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The effect of different solutions in tracheal suctioning on the incidence of pneumonia in patients on the ventilator

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ABSTRACT

Ventilator-associated pneumonia (VAP) is a common nosocomial infection in patients admitted to intensive care units (ICU), leading to prolonged stay in the ICU, increased hospital costs, and mortality. This study aimed to compare the effect of using normal saline with eucalyptus in endotracheal suctioning on the rate of ventilator-dependent pneumonia. For this purpose, a randomized clinical trial study was performed on 120 patients under a ventilator in the hospital ICU. Patients were randomly divided into control and intervention groups. The control group consisted of 60 patients who used 0.9% normal saline to dilute endotracheal secretions. The intervention group also included 60 patients treated with 0.9% normal saline with 5% eucalyptus to dilute endotracheal secretions. The sensitivity of isolated microbes was determined by the diffusion susceptibility test Kirby-Bauer disk protocol. The CDC protocol was used to diagnose VAP. 100 CFU/ml of endotracheal aspiration was considered the differentiation number between the microbe responsible for VAP and colonization. Whenever a VAP guess was made, a blood culture was done. Finally, the incidence of ventilator-associated pneumonia in the two groups was compared. The results showed that the incidence of VAP during using normal saline and normal saline with eucalyptus as a diluent for pulmonary secretions was different between the two groups (P = 0.042). Also, among infected patients with VAP, there was a difference between the types of microorganisms in the two groups (P = 0.019). Seven cases of *Klebsiella pneumonia* were observed in the control group, while no case of this bacterium was observed in the intervention group. In terms of the prevalence of Pseudomonas (two cases), both groups had a similar situation. These findings can reassure nurses and the treatment team that they can use normal saline solution with 5% eucalyptus during suction to dilute pulmonary secretions.

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Introduction

Ventilator-induced pneumonia (VAP) is defined by the Centers for Disease Control and Prevention (CDC) as recurrent pneumonia in people with a tracheal intubation method 48 hours before the onset of infection (1). VAP affects 250,000 patients annually in the United States. It occurs when bacterial, viral, and fungal pathogens enter the sterile area of the lower respiratory tract and lung parenchyma. Staphylococcus aureus and gram-negative microbes are the most common factors responsible for VAP in adults and children (2).

VAP prevention policies are currently available; For example, measures such as raising the head of the bed 30-45 degrees, placing the patient's head higher in the post-feeding stage with a gastric tube, periods away from sedation, evaluation for timely and rapid removal of gastric ulcer prophylaxis endotracheal tube, Prophylaxis of deep vein thrombosis, oral care with chlorine hexine, maintenance of tracheal tube cuff pressure between 30 and 40 mmHg, rotation of the patient from side to side at least once every 2 hours and tracheal and pharyngeal suctioning (3). Patients with endotracheal tubes in ICU wards cannot drain lung secretions due to ineffective coughing. In these patients, secretion retention leads to atelectasis and poor ventilation (4). As a result, endotracheal suctioning is a vital nursing procedure in intubated patients to clear the airway. It is also one of the ways to prevent VAP endotracheal intubation (5).

Nurses experience thick, sticky discharge during suctioning. There are several ways to dilute this discharge. One way is to inject normal saline into the trachea, used since the 1970s. The use of normal saline before tracheal suction causes the catheter to slip, the drip to become softer and thinner, and the

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discharge to the upper airways to stimulate coughing (5-7). Evidence suggests that although normal saline is frequently used in endotracheal intubation, different studies have reported different results on whether or not to use it (8, 9). For example, Hussein *et al*. (10) conducted a study entitled "The effect of different suctioning modalities on physiologic measures and the incidence of ventilator-associated pneumonia". In this study, the results showed that the use of normal saline before suction does not cause significant changes in hemodynamic parameters but increases the amount of VAP. Caruso *et al*. (11) also conducted a study entitled " Saline instillation before tracheal suctioning decreases the incidence of ventilator-associated pneumonia" In this study, they concluded that using normal saline before endotracheal suction reduces the microbiological incidence of VAP. Their study showed that the number of patients without VAP in the suction group with normal saline was higher. Rafiei *et al*. (12) conducted a study comparing the use and non-use of normal saline before suctioning on heart rate and SPO2. They concluded that heart rate increased in both the normal and non-normal saline groups but was slightly higher in the suction group with normal saline. The decrease in SPO2 was more significant in the normal saline group. Rafiei *et al*. (12) suggested that instead of using normal saline to dilute the secretions, other methods such as moistening the inhaled air with distilled water should be used.

