've not had any experience, and I wondered if anybody has.

Durbin: I do not have any experience with that approach.

Ramachandran: I think the point Lena [Napolitano] is trying to make is the importance of communication around an emergent intubation. The most important piece of communication should be when to stop intubation and look at other options. If you look at medicolegal cases where adverse neurological outcomes occurred, they occurred because people hadn't paid attention to the oxygenation and continued with their attempts at intubation. Now, difficult and failed intubations are very difficult situations because someone's got the laryngoscope, trying to secure the airway while everyone else in the room is essentially doing little else. This situation could be helped by communication related to what are the limits, when are we going to stop, and what's our backup? And have one person be responsible for ensuring timeliness and calling for backup. Like for CPR [cardiopulmonary resuscitation], it's imperative to have somebody there with a timer and telling people what to do and when, but unfortunately, we don't always have a similar approach for airway management.

Durbin: I agree, it's challenging. I think most of us feel like our skill set, whatever it may be, should work. And we'll go to the end of the earth to prove that we can do it alone. It's essential to get the ego out of the way and ask for help. The first recommended action when encountering an unexpected difficult airway is to call for help. This is essential to do immediately when the help is far away. There must be a system in place to get help and knowledge of how to activate the system. Most importantly, you must be able to say to yourself that it's OK to ask for help. My most memorable bad airway experience was with a pregnant lady being anesthetized offsite for a urologic procedure. She had been easily intubated just the week before and had a reassuring airway exam. I did not think there would be problems. I was working with a junior resident, who I allowed to manage the airway. The resident had some difficulty achieving satisfactory ventilation and was unsuccessful at visualizing the larynx after a muscle relaxant was given. When I took over, I also struggled to maintain gas exchange and could not see any of the larynx. My first call was for help, which was far away. Fortunately, somebody in that environment asked, "Would you like an intubating LMA?" I was surprised and responded, "Oh, you guys have one here?!" I inserted the device and was able to ventilate, and gas exchange improved. The arterial saturations, which were in the 30s, rose to 100%. The ETT was then placed blindly through the device and confirmed to be in the trachea. Having the device when needed probably saved the patient's life. By the time the help arrived about 10 min later, they were not needed, but calling for help was appropriate, and calling for help early is key because it can take a long time to arrive.

Davies: When you mentioned the ego part of it, we run into that scenario from time to time. The clinician may want to take additional attempts to establish the airway before seeking help so that they won't be viewed as a failure. The other thing is a decision about who's going to do the intubation. For instance, in our ICUs, there are times when it is not in the best interests of the patient for a clinician with limited experience to make the initial attempt at intubation (eg, a patient with anatomical indicators for airway difficulty). In cases of potential airway difficulty, the attending physician should decide who would be the clinician most capable of having success without complication.

Haas: Charlie, you talked about time-outs and checklists for intubations. Are there such devices, or do you recommend these for extubations as well? To make sure the right people are there, and the right equipment is available?

Durbin: I'll defer on commenting on that because we will have a paper on the subject of difficult extubation at another time.

REFERENCES

1. Schmidt UH, Kumwilaisak K, Bittner E, George E, Hess D. Effects of supervision by attending anesthesiologists on complications of emergency tracheal intubation. Anesthesiology 2008;109(6):973-977.
2. Mhyre JM, Martin LD, Ramachandran SK, Kheterpal S. Is faculty presence during emergent tracheal intubations justified? Anesthesiology 2009;111(1):217-218; author reply 218-219.
3. Sharma D. Is Glidescope the best way to intubate? Anesthesiology 2010;113(1):258-259; author reply 259.
4. Apfelbaum JL, Hagberg CA, Caplan RA, Blitt CD, Connis RT, Nickinovich DG, et al. Practice guidelines for the management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on Management of the Difficult Airway. Anesthesiology 2013; 118(2):251-270.
5. Walsh K, Cummins F. Difficult airway equipment in departments of emergency medicine in Ireland: results of a national survey. Eur J Anaesthesiol 2004;21(2):128-131.
6. Chrimes N, Fritz P. The Vortex approach. http://vortexapproach.com/vortex_approach/vortex.html. *Accessed March 4, 2014.*