Recommendations for the prevention of adverse events in endotracheal suctioning – Integrative Review

Recomendações na aspiração do tubo endotraqueal para prevenção de eventos adversos – revisão integrativa

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Keywords
Suction, methods; Suction, adverse effects; Suction, guidelines; Artificial respiration, adverse effects; Intensive care units.

Abstract

Introduction: The use of endotracheal suctioning is a common procedure in intensive care units, which implies various risks, namely hypoxemia, atelectasis, arterial hypertension, microbial colonization, etc. Nevertheless, healthcare professionals can adopt certain strategies to prevent these adverse events.
Aim: To describe good practice relating to endotracheal suctioning in patients undergoing invasive ventilation.
Material and Methods: Integrative literature review. The research occurred in December 2015, using the databases B-on, PUBMED and RCAAP and 534 documents were found. After inclusion/exclusion and quality criteria evaluation, four studies were accepted for inclusion in this review.
Results: Recommendations encountered were: suction only when necessary, pre-oxygenate, use a suction catheter with half the diameter of the endotracheal tube, avoid saline instillation, employ a closed aspiration system when FiO2 or positive end-expiratory pressure is elevated, limit the procedural duration to under 15 seconds and monitor the patient.
Conclusions: The review demonstrates that some conclusions are not consensual, which represents a limitation of this study, since more experimental studies are needed, which represents a limitation of this study, since more experimental studies are needed. However, the stimulation of open debate, reflection, as well as the adoption of preventative measures, can lead to safer practice.

Palavras-chave
*Sucção/métodos; sucção/efeitos adversos; sucção/*guidelines; *respiração artificial/efeitos adversos; unidades de terapia intensiva.*

Resumo

Introdução: *A aspiração endotraqueal é um procedimento bastante comum em unidades de cuidados intensivos. Apesar de frequente, este procedimento implica diversos riscos como hipoxemia, atelectasia, hipertensão arterial, colonização microbiana, entre outros. Os profissionais de saúde podem adotar estratégias para prevenir esses eventos adversos.*
Objetivo: *Descrever as recomendações de boas práticas em relação à aspiração endotraqueal em doentes sob ventilação invasiva.*
Material e métodos: *Revisão integrativa da literatura. A pesquisa foi realizada nas bases de dados B-on, PUBMED e RCAAP em dezembro de 2015. Foram encontrados 534 documentos e, após aplicação dos critérios de inclusão e avaliação qualitativa, foram incluídos quatro estudos.*
Resultados: *As recomendações encontradas foram: aspirar apenas quando necessário, pré-oxigenar, utilizar um cateter de aspiração com metade do diâmetro do tubo endotraqueal, usar a menor pressão de aspiração possível, aspiração superficial, evitar a instilação de solução salina, utilizar sistema de aspiração fechados quando FiO2 ou pressão positiva após expiração elevadas, duração inferior a 15 segundos e monitorizar doente.*
Conclusões: *Alguns aspetos relacionados com a aspiração no tubo endotraqueal não são consensuais, o que representa uma limitação deste estudo, pois são necessários mais estudos experimentais. No entanto, o estímulo ao debate, à reflexão e à adoção de medidas preventivas conduzem a uma prática mais segura.*

Introduction

One of the most common procedures in intensive care units (ICUs) is the suction of endotracheal secretions. This intervention allows airways clearance, preserving their permeability and facilitating adequate gas exchange. The International Council of Nurses describes the procedure as follows: "Process of the respiratory system: maintaining the air passage open from the mouth to the pulmonary alveoli through the cleansing of secretions or obstructions of the respiratory tract".[1]

Suctioning must be undertaken in cases of airway obstruction commonly caused by the presence of secretions, or further by the presence of enteric contents or external objects. Despite the potential benefits, this procedure is not innocuous, being associated with various adverse events, including hypoxemia,[2,3] atelectasis,[4] bronchial tissue trauma,[5] arterial hypertension,[6] intracranial hypertension,[7,8] bronchial spasm[9] and microbial colonization.[10] In addition to these potentially critical effects, this procedure is described by patients as uncomfortable or even painful, and may induce a sensation of choking.[11]

In order to avoid adverse events, it is necessary to identify the most appropriate technique for the suction in the endotracheal tube, and its peculiarities of which have been studied by numerous researchers. However, the results are not consensual, therefore it is important to examine the main aspects of aspiration and disseminate conclusions so that healthcare professionals can make fundamental decisions based on current data. According to current scientific knowledge, this study describes good practice recommendations related to the employment of endotracheal suctioning in patients undergoing invasive ventilation, using as methodology integrated literature review.