Another way to dilute tracheal secretions is to use normal saline and inhaled eucalyptus simultaneously. Eucalyptus is traditionally used by inhalation to treat airway infections (13). Also, in laboratory studies, its antimicrobial effects on the respiratory tract have been identified. Eucalyptus is primarily used to treat coughs, colds, bronchitis and to relieve cold symptoms (14). As a study on the effect of inhaled eucalyptus in mechanically ventilated patients, this method could reduce microbial contamination in endotracheal biofilm, which may also affect VAP (15). The increasing prevalence of VAP in mechanically ventilated patients admitted to intensive care units has provided an incentive to use newer therapies, such as inhalation, which are particularly important for preventing and treating pneumonia.

According to the above, this study aimed to compare the effect of normal saline and normal saline with inhaled eucalyptus on endotracheal suction on the incidence of VAP in patients on a ventilator.

Materials and methods

Study patients

The present study is a randomized clinical trial performed by selecting 120 patients on a ventilator. Research samples were selected based on inclusion criteria: negative endotracheal culture before intubation, absence of lung diseases including infectious lung diseases, chronic obstructive pulmonary disease, and asthma, intubation of the patient at the beginning of admission, stable hemodynamic conditions (systolic blood pressure greater than 90 mmHg without receiving inotropic drug and urine volume greater than 30ml/hour and normal electrolyte levels without cardiac arrhythmias). Exclusion criteria also included: positive endotracheal culture before intubation, improper suctioning by the nurse, and patient death.

The patients were randomly placed in one of the two groups of suction with 0.9% normal saline (control group with 60 patients), and 0.9% normal saline with 5% inhaled eucalyptus (interval group with 60 patients).

Endotracheal and blood culture

A culture sample of the endotracheal was prepared in the first hours of ICU entry or intubation (less than 48 hours after intubation) from patients who were intubated in the emergency room, operating room, and other wards to the laboratory. After suctioning, the end of the suction catheter was placed in pre-prepared sterile containers and immediately transferred to the laboratory unit. The purpose of the primary culture sample was to identify patients with negative endotracheal culture.

The sensitivity of isolated microbes was determined by the diffusion susceptibility test Kirby-Bauer disk protocol. The CDC protocol was used to diagnose VAP. 100 CFU/ml of endotracheal aspiration was considered the differentiation number between the microbe responsible for VAP and colonization. Whenever a VAP guess was made, a blood culture was done. Before blood sampling, the sampling site was cleaned with povidone-iodine and alcohol, and after two minutes, sampling was performed. 4 ml of blood was collected on Blood agar media (Sisco

Research MacConkey Agar, Laboratories Pvt. Ltd., Maharashtra, India). In all patients, CXR, CBC, and blood culture were taken on the first and third day of intubation, and on the third day, aspiration culture of the re-trachea tube was sent by the mentioned method.

The performance of endotracheal suctioning

At the beginning of the work and before data collection, a meeting was held with the nurses regarding the method and purpose of the study. In this session, the correct suction protocol, which was prepared by the researcher following international standards and approved by the hospital education unit, was provided to the nurses. All nurses were asked to study and implement the protocol correctly. It should be noted that the checklist for the suction protocol (handwashing, 100% oxygenation before and after suction, giving the patient the correct position, wearing sterile gloves, and observing sterile tips during suction) was provided, and recording the vital signs of patients was done during the suctioning. Nurses used different solutions to dilute the tracheal secretions depending on which group the patient was in. In the normal saline group, 5ml of 0.9% normal saline was used for washing. In the second group (the normal saline with the eucalyptus group), 2ml of 5% eucalyptus (16) was used with 3ml of 0.9% normal saline.

