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Review article

Reintubation in the intensive care unit: challenges, risks, and strategies for prevention

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Abbreviations

ASA	– American Society of Anesthesiologists
COPD	– chronic obstructive pulmonary disease
HFNC	– high-flow nasal cannula
ICU	– intensive care unit
mFI	– modified Frailty Index
NIPPV	– non-invasive positive pressure ventilation
RSBI	– Rapid Shallow Breathing Index
SBT	– Spontaneous Breathing Trial
VAP	– ventilator associated pneumonia

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Abstract

Background and purpose: *Reintubation in the intensive care unit is a critical event linked to increased morbidity, prolonged hospitalization, and higher mortality. It often results from respiratory muscle weakness, airway edema, neurological impairment, or cardiovascular instability. Patients requiring reintubation face elevated risks of ventilator-associated pneumonia, airway trauma, and hemodynamic instability. Preventive strategies such as careful extubation planning, noninvasive ventilation, high-flow nasal cannula, corticosteroids for airway edema, and optimized fluid management can help reduce reintubation rates. A structured, multidisciplinary approach is essential for improving extubation success and patient outcomes.*

Conclusions: *This review examines the causes, risk factors, and consequences of reintubation, along with strategies for prevention and management, emphasizing the importance of evidence-based weaning protocols and advanced monitoring techniques.*

INTRODUCTION

Mechanical ventilation is essential for supporting critically ill patients, and timely extubation is crucial for improving patient outcomes. However, despite standard weaning procedures, 3–20% of patients require reintubation *(1,2,3)*. Post-extubation respiratory failure can lead to respiratory fatigue, necessitating additional ventilation, which prolongs intensive care unit (ICU) stays, increases costs, and elevates mortality rates. Reintubation is generally defined as the reinsertion of an endotracheal tube following unplanned extubation or extubation failure, typically within 48 – 72 hours, due to inadequate airway protection, respiratory failure, or other complications. Current international guidelines define reintubation as occurring within 48 hours of extubation *(4,5)*. However, clinical trials have used varying timeframes, such as 48 – 72 hours, leading to inconsistencies that can impact patient outcomes and the development of treatment guidelines. Therefore, standardizing the observation period after extubation is important to enhance patient care. Extubation failure is characterized by the inability to sustain spontaneous breathing or maintain adequate gas exchange, necessitating reintubation to prevent respiratory compromise, hypoxemia, or hemodynamic instability. Understanding the risk factors, consequences, and preventive strategies related to reintubation is crucial for improving patient outcomes. A recent multicenter cohort study investigated the association between reintubation timing and patient outcomes. The study included critically ill adult patients who underwent

mechanical ventilation and extubation in ICUs *(3).* A total of 184,705 patients from 75 ICUs were assessed, with 1,849 requiring reintubation out of 48,082 extubated patients. Most reintubations occurred within 24 hours (56.1%), followed by 24 – 48 hours (22.6%), 48 – 72 hours (10.7%), 72 – 96 hours (6.0%), and 96 – 120 hours (4.6%). The highest mortality rates were observed in patients, reintubated between 72 and 96 hours. The findings revealed that reintubation was significantly associated with increased in-hospital and ICU mortality. Further research is warranted to define optimal monitoring and management practices for extubated patients, aiming to standardize reintubation definitions and enhance clinical guidelines.

Risk Factors for Reintubation

The risk of reintubation after extubation is influenced by a variety of patient-specific and clinical factors. One of the most prominent risk factors is prolonged mechanical ventilation, which leads to respiratory muscle weakness. This impairment significantly impacts on the ability of patients to sustain spontaneous breathing once the endotracheal tube is removed. Conditions such as chronic obstructive pulmonary disease (COPD), neuromuscular disorders, and sepsis-related myopathy further exacerbate this muscle weakness, increasing the likelihood of reintubation *(6).* A systematic review and meta-analysis of 38 studies involving 22,304 ICU patients identified 21 risk factors for reintubation, including older age, higher APACHE II scores, COPD, pneumonia, shock, low oxygen levels, weak cough, prolonged mechanical ventilation, and abnormal respiratory parameters, highlighting the need for early recognition and predictive algorithms to improve patient outcomes *(6).*

