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MEDICINE

Indicative Factors for 48 or More Hours of Mechanical Ventilation to Optimize the Use of Orotracheal Tubes with Supra-cuff Suction Devices: a Retrospective Study

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Abstract

The objective of this study is to verify the risk factors for invasive mechanical ventilation (IMV) for ≥48h, aiming at the best indication of orotracheal tubes (OTTs) with supra-cuff suction devices. This retrospective and observational study was carried out at the Adult Intensive Care Unit of the University Hospital during a 2-year period. Patients undergoing orotracheal intubation were enrolled. Demographic and clinical data were collected from medical records. A total of 1185 medical records were analyzed, of which 820 were included in the study. The markers associated with intubation for ≥48h were as follows: positive history of diseases (RR=1.42; 95%CI=1.17 to 1.74), especially alcohol addiction (RR=1.60; 95%CI=1.22 to 2.09) or former alcohol addiction (RR=1.50; 95%CI=1.06 to 2.13); clinical hospitalization (RR=1.06; 95%CI=0.98 to 1.16); emergency intubation (RR=3.24; 95%CI=3.01 to 3.95); intubation performed in the emergency department (RR=3.44; 95%CI=3.01 to 3.95) and other hospital facilities (RR=2.92; 95%CI=2.49 to 3.42); and intubation due to lowered level of consciousness (RR=3.40; 95%CI=2.95 to 3.93), acute respiratory failure (RR=3.43; 95%CI=2.98 to 3.54), and airway protection (RR=2.87; 95%CI=2.32 to 3.54). Patients on IMV for ≥48h had an RR of 2.07 (95%CI=1.79 to 2.40) for death. Patients with history of diseases, especially past or current history of alcoholism with clinical hospitalization, who underwent emergency intubation in the emergency department or in other hospital facilities due to lowered level of consciousness, acute respiratory failure, or protect airways, are most likely to require IMV for ≥48h. Also, patients on IMV for ≥48h had an high RR for death.

Keywords Intratracheal intubation · Pneumonia associated with mechanical ventilation · Artificial respiration · Intensive care unit

Introduction

Ventilator-associated pneumonia (VAP) is the most frequent respiratory infection acquired in intensive care units, and one the major causes of increased morbidity and mortality in ventilated critically ill patients [1–5]. The mortality rate of hospital-associated infections, such as those of the urinary tract and skin, can vary from 1 to 4%; and yet, mortality rate of VAP amounts to over 70% [3]. Concomitantly, ~10 to 20% of mechanically ventilated patients develop VAP worldwide [6, 7] and this incidence ranges from 6 to 52% in Brazil [8].

VAP may prolong the duration of invasive mechanical ventilation (IMV) for ~8 to 12 days and increase the mean length of stay in the intensive care unit (ICU) from 11 to 20 days and hospital stay to 32 days, compared to 20 days of mean hospital stay for patients without a diagnosis of VAP [1, 9, 10]. Additionally, the cost of treating patients with VAP is higher than that of patients without the disease, which contributes to significantly increase hospital costs [9].

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One of the causes for the development of VAP is the presence of microaspirations of secretion above the cuff [5, 6, 11–13], i.e., a favorable site for colonization and infection of microorganisms, including bacteria, which can reach the lower airways [2, 5, 12–14].

One of the strategies to prevent VAP is the use of orotracheal tubes (OTTs) with supra-cuff suction devices [11, 13, 15–22]. The Society for Healthcare and Epidemiology of America indicates their use in patients on IMV for at least 48h, but its protocol does not describe how to identify these patients [23]. The Brazilian National Health Surveillance Agency (ANVISA) published measures to prevent VAP, including the use of OTTs with supra-cuff suction devices in patients who will be mechanically ventilated for ≥48h [24].

OTTs with supra-cuff suction devices may cost 20 times as much as conventional tubes; therefore, it is important to identify which patients should be intubated with this equipment [25]. In the literature, to the best of our knowledge, only one study carried out in the USA aimed to identify which demographic, clinical, and laboratory characteristics of the patients were recommended for ventilation for ≥48h [26].

