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Review article

Procedural guidelines for endotracheal extubation: insights from a narrative review

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Abbreviations

AEC – airway exchange catheter
ASA – American Society of Anesthesiologists
CPAP – Continuous Positive Airway Pressure
DAS – Difficult Airway Society
ENT – ear, nose and throat
HFNO – high-flow nasal oxygen cannula
ICU – intensive care unit
NAP 4 – 4th National Audit Project
OR – pperating room
PACU – post-anesthesia care unit
SBA – Brazilian Society of Anesthesiology

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Abstract

Background and purpose: *Operating rooms (ORs) and intensive care units (ICUs) are two most common medical environments where endotracheal extubation is conducted. The goal of this publication is to investigate the prevalence, causes, and risk factors of endotracheal extubation and to present current guidelines and protocols for performing safe endotracheal extubation of patients.*

Materials and methods*: A narrative review of guidelines related to endotracheal extubation of patients.*

Results: *Coughing and temporary hypertension are minor side effects of endotracheal extubation. With a mortality rate of about 5%, significant complications, such as extubation failure requiring reintubation, pose serious dangers. Inadequate communication between medical personnel, a lack of backup plans, and certain surgical procedures, especially those involving head and neck surgery, are factors that contribute to extubation failure. Reintubation occurs in 0.1% to 25.7% of cases. Patient features that may impact the outcome of extubation and additional extubation issues include obesity, obstructive sleep apnea, and other comorbidities. The endotracheal extubation method can be improved, and the incidence of post-extubation complications can be minimised to the greatest extent possible by implementing thorough standards and protocols to ensure safe extubation practices, especially for patients undergoing complex surgical operations.*

Conclusion: *the approach to each endotracheal extubation should be carefully planned and personalised. Many measures can help avoid complications from endotracheal extubation. As advances in airway management continue to evolve, future research and guideline development should prioritise the integration of new technologies in medicine.*

INTRODUCTION

Endotracheal extubation is a procedure that involves removing an endotracheal tube from the trachea. It can be performed in the operating room (OR), intensive care unit (ICU), as well as outside operation theatre settings where general anaesthesia is administered and the airway is secured with an endotracheal tube *(1,2,3)*. It is an elective procedure that demands meticulous preparation. Just as endotracheal intubation in elective situations requires careful consideration, endotracheal extubation also necessitates careful consideration. But above all, it demands safe management. Ensuring the safe management of endotracheal extubation is a significant responsibility, as unsafely prepared and performed procedures can lead to numerous complications. Postex-

tubation endotracheal complications may be minor or significant. Minor postextubation complications, which are not frequently reported, are: transient hypertension, tachycardia, coughing, bucking, and agitation *(4)*. A clear consensus on a precise definition or time frame for major postextubation complications does not exist; they are referred to as extubation failure, which is defined as the need for reintubation of the patient within 24 to 72 hours after extubation was performed. Extubation failure may be due to pulmonary aspiration, upper airway obstruction, hypoxemia caused by atelectasis or medication-affected respiratory depression *(4)*. The most serious complication is undoubtedly difficult or unsuccessful reintubation, which, as a final consequence, can cause permanent brain damage and brain death *(5)*. The incidence of closed claims regarding the management of the difficult airway during the perioperative period attributed to extubation in the OR from 1985 to 1992 was 8%, with all patients ultimately succumbing to brain death. However, from 1993 to 1999, the incidence of closed claims increased to 14%, alongside a decrease in the rate of brain death to 83% *(6)*. According to the outcomes of the 4th National Audit Project (NAP4), complications such as death, brain damage, and unplanned admission to the ICU due to complications arising from airway management or unplanned surgical airway management are just some of the complications that occurred during patient extubation. These complications were somewhat less frequent than complications related to aspiration of gastric contents or inability to secure an airway with endotracheal intubation. The NAP4 audit revealed that after extubation in the OR or in the patient's recovery room, about one-third of major airway complications occurred, with a 5% mortality rate *(7)*.

This manuscript investigates the frequency, causes, and risk factors associated with endotracheal extubation. The paper also identifies high-risk extubation scenarios and assesses various surgical interventions and related conditions that may increase the risk of reintubation. Additionally, we are committed to presenting comprehensive guidelines and protocols for endotracheal extubation, applicable to both patients recovering from surgical procedures with straightforward intubation and those facing a difficult airway, where the challenges of intubation and extubation are significantly heightened.

