AANA Journal Course

Update for Nurse Anesthetists

The Other Side of the Difficult Airway: A Disciplined, Evidence-based Approach to Emergence and Extubation

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Successful intubation of the patient with a difficult airway marks the beginning of the challenges facing the nurse anesthetist charged with delivery of that patient’s anesthesia care. Too often, on successful intubation of this patient, the anesthetist and other members of the perioperative team may relax too much. Substantial planning and consultations have been employed to achieve the successful intubation of the patient with the difficult airway. Yet frequently, the final aspect of any general anesthetic—extubation—does not receive sufficient planning even though there continues to be a large volume of critical airway incidents surrounding the extubation and transportation of such a patient to the postanesthesia care unit.

Keywords: Bailey maneuver, difficult airway, extubation failure, extubation-related complications, intubation.

Objectives

Upon completion of this course, the reader will be able to:
1. Describe the steps in the progression toward extubation of a patient with or without a difficult airway.
2. Discuss the criteria employed to determine patients who may be at risk of extubation-related complications.
3. Identify perioperative factors that may alter the airway of a patient following induction of general anesthesia and intubation.
4. Discuss the Bailey maneuver.
5. Identify concerns surrounding placement and use of an airway exchange catheter.

Introduction

As anesthetists, challenges are presented to us with each patient for whom we deliver care. A major challenge, and cause for concern, is the patient with the difficult airway. When, during an otherwise routine beginning to an anesthesia induction, we encounter an unanticipated difficult airway, the level of concern becomes greatly amplified, primarily because there is a much greater potential for patient morbidity and/or mortality in conjunction with the difficult airway. If the airway is not secured, the potential for untoward events becomes decidedly greater. Recognition of the associated increased risks among patients with a difficult airway prompted the establishment of the Task Force on Management of the Difficult Airway by the American Society of Anesthesiologists (ASA). In 1993, this task force compiled and published the first consensus guidelines for management of patients with a difficult airway, and these guidelines were subsequently updated in 2003 and 2013.3

A difficult airway is defined as a patient airway with which an experienced anesthesia provider has difficulty providing ventilation, either via bag-valve-mask or insertion of an endotracheal (ET) tube via direct laryngoscopy. To optimize the probability for a positive outcome in a patient with a known difficult airway, substantial management planning must take place. An integral component to that management planning is ensuring that appropriate secondary and tertiary airway management equipment is within quick, easy reach and that this equipment is properly functioning should it become necessary to employ it. Because of the great potential for complications in conjunction with the difficult airway, particularly the unanticipated difficult airway, efforts have been continuous for many years to reduce the incidence of unanticipated difficult airways. Over the past 20 to 25 years, several methods...
have been developed, honed, and refined to identify the patient with the difficult airway during the preoperative/preanesthesia assessment or encounter rather than on induction of general anesthesia (Table 1).

Initially, measuring the patient’s thyromental distance (TMD) was employed almost exclusively, wherein the distance from the superior tip of the thyroid cartilage to the inside tip of the mandible was measured. The classically cited appropriate TMD for a patient without a difficult airway or the traditionally desired measurement has been 3 “finger widths” (fingerbreadths). This measurement method continues to be one of the most commonly employed for assessing a patient for a difficult airway. However, an anesthetist need only look at staff in his or her own department to quickly learn the obvious limitation to this classic measurement; 3 finger widths can be vastly different measurements from one anesthetist to another. A recent study demonstrated the 3 finger-widths measurement to range from 4.2 cm to 7.0 cm. Other recent studies often employed in educating anesthesia providers suggest the appropriate TMD should be at least 5.0 cm or at least 3 “large finger widths” to declare the patient’s airway normal or not difficult. Fewer false-positive evaluations, along with greater specificity, are achievable by using a ruler to measure the TMD. A distance of 5 to 6.5 cm is currently the desired distance for the TMD. Additional airway assessment tools are frequently employed in the continuing effort to predict the difficult airway, including posterior mandibular depth, atlanto-occipital distance, Wilson criteria, sternomental distance, upper lip bite test, and Mallampati test.

Currently, TMD is used in conjunction with the Mallampati test. A visual, cursory inspection of the oropharyngeal area is undertaken using the Mallampati test by placing the patient in a sitting position and having the patient open his or her mouth as widely as possible while extending the tongue. When these 2 assessment tools are employed together, there is a good rate of successful predictions of a difficult airway, with a sensitivity of 37.5% and a specificity of 60% to 80%. In assessing patients regarding a difficult airway, the most consistent predictor for a difficult airway during the current case is a history.
of such difficulty. Additional factors may affect the anesthetist's assessment of whether a patient has a difficult airway or not, including facial appearance, body habitus, documentation of a history—medically and/or surgically documented—of a difficult airway, patient population-based probabilities for a difficult airway, and hunches—also called "educated guesses."

