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INVESTIGATING THE OPTIMAL TIMING AND DURATION OF MECHANICAL VENTILATION FOR SPECIFIC CRITICAL ILLNESS PRESENTATIONS

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Abstract

The objective of this study is to conduct a comprehensive analysis of the symptoms and classifications of laryngeal injuries that occur as a consequence of endotracheal intubation in mechanically ventilated patients in the critical care unit (ICU). The databases used for this study were PubMed, Embase, CINAHL, and Cochrane Library. Research conducted on adult patients who had mechanical ventilation by endotracheal intubation in the intensive care unit (ICU) and underwent post-extubation laryngeal inspections using either direct or indirect vision. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were used to conduct independent, double-data extraction and evaluate the possibility of bias. The risk of bias assessment adhered to the standards established by the Cochrane Collaboration. Laryngeal damage resulting from intubation is often seen in the intensive care unit (ICU) environment. There are no established guidelines for evaluating the larynx and monitoring patients after they have been removed from a breathing tube. Adopting a methodical approach to conducting more resilient research might enhance our awareness of the link between specific injuries and the resulting functional impairments. This would lead to improved comprehension of both the timeline and the prognosis for the recovery of the injury. The results of our study reveal potential areas of investigation and emphasize the well-established but little explored medical consequences of endotracheal intubation with mechanical ventilation in the intensive care unit.

Keywords: endotracheal intubation, acute care, larynx, voice, swallowing

1. Introduction

Annually, there are 13-20 million critically ill patients who are intubated in intensive care units (ICU) worldwide. Like many medical procedures, intubation can have unintended negative effects, causing both immediate and long-lasting symptoms that may require additional medical attention even after the patient is discharged from the ICU.

Patients often complain of hoarseness, loss of voice, throat clearing, sore throat, and vocal fatigue after being removed from a breathing tube. Laryngeal injuries caused by intubation during surgery are usually minor. However, critically ill patients who are intubated in the ICU for longer periods of time are more likely to experience more severe laryngeal injuries. These injuries are often overlooked and can lead to voice and swallowing problems. Despite the potential seriousness of these injuries, evaluations of the larynx are often delayed and only occur if symptoms persist for at least one week, and sometimes as long as one to three months. This delay is partly due to the lack of guidelines for post-extubation assessments. Patients with these injuries are at a higher risk for medical complications (such as post-intubation stenosis with delayed presentation) and long-term functional disabilities (such as chronic dysphonia and chronic dysphagia).

The objectives of this systematic review are to assess the kind and severity of laryngeal damage caused by endotracheal intubation in patients in the intensive care unit (ICU), and to propose areas of research for developing ways to prevent and intervene in such injuries in the future. We specifically examined studies that included the evaluation of laryngeal damage using laryngoscopic examination after extubation.

2. Methodology

2.1.Search Strategy

A clinical informationist (C.P.) devised and implemented the search strategy in the electronic bibliographic databases PubMed, Embase, CINAHL, and Cochrane Library. The searches were restricted to the English language and conducted using controlled vocabulary, such as Medical Subject Headings, Emtree terms, and CINAHL headings, along with relevant keywords for the themes of intubation, visualization methods, and injuries. An attempt was made to exclude research focusing on pediatric subjects by omitting specific phrases relevant to pediatrics from the titles alone, and a filter was used to remove research that only included animals. The Cochrane Highly Sensitive Search Strategy for discovering randomized trials in MEDLINE, sensitivity and precision-maximizing version 26, was used as a research filter. Additional modifications were made to include various forms of clinical studies.

There was a high incidence of mild injury and a decreased incidence of more serious damage. Several injuries were self-limiting, classified as Grade 1 injuries. Overall, erythema was most frequent, with a prevalence of 82% (252/307 patients),35,37,40,41 followed closely by edema with a prevalence of 70% (583/828 patients).34–37,40,41 The interarytenoid space, the area through which the ETT passes and remains present in situ, had a 95% (106/112 patients) - 96% (108/112 patients) prevalence of edema and erythema, respectively.40,41 Ulcerations, with a 31% (174/524 patients) prevalence, were the most frequently reported moderate (i.e., Grade 2) injury.33,34,36–38,40,41 Intubation granulomas/granulation tissue, the only other injury type reported, had a 27% (86/318 patients) prevalence.33,35,36,40,41 Vocal fold immobility was the most frequently reported and most common of the severe (i.e., Grade 3) injuries, with a 21%

(105/508 patients) prevalence.33,34,36,37,40,41 There was a 6% (12/200 patients) prevalence of glottic stenosis39 and 13% (15/112 patients) prevalence of subglottic stenosis.40,41 A prevalence of 5% or less for both subglottic mucosa edema33 and arytenoid(s) dislocation were reported.34