Material and Methods

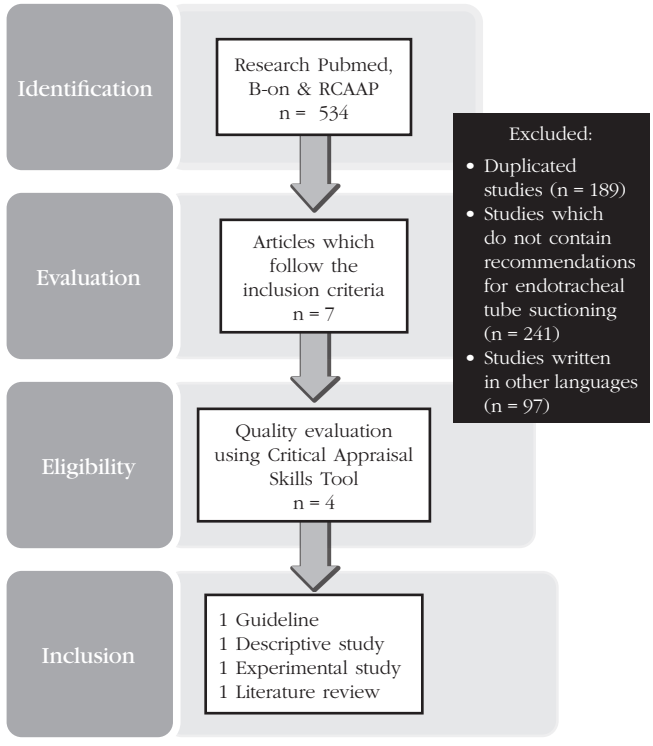
Research was undertaken in December 2015 using the databases B-on, PUBMED and RCAAP. The research terms used were "endotracheal suctioning," "mechanically ventilated patients," "protocol" and "guideline." In order to increase the precision of the results, the Boolean operator "and" was also used. The criteria for inclusion were: (a) guidelines and original articles containing recommendations for endotracheal tube suctioning, (b) date of publication within the last six years, (c) samples ≥ 18 years of age and (d) studies on human subjects. Studies in languages other than English, French, Spanish or Portuguese were excluded.

Were found 534 documents and, subsequent to reviewing the abstracts, were excluded: duplicate studies (n = 189), studies which contained no recommendations regarding endotracheal tube suctioning (n = 241), and studies in languages other than English, French, Spanish and Portuguese (n = 97).

In order to improve quality, reliability and validity, the 7 remaining articles which fit the inclusion criteria were read in their entirety, and then submitted to a quality assessment using the Critical Appraisal Skill Program Tool (CASP). This instrument allows concluding that the research described in the articles is valid and reliable.

The analysis was done by two individual researchers through the completion of forms suggested by the Critical Appraisal Group. Articles which obtained the "recommended" classification were included. Any disagreement was discussed until a consensus was reached. Due to the fact that important methodological aspects weren't described in the articles, three studies were excluded. As a result, four articles were included in this review. Figure 1 summarizes the evidence selection process, following the PRISMA flow diagram.

Figure 1 – PRISMA flow chart for selection of evidence



Results

The following studies were included in this review: one guideline, one descriptive study, one experimental study and one literature review. Table 1 summarizes these articles. In the articles by Pederson et al,[11] AARC,[12] Sole et al[13] and Maggiore et al,[14] indications for the necessity of endotracheal suctioning are discussed, taking into account the potential complications of the procedure. In the articles by Pedersen et al,[11] AARC[12] and Maggiore et al[14] are described the necessary preparation to be undertaken prior to the procedure, which catheter is most suitable, the necessity of using an open or closed suction system, the appropriate suctioning pressure and hyperoxygenation.