Great strides have been made in predicting the difficult airway in the last 20 years, yet anesthetists continue to encounter unanticipated difficult airways. Since the initial report by the ASA Task Force, instruments and interventions have advanced and improved such that untoward outcomes have continued to decline. An important aspect of identification of the difficult airway is that follow-up with the patient occurs to provide counseling regarding the great importance of this problem and that this problem should be made known to all anesthesia providers in the future to allow them to make the necessary preparations and adjustments to the plan for anesthesia. It is also important that patients identified as having a difficult airway carry with them some manner of identification/alert letting future medical personnel know about their difficult airway.

Because of these assessments, tools, and interventions, a patient presenting to the operating theater for surgery and anesthesia with a known difficult airway—be it known by previous documentation or current assessment—becomes the source or genesis for substantial planning and strategy discussions by members of both the anesthesia and surgical teams. When anesthesia induction has been completed and the patient has been tracheally intubated—with or without difficulty—often the heightened concerns regarding the patient's airway fall by the wayside. The sense of relief that the difficult airway has been successfully dealt with, without untoward outcomes, may result in perioperative team members relaxing too much and not giving appropriate consideration to the other side of the difficult airway equation: extubation. This Journal Course has been compiled to present and review factors that must be considered along with options available to complete the care of the patient with a difficult airway.

**Extubation**

The definition of extubation is removal of a tube from a hollow organ or passageway; the opposite of intubation. This is a fairly simple, straightforward definition; it is a simply written statement that describes a task or decision that is not necessarily or always simply accomplished. The processes for anesthetists have been likened to those of airline pilots. There are preflight checklists (anesthesia machine power-up and check), acceleration (induction), liftoff (intubation), ascent/cruising altitude (maintenance of anesthesia), descent (emergence), touchdown (extubation), and debarkation (transfer to the postanesthesia care unit [PACU]). Often the primary focus and planning of an anesthetic are aimed at the processes required to complete the "preflight and early flight" processes up to attaining the "cruising altitude"—maintenance phase of the anesthetic; but, the "flight"—or anesthetic—is not complete until the "plane" touches down safely and the passenger is debarked—emergence, extubation, and transfer to the PACU. The anesthetist is charged with giving the process of emergence, extubation, and transfer to the PACU great contemplation, equal to the preoperative planning, for each patient, especially those patients with a difficult airway.

The establishment of the ASA Task Force on Management of the Difficult Airway yielded guidelines and suggestions resulting in demonstrable reductions in untoward events and outcomes related to the processes of anesthesia induction and intubation. However, those demonstrable reductions in untoward events and outcomes have not carried over to the period of emergence from general anesthesia through admission to the PACU. As much as 16% of documented airway events have been found during emergence from general anesthesia, and 14% of such airway events have occurred during transportation to, or during the stay in, the PACU. The period entailing the PACU admission—both transportation to and length of stay—are especially vulnerable times for patients largely because of the lack of appropriate equipment within easy grasp of the anesthetist if an airway emergency arises. With most patients, extubation is accomplished uneventfully. After all, the logical conclusion—the desired endpoint—of a general anesthetic is extubation. However, before the anesthetist and patient arrive at the junction at which the decision regarding extubation becomes necessary, many factors need to be considered and contemplated. Myriad factors may contribute to morbidity and mortality, including anatomic, physiologic, and human factors (Table 2).

The anesthetist must evaluate several factors before extubating a patient. First and foremost, it is crucial for the anesthetist to realize and remember that extubation, when the surgical procedure is completed, is not mandatory. Whether the patient is extubated must be dictated by the safety of the patient once the surgical procedure is completed. To that end, the patient must be constantly evaluated and then reevaluated as the end of the procedure approaches. The goal for extubating the patient is that oxygen delivery to the patient's lungs must incur the shortest interruption possible, with no interruption being ideal, all the while minimizing or avoiding stimulation of the patient's airway. The anesthetist should develop a secondary or contingency plan that supports rapid employment of ventilator assistance or control, as well as reintubation of the trachea if required, with the least possible delay or difficulty.