3. Signs of Laryngeal Injury

The incidence of laryngeal damage may vary as the length of intubation increases. Based on the data collected from this study, we conducted a detailed analysis of damage results using three typical durations of intubation: (1) less than 5 days, with references 34, 35, and 37, (2) 5 to 10 days, with references 33, 36, 40, and 41, and (3) more than 10 days, with references 38 and 39 (Table 2; Supplementary Table 2). Patients who were intubated for a period of 5-10 days showed a higher occurrence and worse severity of injuries compared to those who were intubated for less than 5 days. More precisely, there was a 37% rise in the occurrence of injury in Grade 1 and a 38% increase in Grade 2. The incidence of Grade 3 increased by 125% during the two eras. Two investigations, each lasting more than 10 days, found three distinct forms of injuries that cannot be summed.

Postponing the evaluation after removing the breathing tube may also lead to differences in the occurrence of laryngeal injuries. We have selected four specific time periods for evaluation in the studies: (1) within 6 hours,36–38 (2) within 24 hours,34,35,39,40 (3) within 72 hours,41 and (4) at 2 weeks33 (Table 3; Supplementary Table 3). When taking into account the general incidence and the fact that data reporting might vary, the timing of assessment had no impact on the prevalence of laryngeal damage within a certain grade. This discovery indicates that the injuries detected show little variation throughout a period of 3 days after extubation. A research conducted evaluations two weeks after extubation and found that 84% of patients who were intubated for an average of 6.2 days (ranging from 2 to 14 days) had injuries, which was consistent with previous assessments at different time intervals.

This systematic review provides evidence that intubation often leads to laryngeal damage, and the severity of the injury worsens with longer duration. However, it is important to note that the studies included in the analysis had different techniques, patient groups, and ways of reporting results. Only a minority of patients will recover without any injuries after being intubated. While less serious injuries are more often seen, Grade 2 and Grade 3 injuries occur at a notable rate of 31% and 13%, respectively. Typically, the number of patients who have moderate or severe injuries affecting their airway, voice, and/or swallowing is more than double the number of patients who do not receive any injuries. Assessments conducted within 72 hours after removing a breathing tube seem to have no impact on outcomes, indicating that the recovery from even milder injuries takes longer than 3 days.

To effectively manage laryngeal injuries, it is crucial to first identify their existence and degree of severity in order to enable suitable and personalized treatment. The coordination of management might be overseen by the ICU team and include a diverse range of other specialties.

Treatment options may involve the administration of glucocorticoids and anti-reflux medications, performing procedures like stenosis dilation and vocal fold medialization by anesthesiology and otolaryngology, therapy provided by speech-language pathology for voice and swallowing, and the use of other complementary therapies to enhance patient function and improve quality of life.

An important discovery to emphasize is that almost 50% of patients encountered dysphagia upon extubation, whereas 20% of patients had vocal fold immobility. It is well acknowledged that when patients are intubated for more than 2 days, they are at a significant risk for both acute and chronic dysphagia. This condition might potentially lead to aspiration, which in turn may cause aspiration pneumonia or pneumonitis. There are several potential causes that can increase the risk of aspiration in this population, including impaired thinking, sensory problems, a weakened reflex in the throat, and weakened muscles involved in swallowing. Recent evidence suggests that damage to the structure of the throat can also lead to aspiration, with a prevalence of 38%−44% during oral consumption in patients with one-sided vocal fold immobility. Furthermore, patients with one-sided vocal fold paralysis have twice the risk of pneumonia. Identifying vocal fold paralysis early on can help reduce the risk of pneumonia or inflammation of the lungs through a timely procedure to restore vocal fold function. Additionally, a thorough investigation can uncover other symptoms such as difficulty swallowing, which can help identify the risk earlier and manage it appropriately.

Research employed ETTs with similar inner diameters, often known as ETT size. However, not all research included information on the size and/or manufacturer of the ETTs. There are two problems when it comes to attributing laryngeal harm to the size of the endotracheal tube (ETT). There is currently no universal standard for determining the size of an endotracheal tube (ETT). However, the size of the tube is based on the diameter of its inner lumen and is not related to its outer diameter measurement. The sizing is generally consistent among different manufacturers. The size of the ETT may also be taken into account for therapeutic purposes, such as determining the appropriate air volume, pressure, and oxygenation, as well as for the use of instruments like a bronchoscope. The outside diameter of the ETT has three main effects: (1) it comes into touch with anatomical structures, (2) it takes up space inside the larynx/trachea, and (3) it is partially responsible for causing laryngeal injuries and their accompanying symptoms.

