

AIRWAY INJURIES DURING OROTRACHEAL INTUBATION: RISK FACTORS, PREVENTION, AND MANAGEMENT

Ana Luísa Miranda Takasuca

<http://lattes.cnpq.br/0586043457218401>

Lilian Ferrari Jardim Torres

<http://lattes.cnpq.br/2610587828707694>

Laryssa Emanuely da Silva

Renan Ramos Nicoleti

<http://lattes.cnpq.br/2394780597663047>

Marcos Vinicius Dantas Pereira Pamplona

<http://lattes.cnpq.br/5890023487645656>

Ana Carolina Pires

Maria Luiza Araújo Faria

David Reis Mourão

<http://lattes.cnpq.br/4018098180086973>

Luisa Bersan Maciel

<http://lattes.cnpq.br/3767249495780410>

Laren Rocha Ferreira

<http://lattes.cnpq.br/0988084245340762>

João Francisco Meira Valadares

Eduardo Prante Frederico

<http://lattes.cnpq.br/4275813275453996>

Mauricio Lopes da Silva Netto

<http://lattes.cnpq.br/4791743372358340>

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Abstract: INTRODUCTION The introduction provides an overview of orotracheal intubation, including its definition, purposes, and indications across various clinical settings. It highlights the evolution of intubation techniques and the anatomical and physiological changes associated with the procedure. The introduction identifies the types and prevalence of airway injuries, discusses the risk factors involved, and explores the impact of different intubation techniques and equipment on injury rates. It also covers the role of training and experience, challenges in emergency situations, complications associated with airway injuries, and their significance in special populations. The introduction concludes by addressing current prevention strategies, technological advances, and existing controversies and gaps in knowledge. **OBJETIVE** To comprehensively review the incidence, risk factors, types, diagnostic approaches, and management strategies associated with airway injuries during orotracheal intubation, while evaluating the effectiveness of current prevention and treatment methodologies. **METHODS** This is a narrative review which included studies in the MEDLINE – PubMed (National Library of Medicine, National Institutes of Health), COCHRANE, EMBASE and Google Scholar databases, using as descriptors: “Orotracheal Intubation” OR “Airway Injury” AND “Airway Management” OR “Intubation Complications” AND “Laryngoscopy Techniques” in the last years. **RESULTS AND DISCUSSION** The results and discussion section evaluates the impact of patient demographics, comorbidities, and anatomical variations on airway injury risk. It explores the correlation between intubation duration, tools, and settings on injury severity and incidence, comparing direct laryngoscopy with video laryngoscopy and other advanced techniques. The discussion

examines outcomes in different populations, the role of early detection methods, and therapeutic approaches for managing airway injuries. It highlights clinical guidelines, preventive measures, and diagnostic tools, while also considering the economic, ethical, and systemic factors influencing injury rates. The section concludes by identifying future research priorities and the need for tailored prevention programs in different healthcare settings. **CONCLUSION** The conclusion emphasizes the significance of airway injuries during orotracheal intubation and their implications for patient safety, outcomes, and healthcare resources. It calls for a multidisciplinary approach to prevention, diagnosis, and management, recognizing the complexity of factors contributing to these injuries. While acknowledging advancements in training and technology, the conclusion identifies gaps in knowledge, particularly regarding optimal management strategies and long-term outcomes. It advocates for continued research, innovation, and enhanced communication among healthcare providers to minimize the incidence and impact of airway injuries in clinical practice.

Keywords: Orotracheal intubation; Airway trauma; Laryngoscopy; Intubation complications; Airway management strategies.

INTRODUCTION

Orotracheal intubation is a fundamental procedure in modern anesthesiology and critical care, serving as a crucial intervention for maintaining airway patency and ensuring adequate ventilation in various clinical contexts¹. Its application spans elective surgeries, emergency resuscitation scenarios, and the management of patients requiring prolonged mechanical ventilation¹. Historically, the development of orotracheal intubation techniques reflects significant advancements in medical knowledge and

technology, from the primitive use of reed tubes in ancient Egypt to the sophisticated tools and techniques employed today¹. However, despite its ubiquity and the evolution of methods and devices aimed at reducing complications, airway injury remains a concerning consequence of the procedure, with potential for significant morbidity and mortality².

