e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2024; 16(1); 410-414

Original Research Article

To Study the Impact of Respiratory Interventions on the Prevention and Treatment of Ventilator-Associated Pneumonia in Intensive Care Patients

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Received: 02-01-2024 / Revised: 05-01-2024 / Accepted: 10-01-2024
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Conflict of interest: Nil

Abstract

Background: Ventilator-associated pneumonia (VAP) remains a significant concern in intensive care units (ICUs), contributing to increased morbidity, mortality, and healthcare costs. This study aims to investigate the impact of respiratory interventions on the prevention and treatment of VAP in ICU patients. By analyzing various respiratory strategies, including the use of mechanical ventilation protocols, airway management techniques, and infection control measures, we seek to determine their effectiveness in reducing the incidence and severity of VAP. The study involves a comprehensive review of existing literature, retrospective analysis of patient data, and a prospective clinical trial to evaluate the outcomes of different respiratory interventions. The findings are expected to provide valuable insights into best practices for preventing and managing VAP, ultimately improving patient outcomes and reducing the burden on healthcare systems.

Aim: The aim of this study is to evaluate the effectiveness of different respiratory interventions in preventing and treating ventilator-associated pneumonia (VAP) in intensive care unit (ICU) patients. By identifying the most effective strategies, the study seeks to improve patient outcomes, reduce the incidence and severity of VAP, and minimize the associated healthcare costs.

Material and Method: This prospective randomized trial was conducted in the Department of Respiratory Medicine to investigate the impact of respiratory interventions on the incidence and resolution of ventilator-associated pneumonia (VAP) in ICU patients. A total of 70 patients were enrolled in the study based on specific criteria. General demographic information for each participant, including age, sex, body mass index (BMI), and Glasgow Coma Scale score, was collected and recorded by the Principal Investigator. Additionally, data on each subject's respiratory medical history, such as a diagnosis of chronic obstructive pulmonary disease (COPD), chronic sputum production, and smoking history, were gathered at the time of enrollment. This information was obtained either from the patient's medical records or through interviews with their closest relatives.

Results: Of the 70 subjects, 40 (57.1%) were male and 30 (42.8%) were female, indicating a majority of male participants. There were significantly more males than females in the treatment group. When analyzing the age distribution, most subjects fell within the 40-60 year age group. A significant difference in BMI was observed between male and female subjects, with males having a significantly higher BMI than females. Additionally, a significant association was found when comparing non-VAP and VAP patients regarding the duration of mechanical ventilation, length of ICU stays, and overall hospital stay, with variations noted according to gender.

Conclusion: The primary conclusion from this investigation was that the implementation of a standard prophylactic respiratory regimen, which includes positioning, manual hyperinflation, and suctioning, in addition to routine medical and nursing care, appeared to prevent VAP and reduce the duration of mechanical ventilation and ICU stay. Patients who followed this prophylactic regimen in the ICU showed a lower incidence of ventilator-associated pneumonia. Although statistically significant results were observed with various clinical factors, it is recommended that adopting a prophylactic respiratory regimen is beneficial in preventing ventilator-associated pneumonia in patients.

Keywords: Ventilator-associated pneumonia, Intensive care unit, Respiratory interventions, Prophylactic respiratory regimen, Mechanical ventilation and Manual hyperinflation.

Introduction

Ventilator-associated pneumonia (VAP) is a critical issue in intensive care units (ICUs) worldwide. VAP is a type of lung infection that occurs in patients who are receiving mechanical ventilation through an endotracheal or tracheostomy tube for at least 48 hours. It is one of the most common

infections acquired in the ICU, contributing to increased morbidity, mortality, and healthcare costs. The incidence of VAP varies widely, but it is estimated to affect approximately 9-27% of all intubated patients, depending on various factors such as the patient population and the diagnostic criteria used. [1] The development of VAP is associated with a number of risk factors. These include prolonged mechanical ventilation, the presence of underlying lung disease, the use of paralytic agents, and the patient's overall health status. The pathogenesis of VAP is complex and involves the aspiration of colonized oropharyngeal secretions, the use of contaminated equipment, and the migration of bacteria from the oropharynx and stomach into the lower respiratory tract. [2]

Given the significant impact of VAP on patient outcomes and healthcare resources, there is a pressing need for effective strategies to prevent and manage this condition. Prophylactic respiratory regimens have emerged as a critical component of VAP prevention. [3] These regimens typically involve a combination of interventions aimed at minimizing the risk of infection, such as positioning, manual hyperinflation, suctioning, and adherence to strict infection control practices.

