

Comparison the Effects of Shallow and Deep Endotracheal Tube Suctioning on Respiratory Rate, Arterial Blood Oxygen Saturation and Number of Suctioning in Patients Hospitalized in the Intensive Care Unit: A Randomized Controlled Trial

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ABSTRACT

Introduction: Endotracheal tube suctioning is essential for improve oxygenation in the patients undergoing mechanical ventilation. There are two types of shallow and deep endotracheal tube suctioning. This study aimed to evaluate the effect of shallow and deep suctioning methods on respiratory rate (RR), arterial blood oxygen saturation (SpO₂) and number of suctioning in patients hospitalized in the intensive care units of Al-Zahra Hospital, Isfahan, Iran.

Methods: In this randomized controlled trial, 74 patients who hospitalized in the intensive care units of Isfahan Al-Zahra Hospital were randomly allocated to the shallow and deep suctioning groups. RR and SpO₂ were measured immediately before, immediately after, 1 and 3 minute after each suctioning. Number of suctioning was also noted in each groups. Data were analyzed using repeated measures analysis of variance (RMANOVA), chi-square and independent t-tests.

Results: RR was significantly increased and SpO₂ was significantly decreased after each suctioning in the both groups. However, these changes were not significant between the two groups. The numbers of suctioning was significantly higher in the shallow suctioning group than in the deep suctioning group.

Conclusion: Shallow and deep suctioning had a similar effect on RR and SpO₂. However, shallow suctioning caused further manipulation of patient's trachea than deep suctioning method. Therefore, it seems that deep endotracheal tube suctioning method can be used to clean the airway with lesser manipulation of the trachea.

Introduction

Most of the patients hospitalized in the intensive care units due to maintain airway patency, oxygenation and prevention from aspiration, need endotracheal intubation.^{1,2}

Endotracheal intubation lead to depression of the cough reflex and loss of the muco-ciliary function, and finally causes accumulation of the secretions and interfere with the removal of the secretions from the airway.³ Accumulation of the secretions with obstructing in the airway can lead to

impairment in mucociliary function, change in tidal volume, increase in pulmonary shunt, weaken the pulmonary neuro-muscular, pneumonia and atelectasis.^{4,5}

Therefore, one of the most important nursing cares in these patients is clearing of the airway.⁶

Cleaning methods and, thus, maintaining airway patency include frequent change of patient position, moisturizing the air entering the lungs, chest physiotherapy, and endotracheal tube suctioning.^{7,8} In patients with endotracheal tube after frequent change of patient position, moisturizing the air

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entering the lungs and chest physiotherapy, secretions moved from the down airways to the central airways and should be removed with suctioning.⁷ Endotracheal tube suctioning is a process in which the catheter inserted in to the endotracheal tube and the secretions of patient's lung removed with applying the negative pressure.⁸ This process prevents accumulation of the secretion and ensures optimal oxygenation.⁹

Endotracheal tube suctioning is necessary for removing secretions, and thereby maintains airway patency and saving the patients' lives.

However, failure to meet the standards in the implementation of this procedure can have numerous detrimental effects.¹⁰ Possible complications of endotracheal tube suctioning include hypoxia, bronchospasm, atelectasis, tracheal tissue injury, ventilator-associated pneumonia, increase in intracranial pressure, and cardiac dysrhythmia.^{8,11} Therefore, updating endotracheal tube suctioning practices is considered to reduce the incidence of these complications.¹²⁻¹⁵

Depth of the endotracheal tube suctioning is one of the issues considered to reduce these side effects. Endotracheal tube suctioning can perform using both shallow and deep methods. In the shallow suctioning, after removing the patient from the ventilator without applying any negative pressure, the suction catheter carried only to the end of the endotracheal tube. Then suctioning performed as the catheter withdrawn. In the deep suctioning method, without the application of any negative pressure, the suction catheter driven forward until resistance met, and then it pulled back one centimeter and suctioning performed, as the catheter is being withdrawn.¹⁶ literature reviews in nursing context have a different opinion about the depth of catheter insertion in to the patient's trachea during endotracheal tube suctioning.