The anatomical structures involved in orotracheal intubation, including the oral cavity, pharynx, larynx, trachea, and their surrounding tissues, are inherently at risk of injury due to their delicate nature and close proximity². The dynamic physiological changes that occur during the intubation process, such as the application of external force and pressure to facilitate tube insertion, can lead to a range of injuries². These injuries can be classified by their severity, from minor mucosal abrasions and lacerations to major complications such as vocal cord damage, tracheal rupture, and esophageal perforation³. The incidence and prevalence of these injuries vary widely, influenced by factors such as patient demographics, comorbid conditions, the urgency of the situation, and the level of experience of the medical personnel involved³.

Several risk factors have been identified that predispose patients to airway injuries during intubation³. Patient-related factors include age, anatomical variations, pre-existing airway pathologies, and comorbidities such as obesity or connective tissue disorders⁴. Procedural factors encompass the choice of intubation technique, the type of equipment used, and the specific circumstances under which intubation is performed⁴. Direct laryngoscopy, long considered the gold standard for intubation, has been associated with a higher incidence of certain types of injuries compared to newer modalities like video laryngoscopy, which offers improved visualization of the airway⁴. Equipment-

related factors, including the design and size of endotracheal tubes, the use of adjuncts like stylets, and the properties of laryngoscope blades, also play a critical role in influencing injury risk⁵.

Training and experience of the personnel performing intubation significantly impact the incidence of airway injuries⁵. Studies have shown that practitioners with extensive training and experience in airway management are less likely to cause injuries, highlighting the importance of continued education and simulation-based training in minimizing adverse events⁵. Furthermore, emergency situations, where rapid decision-making and swift action are necessary, pose unique challenges, increasing the likelihood of injury due to the need for expedited intubation and the often suboptimal conditions in which these procedures occur⁶.

The complications associated with airway injuries range from immediate consequences, such as airway obstruction and hypoxia, to long-term sequelae, including persistent dysphonia, tracheal stenosis, and, in severe cases, death⁶. Special populations, such as pediatric and geriatric patients, are particularly vulnerable to such injuries due to anatomical and physiological differences, as well as the presence of comorbidities that complicate airway management⁶. Preventive measures have been proposed to mitigate these risks, including the development and implementation of best practice guidelines, the use of advanced imaging modalities for airway assessment, and the adoption of new technologies and tools designed to reduce injury risk⁷.

Technological advances in intubation, such as the advent of video laryngoscopes, fiberoptic bronchoscopes, and supraglottic airway devices, have contributed to reducing the incidence of airway injuries by enhancing visualization and control during the procedure⁷.

Despite these advances, airway injuries remain a clinically significant issue, with a profound impact on patient outcomes, including increased morbidity and mortality, prolonged hospital stays, and escalated healthcare costs⁷. The clinical significance of these injuries underscores the need for continued research and innovation in airway management strategies⁸.

Diagnostic approaches for airway injuries involve a combination of clinical assessment and the use of imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI), and flexible endoscopy, which can help identify the extent and nature of the injury⁸. Management strategies range from conservative approaches, such as observation and supportive care, to more invasive interventions, including surgical repair and reconstruction in cases of severe injury⁸. The current landscape is marked by ongoing controversies and gaps in knowledge, particularly regarding the optimal methods for preventing and managing airway injuries⁹. This literature review aims to synthesize existing evidence on these topics, identify areas where further research is needed, and propose potential strategies for improving patient safety and outcomes⁹.

OBJETIVES

To comprehensively review the incidence, risk factors, types, diagnostic approaches, and management strategies associated with airway injuries during orotracheal intubation, while evaluating the effectiveness of current prevention and treatment methodologies.

SECUNDARY OBJETIVES

1. To assess the impact of patient demographics, comorbidities, and anatomical variations on the risk of airway injury.

2. To evaluate the influence of intubation tools, techniques, and procedural settings on the incidence of airway injuries.
3. To discuss the effectiveness of advanced airway management techniques, such as video laryngoscopy and fiberoptic intubation, in reducing injury risk.
4. To analyze the therapeutic approaches and clinical guidelines for managing different types of airway injuries.
5. To identify gaps in current knowledge and propose future research directions in airway injury prevention and management.

