Review

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Airway Management of "At-Risk Extubation'" in Intensive Care

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Abstract

Extubation failure due to airway problems is rare in critically ill patients. Intensive care mortality and morbidity among patients having extubation failure due to airway problems are less than among those requiring re-intubation due to respiratory failure. This is due to the fact that the latter group of patients is mostly comprised of postoperative patients. Postoperative extubation failure may arise because of many possible mechanical problems due to the patient, surgery or anesthesia. Problems which cause the obstruction of upper airways may not give symptoms until tracheal extubation is performed. Obesity, obstructive sleep apnea syndrome, major head and neck surgery, upper airway surgery and cervical column operations are hazardous conditions affecting extubation success. Upper airway obstructing conditions like edema, soft tissue collapse and laryngospasm are frequently observed in this group of patients and because of these conditions, it may become hard to ensure airway integrity after extubation. For this reason, it is necessary to identify the postoperative patients who are expected to have difficult extubation processes and to transfer them to intensive care unit for a careful and planned extubation process. In this review, an efficient strategy for a successful extubation will be explained for patients having high risks for extubation failure and difficult airway problems.

Keywords: At-risk extubation, difficult airway, intensive care

INTRODUCTION

Extubation failure is defined as the "inability to tolerate the removal of a translaryngeal tube," and it generally requires re-intubation. The role played by the removal of an artificial airway is the primary cause of extubation failure rather than that played by the termination of mechanical ventilation. The reasons for extubation failure include airway-obstructing conditions such as laryngospasm; upper airway edema; external compression of hematoma due to bleeding over the airway or internal obstruction of the airway by blood clots; accumulation of respiratory secretions; tracheal collapse due to tracheomalacia; and collapsed soft tissues of the upper airway resulting from the effects of anesthetics, opioids, and muscle relaxants (1, 2).

At-risk extubation is defined as the conditions in which it is difficult to ensure oxygenation or airway integrity after extubation.

This condition can be associated with many mechanical reasons related to surgery or anesthesia as well as the patient. For successful extubation, it is important to evaluate airway integrity and airway reflexes at the preparation stage. For intensive care patients, weaning parameters seem insufficient to evaluate airway integrity and to predict extubation failure. In these situations, risk analysis must be performed by considering airway-related factors and clinical conditions; at-risk patients who can suffer from extubation difficulty, particularly during the postoperative stage, must be determined. They must be taken into the intensive care unit (ICU), and extubation must be performed carefully (3, 4). In this review, we attempt to prepare a schema by considering the current recommendations and guidelines regarding the management of patients taken into the ICU for the possibility of at-risk extubation due to difficult airways.

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Determination of Extubation Failure Risk

Re-intubations following extubation failure both in the ICU and in the postoperative period are observed to be performed immediately and 2 hours after extubation. They are rarely performed after 24 hours. Some authors use the term "early re-intubation" for the re-intubations performed within minutes or within 6 hours after tracheal extubation in the postoperative period and the term "late re-intubation" for the re-intubations that occur after 24 hours, which are rare. In the former case, larynx edema is a frequently observed cause of airway obstruction in the ICU and during the postoperative period. On the other hand, in the latter case, the factors contributing to airway obstructions include comorbid diseases, type of disease, and postoperative management (5-8). This can serve as guidance for clinicians regarding the time for which patients having difficult airways and extubation failure risk in the ICU should be monitored and the duration for which airway exchange catheters should be used, when necessary (9). The determination of patients with extubation failure risk begins with the determination of the factors that can cause extubation failure.

Factors That can Lead to Extubation Failure

a) Changes That Occur in the Airway During Anesthesia

Airway damage when administering anesthesia can be caused by the laryngoscope, tracheal tube, or other auxiliary airway devices. Periglottic trauma can develop because of the use of transesophageal echocardiography probes, nasogastric tubes, excessively wide tubes, high cuff pressure, or the inflation of the tracheal tube cuff in an inappropriate position. According to the data obtained from the American Society of Anesthesiologists (ASA), who have analyzed airway damages during anesthesia administration, damages occur in the larynx at a rate of 33%, in the pharynx at a rate of 19%, in the esophagus at a rate of 18%, in the trachea at a rate of 15%, in the temporomandibular joint at a rate of 10%, and in the nose at a rate of 5%. Vocal cord paralysis (34%) is more frequent among laryngeal damages, followed by granuloma (17%), arytenoid dislocation (8%), and hematoma (3%). With regard to laryngeal damages, 85% occur during short-term tracheal intubations and 80% occur during routine (not difficult) intubations (10, 11).