The aim of this study was to identify risk factors for the need of IMV for ≥48h, demonstrating the cases in which the use of OTTs with supra-cuff suction devices could be indicated. Thus, hospitals could make the proper use of this equipment and guarantee optimization of assistance and cost reduction.

Methods

A retrospective and observational study was carried out, with the analysis of electronic medical records. This research was carried out at the Adult Intensive Care Unit of the University Hospital.

All patients undergoing orotracheal intubation (OTI) admitted at the ICU during a 2-year period were included. The following patients were excluded: patients under 18 years of age, who underwent an OTI procedure outside of the hospital facilities or with previous tracheostomy, who were not intubated, or whose electronic medical records were incomplete.

A single evaluator collected and transcribed the data from electronic medical records to a form, namely demographic characteristics (age (years); sex (male or female); body mass index (BMI)) and clinical characteristics (history of diseases; type of hospitalization; type, location and duration of orotracheal intubation; hospital outcomes). The study was approved by the Research Ethics Committee of the institution (CAAE: #60131316.3.0000.5514). Since this study was retrospective, the Ethics Committee authorized the data collection without the signature of the informed consent form by the participants or their guardians. The author ensures that the work described has carried out in accordance with Declaration of Helsinki for studies involving humans.

In the statistical analysis, the relative risk (RR) and the 95% confidence interval (95%CI) of the categorical variables related to IMV duration of ≥48h were calculated. A multivariate analysis was performed by generalized linear model (GLM) multivariate logistic regression with all variables with p-value <0.20 in the bivariate analysis excluding the death (considered as outcome). The main advantage of using multivariate analysis is to indicate the probability of the outcome to occur when compared to a reference value. In this context, our GLM multivariate logistic regression included the following markers: age, type of hospitalization, type of OTI, reason for OTI, presence of clinical features (such as coronary artery disease, cancer, acute or chronic kidney injury, alcohol addiction, former alcohol addiction, and congestive heart failure), and history for diseases. Statistical analyses used the computer environment R Development Core Team (2016). The level of significance was set to p-value ≤0.05.

Results

The initial search in the electronic medical records showed a total of 1185 patients hospitalized in the 2-year period evaluated. Figure 1 summarizes the exclusion criteria and the final sample with 820 participants.

Demographic and clinical characteristics of the patients included in the study are listed in Table 1. The highest prevalence was among males (60.1%). Regarding family history, the major diseases are in descending order, as follows: systemic arterial hypertension (54.4%), diabetes mellitus (26.2%), and smoking or smoking cessation (12.3% and 13.9%, respectively). The highest prevalence was surgical hospitalization (81.7%), with elective OTI (79.5%) and performed in operating rooms (78.3%). The duration of OTI was ≥48h in 40.5% of hospitalized patients. Finally, death occurred among 15.6% of patients. Patients submitted to prolonged OTI had the highest risk of death (RR=2.07; 95%CI=1.79 to 2.40).

Table 2 shows the characteristics related to duration of OTI ≥48h with p-value ≤0.05. The major risks factors are as follows: presence of family history (as described in Table 1), need for emergency OTI, OTI performed in a non-surgical environment, and need for OTI, due to lowered level of consciousness, acute respiratory failure, or airway protection. A brief association between the main surgical specialties, correlating them with OTI ≥48h, is shown in Table 3.