Potter and Perry, Taylor and Brunner believe that endotracheal tube suctioning should be performed with deep method.^{7,17,18} While, Hess and White believes that

endotracheal tube suctioning should be performed with shallow method.^{16,19} In none of these sources, the application of each shallow and deep endotracheal tube suctioning has not written distinctly. Few studies have been conducted in this field and reported conflicting results. Results of Youngmee and Yonghoon showed that during and after both shallow and deep endotracheal tube suctioning, the arterial blood oxygen saturation (SpO₂) did not have a significant difference.²⁰ On the other hand results of Van de Leur *et al.*, showed that shallow suctioning against deep suctioning caused a significantly minor decrease in SpO₂ 2% vs. 2.7%.²¹

Studies performed in other countries also have reported controversial results. Therefore, this study aimed to compare the effects of shallow and deep endotracheal tube suctioning on the respiratory indices of patients hospitalized in the intensive care units. The results would help to introduce the best practice for nurses and nursing students, so that this procedure is performed with minimal complications.

Materials and methods

This was a single-blinded clinical trial. This study was carried out for two month (since 21.1.2014 until 18.3.2014) in the medical, trauma and neurosurgical intensive care units of Al-Zahra Hospital, Isfahan, Iran. This study was approved by the research ethics committee of Isfahan University of Medical Sciences. Convenience sampling was performed for enrolling the patients in the study. Allocating the subjects to the shallow and deep suctioning groups was done randomly. An informed consent was obtained from the participants. For anesthetized patients, the consent was obtained from their relatives.

The study sample size was calculated using the results of the study conducted by Zolfaghari *et al.*, d and σ were respectively 6.8 and 10.47.² Accordingly, with a type I error probability of 0.05 and a power of 0.80,

the sample size was determined to be thirty-seven patients for each group. The inclusion criteria included the absence of thrombotic diseases, being spend minimum of 2 days and maximum of 7 days of intubation, absence of chronic respiratory disease, and age over 18 years. The exclusion criteria included patient's or relative's (for anesthetized patients) withdrawal from the study, the exit of endotracheal tube during the study, deterioration of the patient's condition (bradycardia: HR<60 beats per minute, arrhythmia, cyanosis, extreme loss of arterial oxygen: SpO₂ < 86%).

In this study, the instrument for data collection consisted of two parts. The first part included demographic and clinical information and the second part included RR, SpO₂ and the frequency of required suction for effective airway cleaning. The instrument was developed by relevant literature, and its content and face validity was examined by the experts. A single researcher performed all endotracheal tube suctioning procedures, measurements, and data recordings. The central suctioning system was used for all the subjects. Measurement of RR and SpO₂ was also performed using vital signs monitoring system with the brand name of Sa'adat, made in Tehran, Iran.

Firstly, the researcher explained the objectives and methodology of the study to hospital administration, anesthesiologist doctors, nurses and authorities of intensive care units of Al-Zahra Hospital, Isfahan, Iran and obtained their consent.

Then the researcher attended in these units every day from 7:00 to 19:00 and randomly allocated the patients who met the inclusion criteria and had signed the consent form to shallow and deep endotracheal tube suctioning groups. Before suctioning, the researcher extracted all the demographic and clinical information of the patients and entered them in the first section of instrument. Then, in the second part of the study, he evaluated the patients' requirement to use endotracheal tube for suctioning. All of

patients in the both shallow and deep suctioning groups were hyper oxygenated with 100% oxygen for 2 min before and after the endotracheal tube suctioning procedure.

The diameter of the suction catheter used in both groups of patients was half of the internal diameter of the endotracheal tube.

Both groups were suctioned with a negative pressure of 120 mmHg for a maximum of three times, each time for 15 s.