The Difficult Airway Society (DAS) initially published extubation guidelines pertaining to patients with dif-
difficult airways in 2004. Those initial guidelines have been updated in the ensuing years, with the most recent updates published in 2012. The DAS guidelines reaffirm the critical nature of extubation as a part of the process of emergence from general anesthesia while also emphasizing that extubation is not simply and merely the inverse of tracheal intubation. In recent years, the circumstances surrounding extubation have become increasingly complex, in part because of external factors such as the push to reduce turnover time and increase the efficiency of the perioperative team members, along with potential patient anatomic and physiological changes. All these factors magnify the importance of the extubation guidelines from the DAS. In the extubation process developed by the DAS, there are 4 steps: (1) planning the extubation, (2) preparation for extubation, (3) execution of the extubation, and (4) follow-up after extubation and the initial recovery period.

**Step 1: Planning for Extubation**
Under ideal circumstances, the planning for extubating a patient should be initiated even before the patient enters the actual operating room for induction of anesthesia. Many cases—not necessarily every case in the operating room—should involve a frank discussion between the anesthetist and the surgeon. First and foremost, is it appropriate for this patient to be extubated immediately after completion of the surgical procedure? The impetus for this question and discussion strongly depends on the information gleaned from assessment of the patient's airway along with consideration of any comorbidities the patient may have. These simultaneous assessments are the initiating process to determine whether the patient will be considered low risk or at risk regarding extubation when the surgical procedure has been completed. The planning for the extubation stage is an ever-evolving enterprise in which is incorporated factors from the

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**Table 2. Factors That May Affect Extubation**

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<th>Patient factors</th>
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<td>Age</td>
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<tr>
<td>• Head and neck abnormalities</td>
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<tr>
<td>• Obesity (body mass index &gt; 30 kg/m²)</td>
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<tr>
<td>• Obstructive sleep apnea</td>
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<tr>
<td>Pregnancy</td>
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<td>• Rheumatoid arthritis</td>
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**Surgical factors**
- Type of operation
  - • Cervical spine
  - • Head/neck
  - • Maxillofacial
  - • Upper airway
- Duration of operation

**Table 3. At-Risk Extubation**

<table>
<thead>
<tr>
<th>Preexisting airway problems</th>
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<tr>
<td>Anticipated or unanticipated difficult intubation on induction</td>
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<tr>
<td>Obesity (body mass index &gt; 30 kg/m²)</td>
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<tr>
<td>Obstructive sleep apnea</td>
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**Perioperative airway deterioration (normal airway at induction/intubation)**
- Anatomical distortion
- Edema
- Hematoma
- Hemorrhage

**Restricted air access (normal airway at induction/intubation, access limited after surgery)**
- Restricted head/neck movement
- Cervical spine fixation
- Halo fixation device
- Mandibular wiring
- Surgical implants

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Assessment of the patient's airway, any comorbidities, and any cogent factors that may have been encountered during induction and intubation. The anesthetist must also consider what changes to the patient’s airway might have occurred intraoperatively. The patient deemed to be at low risk for extubation is a patient in whom airway assessment was normal without suspicion for any difficulty, the processes of induction and intubation were accomplished without any complications or untoward events, and perioperative changes to the patient’s airway were deemed minimal to no changes at all. The patient deemed at risk of complications associated with extubation may be viewed as the inverse of the low-risk patient. Several factors may result in a patient being deemed at risk of extubation-associated complications (Tables 3 and 4). Patient factors include difficult to intubate, difficult to ventilate with bag-valve-mask, and substantial changes to the airway perioperatively (Table 4). Or, there may be devices or circumstances that severely restrict access to the patient’s airway in the immediate postoperative period, such as a halo device for cervical traction or the wiring together of the patient’s jaws following orthognathic surgery (Table 3). The anesthetist must be knowledgeable of additional generalized factors that may influence the decision on whether the patient should be extubated: cardiovascular or hemodynamic stability, patient temperature abnormalities (hypothermia or hyperthermia), coagulopathy, acid-base abnormality, electrolyte derangement, respiratory tract impairment, and neurologic or neuromuscular impairment.

**Step 2: Extubation Preparation**
Following planning for extubation, the patient must be prepared for extubation. This step involves optimizing
the patient and the prevailing conditions surrounding the patient to provide the best opportunity for extubation to be successful. As always, the primary objective is for the patient to be self-sustaining and maintain his or her airway with little to no external assistance. The extubation preparation period is also the time when the anesthetist should scrutinize the patient and any associated conditions or comorbidities to better stratify the patient’s extubation risk. The goal is to determine whether the patient remains at low risk or whether conditions have changed such that the patient has become at risk. It is during the preparation for extubation that the anesthetist should complete the planning and equipping of a backup or fallback plan should the patient be extubated but fail to be self-sustaining. This preparatory time is characterized by constant assessment and reassessment that must be conducted via a logical progression, starting with the airway in general. Some general questions must be asked and answered. Is there airway edema? Is there active bleeding and/or blood clots that may result in airway obstruction? Has the patient’s airway been traumatized in any way by either the surgical procedure or the intubation process? Is it possible or probable for any foreign bodies to be near the patient’s airway? Has the patient’s airway become distorted in any way?