b) Complications That Develop During Operation

An airway that is normal before an operation can deteriorate after surgical interventions performed in or around the airway and can lead to problems after extubation. Thyroid, maxillofacial, cervical colon, carotid, and other head-neck surgeries are risky operations in terms of the airway. Airway damage in such surgeries can occur directly, such as hematoma, edema, and impaired lymphatic drainage (12, 13).

c) Restricted Access to the Airway After Operation

In some situations such as maxillofacial, neck, and upper respiratory tract surgeries, access to the airway, which is easy at the beginning of the operation, can be difficult after the operation because of some factors such as halofixation, mandibular wiring, surgical implants, and cervical colon fixators.

d) Patient-Related Factors

According to the 4th National Audit Project of the Royal College of Anesthetists and the Difficult Airway Society (NAP4), the rate of severe complications after extubation is reported to be 0.001%. The most common comorbidities in this group are obesity (46%), chronic obstructive pulmonary disease (34%), and obstructive sleep apnea syndrome (OSAS) (13%). The mortality rate is 5%. The cumulative death rate and severe morbidity rate (including resuscitation after cardiac arrest and brain damage) have been found to be 13% (14). Therefore, patients must be carefully evaluated in terms of the presence of obesity and OSAS.

Obesity and OSAS

Obesity is defined as the situation in which the body mass index exceeds 30 kg/m^2. OSAS is characterized by partial or complete periodical obstruction of the upper respiratory tract during sleep. Approximately 71% of morbidly obese patients suffer from OSAS. Difficult ventilation with a mask is more common in obese patients during the perioperative period. The risks of aspiration, airway obstruction, and rapid oxygen desaturation is more frequently observed in such patients. The frequency of difficulty in intubation is reported to be 7.5% in morbidly obese patients. In the 2005 ASA "Closed Claims" database, it is specified that 156 out of 165 perioperative airway events (42%) occur in obese patients; this rate is 42% (77/184) according to NAP4 data. However, it is specified that this high rate does not increase the duration of hospitalization and mortality, particularly in moderately obese patients. The points to take into consideration, which are related to the respiratory tracts of obese patients, are as follows: these patients have increased sensitivity toward respiratory suppressive effects of opioids and anesthetics; the risk of hypoxemia is increased; and the position of the patient is important (the supine position should be preferred, if possible). In the study on obese patients who suffered from snoring and underwent elective surgery under our supervision, the heads of the patients were maintained in the supine position without performing hyperextension. The base of the tongue and the larynx of these patients were viewed through an endoscope while administering anesthesia. It was found that the obstructive effect of the tongue base apparently decreased with the jaw thrust maneuver in the supine position and the retroglossal airway opened significantly. Moreover, continuous monitoring is necessary for the early detection of cardiac and respiratory impairments of these patients (for instance, using a pulse oximeter and capnography) (15-24).

Chronic Obstructive Pulmonary Disease (COPD)

Although the rate of extubation failure is reported to be between 35% and 67% in patients having COPD and needing mechanical ventilation, no obvious data exist on extubation failures occurring because of non-protected airway integrity. Airway secretions increasing with chronic bronchitis can lead to extubation failure in COPD patients. Adequate cough reflex and cough force before extubation are important for the excretion of secretions in this patient group. In a previous study, it has been specified that patients demonstrating a high amount of secretion before extubation exhibit an 8-fold increased risk of re-intubation. In another study, it has been reported that COPD patients needing aspiration at 2-hours or shorter intervals have a 16-fold increased risk of re-intubation. Therefore, the quantitative measurement or subjective grading of the amount of secretions before extubation in COPD patients is used for predicting successful extubation (25-27).

Head-Neck Pathologies

Tracheal re-intubation in the presence of head-neck pathologies and after maxillofacial or major neck surgery is reported to be between

0.7% and 11.1%. According to NAP4 data, the rate of negative airway events is specified to be 39.1% in patients with acute or chronic neck pathologies. Of these cases, 41.3% are related to anesthesia and others occur in the ICU or emergency services (28, 29).

Extubation is not simply the reversal of tracheal intubation. In general, the conditions during extubation are not as appropriate as those during intubation and induction. According to both ASA "Closed Claims" and NAP4 data, negative outcomes often develop because of the lack of necessary preparation (often in the presence of head-neck pathologies and changes after surgery) (14, 21). Therefore, it is recommended that extubation must be an elective process, and plan and equipment must be effectively prepared before this process. Oxygen support after extubation must be provided without interruption, and there must be a plan for re-intubation that can be rapidly implemented in case of failure. In this sense, a route that can be safely managed from the decision of extubation until the implementation of extubation must be followed. A step-by-step approach including planning, preparation, and implementation of extubation and monitoring after extubation is recommended (3).

I. Planning at-Risk Extubation

An extubation plan begins with the evaluation of airways and general risk factors of the patient. Whether risk factors related to airways are present, whether the airway is normal or complicated, and whether the anatomical structure changes during an operation must be investigated.