In the shallow suctioning group, after removing the patient from ventilator without applying any negative pressure, the suction catheter was carried only to the end of the endotracheal tube. For this purpose, the different sizes of endotracheal tube were marked on a ruler. Then, using this ruler and according to the size of patient's endotracheal tube, the size of inserted suction catheter was determined, and with the dominant hand, the catheter was prevented from entering further into the patient's endotracheal tube. To perform a sterile procedure, it was ensured that the catheter did not touch the ruler and the measurement on the ruler was done from a close distance. But in the deep suctioning group, without the application of any negative pressure, the suction catheter was driven forward until resistance was met, then it was pulled back a centimeter and suctioning was performed while removing the catheter.¹⁶

After each endotracheal tube suctioning, patient's airway was heard to ensure effective cleaning. If the airway secretions were not cleaned properly, endotracheal tube suctioning was performed again. This procedure was continued until all the airway secretions were cleaned. The patients' respiratory indices were measured and recorded only in the first time of suctioning.

If the condition of any of the subjects was deteriorating (bradycardia: HR <60 beats per minute, arrhythmia, cyanosis, extreme drop in arterial oxygen: SpO₂< 86%), cardiopulmonary resuscitation procedure was performed on them and they were excluded from the study. Patients' RR and

SpO₂ immediately before, immediately after and 1 and 3 min after endotracheal tube suctioning were measured and entered in the second part of the instrument. The number of suctionings needed to effectively airway clearance was also calculated and entered in the second part of the instrument.

Data were analyzed by using the Statistical Package for Social Sciences (SPSS Ver. 13). The matching of the study groups regarding demographic and clinical data was assessed by using the independent-samples t and the Chi-square tests. Repeated measures analysis of variance was performed to compare the effects of endotracheal tube suctioning on the respiratory indices of patients in the both groups. Chi-square test was performed to compare the number of suctioning was required for effective airway clearance of patients in the both groups.

Results

In the present study, 74 subjects in two groups of shallow suctioning (37 people) and deep suctioning (37 people) were studied.

During the study, none of the subjects was excluded based on the exclusion criteria.

Mean age of the subjects in the shallow and deep suctioning groups was 59.4 (21.45) and 60.0 (22.3) years, respectively. Of the participants 40.6% were women and 59.4% were men. The reasons for hospitalization of the subjects were trauma 27%, gastrointestinal diseases 27%, and other diseases 46%. Majority of the subjects 44% had a history of heart disease. In addition, majority of them 51% were under mechanical ventilation of Intermittent Mandatory Ventilation (SIMV) mode. Chi-square and independent t-tests showed that the subjects of both shallow and deep suctioning groups were similar regarding age, gender, reason of admission, patients' records, and mechanical ventilation mode ($P > 0.05$). (Table 1)

Table 2 shows the results of the changes in the mean RR and SpO₂ in the stages immediately after, 1 min after, and 3 min after

endotracheal tube suctioning compared to the stage immediately before in the shallow and deep endotracheal tube suctioning groups.

The findings showed that the changes in the mean RR and SpO₂ of the patients in the stages immediately after, 1 min after, and 3 min after endotracheal tube suctioning compared to the stage immediately before was similar in two groups ($P < 0.05$). Results of repeated measures ANOVA showed that the trend of the mean RR and SpO₂ of the patients in the stages immediately after, 1 min after, and 3 min after endotracheal tube suctioning compared to the stage immediately before was significantly different in the shallow and deep endotracheal tube suctioning groups ($P < 0.05$).

However, there was no significant difference between two groups ($P > 0.05$).

The results of this research also showed that in order to effective airway clearance in the shallow suctioning group, in 56.8% of the subjects (21 people), one time suctioning and in 43.2% subjects (16 people), two times suctioning was required. However, in the deep suctioning group, in 81.1% of the participants (30 people), one time suctioning and in 18.9% (7 people), two times suctioning was required. Results of Chi-square test showed that the numbers of suction needed to effectively clear airway in the shallow suctioning group was significantly higher than in the deep suctioning group ($P < 0.05$).

Discussion

The results of this research showed that the mean RR of the patients in both shallow and deep endotracheal tube suctioning groups in the stage immediately after suctioning was increased; then at 1 min after suctioning, it reduced and eventually at 3 min after suctioning, the value was close to the value at the stage immediately before suctioning.