The larynx can be assessed by using a cuff-leak test (CLT; Table 5). Although seldom employed in the operating room setting, the CLT can help the anesthetist learn whether there is some degree of laryngeal edema, but may also indicate the presence of some other occlusive mechanism.20 A CLT entails determination of the presence of air escape around an appropriately sized ET tube as an evaluation tool for the potential development of postextubation stridor. An abnormal or “positive” CLT result occurs where there is an absence of air leakage around the ET tube, while a normal or “negative” result occurs when air does leak around the ET tube. Should the CLT result be “negative,” the anesthetist must maintain vigilance in completing further assessment of the lower airway to determine the presence or absence of trauma to the lower airway, edema, increased secretions, or possibly the presence of an infectious process. The anesthetist should also evaluate the patient for possible signs and symptoms of pneumothorax, endobronchial intubation, subcutaneous emphysema, or any other lung abnormality.

On completion of the assessment of the various aspects of the patient’s airway, the anesthetist must contemplate potential exogenous factors that may affect the decision to extubate. Gastric distention is a distinct possibility, especially if bag-valve-mask ventilation was difficult before intubation. The stomach may have been inflated during attempts to ventilate the patient if the positive pressures generated were excessive. Gastric inflation/distention may press on the diaphragm, thus interfering with spontaneous breathing.

The anesthetist must be cognizant of the state of the patient’s neuromuscular functioning. The patient’s train-of-four (TOF) ratio should ideally be 0.9 or higher to give the patient the greatest chance to sustain spontaneous respiratory efforts. The most accurate measurement method for assessing neuromuscular blockade via the TOF is the accelerometer. Simply described, an accelerometer is a measure of the rate of angular acceleration using a piezoelectric transducer. The piezoelectric transducer measures changes in pressure, acceleration, temperature, strain, or force by converting those measurements into an electrical charge. The measurement made with the accelerometer is an application of the Newton Second Law:

\[ F = ma \]

where \( F \) is Force, \( m \) is mass, and \( a \) is acceleration. The accelerometer appears similar to a traditional nerve stimulator (with the exception of the piezoelectric transducer), which may be placed on the thumb or on the corrugator supercilius muscle (Figures 1 and 2) when the thumb is not available.21,22 Across the spectrum of general anesthetics administered, postoperative residual neuromuscular blockade is frequently encountered at the end of a procedure and even into the PACU admission. Therefore, when neuromuscular blockade is required to

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**Table 4. Perioperative Causes of Airway Changes**

- Head/neck surgery
- Maxillofacial surgery
- Obesity (body mass index > 30 kg/m²)
- Obstetrics
- Obstructive sleep apnea
- Surgical positioning
- Upper airway surgery

**Table 5. Test for Endotracheal Tube Cuff Leak**

1. Place the intubated patient in the semi-Fowler position
2. Perform intratracheal and intraoral suctioning
3. Place the patient on assist-control ventilation
4. While endotracheal (ET) tube cuff is inflated, measure
   a. Minimum occlusion volume
   b. Mechanical exhaled volume
5. Deflate ET tube cuff
   a. Observe 6 respiratory cycles’ mechanical exhaled tidal volumes
   b. Record the average of the 3 lowest exhaled volumes
6. Calculate the cuff leak by the following formula

\[
\text{Mechanical exhaled volume}_{(\text{cuff inflated})} - \text{Average of 3 lowest exhaled volumes}_{(\text{cuff deflated})}
\]
facilitate a surgical procedure, that blockade should be reversed to optimize the patient's return to preanesthetic muscle strength, thus affording the best chance to sustain the patient's own airway control.