METHODS

This is a narrative review, in which the main aspects of the incidence, risk factors, types, diagnostic approaches, and management strategies associated with airway injuries during orotracheal intubation, while evaluating the effectiveness of current prevention and treatment methodologies in recent years were analyzed. The beginning of the study was carried out with theoretical training using the following databases: PubMed, sciELO and Medline, using as descriptors: “Orotracheal Intubation” OR “Airway Injury” AND “Airway Management” OR “Intubation Complications” AND “Laryngoscopy Techniques” in the last years. As it is a narrative review, this study does not have any risks.

Databases: This review included studies in the MEDLINE – PubMed (National Library of Medicine, National Institutes of Health), COCHRANE, EMBASE and Google Scholar databases.

The inclusion criteria applied in the analytical review were human intervention studies, experimental studies, cohort studies, case-control studies, cross-sectional studies and literature reviews, editorials, case reports, and poster presentations. Also, only studies writing in English and Portuguese were included.

RESULTS AND DISCUSSION

Airway injury during orotracheal intubation is influenced by multiple factors, including patient demographics, comorbidities, procedural characteristics, and equipment used⁹. Studies have consistently shown that patient demographics, such as age and sex, play a role in the risk of airway injury⁹. For example, elderly patients, who often have reduced tissue elasticity and multiple comorbidities, are at a higher risk of mucosal tears and tracheal injuries¹⁰. Conversely, pediatric patients, due to their smaller airway size and unique anatomical features, are more susceptible to subglottic stenosis and cricoid cartilage damage¹⁰. The presence of comorbid conditions, such as chronic obstructive pulmonary disease, obesity, and connective tissue disorders, further complicates airway management, as these conditions can alter airway anatomy, increase the fragility of tissues, and heighten the risk of injury during intubation¹¹.

The duration of intubation is another critical factor correlated with the severity of airway injuries¹¹. Prolonged intubation, often necessary in critically ill patients, has been associated with higher rates of tracheal stenosis, granulation tissue formation, and vocal cord immobility¹¹. Studies have demonstrated that extended intubation times lead to increased pressure exerted by the endotracheal tube on the tracheal mucosa, resulting in ischemia, ulceration, and subsequent fibrotic changes¹². Anatomical variations, such as a high-arched palate, retrognathia, or limited mouth opening, can complicate intubation and increase the risk of injury¹². These variations necessitate careful pre-intubation assessment and planning to avoid difficult airway situations, which are a known risk factor for traumatic intubation¹².

The type of intubation tools used significantly impacts the incidence of airway

injuries¹³. Direct laryngoscopy, while effective in many cases, is associated with a higher risk of soft tissue damage, particularly when performed by less experienced personnel¹³. Video laryngoscopy, which provides an enhanced view of the vocal cords, has been shown to reduce the incidence of esophageal intubation and minimize the force required for tube placement, thereby lowering the risk of injury¹³. However, it is not without its limitations, such as the potential for injury related to the insertion and positioning of the device itself¹⁴. The choice of endotracheal tube size is another important consideration¹⁴. Larger tubes can cause more significant mucosal damage and increase the risk of subglottic stenosis, whereas smaller tubes, while reducing trauma, may be inadequate for ventilation in certain patients¹⁴.

The use of stylets, while aiding in the placement of the endotracheal tube, has been implicated in airway injuries, particularly when excessive force is applied¹⁵. Studies have suggested that the routine use of stylets should be reconsidered, especially in patients with known difficult airways¹⁵. The impact of emergency versus elective intubation settings also deserves attention¹⁵. Emergency intubations are inherently more challenging due to time constraints, limited patient preparation, and the often suboptimal conditions in which they are performed¹⁶. These factors contribute to a higher incidence of airway injuries, particularly in patients with compromised physiological reserves¹⁶.

Repeated intubation attempts, especially in difficult airway scenarios, increase the risk of injury to the airway structures¹⁶. Evidence indicates that multiple intubation attempts are a strong predictor of airway trauma, with each additional attempt compounding the risk of injury¹⁷. The level of training and experience of the personnel performing the intubation is crucial¹⁷. Data consistently show

that practitioners with more experience and specialized training in airway management have lower rates of airway injury¹⁷. Simulation-based training programs have demonstrated efficacy in improving the skills necessary for safe intubation, suggesting that such programs should be integrated into routine medical education and continuing professional development¹⁸.