Ultimately, Table 4 displays the data obtained from the GLM multivariate logistic regression analysis (p-value ≤0.20). In brief, the indication of OTI (due to lowered level of consciousness or due to acute respiratory failure) was the

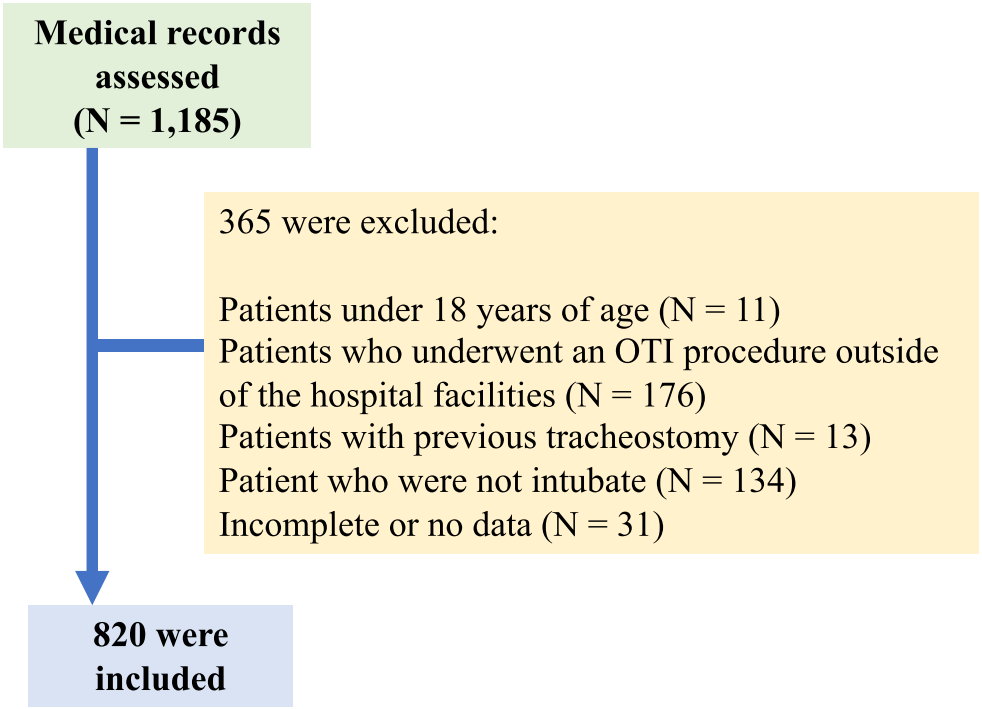

Fig. 1 Exclusion criteria for patients

marker that showed association with the longest IMV duration. The GLM multivariate logistic regression demonstrated a significant p-value for three categories only, such as (i) intercept (p-value=0.005) which indicates a probability of 0.2584 (25.84%) to duration of OTI ≥48h when all reference markers are considered; (ii) OTI due to acute respiratory failure (p-value=0.021) which indicates a probability of 0.9669 (96.69%) of patients to duration of OTI ≥48h when compared with the reference (use of anesthesia); (iii) OTI due to lowered level of consciousness (p-value=0.029) which indicates a probability of 0.9632 (96.32%) of patients to duration of OTI ≥48h when compared with the reference (use of anesthesia).

Discussion

The present study aimed to verify the demographic and clinical characteristics that lead patients to receive IMV for ≥48h, who would benefit from the use of OTTs with supra-cuff suction devices. Guidelines indicate their use in patients on IMV for at least 48h; however, they do not indicate a technique to identify these patients before OTI [23]. In addition, until now, the duration of OTI and IMV could be accurately determined through clinical evaluation [27].

In the literature, studies attempt to associate the clinical characteristics with the duration of IMV, such as, levels of serum albumin, C-reactive protein, PaO_2/FiO_2 ratio (ratio of partial pressure arterial oxygen and fraction of inspired oxygen), SOFA score (Sequential Organ Failure Assessment), APACHE score (Acute Physiology and Chronic Health Evaluation), and BMI. However, none of them associated clinical history in order to establish a target population for the use of OTTs with supra-cuff suction devices [27–34], although the clinical features are easy to access and quick to interpret. Mareiniss et al. analyzed more than 1000 patients in a USA hospital in order to predict which patients would benefit from the use of OTTs with supra-cuff suction devices and reported that patients with a history of dementia and acute kidney injury showed increased RR for at least 48h of IMV at the time of OTI [26].