There is a little (≤0.5 mm) variation in the outer diameter across different manufacturers (such as Mallinckrodt,™ Portex, Smiths Medical, Unoflex), all of which use comparable materials. Presently, Mallinckrodt™ manufactures two endotracheal tubes (ETTs), namely TaperGuard™ Evac and SealGuard™ Evac, which have outer diameters that are roughly 1 mm bigger than ETTs produced by other manufacturers and available in different sizes. The wide range of results seen in different research makes it impossible to draw any definitive conclusions about the relationship between laryngeal damage, endotracheal tube (ETT) size, and/or materials/manufacturing. To address this risk, future research should provide a detailed description of these specific features.

Our research supports the need for regular, prompt, and consistent use of a laryngeal evaluation and dysphagia screening after removing a breathing tube, particularly in light of changes in payment systems and a national emphasis on patient safety. Hospital-acquired illnesses pose a complex risk that encompasses both financial and exposure aspects. Aspiration pneumonia and pneumonitis are hospital-acquired conditions that can be prevented and require substantial resources, such as primary care and specialty physicians. These conditions have a prevalence as high as 14% in post-extubated ICU patient populations. Hospital-acquired pneumonia can prolong the length of stay in the ICU by more than 8 days. The potential damage that may be avoided, together with the expenses (both financial and in terms of occupancy), provide a compelling argument for prevention, or at the very least, early screening, evaluation, and treatment. Assessing for laryngeal damage is, perhaps, more complex.

Laryngeal injuries of moderate to severe nature may lead to a duration of more than 2 days and incur expenditures up to $6000, including readmission for repair. Although there are many reports of dysphonia and discomfort after extubation, it is challenging to determine which individuals are most likely to have moderate to severe laryngeal damage and the optimal timing for examination. Furthermore, there is a significant lack of screening methods or published recommendations that provide guidance on this matter, creating a substantial vacuum in the understanding of critical care patient groups and their long-term results.

Despite the existence of evidence and recommendations for more timely evaluations, the most common approach to identifying and managing these injuries is still to "wait and see". Surprisingly, there are no published guidelines for assessing laryngeal injury or dysphagia after extubation. The only published guideline on post-extubation assessment focuses solely on one symptom, which is hoarseness. According to this guideline, patients with both hoarseness and a history of intubation can undergo laryngoscopic evaluation at any time.

However, clinicians are advised to perform laryngoscopy within 4 weeks or sooner if there is suspicion of a serious underlying cause, regardless of the duration of hoarseness. It is important to note that these recommendations are open to interpretation as they are intended for hoarseness of any cause, written for ambulatory outpatients rather than at-risk ICU patients, and are not specifically tailored to intubation-related injuries. It is important to note that hoarseness might be only one of many indications of laryngeal damage. Pain is one of the most common symptoms and might suggest a severe damage to the larynx. Dysphagia is a common condition that may have catastrophic effects shortly after removing a breathing tube. It is important for future research and screening recommendations to take into account these additional symptoms.

More than 50% of the rating factors exhibited a significant risk of bias. The data seem to indicate challenges in managing biases from the experimenters, particularly in the areas of 1) bias in detecting, 2) bias in attrition, 3) bias in avoidance, and 4) bias in reporting. The review includes two cross-sectional studies conducted by the same laboratory, which have a low risk of bias in all parameters. Additionally, there are seven cohort studies, all of which have introduced

either unknown or high risks of bias. These biases may be attributed to the dynamic and often unpredictable nature of the ICU setting, as well as the collection of data at multiple time points. It is crucial to exercise additional caution in order to minimize biases by implementing methodological controls in these specific research designs. The issue of clarity in writing for research replication is also a cause for worry. The editorial review and publishing criteria for clinical research should aim to enhance writing clarity and minimize study biases.

4. Conclusion

Given the high occurrence of laryngeal damage, dysphonia, and dysphagia, along with their potential to lead to more severe medical consequences, it is necessary to establish practice standards for post-extubation screening and evaluation in the intensive care unit (ICU). There is compelling evidence that the length of time a patient is intubated is closely linked to the occurrence and severity of laryngeal injuries. Post-extubation, injuries occur often and vary greatly in severity. While minor injuries are common, moderate to severe injuries occur regularly and need prompt medical treatment. Currently, there are no established clinical guidelines that specifically treat these potentially severe injuries, and this study provides little information to provide guidance. The findings indicate new avenues for scientific investigation and emphasize the previously recognized but underestimated harm caused by endotracheal intubation, which is one of the most frequently performed medical operations.

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