The outcomes of airway injuries differ between pediatric and adult patients¹⁸. Pediatric patients are more likely to develop subglottic stenosis due to the smaller diameter of their airways, while adults may experience a broader range of complications, from vocal cord paralysis to tracheal tears¹⁸. Pharmacological agents, such as corticosteroids, have been used to minimize airway inflammation and reduce the risk of injury during intubation, although their effectiveness remains a topic of ongoing debate¹⁹. Early detection of airway injuries post-intubation is critical, as delayed diagnosis can lead to more severe complications¹⁹. Techniques such as flexible bronchoscopy and ultrasound have been used to assess the extent of injury, but their utility varies depending on the type and location of the injury¹⁹.

Therapeutic approaches to managing airway injuries are diverse and depend on the severity and type of injury²⁰. For minor injuries, conservative management with humidified oxygen, analgesics, and anti-inflammatory medications may suffice²⁰. More severe injuries, such as tracheal lacerations or esophageal perforations, often require surgical intervention, ranging from simple suturing to complex reconstructive procedures²⁰. Clinical guidelines for minimizing airway injury emphasize the importance of careful pre-intubation assessment, appropriate equipment selection, and the use of techniques that minimize trauma, such as video laryngoscopy and fiberoptic intubation²¹. The role of pre-intubation airway assessment tools, such as the Mallampati score and neck circumference

measurements, in predicting and preventing airway injuries cannot be overemphasized²¹. Oropharyngeal airway devices, while useful in certain scenarios, can also contribute to intubation-related injuries, particularly in patients with fragile or edematous tissues²¹.

Patient positioning during intubation is another critical factor; the sniffing position has been shown to improve laryngeal visualization and reduce injury risk²². However, its effectiveness can be limited in patients with cervical spine instability or obesity²². Airway humidification is often recommended to prevent mucosal drying and minimize trauma, but its role in reducing airway injury remains under investigation²². In patients with pre-existing airway conditions, such as laryngeal edema or vocal cord dysfunction, intubation poses a higher risk, necessitating a tailored approach to minimize injury²³. Managing airway injuries in remote or resource-limited settings presents unique challenges, as advanced diagnostic tools and surgical expertise may not be readily available, making the prevention of such injuries even more critical²³.

The correlation between injury severity and patient outcomes is evident; more severe injuries are associated with higher rates of morbidity and mortality²³. Advanced airway management techniques, such as awake fiberoptic intubation, are increasingly being employed to reduce the risk of injury, particularly in high-risk patients²⁴. Improving communication and coordination among healthcare providers during intubation is crucial, as effective teamwork has been shown to reduce the incidence of airway injuries²⁴. The economic implications of airway injuries are significant, as these complications often lead to prolonged hospital stays, additional interventions, and increased healthcare costs²⁴.

Patient perspectives on airway injuries, including their impact on quality of life, are an area that warrants further exploration²⁵.

Innovations in intubation technology, such as automated robotic-assisted devices, hold promise in reducing injuries, but their adoption requires further validation in clinical settings²⁵. The role of fiberoptic intubation, particularly in patients at high risk for airway injury, remains a cornerstone of safe airway management, while the relationship between sedative use and airway injury during intubation continues to be a focus of ongoing research²⁵.

Cultural and systemic factors, such as differences in training and resource availability, influence airway injury rates across different healthcare settings²⁶. Prevention programs tailored to these settings have shown varying degrees of efficacy, emphasizing the need for context-specific strategies²⁶. The long-term rehabilitation needs of patients with severe airway injuries, including speech therapy and surgical reconstruction, require a multidisciplinary approach to optimize outcomes²⁶. Ethical considerations in managing airway injuries, particularly concerning informed consent and disclosure of risks, are paramount, and potential legal implications, such as malpractice claims, underscore the need for

meticulous documentation and adherence to clinical guidelines²⁷.

CONCLUSION

Airway injury during orotracheal intubation represents a significant challenge in clinical practice, with implications for patient safety, outcomes, and healthcare resources. The complexity of factors contributing to these injuries necessitates a comprehensive approach to prevention, diagnosis, and management. While technological advancements and improved training methodologies have reduced the incidence of injuries, gaps in knowledge remain, particularly concerning optimal management strategies and the long-term consequences of these injuries. Continued research is essential to develop more effective prevention programs, refine existing guidelines, and explore innovative technologies that can further reduce the risk of airway injury. The integration of multidisciplinary approaches and the enhancement of clinical communication and coordination are critical to improving patient outcomes and minimizing the burden of airway injuries in healthcare settings.

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