II. Preparation of at-Risk Extubation

A successful extubation must begin with the optimization of the airway that involves general and logistical factors. The preparation of a plan involves the risk evaluation of extubation. In the case of failure in the continuance of the airway after extubation, all the preparations for re-intubation must be made.

a) Evaluation of the Airway in Terms of Appropriateness for Extubation

At the beginning, the physician must identify whether balloon-mask ventilation can be easily performed after extubation. The presence of edema, bleeding, clot, trauma, and foreign body in the airway and distortion of the airway can be evaluated through direct or indirect laryngoscopy. A tracheal tube can inhibit the evaluation of the larynx through direct laryngoscopy. Although the airways appear normal, edema can develop after extubation. For assessing the subglottic region, a cuff-leak test is performed. Clinically, there must be an audible air leakage when the cuff of the tracheal tube is pulled downward. The lack of air leakage after pulling down the cuff of the tracheal tube in an appropriate manner shows that extubation will not be safe. A spirometer provides quantitative evaluation of the cuff leakage; although it has high sensitivity, its specificity is low (14).

With regard to cases in which intubation is difficult and oxygenation is suboptimal during surgery, chest radiography can be required for ruling out bronchial intubation, pneumothorax, surgical emphysema, and other pulmonary complications. A distended stomach can make respiration more difficult by pushing the diaphragm. Therefore, the decompression of the stomach can be needed before extubation. For cases in which ventilation is performed through a facial mask or supraglottic airway techniques, gastric decompression must be performed via an oral or nasogastric tube.

b) Optimization of Anesthesia-Related Factors

For the control of protective airway reflexes and upper airway secretions, it must be ensured that the effect of neuromuscular blockers disappears completely. It must be remembered that when peripheral nerve stimulation is used for evaluating the return of the effects of neuromuscular blockers, the train-of-four (TOF) ratio of 0.9 and above is significant. Compared with visual elevation, an accelerometer provides safer results for the TOF response (30).

"Awake extubation," in which the airway tone, airway reflexes, and respiratory drive return to normal and patients maintain airways on their own, is the primarily preferred extubation method after surgery. On the other hand, in the extubation performed under deep sedation, it is aimed to minimize hemodynamic changes that result from coughing and the movement of the tracheal tube; however, there is a risk of obstruction of the upper airway. Extubation under deep sedation should be preferred only in patients for whom airway management can be performed easily and there is no risk of aspiration. The risk of airway obstruction can be reduced by changing the tracheal tube with a laryngeal mask (LMA) (31).

Suppression of Cough Reflex

The use of opioids such as alfentanyl, fentanyl, and morphine can suppress cough reflex. Short-acting remifentanil via an infusion can be preferred at this stage, but it must be administered carefully. Increased sedation can also lead to respiratory depression in addition to the suppression of cough reflex. For decreasing coughing, lidocaine can be employed topically, through a tube, or intravenously. In order to reduce cardiovascular and respiratory changes, opioids, calcium channel blockers, magnesium, lidocaine, clonidine, ketamine, and beta blockers can be used. Doxapram is used for preventing laryngospasm and/or preventing it. Steroids are preferred for decreasing airway edema. However, if steroids are to be used for this aim, they must be given at least 1 hour before the operation (32-34).

III. Implementation of Extubation

At-risk extubation involves potential complication risk and risk factors. Whether there will be a need for an advanced technique at the end must be decided. There are several equipment and advanced techniques for performing at-risk extubation. However, none of these techniques are sufficient alone for resolving problems in all the at-risk patients. The practicality of a technique and the experience of a team must absolutely be evaluated as well as the risks of the procedure.

I. Exchange with LMA (Bailey Maneuver)

Surgical repair can be negatively affected by cardiovascular stimulation associated with the tracheal tube. For patients in whom the tracheal tube must be removed under stable physiological conditions without stimulating the patient airway, the tracheal tube is exchanged with the LMA for the maintenance of the airway (Figure 1). The insertion of LMA in non-intubated patients is shown in Figure 2. It can be used in patients with a sensitive airway, such as smoking or asthmatic patients. This method is not suitable for patients with difficult and risky re-intubation or with regurgitation. An adequate level of sedoanalgesia is essential for the prevention of laryngospasm. Initially, the patient is oxygenated with 100% oxygen. For preventing airway stimulation, either deep anesthesia or neuromuscular blockade is performed. Aspiration is performed while monitoring using a