INCIDENCE, CAUSES, AND RISK FACTORS ASSOCIATED WITH ENDOTRACHEAL EXTUBATION

The incidence of postoperative reintubation in surgical patients in the operating room (OR) or post-anesthesia care unit (PACU) following elective surgery ranges from 0.1% to 0.45% *(8)*. In the ICU, the incidence of unsuccessful extubation in patients is even higher, at up to 25.7% *(9)*. Some of the factors that can contribute to the need for reintubation of patients and the occurrence of severe complications are the lack of a backup plan in case of the need for difficult endotracheal reintubation of the patient, inadequate communication of the medical staff in the OR and the ICU, the type of surgical intervention *(5)*. In the above-mentioned NAP4 audit, 20 adverse events related to respiratory complications at the end of general anaesthesia occurred in the OR, 16 in the PACU, and two during patient transport from the OR to the PACU. Of this number, five patients developed severe hypoxia requiring cardiopulmonary resuscitation measures. Poor anticipation and planning of procedures after endotracheal extubation of the patient, especially those involving airway surgical intervention, were the cause of complications following extubation. Two patients out of 38 who developed post-extubation complications died. The most common cause of adverse events associated with patient extubation was hypoxia caused by airway obstruction *(7)*.

RISK FACTORS FOR FAILED EXTUBATION

The risks associated with failed endotracheal extubation are multifactorial and can be categorised into those resulting from medical intervention and those arising from the patient's clinical condition. When discussing risk factors attributable to medical intervention, the most prevalent causes of unsuccessful extubation include surgical procedures related to head and neck surgery, which encompass interventions in the fields of ear, nose and throat (ENT) and maxillofacial surgery. An increased risk of reintubation was observed following ENT interventions in patients who underwent laryngomicroscopy and panendoscopy. The primary cause of unsuccessful extubation in these patients is airway obstruction. A contributing factor to failed extubation is the presence of comorbidities, particularly chronic obstructive pulmonary disease. Furthermore, pharyngolaryngeal swelling and mucosal haemorrhage after endoscopic laryngeal intervention are responsible for postoperative respiratory complications. Additionally, radiotherapy in the head and neck region has heightened the risk of post-extubation respiratory complications (*10,11*). Post-surgical swelling in maxillofacial procedures (affecting the face, tongue, and glottis) may result in potential complications concerning the respiratory tract after patient extubation, some of which can lead to fatal outcomes. Airway obstruction caused by blood or blood clots, along with patient comorbidities, necessitates careful consideration of the patient's needs for reintubation *(12,13)*. Complications following surgical intervention on the thyroid gland are not uncommon, occurring in 21-24% of cases. Such complications can compromise the airway and may necessitate the patient's reintubation. These complications include bleeding and the formation of a hematoma, lesions

of the recurrent laryngeal nerve, tracheomalacia, and pneumothorax pneumomediastinum *(14,15)*. A haematoma in the neck region that compresses the larynx and the upper parts of the trachea may lead to paralysis of the cranial nerves (vagus nerve, hypoglossal nerve, glossopharyngeal nerve, and a branch of the facial nerve), which can result in upper airway obstruction. Of particular importance is the paralysis of the recurrent laryngeal nerve, a branch of the vagus nerve *(16)*. Cervical spine surgery can also affect the postoperative patency of the airway and the incidence of respiratory insufficiency following patient extubation. Consequently, the most common complications associated with surgical intervention at the anterior cervical spine include adjacent segment disease, dysphagia, C5 palsy, graft or hardware failure, pseudarthrosis, recurrent laryngeal nerve palsy, infection, haematoma, cerebrospinal fluid leak, Horner syndrome, vertebral artery injury, oesophageal perforation, and new or worsening neurological deficits. Regarding surgical interventions in the posterior cranial fossa, patients may experience significant swelling of the retropharynx and hypopharynx, as well as the tongue. The fixation of the cervical spine can exacerbate the swelling of these structures. All of these factors further jeopardise airway patency both preoperatively and postoperatively *(17,18)*. Postoperative complications arising from the posterior cranial fossa surgical interventions are: postoperative hematoma, cranial nerve palsies, pneumocephalus, vocal cord paralysis, hydrocephalus, ischaemia, respiratory control centre injury, and macroglossia. All these complications can lead to the development of respiratory insufficiency and may necessitate the reintubation of the patient following surgical intervention *(19)*. Stenoses of the upper airway can occur at the level of the larynx, subglottis, or trachea. Furthermore, stenoses of the upper respiratory tract can be classified as rigid or dynamic, and extra- or intrathoracic. The most common complications of tracheal and cricotracheal resection are recurrent laryngeal nerve paralysis, granuloma at the site of anastomosis, anastomotic leakage, pneumonia, infection, bleeding, recurrent stenosis, crusting, subcutaneous emphysema, dyspnoea, dysphagia, and dysphonia (*20*). Each of these complications can lead to respiratory insufficiency after surgical intervention, necessitating reintubation. Therefore, it is essential to closely monitor the patient and determine the appropriate time for endotracheal extubation.