The anesthetist must review the patient's cardiovascular state in conjunction with his or her fluid balance. The anesthetist should also scrutinize the patient's acid-base balance, electrolyte levels, and coagulation state where possible, particularly following intricate, complex surgical procedures. Obviously, obtaining new laboratory values for each of these parameters is not feasible for every surgical procedure. However, a review of the preoperative laboratory data in conjunction with the conditions present at or near the end of surgery and emergence from general anesthesia may be suggestive of the potential future course. Any derangements should be evaluated and corrective interventions initiated before the anesthetist proceeds with extubation. Before extubation, the patient should be, or at least appear to be, comfortable. The anesthetist should strive to provide an adequate level of analgesia so that the patient can deep breathe postoperatively without an undue degree of discomfort and/or splinting. The level of analgesia can be a joint effort between surgeon and anesthetist, with the surgeon infiltrating local anesthetic into the surgical wound and the anesthetist using a multimodal method for analgesia, including dexamethasone, opioids, nonsteroidal anti-inflammatory drugs, and regional blockade where appropriate.

**Step 3: Execution of Extubation**

Planning and preparation for extubation are directed toward the end action at completion of the surgical procedure: the final evaluation of the patient regarding extubation. Should this patient be extubated when the surgical procedure is completed? Or, should this patient be transferred to the intensive care unit (ICU) or PACU while still intubated, to receive ongoing ventilator assistance (which may range from humidified oxygen via T-bar or fully mechanically ventilated with positive pressure ventilation)? Proceeding to extubation of the patient must be approached with caution, monitoring, and available equipment, as was employed to accomplish the intubation. If the patient was particularly difficult to intubate, such that video or fiberoptic laryngoscopy was required, prudence dictates the same method employed to accomplish intubation be present at the time of extubation in the event the extubation fails immediately and reintubation becomes necessary.

On extubating the patient, the anesthetist must strive for minimal to zero interruption of delivery of supplemental oxygen to the patient's lungs. The process of extubating the patient can be aided greatly by administration of 100% oxygen for several minutes before extubation. In essence, this is a reverse preoxygenation, with the same goals in mind as preoxygenation: maximization of the patient's oxygen stores and achievement of an exhaled oxygen concentration (FeO₂) of 0.9 or higher, or as close to the inspired oxygen concentration (FiO₂) as possible.

To the author's knowledge, there is no currently available evidence that conclusively and universally supports an optimal patient position for extubation. Logically, placing the patient in a position that contributes to maximization of functional residual capacity while also reducing the work of breathing would be welcome and beneficial. Such benefits can be obtained by placing the patient in 10 to 15 degrees of reverse Trendelenburg position or
in the dorsal recumbent or semi-Fowler positions. Any of these positions employ gravity to pull the abdominal contents away from the diaphragm and thoracic cavity to afford better inspiratory efforts and lung expansion. There is an increasing trend for use of these positions at or immediately following extubation. Placing an obese patient in one of these positions may prove particularly beneficial. However, the anesthetist must not elevate the head of the bed too far because gravity can then work against the intent of the positioning of the bed and the still drowsy patient may slump to the degree that lung expansion and deep breathing is not properly accomplished.

Before extubation, the oropharynx should be cleared of secretions and/or any blood. The accumulation of secretions and/or blood may potentially stimulate the patient’s airway, leading to partial or complete obstruction or, potentially, laryngospasm. Traditionally, any such potential stimulants have been removed using oropharyngeal suctioning. More often than not, oropharyngeal suctioning is accomplished by blindly inserting the suction device into the oral and pharyngeal cavities and sweeping around the boundaries to remove any liquids that have accumulated there. The most recent guidelines from the DAS recommend that oropharyngeal suctioning be undertaken in a safer manner—under direct vision using direct laryngoscopy—while the patient is sufficiently anesthetized so as not to cause patient movement that may be problematic for the surgeon or may contribute to patient harm. Suctioning deep into the oropharyngeal area is especially recommended to be accomplished via direct vision because of the potential for severe trauma to the surrounding tissues by suctioning blindly. Such a recommendation, however, represents a major shift in current practice for most anesthetists. Alveolar recruitment methods have proved efficacious during the intraoperative period to reverse atelectasis; however, those interventions have yet to demonstrate benefits in the immediate postoperative period. When the patient is extubated during the peak of a sustained positive pressure inspiration, the patient will necessarily exhale forcefully, thus forcefully expelling any accumulated secretions and blood, to aid in a reduction of the possibility of laryngospasm and/or breath holding.

The final aspect of extubation is avoidance of airway stimulation as much as possible. There are 2 established methods for executing extubation: keeping the patient fully awake or deeply anesthetized. Having the patient fully awake at the time of extubation has long been viewed as a safer option. The patient who is fully awake should exhibit a better ability to maintain his or her airway and not require external assistance because this patient should have experienced better return of airway muscle tone and better airway reflexes, along with better spontaneous respiratory drive. However, the fully awake patient is more likely to demonstrate major increases in cardiovascular tone—elevated blood pressure and heart rate—along with a concomitant substantial increase in cardiac metabolic oxygen requirements. The increased cardiac metabolic oxygen requirements may result in an increased potential for cardiac ischemia and ischemic injury, particularly in patients with poor cardiac reserves.