Each time, the endotracheal suction lasted 15 seconds, and the total duration of the suction was 3 to 5 minutes depending on the patients' needs. Without informing the suction nurses, the researcher monitored them for the correct suctioning technique, and a sample subjected to more than three non-standard suctions was excluded from the study. If the result of the first culture was negative, the sample remained in the study. After five days from intubation, a sample of endotracheal culture was prepared and cultured. Decisions were made according to the answer of the second culture about the positives and negatives of VAP.

To unify the study group's conditions, patients were received the same antibiotics. They took the same preventive measures against VAP, such as bed position, mouthwash with chlorhexidine, and prophylactic measures for deep vein thrombosis and ulcers. In this study, demographic characteristics were also used to collect data.

Preparing eucalyptus

In this study, the essential oil of *Eucalyptus camaldulensis* containing 60-70% of cineole was prepared at a concentration of 5%. Inhalation of eucalyptus is safe, and no severe side effects have been reported in humans (17, 18). After grinding the plant samples for 3 hours, the essential oil was extracted by distillation with water by the Clevenger apparatus. After the essential oil was taken, it was collected from the Clevenger column by a pasteurizer pipette. The yield of essential oil (percent) after dehydration of its water by dry sodium sulfate was calculated relative to the dry weight of the plant and kept at 4°C until the analysis of its essential oils.

Gas chromatography (GC) and gas chromatography-mass spectrometry (GC / MS) were used to analyze and identify the essential oil constituents. The spectra were identified by calculating the Kovats Retention Index (RI) by injecting normal hydrocarbons (C6-C24) under the same conditions as the essential oils and comparing them with the values published in different sources. Mass spectra were also examined to identify combinations, and the identifications were confirmed using standard combinations of mass spectra and information available in various libraries. The relative percentage of each of the constituents of the essential oils was obtained according to the area under its curve in the chromatogram spectrum. It was compared with the values published in different sources considering the Kovats Retention Index.

Statistical analysis

The data were entered in SPSS software version 20 and analyzed using descriptive statistics, central indicators, and dispersion calculations. Therefore, the Chi^2 test or Fisher's exact test (for qualitative variables) and independent t-test (for quantitative variables) were used. The significance level was considered $P < 0.05$ for all tests.

Results and discussion

According to the study's findings, there was no statistically significant difference between the two groups in terms of demographic characteristics and disease history before the intervention, and the two groups were homogeneous (Table 1). In this study, the control group means those patients who received 0.9%

normal saline, and the interval group means those patients who received normal 0.9% saline + 5% eucalyptus.

Table 1. Demographic characteristics of two studied groups

Characteristics		Control Group (n = 60)	Interval Group (n = 60)	P-value
Gender	Male	24 (40%)	28 (46.66%)	0.57
	Female	36 (60%)	32 (53.34%)	
Hospitalization Cause	After Surgery	12 (20%)	8 (13.33%)	0.08
	Multiple Injuries	48 (80%)	52 (86.67%)	
Cause of Intubation	Consciousness Loss	36 (60%)	30 (50%)	
	Reduction of blood oxygen saturation	24 (40%)	30 (50%)	0.59
Underlying Disease	High Blood Pressure	4 (6.67%)	3 (5%)	
	Diabetes	0 (0%)	2 (3.34%)	0.35
	Heart Attack	1 (1.67%)	0 (0%)	
	Stroke	2 (3.34%)	3 (5%)	
	Other Diseases	12 (20%)	14 (23.34%)	
Medication History	Yes	18 (30%)	21 (35%)	0.34
	No	42 (70%)	39 (65%)	

The study's findings showed that the endotracheal secretion culture after the intervention was negative in 63.3% of patients in the normal saline group and 88.33% of patients in the normal saline group with eucalyptus. Thus, the two groups were significantly different in secretion culture and VAP incidence (P = 0.04) (Table 2).