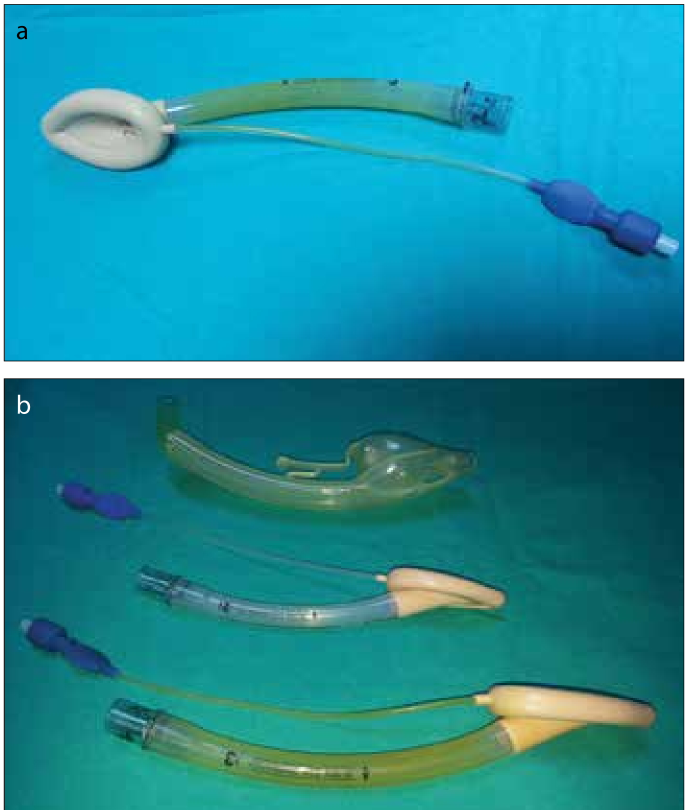

Figure 1. a, b. Laryngeal mask (LMA): It consists of a silicone mask with a size appropriate to the shape of the hypopharynx and covers the larynx as a gasket and a tube that is connected to that at an angle of 30°. There is an inflatable air pad around the mask

laryngoscope. LMA is inserted behind the tracheal tube, and the tip and position of LMA are fixed. While deflating the cuff of the tracheal tube, LMA is inflated and the tube is pulled (Figure 3). Oxygen is continuously administered to the patient; the patient is maintained in a semi-sitting position while the effect of anesthesia disappears. There are other techniques similar to the Bailey maneuver, in which the tracheal tube is exchanged with LMA. In one of them, the tracheal tube is removed before the insertion of LMA, the pharynx is aspirated with the help of a laryngoscope, and LMA is placed. In the second method, the location of LMA is confirmed using a fiber-optic bronchoscope, the movement of the vocal cords is observed, and LMA is inserted either via the nasotracheal tube or by pulling onto the tracheal tube. This technique can be used in patients who have undergone thyroid or parathyroid surgery and whose airway integrity is impaired due to the stimulated airway (31, 35-38).

II. Extubation with Tracheal Tube Exchange Catheters

In patients who can have difficulty in re-intubation, the maintenance of the airway can be provided through tracheal tube exchange catheters. Tracheal tube exchangers used in patients with difficult airways are specially designed, semi-rigid, long, thin, heat-resistant, radio-opaque catheters that have holes in their distal-blind tips. Numbers etched on their external surface indicate their length. They have a connector on the proximal tip for providing oxygen support or ventilation with high pressure (jet ventilation) (Figure 4). Tube exchange catheters having different sizes are available. The ones that are more appropriate for extubation have a length of 83 cm, thickness of 11 and 14 F, internal diameters of 2.3 and 3 mm, and external diameters of 3.7 and 4.7 mm. These catheters are suitable for tracheal tubes with internal diameters of 4 and 5 mm. They were first developed by Bedger and Chang and were then used by Cooper in a patient group with 202 series (39, 40).