Executing extubation in a patient who is deeply anesthetized should not be undertaken by an anesthetist who has minimal posttraining experience. This option also should not be employed in any patient whose airway management following extubation is expected to be challenging or difficult. By employing the option of extubating the patient while deeply anesthetized, the anesthetist may greatly decrease the incidence of coughing or bucking on the ET tube, which, in turn, may translate to a reduction in cardiovascular or hemodynamic surges associated with coughing and bucking. The patient who is extubated while still deeply anesthetized has a decidedly greater risk of upper airway obstruction. Because of this greater risk, the anesthetist must maintain more vigilance to see this patient through the process of emerging from general anesthesia until the patient is fully awake and demonstrates intact airway reflexes and control.

There is a third option for execution of extubation of the patient—an intermediate option. This intermediate option incorporates the advantages of decreased cardiovascular stimulation seen with extubation while the patient is deeply anesthetized with being able to maintain a secure airway through the process of emergence from general anesthesia. This option is generally known as the Bailey maneuver. The Bailey maneuver was first proposed in 1995. Use of the Bailey maneuver allows the anesthetist to extubate the patient who is deeply anesthetized, yet maintain greater control of the patient’s airway through the process of emergence from general anesthesia. The Bailey maneuver is accomplished by replacing the ET tube with a laryngeal mask airway (LMA). This replacement maneuver should be undertaken with the patient deeply anesthetized. There are 2 options for accomplishing the replacement maneuver: (1) The LMA can be inserted to the proper position while the ET tube remains in place, after which the ET tube is removed, or (2) the patient may be extubated, followed immediately by insertion of the LMA. Employing the LMA affords the anesthetist greater control of the patient’s airway, with a degree of protection from blood and/or secretions, without the patient enduring the heightened cardiovascular/hemodynamic stimulation associated with the ET tube. Use of the Bailey maneuver can prove particularly beneficial when patients have severe cardiac disease, when they smoke, or when they have asthma, and/or there is a substantial risk of disruption of the surgically accomplished repair secondary to the emergence process when the ET tube is in place. The original presentation of the Bailey maneuver described...
In the patient deemed at risk of extubation-related complications, extubation may be a slightly less risky proposition if an airway exchange catheter (AEC) is used, particularly for any patient for whom reintubation is considered a very likely outcome following extubation. An AEC is a thin, hollow, long tube. The AEC must be inserted more than 25 cm in an adult patient. The flow rate for insufflation of oxygen via the AEC, if such an intervention becomes necessary, should never be more than 1 or 2 L/min, and there must be an escape route for any excess gas in order to lessen the potential for barotrauma.

After the anesthetist has carefully considered all variables, the patient is classified as either low risk or at risk of complications associated with extubation or extubation failure (Table 7). The moment arrives when the anesthetist must make the final decision whether to extubate the patient. For patients classified at low risk,
the progression to that decision may be a rather straightforward conclusion and will likely be the scenario found in most extubations that are undertaken. With extubation of the patient, be it with the patient fully awake, deeply anesthetized, or via use of the Bailey maneuver or an AEC, the anesthetist must administer 100% oxygen via the anesthesia circuit or bag-valve-mask. Following the extubation, the patient should be observed while still in the operating suite for a short time to assess the patient for the ability to maintain his or her airway, indicated by the rate and quality of the patient’s respiratory efforts. With an adequate, patent airway having been established, the low-risk patient may progress on to Step 4: Recovery and Follow-up (see next section).

If the patient has been deemed at risk, the anesthetist may determine that this patient has not sufficiently demonstrated the ability to independently maintain the airway following extubation. Therefore, it may be prudent to delay extubating the patient. But, how long should extubation be delayed? The delay may be for as short a time as required for transportation to the PACU or as long as a day or days following the surgery—and then under the purview of pulmonary and critical care specialists. The exact answer to the duration of the delay in extubation will ultimately be dictated by the patient. By delaying the extubation, the anesthetist affords the patient time to resolve any mechanical and/or physiological problems that would be detrimental to the newly extubated patient. Delaying the extubation may prove particularly beneficial if the complexity of the surgical procedure might require another journey to the operating room within the ensuing 24 hours; this becomes even more prudent if the patient has a difficult airway.