In the present study, patients with a history of diseases, especially alcoholism, had increased RR for at least 48h of IMV. Patients with a history of coronary artery disease had RR lower than 1 and, despite the significant p-value, we considered the discrepancy between the number of patients in the sample with (n=18) and without (n=802) history of coronary artery disease, showing low power analysis.

Troche and Moine (1997) conducted a cohort study in a surgical ICU of a university hospital to predict IMV duration by analyzing clinical and physiological characteristics and obtained results similar to the present study regarding emergency OTI, showing that this marker can predict the longest ventilatory support period[30]. Mareiniss et al., in a previous study, observed that patients who had an emergency OTI showed increased RR for at least 48h of OTI [26].

The results found in this study reaffirm the findings of the literature: patients who underwent emergency OTI is more likely to be submitted to IMV for ≥48h. In the present study, the data analyzed regarding indication of OTI complement the

Table 1 Characteristics of the sample of patients on invasive mechanical ventilation in an intensive care unit

Characteristics	n	%
Age [median (p25 to p75)], years	64 (52 to 73)	
18 to 24	28	3.4
25 to 34	34	4.1
35 to 44	58	7.1
45 to 54	118	14.4
55 to 64	184	22.5
65 to 74	219	26.7
≥75	179	21.8
Sex		
Male	493	60.1
History		
Systemic arterial hypertension	446	54.4
Diabetes mellitus	215	26.2
Smoking	101	12.3
Smoking cessation	114	13.9
Heart diseases	82	10
Chronic obstructive pulmonary disease	60	7.3
Dyslipidemia	44	5.4
Obesity	40	4.9
Neurological diseases	38	4.6
Alcohol addiction	37	4.5
Fomer alcohol addiction	24	2.9
Acute or chronic kidney injury	31	3.8
Congestive heart failure	23	2.8
Cancer	23	2.8
Coronary artery disease	18	2.2
Dementia	15	1.8
Liver failure or Cirrhosis	2	0.2
None	148	18
Others	353	43
Body mass index [median (p25 to p75)], kg/m^2	26.9 (23.8 to 30.0)	
Type of hospitalization		
Surgical	670	81.7
Clinic	150	18.3
Type of orotracheal intubation		
Elective	652	79.5
Emergency	168	20.5
Orotracheal intubation site		
Surgery center	642	78.3
Emergency department	81	9.9
Others	97	11.8
Duration of orotracheal intubation		
<48h	488	59.5
≥48h	332	40.5
Outcomes		
Hospital discharge	692	84.4
Death	128	15.6

p25, percentil 25; *p75*, percentil 75

Table 2 Characteristics associated with invasive mechanical ventilation ≥48h

Markers	n (820)	Orotracheal intubation ≥48h, n (%)	Relative risk (95%CI)	p-value
History				
Absent	148	62 (41.9)	Reference	<0.001
Present	672	402 (59.8)	1.42 (1.17 to 1.74)	
Coronary artery disease	18	1 (5.6)	0.13 (0.03 to 0.91)	0.005
Cancer	23	4 (17.4)	0.42 (0.17 to 1.03)	0.038
Alcohol addiction	37	23 (62.2)	1.60 (1.22 to 2.09)	0.004
Fomer alcohol additction	24	14 (58.3)	1.50 (1.06 to 2.13)	
Type of hospitalization				
Surgical	670	202 (30.1)	Reference	<0.001
Clinic	150	130 (86.7)	1.06 (0.98 to 1.16)	
Type of orotracheal intubation				
Elective	652	181 (27.8)	Reference	<0.001
Emergency	168	151 (89.9)	3.24 (3.01 to 3.95)	
Orotracheal intubation site				
Surgery center	642	177 (27.7)	Reference	<0.001
Emergency department	81	77 (95.1)	3.44 (3.01 to 3.95)	
Others	97	78 (80.4)	2.92 (2.49 to 3.42)	
Reason for orotracheal intubation				
Use of anesthesia	648	177 (27.3)	Reference	<0.001
Lowered level of consciousness	57	53 (93.0)	3.40 (2.95 to 3.93)	
Accute breathing insufficiency	78	73 (93.6)	3.43 (2.98 to 3.93)	
Airway protection	37	29 (78.4)	2.87 (2.32 to 3.54)	
Outcomes				
Hospital discharge	692	240 (34.7)	Reference	<0.001
Death	128	92 (72.4)	2.07 (1.79 to 2.40)	