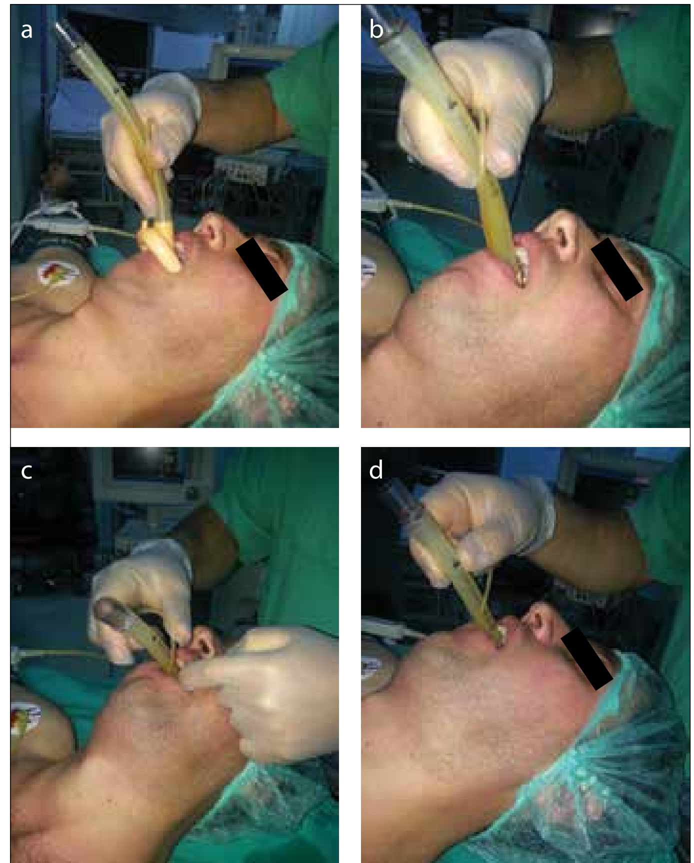

Figure 2. a-d. Insertion of laryngeal mask

Catheters exhibit a high success rate when used as a guide for re-intubation. The most important morbidity during the use of catheters occurs while providing oxygen support and in case of malpositioning of the catheter. Therefore, the distal end of the catheter must be at the middle point of the trachea. Barotrauma and fatal complications of oxygen insufflation and jet ventilation have been reported (41-43).

In the study of Mort (9), in which 354 patients were prospectively examined in terms of the safety and efficiency of tracheal tube exchange catheters for 9 years, the success rate of re-intubation at the first try was found to be high. Other complications were reported to be low oxygen saturation, bradycardia, hypotension, and esophageal intubation.

When a tracheal tube exchange catheter is used, the possible use of other airway devices in re-intubation decreases. In other studies on difficult airways, similar successful results have been reported. Monitoring the larynx using a direct or video laryngoscope increases the success rate of re-intubation and reduces complications (44, 45).

When a tracheal tube exchange catheter is used, oxygen support must be provided. If respiration deteriorates, its cause must be detected immediately. When an upper airway obstruction develops, oxygen

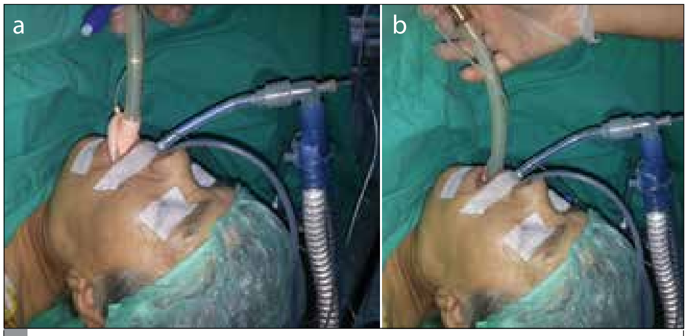

Figure 3. a, b. Bailey maneuver in which the tracheal tube is exchanged with the laryngeal mask

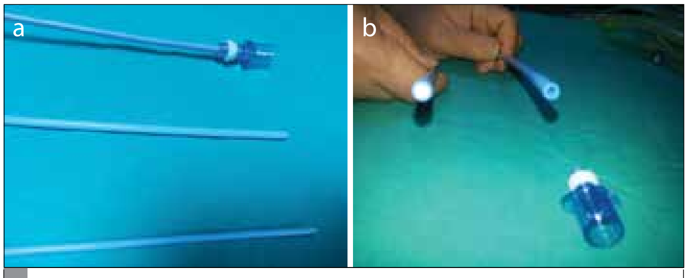

Figure 4. a, b. Tracheal tube exchange catheter and connector

support at high current must be administered through a facial mask instead of using a catheter. For improving the upper airway obstruction, standard airway maneuvers or additional airway devices can be used. Continuous positive airway pressure (CPAP) can be used with the facial mask. For decreasing airway edema, adrenalin or temporary helium-oxygen (Heliox) can be given through a nebulizer. Oxygen support via a tube exchange catheter should be given only in exceptional cases because it poses the risk of barotrauma. It must be ensured that the tip of the catheter is on the carina for allowing the passage of exhaled air. The current should not be above 1-2 L per minute (46, 47).

Re-intubation Using a Tracheal Tube Exchange Catheter

This process requires complete monitoring of the patient, an equipped team, and comprehensive equipment. The patient is maintained in a semi-sitting position. Further, 100% oxygen is supplied with CPAP through a facial mask. For re-intubation, soft and blunt-ended small tracheal tubes, through which a tracheal tube exchanger can pass easily, must be used. Anesthetic and topical agents must be employed, when necessary. Direct or indirect laryngoscopy can be used for drawing the tongue back and for pushing the tracheal tube. The location of the tracheal tube after re-intubation can be confirmed by capnography (3).