Table 1 – Characteristics of included studies

Author	Title	Method-ology	Results	Conclusions
AARC [12]	Endotracheal suctioning of mechanically ventilated patients with artificial airways	Guideline	Endotracheal suctioning must be performed only when secretions are present, and not routinely. It is suggested that pre-oxygenation be considered if the patient has a clinically important reduction in oxygen saturation. Perform suctioning without disconnecting the ventilator tube. Superficial instead of deep suctioning is suggested, based on evidence of studies on children. It is suggested that routine instillation of saline solution prior endotracheal suctioning should not be performed. The use of closed suctioning is suggested for adults with high FiO2, or PEEP, or with risk of pulmonary derecruitment, and for neonates. Avoid disconnection in patients with acute pulmonary lesions. Use of a suction catheter with an occlusion inferior to 50% of the endotracheal tube lumen is suggested in adults and children, and one of less than 70% in nursing infants. The duration of the suctioning should be limited to less than 15 seconds.	----------
Sole et al [13]	Clinical Indicators for Endotracheal Suctioning in Adult Patients Receiving Mechanical Ventilation	Descriptive study	The majority of the patients were male (62%) and white (93%). The medium age was 51 years old and the average duration of mechanical ventilation was 7.5 days. The medium duration of endotracheal suctioning was 2 hours and an average of 4.4 ml de secretions were removed. Three patients did not exhibit identifiable indication, but had 1.0 ml or more of secretions. The most frequent indications were course crackles in the trachea (88%), a saw-tooth pattern ventilator waveform (33%), cough (29%) and visible secretions (5%). Signs & physiological parameters improved after suctioning. Coarse pulmonary sounds did not improve.	The presence of secretions must be routinely evaluated in patients undergoing mechanical ventilation. Despite being common practice, the evaluation of pulmonary sounds to identify the necessity of aspiration is not supported by this study.
Pedersen et al [11]	Endotracheal suctioning of the adult intubated Patient – What is the evidence?	Literature review	The main recommendations are: -Suctioning solely when necessary, using a catheter with an occlusion less than half the lumen of the endotracheal tube diameter & utilizing the lowest pressure possible; -Introducing the catheter not more distal than the carina and for a duration of no more than 15 seconds; -Executing continuous rather than intermittent suctioning; -Avoiding instillation with saline solution; -Executing hyperoxygenation prior to and after the procedure balancing hyperinflation combined with hyperoxygenation on non-routine basis; -Always using aseptic technique and an open or closed system.	----------
Maggiore et al [14]	Decreasing the Adverse Effects of Endotracheal Suctioning During Mechanical Ventilation by Changing Practice	Experimental study	Before implementing the guidelines, adverse effects occurred frequently: desaturation of oxygen in 46.8% of the patients, blood secretions in 31.6%, alteration of blood pressure in 24.1% and alteration in heart rate in 10.1% of the patients. After implementing the guidelines, The incidence of all the complications together diminished in from 59.5% to 42.6% of the individuals. Receiving more than six aspirations per day was a risk factor for desaturation and blood secretions. The use of the guidelines was associated with a reduced incidence of complications.	Endotracheal suctioning frequently causes adverse effects. Technique, frequency of suctioning and elevated PEEP are risk factors for complications. Their incidence can be reduced through the implementation of the suctioning guidelines.

The technique of aspiration is discussed by Pedersen et al,[11] AARC,[12] Sole et al[13] and Maggiore et al [14] as well as the depth and duration of aspiration.