95%CI, 95% confidence interval

information previously explained about emergency OTI: OTI performed in patients due to lowered level of consciousness, acute respiratory failure, and airway protection show greater chances of requiring at least 48h of IMV. In addition, multivariate analysis evidenced that patients who are intubated due to lowered level of consciousness and acute respiratory failure are ~96% likely to remain intubated for ≥48h. Interestingly, no studies were found that analyzed indication of OTI for comparative purposes.

OTI location showed a significant p-value with increased RR for the emergency department and other hospital facilities for IMV duration ≥48h. No studies were identified in the literature that researched OTI location; however, the analysis of this data showed that 98.76% of OTI performed in the

Table 3 Characteristics of surgical patients and the risk for invasive mechanical ventilation ≥48h

Type of hospitalization	n	Orotracheal intubation ≥48h, n (%)	Relative risk (95%CI)	p-value
Clinic	150	130 (86.7)	Reference	<0.001
Surgical				
Neurosurgery	92	33 (35.9)	0.41 (0.31 to 0.54)	
General surgery	252	73 (28.9)	0.33 (0.27 to 0.40)	
Orthopedic surgery	69	13 (18.8)	0.21 (0.13 to 0.35)	
Cardiac and vascular surgey	232	77 (33.2)	0.38 (0.31 to 0.46)	
Gynecologic surgery	14	4 (28.6)	0.33 (0.14 to 0.75)	
Pneumology procedures and lung surgery	5	0	0	
Otorhinolaryngologic surgical procedure	6	3 (33.3)	0.38 (0.12 to 1.19)	

95%CI, 95% confidence interval

Table 4 GLM Multivariate analysis of the characteristics associated with invasive mechanical ventilation ≥48h

Characteristics	Estimate	p-value
Intercept	−105.407	0.005
Age, years		
18 to 24	−0.209	0.731
25 to 34	0.063	0.907
35 to 44	−0.075	0.851
45 to 54	0.181	0.630
55 to 64	0.106	0.775
65 to 74	−0.417	0.289
≥75	0.302	0.499
Type of hospitalization		
Clinic	0.302	0.499
Orotracheal intubation site		
Surgery center	−0.339	0.808
Emergency department	122.805	0.131
Other	0.014	0.981
Reason for orotracheal intubation		
Acute respiratory failure	337.462	0.021
Lowered level of consciousness	326.484	0.029
Airway protection	192.542	0.174
Disease		
Coronary artery disease	−197.702	0.057
Cancer	−103.103	0.113
Acute or chronic kidney injury	0.339	0.471
Alcohol addiction	0.214	0.627
Former alcohol addiction	0.877	0.058
Congestive heart failure	0.458	0.421
History for diseases	0.100	0.689

GLM, generalized linear model

emergency department and 85.57% of OTI performed in the other hospital facilities were emergency OTI, which supports the data previously discussed about the type of OTI. The other hospital facilities were composed of medical and surgical wards, semi-intensive care unit, and ICU.

Sanabria et al. conducted a cohort study in a general ICU in Colombia aiming to determine the predictive factors for OTI for more than 7 days, including the APACHE II score. They found a weak relationship between the outcomes and the APACHE II score [35]. However, Seneff et al. (1996), in a cohort study conducted in 40 USA hospitals with more than 5,000 patients, determined that the score of the APACHE III score was associated with the duration of IMV: the greater the score, the greater the clinical severity, the probability of death, and the duration of IMV [28].