Jet Ventilation With a Tracheal Tube Exchange Catheter

The aim of jet ventilation via a tube exchange catheter is to protect the patient against life-threatening hypoxemia rather than ventilation. When the catheter is displaced or it moves toward the subcarinal region, jet ventilation can lead to serious complications. Therefore, this technique should be considered as the final alternative. It should not be used when expiratory flow and air leakage from the edge of the catheter are not possible. The air entrapped in the lungs can cause barotrauma. Providing the patency of the upper airway with airway maneuvers can help the prevention of barotrauma. There are many high-pressure ventilation sources. However, the safest pause pressure is 10-20 cm H_2O. Other maneuvers that can decrease barotrauma include using minimum inflation pressure, keeping the rib cage in a neutral position, and having a shorter time of inspiration. In addition to barotrauma, tracheal tube exchange catheters can cause the perforation of the tracheal mucosa and interstitial pulmonary emphysema because of reasons such as weak patient cooperation, poorly fixed catheter, or other airway manipulations (9, 41).

III. Extubation with Remifentanil

Symptoms such as cough, agitation, or hemodynamic impairment, which develop during the removal of the tracheal tube in patients having undergone intracranial, maxillofacial, or esthetic surgery and having severe cardiac or cerebrovascular comorbidities, can lead to critical problems. Remifentanil can resolve all these problems; it allows a patient to communicate in the awakened state and follow instructions and therefore increase the tolerance of the patient to extubation. Remifentanil infusion has been used for providing "conscious sedation" when performing fiber-optic bronchoscopy. In the same way, it has also defined in emergent cases and during extubation. The dose of remifentanil necessary for the suppression of cough during extubation is influenced by several factors, including the type of surgery, anesthesia technique, and patient's characteristics. Remifentanil infusion can be initiated intraoperatively and then continued until extubation or it can be initiated while planning extubation. A wide range of doses has been specified in the literature. The appropriate dose is generally a titration dose that will suppress the cough but not induce respiratory depression (48-53).

CONCLUSION

Extubation must be a completely elective process. In some situations, the postponement of extubation can prove to be the most appropriate choice. During this delay, airway edema decreases and the possibility of successful extubation increases. Existent opportunities and the experience of a team are important while performing extubation. If extubation is to be performed after transferring the patient to the ICU, there must be an extubation plan. The need for auxiliary equipment during extubation must be determined.

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REFERENCES

1. Epstein SK. Decision to extubate. Intensive Care Med 2002; 28: 535-46. [CrossRef]
2. Su WL, Chen YH, Chen CW, Yang SH, Su CL, Perng WC, et al. Involuntary cough strength and extubation outcomes for patients in an ICU. Chest 2010; 137: 777-82. [CrossRef]
3. 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: 318-40. [CrossRef]
4. Ko R, Ramos L, Chalela JA. Conventional weaning parameters do not predict extubation failure in neurocritical care patients. Neurocrit Care 2009; 10: 269-73. [CrossRef]
5. Ramachandran SK, Nafiu OO, Ghaferi A, Tremper KK, Shanks A, Kheterpal S. Independent predictors and outcomes of unanticipated early postop-