Should the anesthetist ultimately determine postponement of extubation to be the proper course of action, a dialogue must occur between the anesthetist and the surgeon concerning the length of time that the patient may need to remain intubated. If the anticipated duration for continuation of the ET tube for the patient is 24 hours or less, the patient should receive sedation via an established facility sedation protocol to keep the patient calm and minimize discomfort—both surgical and ET tube related—so the patient will better tolerate any ventilator support required. If the delay is anticipated to be long, whether because of preexisting comorbidities or the just completed surgery, the anesthetist and surgeon should engage in a frank discussion about the need or desire for a tracheostomy. There are 4 factors/questions that should be integral to the discussion regarding performing a tracheostomy17: (1) When this surgical procedure is completed, to what extent will this patient’s airway be compromised? (2) What is the probability that this patient’s airway will deteriorate postoperatively? (3) How easy or difficult will it be to rescue the patient’s airway if necessary? (4) What period might this patient’s airway be greatly compromised?

If the patient does require long-term airway support, having that support in the form of continuous presence of the ET tube incurs substantial risk of vocal cord damage. Placement of a tracheostomy greatly reduces the risk of potential long-term injury. A tracheostomy tube in place may also afford the patient a more rapid, while safe, emergence from the general anesthetic. The presence of the tracheostomy tube would also alleviate concerns about unintentional extubation and the potential inability to ventilate and/or reintubate the patient.

### Step 4: Postextubation Care, Recovery, and Follow-up

Completion of the surgical procedure and tracheal extubation signal the beginning of one of the anesthetist’s most challenging periods of care: transportation of the patient to the PACU. It is imperative to deliver supplemental oxygen to the patient from the moment of extubation through and into PACU admission. The challenge is found in the paucity of available equipment for the anesthetist to use to successfully deal with any airway emergency that may arise during transportation and early during the PACU admission. This vulnerability may be amplified by manifestation of any residual effects from anesthesia-related medications and possibly effects secondary to the surgical procedure.

On arrival to the PACU, there must be good communication between the anesthetist and the PACU nurse. For the patient in whom airway difficulties were encountered and continue to cause concern, there should be a nurse dedicated to that patient’s care for the initial period of the PACU admission until the patient’s protective airway reflexes return and the patient is considered physiologically stable. There must be a very clear verbal handover communication from the anesthetist to the PACU nurse, in which the anesthetist specifically delineates all problems that were encountered with the patient’s airway at any time across the intraoperative period. Ideally, there should be at least 2 PACU staff members present, particularly with admission of a patient who experienced any critical events across the perioperative period. The PACU nurse may also benefit from a receiving clearly written, detailed instructions and postoperative orders specifically concerning the patient’s time in the PACU and continuing care following PACU recovery and transfer to the general ward or ICU setting. When the patient

### Table 7. Causes and Mechanisms of Extubation Failure

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<tr>
<th>Cause</th>
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<tr>
<td>Laryngeal obstruction</td>
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<tr>
<td>Lesions</td>
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<tr>
<td>Lingering effects of perioperative medicines</td>
</tr>
<tr>
<td>Masses</td>
</tr>
<tr>
<td>Pharyngeal obstruction</td>
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<tr>
<td>Postoperative bleeding</td>
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1. For more information about causes and mechanisms of extubation failure, see the article’s Table 7.

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has been successfully transferred to the PACU, an experienced anesthetist should continue to be readily available to rescue the patient’s airway if an emergent or urgent situation arises—regardless of the time of day.

When the patient is admitted to the PACU, he or she requires very close monitoring. There should be almost zealous nurse-patient interactions to maintain an ongoing assessment of the patient’s level of consciousness and intensity of pain while the nurse is measuring blood pressure, heart rate and rhythm, respiratory rate, temperature, and pulse oximetry. Capnography, where available, can be an invaluable addition to PACU monitoring patients with a difficult airway because detection of airway obstruction can be accomplished earlier, which is something for which pulse oximetry was not designed. Pulse oximetry may generate a false sense of security because of the potential for incorrect readings. Problems with the patient’s airway are apt to develop quickly, with little to no warning and at any time following extubation. Agitation, obstructed breathing, stridor, and excessive somnolence are early signs of airway insult. These signs of airway insult may be the result of the loss of a surgical site drain or drains, hematoma, bleeding into the airway, airway edema, and problems with perfusion to a free flap. The airway problem may not become evident until the patient has been discharged from the PACU to a general ward, and it may be secondary to mediastinitis and/or occult airway injury (Table 8). It is incumbent on both the anesthetist and the PACU staff to be attentive for any patient complaint of difficulty breathing as well as any instance of the patient becoming increasingly agitated, even when there are no overt signs and symptoms of respiratory distress or insult.