Patients who died in our sample had an increased RR for the IMV period of at least 48h. This information could be identified using the APACHE and SAPS scores, which aim to estimate the severity and mortality risk of adult patients admitted to the ICU [34]. However, a limiting factor of this study was the absence of these scores, as they were not described in the evaluated medical records.

Mareiniss et al. and Seneff et al. described that patients with clinical hospitalizations remain intubated for a longer period when compared to patients with surgical hospitalizations [26, 28]. The patients in the present study who were hospitalized for clinical reasons had increased RR for at least 48h of IMV, which is in line with the findings in the literature.

An additional analysis compared only patients with surgical hospitalization, dividing them among the main specialties. It was observed that, although neurosurgery is the specialty with the highest RR for at least 48h of IMV, surgical patients showed low risk of undergoing IMV for a longer period and, therefore, there is less indication of OTTs with supra-cuff suction devices. These outcomes support those findings explained above.

Orotracheal tubes with supra-cuff suction devices are widely known for reducing the incidence of VAP in mechanically ventilated patients, but their use incurs an additional cost for the hospitals. Therefore, their use should be targeted and restricted to previously selected patients.

In addition, the postoperative context is a risk factor for VAP, namely, in situations where the clinical context and evolution drives a need to prolong the duration of MV. However, in our data, it is noted that there was a joint assessment of risk factors for a ventilation time ≥48h, specifically the following: (i) surgical sample, of which almost all cases had elective intubation; (ii) medical sample which is not characterized because the limited access to information of the patients. Both data were considered as significant bias to the significance of the results presented in the analysis of the RR, namely with regard to its correlation with comorbidities (Tables 1 and 2). Also, the different types of surgery (Table 3) with predictable different surgical times did not show an increased RR for intubation duration ≥48h in either group. With regard to clinical conditions, there are deficiencies in definition as present and previous alcohol addiction, acute or chronic kidney injury, lower level of consciousness and its severity degree, air protection, and acute respiratory failure without characterization of type and severity. Regarding the assessment of obesity, only the presence or absence and average BMI was mentioned, but it has not been subject to a risk assessment or evaluation of a potential relationship with the duration of intubation. Maybe, if patients that died had OTI with a supra-cuff suction device, mortality could have been lower; however, this is a speculative conclusion because we were not able to verify whether mortality was related to the eventual development of VAP or for other reasons.

Our study has some limitations, such as its retrospective design, the absence of APACHE and/or SAPS scores, and the need for prospective validation. Although this study includes a total of 820 participants, in some markers, the number of cases

is small and limits the sample power. Nonetheless, our study provides information on the identification of patients who may require IMV for at least 48h, targeting the indication and use of OTTs with supra-cuff suction devices for the patients who will benefit the most of this equipment. Thus, the use of OTTs with supra-cuff suction devices may be personalized to allow accurate treatment of these patients.

Conclusions

Patients with a history of diseases, especially past or current history of alcoholism, with clinical hospitalization, who underwent an emergency OTI in the emergency department or in other hospital facilities, due to lowered level of consciousness, acute respiratory failure, or to protect airways, are most likely to receive IMV for ≥48h, and this factor could be associated with a higher risk of death during further studies. Besides that, the evaluation of the multivariate analysis only establishes an increased risk of IMV for a period ≥48h, in the context of OTI, for situations of low level of consciousness or due to acute respiratory failure.

Availability of Data and Material The data will be available on request
Code Availability Not applicable

Author Contribution All authors contributed to the idealization of the theme, data collection, data analysis, and construction of the text of the article.

Declarations

Ethics Approval The study was approved by the Research Ethics Committee of the institution (CAAE: #60131316.3.0000.5514)

Consent to Participate Since this study was retrospective, the Ethics Committee authorized the data collection without the signature of the informed consent form by the participants or their guardians. The author ensure that the work described has carried out in accordance with Declaration of Helsinki for studies involving humans.

Consent for Publication Not applicable

Competing Interests The authors declare no competing interests.

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