Post-extubation airway complications are also a significant risk factor for reintubation. These complications may include upper airway obstruction, excessive secretions, or vocal cord dysfunction. Post-extubation stridor, which often occurs due to laryngeal edema, is a well-known predictor of reintubation, particularly in patients with a history of prolonged intubation. If airway protection is inadequate during extubation, patients may experience aspiration or upper airway collapse, both of which require reintubation to maintain adequate ventilation *(7).*

Cardiovascular instability, such as congestive heart failure or fluid overload, also increases the risk of reintubation. These patients experience increased work of breathing, and if fluid balance and cardiovascular function are not managed effectively, respiratory failure may occur, necessitating reintubation to restore oxygenation and stability *(8,9,10).* Neurological impairments, including traumatic brain injury, stroke, or prolonged sedation, also contribute to the risk of reintubation *(11).* These impairments can compromise respiratory drive and muscle strength, hindering the ability to maintain adequate ventilation after extubation. As a result, these patients are at a higher risk of experiencing respiratory failure, necessitating reintubation. Age is another important risk factor influencing the likelihood of reintubation. Both very young and elderly patients are at an increased risk. Infants have underdeveloped respiratory muscles, which makes extubation more difficult, while older adults often experience diminished muscle strength and have higher rates of comorbidities *(12).* A study analyzing 17,051 postoperative reintubations in adults found an overall mortality rate of 29.4%. Mortality increased with delayed reintubation, from 19.8 % on postoperative day 1 to 35.0% on day 7 and beyond. Higher mortality was associated with an increasing Modified Frailty Index (mFI), ASA score, and age. Patients aged 80–89 had a 42.1% mortality rate compared to 17.9% in those aged 40–49. After adjusting for confounders, mFI, ASA score, age, and delayed reintubation remained significant predictors of mortality *(13).* Preoperative nutritional status, specifically hypoalbuminemia, is another key risk factor. Hypoalbuminemia indicates poor nutritional status and is associated with higher postoperative complications, including reintubation. In the study, hypoalbuminemia (albumin level ≤ 3.1 g/dL) was found to be an independent predictor of reintubation in ICU patients. Reintubated patients had significantly lower albumin levels (2.47±0.61 g/dL) compared to those who were successfully extubated *(14).*

Renal insufficiency is another factor that contributes to reintubation risk. Impaired renal function leads to fluid imbalance, which can affect respiratory muscle performance. A study involving patients in a post-anesthetic care setting identified renal insufficiency**,** as measured by creatinine clearance <24 mL/min**,** as an independent risk factor for reintubation in post-anesthetic care units. The odds ratio for reintubation in patients with reduced creatinine clearance was 4.1 (95% CI = 1.2–13.4), highlighting the increased risk associated with impaired renal function (12). Renal insufficiency is considered a significant patient-related factor influencing reintubation risk, likely due to fluid imbalance and impaired respiratory muscle function.

Additionally, patients classified as American Society of Anesthesiologists (ASA) physical status III, those with severe systemic disease, have a higher risk of reintubation. In a case-control study, ASA status III was associated with an odds ratio of 3.8 for reintubation compared to ASA status I, suggesting a significantly increased risk *(12,15).*

Sepsis, a common complication in critically ill patients, also significantly increases the risk of extubation failure and reintubation. Sepsis leads to systemic inflammation and organ dysfunction, including respiratory failure. A study identified that the absence of sepsis or septic shock was associated with a lower likelihood of extubation failure, with an odds ratio of 0.77, indicating that sepsis presence increases the risk of extubation failure *(16).* These findings underscore the importance of assessing both ASA physical status and the presence of sepsis when evaluating the risk of reintubation in postoperative patients.

The Rapid Shallow Breathing Index (RSBI), which is calculated as the ratio of respiratory frequency to tidal volume, is another important predictor of reintubation. An RSBI greater than 100 has been associated with a higher risk of extubation failure. In a study, 90% of patients with an RSBI greater than 100 immediately before extubation required reintubation, suggesting that the RSBI is a valuable tool in predicting extubation outcomes *(17)*.