erative tracheal intubation after nonemergent, noncardiac surgery. Anesthesiology 2011; 115: 44-53. [CrossRef]
6. Hill RS, Koltai PJ, Parnes SM. Airway complications from laryngoscopy and panendoscopy. Ann Otol Rhinol Laryngol 1987; 96: 691-4. [CrossRef]
7. Wittekamp BH, van Mook WN, Tjan DH, Zwaveling JH, Bergmans DC. Clinical review: post-extubation laryngeal edema and extubation failure in critically ill adult patients. Crit Care 2009; 13: 233. [CrossRef]
8. Demirel CB, Katı I, Çankaya H, Hüseyinoğlu ÜA, Egeli E. Difficult tracheal extubation (case report). Turk J Anaesthesiol Reanim 2003; 31: 309-12.
9. Mort TC. Continuous airway access for the difficult extubation: the efficacy of the airway exchange catheter. Anesth Anal 2007; 105: 1357-62. [CrossRef]
10. Sandhu GS. Laryngeal and Esophageal Trauma. In: Flint PW,Haughey BH, Lund VJ, et al. Cummings Otolaryngology -Head and Neck Surgery. New York: Mosby Elsevier, 2010: 933-42. [CrossRef]
11. Domino KB, Posner KL, Caplan RA, Cheney FW. Airway injury during anesthesia: a closed claims analysis. Anesthesiology 1999; 91: 1703-11. [CrossRef]
12. Shaha AR, Jaffe BM. Practical management of post-thyroidectomy hematoma. Journal of Surgical Oncology 1994; 57: 235-8. [CrossRef]
13. Rosenbaum MA, Haridas M, McHenry CR. Life-threatening neck hematoma complicating thyroid and parathyroid surgery. Am J Surg 2008; 195: 339-43. [CrossRef]
14. Cook TM, Woodall N, Frerk C; Fourth National Audit Project. Major complications of airway management in the UK: results of the Fourth National Audit Project of the Royal College of Anaesthetists and the Difficult Airway Society. Part 1: anaesthesia. Br J Anaesth 2011; 106: 617-31. [CrossRef]
15. Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults--The Evidence Report. National Institutes of Health. Obesity Res 1998; 6(Suppl 2): 51S–209S.
16. Gross JB, Bachenberg KL, Benumof JL, Caplan RA, Connis RT, Coté CJ, et al. Practice guidelines for the perioperative management of patients with obstructive sleep apnea: a report by the American Society of Anesthesiologists Task Force on Perioperative Management of patients with obstructive sleep apnea. Anesthesiology 2006; 104: 1081-93. [CrossRef]
17. Frey WC, Pilcher J. Obstructive sleep-related breathing disorders in patients evaluated for bariatric surgery. Obes Surg 2003; 13: 676-83. [CrossRef]
18. Langeron O, Masso E, Huraux C, Guggiari M, Bianchi A, Coriat P, et al. Prediction of difficult mask ventilation. Anesthesiology 2000; 92: 1229-36. [CrossRef]
19. Kheterpal S, Martin L, Shanks AM, Tremper KK. Prediction and outcomes of impossible mask ventilation: a review of 50,000 anesthetics. Anesthesiology 2009; 110: 891-7. [CrossRef]
20. Kristensen MS. Airway management and morbid obesity. Eur J Anaesthesiol 2010; 27: 923-7. [CrossRef]
21. Peterson GN, Domino KB, Caplan RA, Posner KL, Lee LA, Cheney FW. Management of the difficult airway: a closed claims analysis. Anesthesiology 2005; 103: 33-9. [CrossRef]
22. Frat JP, Gissot V, Ragot S, Desachy A, Runge I, Lebert C, et al. Impact of obesity in mechanically ventilated patients: a prospective study. Intensive Care Med 2008; 34: 1991-8. [CrossRef]
23. Mullen JT, Moorman DW, Davenport DL. The obesity paradox: body mass index and outcomes in patients undergoing non-bariatric general surgery. Ann Surg 2009; 250: 166-72. [CrossRef]
24. Uzun L, Ugur MB, Altunkaya H, Ozer Y, Ozkocak I, Demirel CB. Effectiveness of the jaw-thrust maneuver in opening the airway: a flexible fiberoptic endoscopic study. ORL J Otorhinolaryngol Relat Spec 2005; 67: 39-44. [CrossRef]
25. Nantsupawat N, Nantsupawat T, Limsuwat C, Sutamtewagul G, Nugent K. Factors Associated With Reintubation in Patients With Chronic Obstructive Pulmonary Disease. Qual Manag Health Care 2015; 24: 200-6. [CrossRef]
26. Khilnani GC, Banga A, Sharma SK. Predictors of mortality of patients with acute respiratory failure secondary to chronic obstructive pulmonary disease admitted to an intensive care unit: a one year study. BMC Pulm Med 2004; 4: 12. [CrossRef]
27. Khamiees M, Raju P, DeGirolamo A, Amoateng-Adjepong Y, Manthous CA. Predictors of extubation outcome in patients who have successfully completed a spontaneous breathing trial. Chest 2001; 120: 1262-70. [CrossRef]
28. Mathew JP, Rosenbaum SH, O'Connor T, Barash PG. Emergency tracheal intubation in the postanesthesia care unit: physician error or patient disease? Anesth Analg 1990; 71: 691-7. [CrossRef]
29. Dosemeci L, Yilmaz M, Yegin A, Cengiz M, Ramazanoglu A. The routine use of pediatric airway exchange catheter after extubation of adult patients who have undergone maxillofacial or major neck surgery: a clinical observational study. Crit Care 2004; 8: R385-90. [CrossRef]