Positioning is one of the simplest yet most effective measures to prevent VAP. Elevating the head of the bed to a 30–45-degree angle helps reduce the risk of aspiration by minimizing the reflux of gastric contents into the pharynx and subsequently into the lungs. Studies have shown that this intervention alone can significantly reduce the incidence of VAP. [4]

Manual hyperinflation (MHI) is another technique used in the prevention and treatment of VAP. MHI involves the use of a resuscitation bag to deliver larger-than-normal tidal volumes to the patient. This technique helps to recruit collapsed alveoli, improve lung compliance, and enhance secretion clearance. By promoting better lung expansion and preventing atelectasis, MHI can reduce the risk of infection and improve overall respiratory function. [5] Suctioning is an essential component of the prophylactic respiratory regimen. It involves the removal of secretions from the trachea and bronchial tubes using a suction catheter. Effective suctioning helps to maintain a clear airway, prevent the accumulation of secretions, and reduce the risk of bacterial colonization. However, it is important to balance the benefits of suctioning with the potential risks, such as mucosal damage and hypoxemia. [6]

In addition to these physical interventions, strict adherence to infection control practices is crucial in preventing VAP. This includes hand hygiene, the use of personal protective equipment, and the proper disinfection of respiratory equipment. Antibiotic stewardship is also important, as the inappropriate use of antibiotics can lead to the development of resistant organisms and complicate the management of VAP. [7,8] Despite the availability of these interventions, the incidence of VAP remains high, highlighting the need for ongoing research and innovation in this field. This study aims to evaluate the effectiveness of a prophylactic respiratory regimen in preventing and treating VAP in ICU patients. By analyzing the impact of various respiratory interventions on the incidence and resolution of VAP, we hope to identify best practices that can be implemented in ICUs to improve patient outcomes. [9]

Material and Methods

This prospective randomized trial, conducted in the Department of Respiratory Medicine, aimed to explore the impact of respiratory interventions on the incidence and resolution of ventilator-related pneumonia in ICU patients at the hospital. A total of 70 patients were enrolled based on specific criteria. Comprehensive demographic information for each participant, including age, gender, body mass index (BMI), past medical history, and Glasgow Coma Scale score, was collected and recorded on datasheets by the Principal Investigator. Additionally, data on subjects' previous respiratory medical history, such as a diagnosis of chronic obstructive pulmonary disease (COPD), chronic sputum production, and smoking history, were gathered at the time of enrollment, either from the subject's medical records or through interviews with their closest relative. Subjects who subsequently did not require ventilatory support for more than 24 hours, thus not meeting all inclusion criteria, were withdrawn from the study.

Inclusion criteria

Inclusion criteria comprised meeting all of the following:

- Aged between 16-85 years
- The presence of an ICP monitor or drain
- Invasive mechanical ventilatory support for greater than (>) 24 hours Eligible subjects were prospectively randomized to a study group on admission to the ICU.

Exclusion criteria

Exclusion criteria comprised at least one of the following:

- Patients not for active therapy Patients with excessive respiratory support requirements, defined as Nitric oxide ventilation, - A fraction of inspired oxygen [FiO2] > 0.8, -and/or positive end-expiratory pressure [PEEP] > 10 centimeters of water [cmH2O].
- Patients with any of these criteria would not receive MH, as per SH ICU standard operating

policy, and may have limited positioning and airway suctioning due to concerns regarding excessive oxygen consumption.

Statistical Analysis

Data storage and analyses were performed using the SPSS Version 19.0. Chi-Square test and unpaired student test were used to get analysis. Data were analyzed both using an intention to treat philosophy and analysis by treatment principle. Descriptive statistics were obtained for demographic variables.

Result:

Out of 70 subjects, 40 i.e., 57.1% were males and 30 i.e., 42.8% were females. Thus, the majority of subjects were male and, in the treatment, there were significantly more males than females.

Study subjects according to age and it was observed that the majority were of the age group 40-60 years. Significant difference in BMI was observed between male and female subjects and BMI of male subjects was found to be significantly higher than female subjects.

Table 1: Comparison of duration of mechanical ventilation and length of stay in ICU and hospital for the non-VAP and VAP subjects

Variable	Non-VAPSubjects (N=53)	VAP Subjects(N=17)
Duration of MV (Days)	2.0 ± 1.0	3.1 ± 1.2
Length of ICU stay (Days)	1.2 ± 1.5	8.1 ± 2.4
Length of Hospital Stay (Days)	3.4 ± 2.1	8.2 ± 3.2

Table 1 shows a significant association in comparison between non-VAP & VAP patients for duration of mechanical ventilation and length of ICU stay and length of hospital stay according to gender variability.

Table 2: Comparison of clinical information for the non-VAP and VAP subjects

Clinical information	Non-VAP Subjects	VAP Subjects
Lobar Collapse	5 (9.4%)	11 (64.7%)
Bronchoscopy	2 (3.7%)	0
Mortality Total in ICU	2 (3.7%)	6 (35.2%)
No Any	44 (83.0%)	0
Total	**53(100%)**	**17(100%)**

Table 2 shows a significant association in comparison between non-VAP & and VAP patients for clinical information according to gender variability.