Discussion

Indications for aspiration in the endotracheal tube

According to the studies included in this review, the premise of suctioning secretions is consensual only when necessary.[11-14] In order to minimize the risk of possible complications resulting from suctioning secretions, the necessity of the suctioning must be evaluated prior to the procedure, and Sole et al[13] recommend that this evaluation should be made every two to four hours. According to these researchers, and contrary to common practice, the presence of ronchi during pulmonary auscultation does not indicates the need for suctioning, as this procedure removes only secretions above the carina. According to the findings of this observational study,[13] 45% of the patients continued to exhibit ronchi after suctioning. Therefore, auscultation is recommended above the trachea. The presence of secretions must be routinely evaluated, as described by evidence, trough auscultation above the trachea and by observation of the ventilator curves.[12, 13]

A saw-tooth flow volume curve, low ventilator volume, low inhalation volume with controlled ventilation, deterioration in oxygen saturation, suspected aspiration of enteric contents or of upper airway excretions, presence of visible secretions and cough, are all indicators for the necessity of suctioning.[11-14] In patients whose cough reflex is absent, for example during curarization, Pedersen et al[11] recommend suctioning to be performed every eight hours, despite the absence of signs of secretions, due to the risk of obstruction of the endotracheal tube and the accumulation of secretions.

Preparation of the patient

The utilization of catheters with a diameter equal to or inferior to half the diameter of the endotracheal tube is recommended in the majority of the studies consulted, so long as they permit the passage of air through the endotracheal tube, thereby preventing a sudden drop in the residual pulmonary function, and minimizing the risk of atelectasis.[11,12,14] A meta-analysis[11] concluded that pre-oxygenation with 100% oxygen reduces the incidence of hypoxemia by 32%, therefore hyperoxygenation is recommended for 30 – 60 seconds prior to and subsequent to the procedure with the objective of avoiding possible hypoxemia.[11,12] Hyperoxygenation must not be confused with hyperinflation. While hyperinflation is routinely performed with 100% oxygen, this term refers to pulmonary inflation to approximately 1.5 times the usual tidal volume of the patient. This procedure can be performed manually or with a mechanical ventilator, permitting pulmonary volume recruitment and liberation of secretions. Nevetheless, it is frequently associated with a risk of barotrauma, cardiac instability and an increase in intracranial pressure.

The use of manual ventilation is contraindicated as the volume provided varies considerably among individuals that perform this procedure, and is frequently inferior to the volume induced by the ventilator, as proved by Clapham et al and Robson.[11] On the other hand, pulmonary recruitment through the application of inspiratory pressure of 45 cmH_2O for 20 seconds in patients with respiratory distress syndrome and acute pulmonary lesions, allowed a more rapid return to normal basis levels of volume and oxygen saturation after aspiration, according to a study by Dyhr et al.[11]

Suction pressure should be as low as possible, while still sufficient for effective suctioning. On one hand, low suction pressure minimizes possible complications, on the other it may reduce the effectiveness of the suctioning when secretions are thicker. Ideally, according to the American Association for Respiratory Care (AARC), the pressure applied must be less than 150 mmHg in adults, and testing the function of the negative pressure of the unit should be performed before usage.

Maggiore et al,[14] recommend a pressure of between 200 and 250 mmHg. Pedersen et al[11] cite a meta-analysis in which a pressure of between 80 and 120 mmHg was identified in 50% of the studies, while another study concluded that no difference existed between using pressures from 145 mmHg to 500 mmHg when the diameter of the catheter is equal to or less than half the diameter of the endotracheal tube. These researchers advocate that pressures between 200 and 300 mmHg can be utilized when performed with a suction catheter of appropriate diameter.

The use of an open versus a closed suction system continues to create doubt among professionals. A closed suction system is an aspiration catheter protected by a sleeve, which blocks contact with the environment, and is connected to the endotracheal

tube, the mechanical ventilator and the negative pressure tube, allowing suction without disconnecting the ventilator circuit. This system is commonly associated with less effectiveness in the removal of secretions than the open system, while some studies identify no difference between the two systems.[11]

Pedersen et al,[11] AARC [12] and Maggiore et al[14] recommend the use of a close aspiration circuit in cases of elevated FiO_2 and PEEP due to the fact that this system avoids disconnections, maintains ventilation during the procedure, and prevents de-recruitment and desaturation. According to various studies[11, 12] the use of these systems has no influence on the incidence of pneumonia. Furthermore, the monitoring of peripheral venous saturation is recommended before, during and after the procedure, due to the high risk of desaturation.[12, 14]