Table 2. Comparison of bacterial culture frequency among patients of control and interval groups

Bacteria Culture	Control Group	Interval Group	P-value
Positive	22 (36.7%)	7 (11.67%)	
Negative	38 (63.3%)	53 (88.33%)	0.042
Total	60 (100%)	60 (100%)	

Table 3 shows the types of microorganisms of patients in the two groups of normal saline and normal saline with eucalyptus. The results of this section showed that there is also a difference between the types of microorganisms (P = 0.019). According to the results obtained from this section, 7 cases of *Klebsiella pneumonia* were observed in the control group, while no case of this bacterium was observed in the intervention group. Also, in the control group, 9 cases were infected with *Staphylococcus aureus*, while only 3 cases were infected with this bacterium in the intervention group. In terms of the prevalence of Pseudomonas (2 cases), both groups had a similar situation.

Table 3. Comparison of different microorganisms types in patients of control and interval groups

Microorganism	Control Group (n=22)	Interval Group (n=7)	P-value
Klebsiella pneumoniae	7 (11.67%)	0 (0%)	
Staphylococcus aureus	9 (15%)	3 (5%)	
Acinetobacter	4 (6.67%)	2 (3.33%)	
Pseudomonas	2 (3.33%)	2(3.33%)	0.019
Non-hemolytic streptococci	3 (5%)	1 (1.67%)	
Streptococcus pneumoniae	1 (1.67%)	0 (0%)	
Total	60 (100%)	60 (100%)	

This study aimed to determine the effect of normal saline and eucalyptus in tracheal suctioning on the incidence of ventilator-associated pneumonia (VAP) in patients on a ventilator. The results showed that VAP was observed in 7 patients (11.67%) in the intervention group (the group that used 0.9% normal saline with 5% eucalyptus). In other words, eucalyptus reduced ventilator-associated pneumonia compared with the control group (the group that received only 0.9% normal saline), in which VAP was seen in 22 cases (36.7%). A study performed on twelve patients concluded that smoking eucalyptus could reduce VAP incidence (19).

Another study investigating inhaled eucalyptus on the microbial load of the endotracheal tube in ventilated patients reported that eucalyptus reduced the microbial load and significantly reduced *Klebsiella pneumonia* in the endotracheal (15). This result is in line with the present study results. The antimicrobial effect of different species of eucalyptus on viral influenza (20), various microbial species, including Klebsiella, Pseudomonas, Proteus, *E. coli*, and methicillin-resistant *Staphylococcus aureus* and *S. aureus*, have been shown *in vitro* and *in vivo* (21, 22). The antimicrobial effects of eucalyptus are attributed to cineole (17), in which the essential oil used in this study contained 80% of cineole. On the other hand, Caruso *et al*. (23) showed that the use of normal saline reduces VAP incidence compared to not using it. In Caparros *et al*. (24), the incidence of VAP in the normal saline group was significantly higher than in the non-normal saline group. In this study, the use and non-use of normal saline solution on VAP incidence were investigated. While in the present study, the effect of using normal saline and normal saline solution with eucalyptus on the incidence of VAP was compared.

In general, the present study results showed that eucalyptus is essential for reducing VAP, thus reducing morbidity and mortality and reducing the treatment costs of patients admitted to intensive care units. It is suggested that eucalyptus incense for the treatment of VAP should also be considered. One of the limitations of our study was the lack of sputum culture by the Broncho Alveolar Lavage method due to the cost of microbial culture tests and lack of easy access to alveolar secretions, which is suggested to be used in future studies of sputum culture.

Conclusions

Based on the findings of our study, the incidence of VAP during using normal saline and normal saline with eucalyptus as a diluent for pulmonary secretions was significantly different between the two groups. This finding can reassure nurses and the treatment team that they can use normal saline solution with 5% eucalyptus during suction to dilute pulmonary secretions. The study also had limitations, including low sample size and the use of an ICU in a hospital. Perhaps using more sample sizes and multiple centers and hospitals could provide more valuable and reliable results. Thus, based on the different outcomes of the studies, it is recommended to conduct more studies with higher sample sizes in various hospitals. It is also recommended to use other solutions such as distilled water and compare it with eucalyptus solution in endotracheal suction.

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Conflict interest

None.

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