30. Murphy GS, Brull SJ. Residual neuromuscular block: lessons unlearned. Part I: definitions, incidence, and adverse physiologic effects of residual neuromuscular block. Anesth Analg 2010; 111: 120-8. [CrossRef]
31. Nair I, Bailey PM. Use of the laryngeal mask for airway maintenance following tracheal extubation. Anaesthesia 1995; 50: 174-5.
32. Kovac AL, Masiongale A. Comparison of nicardipine versus esmolol in attenuating the hemodynamic responses to anesthesia emergence and extubation. J Cardiothorac Vasc Anesth 2007; 21: 45-50. [CrossRef]
33. Arar C, Colak A, Alagol A, Uzer SS, Ege T, Turan N, et al. The use of esmolol and magnesium to prevent haemodynamic responses to extubation after coronary artery grafting. Eur J Anaesthesiol 2007; 24: 826-31. [CrossRef]
34. Fan T, Wang G, Mao B, Xiong Z, Zhang Y, Liu X, et al. Prophylactic administration of parenteral steroids for preventing airway complications after extubation in adults: meta-analysis of randomised placebo controlled trials. BMJ 2008; 337: a1841.
35. Jaber S, Jung B, Chanques G, Bonnet F, Marret E. Effects of steroids on reintubation and post-extubation stridor in adults: meta-analysis of randomized controlled trials. Critical Care 2009; 13: R49. [CrossRef]
36. Stix MS, Borromeo CJ, Sciortino GJ, Teague PD. Learning to exchange an endotracheal tube for a laryngeal mask prior to emergence. Can J Anaesth 2001; 48: 795-9. [CrossRef]
37. Cankaya H, Kati I, Egeli E, Demirel CB. Use of the laryngeal mask to evaluate a laryngeal web. Eur Arch Otorhinolaryngol 1999; 256: 523-4. [CrossRef]
38. Koga K, Asai T, Vaughan RS, Latto IP. Respiratory complications associated with tracheal extubation. Timing of tracheal extubation and use of the laryngeal mask during emergence from anaesthesia. Anaesthesia 1998; 53: 540-4. [CrossRef]
39. Cooper RM. The use of an endotracheal ventilation catheter in the management of difficult extubations. Can J Anaesth 1996; 43: 90-3. [CrossRef]
40. Biro P, Priebe HJ. Staged extubation strategy: is an airway exchange catheter the answer? Anesth Analg 2007; 105: 1182-5. [CrossRef]
41. Benumof JL. Airway exchange catheters: simple concept, potentially great danger. Editorial views. Anesthesiology 1999; 91: 342-4. [CrossRef]
42. Baraka AS. Tension pneumothorax complicating jet ventilation via a cook airway exchange catheter. Anesthesiology 1999; 91: 557-8. [CrossRef]
43. Duggan LV, Law JA, Murphy MF. Brief review: supplementing oxygen through an airway exchange catheter: efficacy, complications, and recommendations. Can J Anaesth 2011; 58: 560-8. [CrossRef]
44. Mort TC. Tracheal tube exchange: feasibility of continuous glottic viewing with advanced laryngoscopy assistance. Anesth Analg 2009; 108: 1228-31. [CrossRef]
45. Loudermilk EP, Hartmannsgruber M, Stoltzfus DP, Langevin PB. A prospective study of the safety of tracheal extubation using a pediatric airway exchange catheter for patients with a known difficult airway. Chest 1997; 111: 1660-5. [CrossRef]
46. Solomons NB, Livesey JR. Acute upper airway obstruction following Teflon injection of a vocal cord; the value of nebulized adrenaline and a helium/oxygen mixture in its management. J Laryngol Otol 1990; 104: 654-5. [CrossRef]
47. Ho AM, Dion PW, Karmarkar MK, Chung DC, Tay BA. Use of heliox in critical upper airway obstruction. Physical and physiologic considerations in choosing the optimal helium: oxygen mix. Resuscitation 2002; 52: 297-300. [CrossRef]
48. Mingo OH, Ashpole KJ, Irving CJ, Rucklidge MWM. Remifentanil sedation for awake fibreoptic intubation with limited application of local anaesthetic in patients for elective head and neck surgery. Anaesthesia 2008; 63: 1065-9. [CrossRef]
49. Lallo A, Billard V, Bourgain JL. A comparison of propofol and remifentanil target controlled infusions to facilitate fiberoptic nasotracheal intubation. Anesth Analg 2009; 108: 852-7. [CrossRef]
50. Goodman CTD, Kessell G. Remifentanil for fibre-optic intubation: use in difficult airways. Anaesthesia 2009; 64: 852-7. [CrossRef]
51. Lee B, Lee JR, Na S. Targeting smooth emergence: the effect site concentration of remifentanil for preventing cough during emergence during propofol-remifentanil anaesthesia for thyroid surgery. Br J Anaesth 2009; 102: 775-8. [CrossRef]
52. Shajar MA, Thompson JP, Hall AP, Leslie NA, Fox AJ. Effect of a remifentanil bolus dose on the cardiovascular response to emergence from anaesthesia and tracheal extubation. Br J Anaesth 1999; 83: 654-6. [CrossRef]
53. Lee JH, Koo BN, Jeong JJ, Kim HS, Lee JR. Differential effects of lidocaine and remifentanil on response to the tracheal tube during emergence from general anaesthesia. Br J Anaesth 2011; 106: 410-5. [CrossRef]