Procedure

All studies found recommended the adoption of an aseptic technique. As a procedure that makes the patient more susceptible to infection caused by bacteria from the exterior environment, it is recommended that universal infection control precautions should be adopted, specially correct hand washing (before and after the procedure) and the use of gloves. In order to protect health personnel from splashes from disconnection of the ventilator circuit, even with a closed system, eye protection is recommended.[11] If an open system is used, a sterile catheter must be inserted into the endotracheal tube using sterilized gloves.[11,14] After suctioning, the catheter must be disposed, due to risk of contamination from the environment, and the in-line suction catheters must be washed with water stored in a vessel in the patient's room. This water, according to the Statens Serum Institut, must be changed every 8 hours.[11]

The recommendation of shallower suctioning is consensual among the studies found,[11-14] and according to Maggiori et al,[14] from 8 to 10 cm of the suction catheter must be kept outside the endotracheal tube, or less than half the length of the catheter in the case of tracheostomies. Pedersen et al[11] warn that in cases where secretions are present in the lower airways, deeper suctioning is necessary, although this technique is associated with a greater number of adverse effects due to the greater negative pressure exerted on the lungs.

The duration of suctioning is one of the factors that affect the appearance of possible complications stemming from this procedure, however it is difficult to determine the consequence associated with a certain space of time. A study that analyses complications associated with suctioning recommends 10 seconds of suctioning and 15 seconds for the entire procedure.[11] There is lack of evidence to determine the maximum duration, though as a result of clinical practice, the authors recommend less than 15 seconds.[11, 14]

The use of intermittent or continuous technique remains a controversial aspect. While, in theory, an intermittent technique can prevent damage to the tracheal mucosa, there is lack of studies which prove the benefits of one technique over another. Nevertheless, one study associated intermittent aspiration with a greater risk of alveolar collapse. Therefore, continuous aspiration is recommended.[11]

In clinical practice, instillation of saline solution is commonly used prior to suctioning, under the pretext of thinning secretions or stimulating coughing. However, according to Pedersen et al,[11] various studies prove that secretions are not soluble in a saline solution. Furthermore, this practice will promote the migration of existent bacteria in the biofilm of the endotracheal tube to the lower airways. Routine instillation of saline solution is therefore not recommended.[11, 12, 14]

Conclusions

This study demonstrates that some aspects regarding endotracheal tube suctioning are not consensual. At the same time, some of the primary studies on which the publications used in this study are based are not recent, and others, lacking greater evidence, are based on expert opinion, which represents a limitation of this study. Also, another limitation relies on the fact that relevant studies regarding this matter may have been excluded because they did not meet the inclusion criteria. Nevertheless, the following recommendations demonstrate a higher level of consensus:

- Use of suction catheters with a diameter equal to or less than half the diameter of the endotracheal tube;
- Pre-oxygenation with 100% oxygenation for 30-60 seconds before and after the procedure;
- Use of the lowest possible suction pressure, as long as it is sufficient for effective suctioning;
- Use of a closed suction circuit in cases of elevated FiO2 and PEEP;
- Adoption of aseptic suctioning technique;

- Use of individual universal precautions, i.e. eye protection, mask & gloves;
- Performing shallow suctioning;
- Duration of suctioning of less than 15 seconds;
- Non routine instillation of saline solution.

It would be relevant for clinical practice if were undertaken experimental studies which clarified questions regarding the necessity for routine suctioning in cases of patients with an absence of cough reflex, the use of open or closed suction systems, and the use of intermittent or continuous suction pressure.

The adverse events related with endotracheal suctioning are frequent, and can be reduced through the implementation of Guidelines. This review intends to contribute to the dissemination of good practice and attention to quality of care. The study further seeks to raise awareness among healthcare professionals regarding the importance of preventing adverse effects during the execution of the tracheobronchial suction procedure, in a way that guarantees a more thoughtful and safer practice.

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