Airway edema resulting from inflammation may be reduced by administration of a corticosteroid. These agents will prove ineffective in treating airway edema that is generated by a mechanical process, such as venous obstruction or neck hematoma. It is not so important which corticosteroid is administered for preventing inflammatory airway insult or edema. The important factor is that the corticosteroid selected be administered at an adequate dose. Currently, an adequate regimen entails administration of a dose equivalent to hydrocortisone, 100 mg every 6 hours. For those patients deemed to be at highest risk of inflammatory airway edema, it is appropriate to initiate corticosteroid therapy as early as possible and continue the therapy for at least 12 hours postoperatively. Administration of a single dose of corticosteroid shortly before extubation has been found not to be efficacious. Epinephrine can also be helpful in reducing airway edema that may be present. If stridor or upper airway partial obstruction develops, nebulized administration of racemic epinephrine may contribute to the reduction of the partial obstruction and stridor. Helium-oxygen gas, or heliox, is a commercially prepared but seldom used admixture of the gases helium and oxygen, with an FIO2 of 21%, 30%, or 40%. This gas admixture has a long history as an available alternative to aid in the delivery of oxygen past or through an edematous airway. Thus, if the anesthetist employs heliox, he or she must be aware of the potential limitations of the FIO2 that can be delivered.

Patients deemed at risk should be closely observed beyond their time in the PACU. Such an at-risk patient should continue to fast and not drink liquids for 6 hours following extubation so that the risk of aspiration of gastric contents is minimized if extubation fails and reintubation becomes necessary. The anesthetist should also remember, and communicate to the nursing staff caring for the at-risk patient, that extubation failure can occur as long as 72 hours following extubation.

Extubation failure seldom occurs in the early postextubation period in postoperative, elective surgical patients in whom planned extubation has been completed; the incidence of extubation failure in such patients is about 0.1% to 0.45%. Early extubation failure, when it occurs, whether in ICU or PACU patients, is most often believed to be secondary to laryngeal edema. The edema is usually encountered within an hour of extubation and only rarely when 24 or more hours have elapsed following extubation.

Conclusion

One of the primary functions of the anesthetist is assumption of control and protection of the airway of the surgical patient. This basic tenet of the practice of anesthesia is made more challenging when the patient presents with a difficult airway. Over the previous 20 to 25 years, methods and evaluation tests have been developed to predict which patient may have a difficult airway to afford better preprocedural planning. When a patient presents with a probable difficult airway, the anesthetist conducts extensive preparations and consultations/conversations geared toward maximizing the success in securing the patient’s airway. Despite these tests and evaluations, there are still patients who have an unexpectedly difficult airway. After a difficult airway has been secured, a sense of relief and relaxation may envelop the anesthetist and members of the perioperative team, often all the way to the conclusion of the surgical procedure and emergence from general anesthesia. It is imperative that preparations for the completion of surgery and anesthesia be equally extensive and meticulous. A multitude

Table 8. Signs and Symptoms of Mediastinitis

<table>
<thead>
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<th>Sign or Symptom</th>
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<tr>
<td>Chest pain</td>
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<td>Crepitus</td>
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<tr>
<td>Deep cervical pain</td>
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<tr>
<td>Dysphagia</td>
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<tr>
<td>Fever</td>
</tr>
<tr>
<td>Painful swallowing</td>
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<tr>
<td>Severe sore throat</td>
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These signs and symptoms of mediastinitis are important to recognize and communicate to the nursing staff so that it can be treated as early as possible. The at-risk patient must be known as someone who will require ongoing assessment and monitoring; this is something that cannot be done by any single individual, especially when many of the above signs and symptoms are subtle. Throughout the perioperative time, there should be constant communication between the anesthesia team and the PACU team, including the anesthetist, the PACU nurse, and the patient. The at-risk patient must be known as someone who will require a clear and ongoing plan to avoid the complications that can arise from mediastinitis.
of factors may contribute to altering the patient’s airway such that a normal airway on induction and intubation becomes a difficult airway at the end of the surgical procedure, or that a difficult airway initially may become even more difficult. Because of these numerous factors, the anesthetist must always keep in mind that extubating the patient with a difficult airway—or any patient for that matter—is an elective procedure. Extubation is not mandatory. The anesthetist must understand that a patient’s progression toward extubation is a constant evaluation process that is initiated before the induction of general anesthesia and attempted tracheal intubation.

REFERENCES


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DISCLOSURES

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