Patient-dependent risk factors that can lead to unsuccessful endotracheal extubation include obesity, obstructive sleep apnoea, Parkinson's disease, and rheumatoid arthritis. A patient's obesity is defined as a body mass index of 30 kg/m² or greater. Obesity is related to various comorbidities that can result in multiple perioperative complications among surgical patients. Respiratory complications are among the most common perioperative issues, manifesting as hypoventilation, airway obstruction, and subsequent desaturation *(21)*. Therefore, meticulous monitoring and planning prior to endotracheal extubation is mandatory (7). A comorbidity that occurs in individuals with obesity is sleep-disordered breathing. Sleep-disordered breathing encompasses a full spectrum of respiratory disorders, ranging from snoring to obesity hypoventilation syndrome. Obstructive sleep apnoea, one of the most prevalent sleep-related breathing disorders, is caused by a temporary collapse of the upper airways, clinically manifesting as alternating periods of reduced or absent airflow through the airways *(22)*. To prevent respiratory complications and the necessity for endotracheal reintubation following surgical intervention, according to the Guidelines of the American Society of Anesthesiologists (ASA), endotracheal extubation should be conducted in a semi-upright or lateral position, ensuring complete cessation of the effects of neuromuscular blockade and hypnotics. The ASA advocates for the routine use of nasal continuous positive airway pressure (CPAP) after extubation or via an endotracheal exchange catheter *(23)*. Parkinson's disease is a neurodegenerative disorder affecting the central nervous system. It results from the degeneration of dopaminergic neurons in the substantia nigra. Besides motor symptoms, the disease manifests as cognitive decline and autonomic dysfunction. Due to bulbar dysfunction, individuals with Parkinson's disease are susceptible to pulmonary aspiration, secretion retention, laryngospasm, and upper airway obstruction *(24)*. Multiple system atrophy is a neurodegenerative disease that is clinically manifested by obstruction of the upper airway at the level of the soft palate, base of the tongue, epiglottis, and arytenoids (25*,26)*. Rheumatoid arthritis is a chronic inflammatory autoimmune disease that primarily affects the joints but also results in changes to other organs and organ systems. Regarding the respiratory tract, special attention should be given to the potential for atlanto-axial subluxation, alterations in the temporomandibular joint, and involvement of the cricoarytenoid and cricothyroid joints. Patients with rheumatoid arthritis are at a higher risk of complications following endotracheal extubation due to the aforementioned changes in the joints and cartilages of the upper airway, as well as the risk of post-extubation airway obstruction. Therefore, awake extubation of the patient is recommended *(27)*. Other factors associated with the unsuccessful extubation of the patient include laryngospasm, chronic obstructive pulmonary disease, a history of radiation therapy to the head and neck region, female sex, and age (over 70 years) *(28)*.

To minimise the incidence of endotracheal extubation complications and reduce significant morbidity and mortality, individual national associations of anaesthetists or specialised societies dedicated to furthering the management of the airway have developed guidelines for endotracheal extubation. The aims of the guidelines include the prevention of complications associated with endotracheal extubation, standardising physiological criteria for patient extubation, devising strategies for difficult extuba-

tion cases, adopting a unique approach to endotracheal extubation, providing staff education and reducing mortality and morbidity. Some guidelines are focused solely on endotracheal extubation, while others incorporate recommendations for it within broader guidelines for difficult airway management.