Lastly, inadequate respiratory drive and neurological dysfunction, such as in patients with traumatic brain injury, stroke, or prolonged sedation, can compromise the ability to maintain adequate ventilation post-extubation *(18,19)*. Understanding the complex and multifactorial nature of reintubation risk is essential for clinicians in managing critically ill patients. By identifying these risk factors early and employing appropriate preventive measures, healthcare providers can improve patient outcomes, reduce the need for reintubation, and enhance the overall quality of care.

Consequences of reintubation

Reintubation carries significant risks, impacting both short-term and long-term patient outcomes. One of the most concerning consequences is an increased risk of ventilator-associated pneumonia (VAP), as repeated exposure to mechanical ventilation heightens the risk of bacterial colonization and infection *(20)*. Additionally, reintubation often leads to longer ICU stays and prolonged hospitalizations, adding to the burden on healthcare resources *(21,22)*.

Another major concern is hemodynamic instability, as reintubation itself can trigger cardiovascular stress, leading to hypotension or arrhythmias, particularly in patients with preexisting cardiac disease *(23)*. Furthermore, repeated intubation attempts increase the likelihood of airway trauma, potentially causing laryngeal injury, tracheal stenosis, or even failed intubation in critical situations *(24)*. Studies have also shown that reintubation is associated with higher mortality rates. Studies indicate that ICU mortality rates for reintubated patients range from 25% to 50% *(17)*. Additionally, research has shown that patients requiring reintubation have hospital mortality rates exceeding 30% to 40% *(25)*.

Strategies to reduce reintubation risk

Given the high risks associated with reintubation, proactive measures to prevent extubation failure are essential. One of the most effective strategies is careful patient selection for extubation. This involves comprehensive assessments, including spontaneous breathing trials (SBTs), measuring the rapid shallow breathing index (RSBI), and evaluating cough strength and secretion clearance ability *(25)*.

Noninvasive ventilation (NIV) and high-flow nasal cannula (HFNC) have emerged as valuable tools in preventing reintubation. Studies have demonstrated that applying NIV immediately after extubation, particularly in high-risk patients, reduces the incidence of respiratory failure and the need for reintubation *(26)*. Similarly, HFNC is a reliable alternative to non-invasive positive pressure ventilation (NIPPV) for reducing the rate of reintubation in adult patients after extubation, with no significant advantage over NIPPV or conventional oxygen therapy (COT) in terms of ICU mortality or length of stay *(27)*.

Another key factor is post-extubation respiratory muscle support, which includes early mobilization, optimizing nutrition, and avoiding excessive sedation. Ensuring that patients receive adequate physiotherapy and pulmonary rehabilitation can improve respiratory muscle endurance and reduce the likelihood of failure after extubation. Excessive fluid accumulation can lead to pulmonary edema and respiratory distress, increasing the risk of extubation failure. Close monitoring of fluid balance, especially in patients with heart failure, is crucial to prevent such complications. A study by Frutos-Vivar et al. (28) identified positive fluid balance 24 hours prior to extubation as a significant predictor of extubation failure. Similarly, a study by Ghosh et al. *(29)* found that higher cumulative fluid balance at extubation was significantly associated with increased risk of extubation failure in ICU patients. Therefore, careful fluid management is essential to reduce the risk of extubation failure in these patients. Lastly, early recognition of airway complications is essential. Administering corticosteroids prior to extubation in high-risk patients has been shown to reduce airway edema and the incidence of post-extubation stridor, thereby decreasing the likelihood of reintubation. A systematic review and meta-analysis indicated that prophylactic corticosteroid administration before elective extubation was associated with a significant reduction in post-extubation airway events and reintubation rates, particularly among patients at high risk for airway complications *(30)*. However, the effectiveness of corticosteroid therapy can vary based on factors such as the specific corticosteroid used, dosage, timing of administration, and patient characteristics *(31)*. Therefore, it's essential to assess individual patient risk factors and consult current clinical guidelines when considering corticosteroid therapy prior to extubation

CONCLUSION

Reintubation in the ICU remains a significant challenge, with considerable implications for patient outcomes. Understanding the risk factors and implementing preventive strategies, such as optimizing extubation readiness, using noninvasive ventilation, managing fluids carefully, and addressing airway complications, can substantially reduce the incidence of reintubation. Future research should continue to refine protocols for extubation and explore new technologies to enhance respiratory support in critically ill patients.

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