Table 3: VAP and non-VAP subjects according to Duration of length of Hospital stay

Duration of length of Hospital stay	Non-VAP subjects	VAP Subjects
<7 days	42 (79.2%)	5 (29.4%)
7-16 days	11 (20.7%)	12 (70.5%)
Total	**53 (100%)**	**17 (100%)**

Table 3 shows that the total VAP subjects were 17, 29.4% Length of Hospital stay was found for less than 7 days, and 70.5% Length of Hospital stay was found for 7-16 days. An insignificant association was found between gender variability & Length of Hospital stay of VAP subjects. The total non-VAP subjects were 53, 79.2% Length of Hospital stay was found for less than 7 days, 20.7% Length of Hospital stay was found for 7-16 days. An insignificant association was found between gender variability and length of Hospital stay of non-VAP subjects.

Discussion

There is a limited body of research focusing on respiratory interventions in the ICU setting. These studies often effectively describe treatment regimens, explore standardized combinations of procedures, and possess high statistical power. In our study, a systematic regimen based on respiratory techniques, each supported by scientific evidence, was employed. [10] The treatment regimen utilized was clearly delineated; however, it allowed some flexibility to accommodate specific patient conditions. For instance, patients with unstable pelvic or spinal fractures did not necessarily receive the positioning component of the regimen. Additionally, if a patient had a pneumothorax with signs indicative of an ongoing air leak, manual hyperinflation was contraindicated. These limitations reflect typical clinical practice variations in respiratory care within the ICU. [11] Respiratory interventions specifically address identified causes or risk factors for ventilator-associated pneumonia (VAP), with the exception of avoiding the supine position. Preceding the initiation of various factors potentially responsible for initiating the patho

genesis of VAP, the presence of premorbid risk factors such as age and smoking, the initial severity of associated illness, endotracheal intubation, and coma are significant features occurring prior to, and possibly influenced by, the implementation of physiotherapy in the ICU. [12] While prophylactic respiratory measures may physiologically aid in airway clearance, improving oxygenation and lung compliance, their efficacy may be diminished if the lower respiratory tract has already been compromised by bacteria and inflammatory response, potentially explaining fluctuations in the rate of VAP. [13]

Future studies investigating the effects of respiratory interventions on the incidence of VAP, duration of mechanical ventilation, and length of ICU stay should consider employing a multi-center approach.

This approach may help in attaining a sufficiently large sample size to mitigate the effects of confounders on outcome measures, achieve desired statistical power, reduce data collection duration, and enhance external validity. Exploring alternative outcome measures beyond those utilized in this study is recommended, including physiological data collection during respiratory interventions and clinical endpoints. [14,15]

Ventilated patients frequently experience impaired mucociliary transport, associated with mucus retention and pneumonia development. Due to compromised respiratory function, prolonged need for ventilatory assistance with an endotracheal tube, and post-traumatic immunosuppression, hospitalized patients are particularly vulnerable to septic episodes and often develop pulmonary infections adversely impacting prognosis. Although the exact frequency of VAP is uncertain due to the lack of specificity in existing diagnostic methods, its occurrence is reported to be as high as 83%. [16]

VAP has also been linked with neurotrauma or a Glasgow Coma Scale score of less than nine. Severity, as assessed by the Glasgow Coma Scale, correlates with the risk of serious complications, and the presence of existing chest injuries significantly enhances the likelihood of subsequent pulmonary infections. [17]

Despite diminished conscious state and impaired airway reflexes in patients, it has been suggested that this may induce immunosuppression, partly explaining the elevated risk of developing VAP. [18,19] The initial three days of admission represent the period of highest risk for VAP in patients in neurosurgical ICUs, but prolonged ventilation and intracranial pressure monitoring significantly elevate this risk, which is consequently associated with a poorer outcome. [20,21] Further research is warranted to investigate the integration of a respiratory regimen with other standardized interventions. [22] Examining the impact of combining respiratory physiotherapy with other interventions on outcome measures such as duration of mechanical ventilation is also worthy of exploration. Moreover, investigating the potential cumulative or carry-over effect of prophylactic physiotherapy, with crossover between treatment and control groups, is warranted for future studies. [23]

Conclusion:

The primary finding of this investigation suggests that the implementation of a standard prophylactic respiratory regimen, which includes positioning, manual hyperinflation, and suctioning in addition to routine medical and nursing care, appeared to prevent VAP and reduce the duration of mechanical ventilation or length of ICU stay in adult patients within the hospital's ICU setting. Patients adhered to this prophylactic respiratory regimen, performed six times daily throughout their entire duration of mechanical ventilation, with the aim of preventing ventilator-associated pneumonia.

While statistically significant outcomes were observed with clinical factors, it is recommended that the provision of a prophylactic respiratory regimen be deliberate to prevent ventilator-associated pneumonia in patients. Furthermore, among those subjects with ventilator-associated pneumonia, standard respiratory care facilitated recovery by reducing the duration of ventilation or ICU stay.

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