The Difficult Airway Society (DAS) Guidelines for the management of tracheal extubation are published in 2012 (*29*). The DAS guideline was developed to offer a strategy for safe endotracheal extubation in adult patients. It highlights the necessity of planning and preparing for the patient's endotracheal extubation. The guide also includes practical techniques and recommendations for post-extubation care measures. The DAS guideline was developed through an analysis of existing international guidelines and published research, identifying relevant evidence and expert opinion on endotracheal extubation and airway management. According to DAS recommendations, extubation can be hazardous for several reasons. Firstly, issues related to airway reflexes, such as exaggerated or diminished laryngeal reflexes, as well as the presence of laryngeal reflex dysfunction, can render extubation dangerous. Additionally, numerous factors can lead to the depletion of oxygen reserves and reduced haemoglobin saturation with oxygen. Injury to the airway resulting from endotracheal intubation or surgical intervention on the airway constitutes another hazardous factor during endotracheal extubation. Furthermore, there are physiological effects on other systems, including the cardiovascular system, central nervous system, and vision. Finally, the human factor can significantly contribute to the risks associated with extubating a patient *(29).* According to the DAS, there are four basic steps for extubation outlined in the guideline, which are summarised in Table 1.

Table 1: *The DAS extubation basic steps (29)*

Step 1	plan extubation
Step 2	prepare for extubation
Step 3	perform extubation
Step 4	post-extubation care: recovery and follow-up

The 2016 guideline published by the All India Difficult Airway Association addresses the extubation of patients for whom difficult extubation is anticipated. According to this guideline, if the patient has a normal airway and no additional comorbidities (cardiovascular or respiratory), the process of endotracheal extubation consists of the following steps: 1. assessment of difficult airway management, presence of the residual neuromuscular block and cardiorespiratory insufficiency; 2. evaluation of criteria for patient extubation; 3. performing endotracheal extubation; 4. an individualised approach to applying oxygen therapy to each patient after extubation (including oxygen content and delivery device) *(30).*

The All India Difficult Airway Association guidelines categorise patients into three groups. The first category includes patients with a normal airway who require suppression of the haemodynamic response to extubation. This group consists of individuals undergoing eye, neurosurgery, vascular, or thoracic surgery. According to these guidelines, suppression of the haemodynamic response can be achieved through the topical administration of 10% lidocaine, intravenous administration of β-blockers, intravenous administration of lidocaine at a dose of 1 mg•kg^{-1} a few minutes before extubation, intravenous administration of fentanyl at a dose of 0.5–1 μg•kg^{-1}, or timely administration of dexmedetomidine at a dose of 0.75 μg•kg-1. An alternative to pharmacological methods for suppressing the haemodynamic response during endotracheal extubation is the replacement of the endotracheal tube with a supraglottic device under deep anaesthesia. Before replacing the endotracheal tube with a supraglottic device, it is necessary to pre-oxygenate the patient with 100% oxygen and clear the oral cavity of any secretions. The replacement of the endotracheal tube with a supraglottic device can be carried out in three ways: 1. By removing the endotracheal tube and inserting the supraglottic device using the "blind" technique, 2. By placing the supraglottic device while the endotracheal tube remains in the trachea, after which the endotracheal tube is removed (Bailey's manoeuvre), 3. Removing the endotracheal tube via the exchange catheter through which the supraglottic device is subsequently placed. This technique carries inherent risks of respiratory complications and is typically performed by experienced anaesthetists *(30).*

The second category of patients consists of those with breathing difficulties. The four D classifications include difficult mask ventilation, difficult intubation or reintubation, delayed recovery, and difficult airway resulting from the previously mentioned conditions. As noted earlier in this text, comorbidities such as obesity, obstructive sleep apnoea, rheumatoid arthritis, and others can further contribute to the risk of difficult extubation *(21,22,27,30).* Extubation in these patients should occur in a controlled environment, equipped with the appropriate instruments and staffed by trained personnel. It is carried out in an awake state with complete reversal of the neuromuscular block and adequate preoxygenation using 100% oxygen. For these patients, it is advisable to extubate using an airway exchange catheter (AEC). The AEC should be positioned at a depth of 20-22 cm for orotracheal or 26-30 cm for nasotracheal intubation. Before inserting the AEC, a lubricant must be applied, and then it should be threaded through the endotracheal tube to the proper depth. The subsequent step involves withdrawing the endotracheal tube. After the endotracheal extubation procedure, the patient can be oxygenated via the AEC or through other methods, depending on the anaesthetist's capabilities and expertise. The AEC may remain in situ for up to two days *(30).*

Finally, the All India Difficult Airway Association guidelines address the extubation of patients with compromised airways due to surgical intervention, airway oedema, or airway collapse, which are referred to in the literature as the "3 Ss." As noted in the previous section of recommendations, patients who have undergone airway interventions, experience oedema, or suffer from airway collapse are at an increased risk during extubation if they have comorbidities, such as obesity or obstructive sleep apnoea. The most common causes of surgical airway obstruction, and consequently post-extubation complications, include surgical procedures that affect the nerves innervating the upper airway, as well as those that result in glottic and periglottic swelling. The surgical interventions most frequently leading to these complications occur in the realms of otorhinolaryngology, head and neck surgery, and maxillofacial surgery. Supraglottic oedema may arise from the presence of haematomas, significant fluid replacement, or reduced venous drainage. It is important to note that iatrogenic lesions of the supraglottis can result from multiple endotracheal intubation attempts. According to the guidelines from the All India Difficult Airway Association, an assessment of the feasibility of extubation in these patients is conducted using the cuff leak test, with priority given to quantitative values over qualitative measures. If the cuff leak test is positive, endotracheal extubation should be performed under controlled conditions in the operating theatre or intensive care unit (ICU) using an airway exchange catheter (AEC) or fibreoptic bronchoscope, following a recruitment manoeuvre and continuous oxygen therapy at 100% oxygen. Should the cuff leak test yield a negative result, endotracheal extubation should be deferred, and the utilisation of corticosteroid therapy should be contemplated. In cases of laryngeal oedema, treatment with nebulised adrenaline, corticosteroids, and a head-up position is advised. Re-evaluation of the patient's extubation capability, as per these guidelines, should occur after 24 hours. Extubation under deep inhalational anaesthesia using an AEC or fibreoptic bronchoscope in the operating theatre is recommended for patients who present with a collapsed airway. If respiratory failure occurs after extubation, endotracheal reintubation is necessary. The consideration of early tracheostomy is warranted in all patients where there is reasonable suspicion of airway obstruction due to existing airway pathology or the nature of the surgical intervention *(30)*.

Canadian consensus-based recommendations for managing difficult airways were published in 2021. These recommendations apply to patients with a predicted difficult airway. In the section on the recommendations related to extubation, the authors state that extubation as an elective procedure must be meticulously planned. As a strategy in planning, they suggest using the acronym "REVERSE", which stands for reversal of neuromuscular block ("R"), extubation plan ("E"), verification ("V") of equipment and personnel optimisation, extubation ("E"), recovery ("R") indicating a pre-planned location and resources needed for monitoring and observing the patient post-extubation, safe patient ("S") which involves ensuring the successful transport and a safety handover plan. The authors of the recommendations advocate for anticipating the criteria for unsuccessful extubation and preparing personnel, along with the appropriate equipment, for the potential need for repeated reintubation *(31)*. Among the potential causes of extubation risks, the authors of these recommendations noted functional obstruction of the airway and inadequate secretion removal from the airways, obstruction due to anatomical changes, numerous cardiopulmonary causes that are particularly relevant when considering endotracheal extubation of patients in intensive care units (ICU), as well as other perioperative conditions, the most common of which include: impaired acid-base status, hypothermia, and postoperative pain *(31)*. Re-intubation of the patient, should the need arise after extubation, can be challenging if: the initial endotracheal intubation was difficult; anatomical changes in the airway resulted from the surgical intervention; a sufficient amount of time has passed for airway swelling; or there are mechanical obstructions such as intermaxillary fixation *(31)*. Recommendations for the extubation of patients with low risk of morbidity, according to Canadian guidelines, are as follows: minimise distraction of the anaesthetist during the patient's extubation period; use of pulse oximetry and oxygen support not only during the extubation period but also during the patient's transport to the recovery room; detailed handover between staff regarding the course of airway management. When considering low-risk extubation of patients in the ICU, it is necessary to discuss the rationale of extubating the patient and the timing of extubation. It is also essential to gather all necessary medical documentation regarding any difficulties encountered during the patient's endotracheal intubation. This documentation can assist in creating an endotracheal extubation plan in the ICU (*31*). In patients at potential risk of tracheal extubation, recommendations support multimodal analgesia while avoiding opioids, complete antagonism of neuromuscular blockade with quantification, extubation of the patient while awake, patient monitoring, and early use of noninvasive mechanical ventilation or high-flow oxygen administration through a high-flow nasal oxygen cannula (HFNO). In cases of airway oedema, it is advisable to assess it objectively through a cuff leak test or by indirect visualisation of the pharynx and larynx (video laryngoscopy, flexible endoscopy), ensuring adequate patient positioning and the application of corticosteroid therapy. Before extubating a high-risk patient, optimisation of cardiorespiratory, neurological, acid-base, and thermoregulatory status is essential. If the assessment indicates that reintubation will be necessary following the extubation of a patient at risk, it is crucial to ensure the patient's optimisation, provide appropriate equipment, and ensure that trained personnel

are available. Additionally, it is recommended to consider the option of extubating the patient via an exchange catheter, as well as the feasibility of securing the airway through an elective surgical technique *(31)*.

In 2022, the American Society of Anesthesiologists published Practice Guidelines for the Management of the Difficult Airway, which includes recommendations for the extubation of patients with a difficult airway. According to these Guidelines, before endotracheal extubation of a patient with a difficult airway, it is essential to develop an extubation strategy. The strategy will depend on the type of procedure and surgical intervention the patient underwent, the patient's perioperative condition, and the skill of the anaesthetist. It is crucial to plan the steps that will follow after extubation. Following a well-planned extubation strategy, the patient's readiness for extubation is assessed *(32)*. The clinical assessment of the patient's readiness for extubation is contained in Table 2 *(33)*. The ASA Guidelines also advocate for the necessity of ensuring the presence of another experienced anaesthetist, as well as for carefully determining the time and place of extubation. Advanced airway management measures after extubation include the use of exchange catheters and/or supraglottic devices that may be beneficial in the event of expected re-intubation of the patient. The latest ASA Guidelines recommend consideration of the potential risks and benefits of performing elective surgical tracheostomy. Additionally, it is essential to determine whether extubation should be performed under awake or deep anaesthesia. During the extubation process, supplemental oxygen should be used whenever possible. Finally, it is essential to assess the predictors of difficult ventilation in patients *(32)*.

Table 2: *The clinical assessment of the patient's readiness for extubation (33)*

Respiratory	– Tidal volume during spontaneous breathing > 6 ml · kg^{-1} – Vital capacity > 15 ml · kg^{-1} – Respiratory rate < 30 breaths · min^{-1} – Maximum inspiratory pressure < –20 cmH_2O – Adequate gas exchange
Cardiovascular	– Hemodynamic stable patient including hemodynamic stability is ensured with moderate inotropic support
Reversal of neuromuscular block	– Quantitative neuromuscular monitoring
Risk of airway oedema	– Qualitative cuff leak test – Quantitative cuff leak test

To reduce the rate of complications associated with extubation and the need for reintubation, the Brazilian Society of Anesthesiology (SBA) recommendations for managing difficult airways in adults include a specific section dedicated to safe tracheal extubation (34). The SBA recommendations are largely consistent with the previously mentioned ASA recommendations. Namely, according to the SBA guidelines, successful extubation of a difficult airway requires careful preparation. This includes antagonising the neuromuscular blockade, preoxygenation, adequate patient positioning, effective communication within the team, and planning for potential complications following extubation. The extubation strategy depends on the type of surgical intervention, the patient's clinical condition, and the anaesthesiologist's skill. For extubating a patient with a difficult airway, it is crucial to have an experienced anaesthesiologist present and to assess the feasibility of alternative short-term use of exchange catheters or supraglottic devices. Furthermore, in certain situations, the risks and benefits of elective surgical tracheostomy, as well as the advantages of awake extubation compared to deep extubation, should be considered. The SBA guidelines highlight the benefit of using supplemental oxygen during the extubation process *(34)*.

CONCLUSION

The approach to each endotracheal extubation should be carefully planned and personalised, taking into account the patient's condition, the type of surgical intervention, and the available technical and human resources. With a pre-planned endotracheal extubation strategy, many life-threatening circumstances can be anticipated and preemptively addressed. Some measures that can help avoid complications from endotracheal extubation include extubating the patient under deep anaesthesia, replacing the endotracheal tube with a supraglottic device before waking the patient, examining the tracheobronchial tree through the supraglottic device using a bronchoscope, and extubating the patient utilising an airway exchange catheter.

As advances in airway management continue to evolve, the development of standardised, evidence-based procedural guidelines for endotracheal extubation remains a priority. To enhance decision-making and patient safety during extubation, future research should prioritise the integration of new technologies, including artificial intelligence and real-time endotracheal intubation. Additionally, patient-specific factors such as airway anatomy and comorbidities may contribute to the development of tailored and practical extubation guidelines. A multidisciplinary approach and ongoing education will be necessary to adapt guidelines to new evidence and clinical innovations, ultimately improving outcomes and reducing the need for extubation procedures.

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