Zolfaghari *et al.*, also concluded that RR of the patients after endotracheal tube suctioning compared to the value immediately before was significantly

Table 1. Comparing the demographic and clinical characteristics between shallow (n=37) and deep (n=37) endotracheal tube suctioning groups

Characteristics	Groups	Deep suctioning N (%)	Shallow suctioning N (%)	χ^2	P
Gender					
Male		21 (56.8)	23 (62.2)	0.636	0.224
Female		16 (43.2)	14 (37.8)		
Reason for admission					
Trauma		11 (29.7)	9 (24.3)	0.572	1.118
Gastrointestinal diseases		8 (21.6)	12 (32.4)		
Others		18 (48.7)	16 (43.2)		
Patients' records					
Cardiac		13 (35.1)	12 (32.4)	0.672	3.473
Cerebral		2 (5.4)	0 (0)		
Diabetes		4 (10.8)	4 (10.8)		
Cardiac and diabetes		3 (8.1)	4 (10.8)		
Cardiac and cerebral		1 (2.7)	0 (0)		
No previous record		14 (37.8)	17 (46)		
Modes of mechanical ventilation					
SIMV		22 (59.5)	16 (43.2)	0.388	5.233
CPAP		16 (16.2)	8 (21.6)		
ASV		0 (0)	3 (8.1)		
AC		6 (16.2)	6 (16.2)		
PCV		0 (0)	1 (2.7)		
Spont		3 (8.1)	3 (8.1)		

SIMV: Synchronized Intermittent Mandatory Ventilation, CPAP: Continuous Positive Airway Pressure, ASV: Adaptive Support Ventilation, AC: Assist-Control ventilation, PCV: Pressure-Controlled Ventilation

Table 2. Comparison of changes in the mean RR and SpO₂ in the phases immediately after, 1 min after, and 3 min after endotracheal tube suctioning compared to the phase immediately before in the shallow (n=37) and deep (n=37) endotracheal tube suctioning groups

Variables Groups Stage	SpO ₂		RR	
	Shallow suctioning Mean (SD)	Deep suctioning Mean (SD)	Shallow suctioning Mean (SD)	Deep suctioning Mean (SD)
Immediately before	92.91 (4.1)	93.32 (4.8)	21.21 (6.8)	21.29 (5.1)
Immediately after	90.27 (3.3)	90.70 (3.8)	24.21 (6)	25.47 (6.1)
1 min after	93.15 (3.3)	93.27 (3.5)	22.51 (7.8)	23.91 (5.4)
3 min after	94.47 (2.7)	95.02 (3.2)	20.94 (6.8)	21.74 (4.8)
Immediately after and immediately before	-2.64 (1.8)	-2.62 (2.7)	3 (3.8)	4.18 (3.8)
Independent t-test	t = -0.05	P = 0.960	t = -1.32	P = 0.190
1 min after and immediately before	0.34 (2.3)	-0.05 (2.7)	1.3 (2.8)	2.62 (3.1)
Independent t-test	t = 0.50	P = 0.619	t = -1.82	P = 0.072
3 min after and immediately before	1.56 (2)	1.70 (2.8)	-0.27 (1.5)	0.45 (2.5)
Independent t-test	t = 0.23	P = 0.816	t = -1.48	P = 0.141
RM ANOV Among the group	F = 247.25	P = 0.798	F = 55.61	P = 0.000
RM ANOV Different levels of measurement	P = 0.798	F = 0.06	P = 0.170	F = 2.66

returned to the original levels found before suctioning.²

The results of this study also showed that the mean SpO₂ of the patients in both shallow and deep endotracheal tube suctioning groups in the stage immediately after suctioning was decreased; then at 1 min after suctioning, it increased and was close to the value at the stage immediately before suctioning. After that increasing in SpO₂ continued such that at 3 min after suctioning it was higher than the value at the stage immediately before suctioning. Zolfaghari *et al.*, Seyyed Mazhari *et al.*, concluded that SpO₂ of the patients after endotracheal tube suctioning compared to the value immediately before it was decreased, then it increased and until 5 min after suctioning, it returned to the original levels found before suctioning.^{2,22}

According to the results of this study, the changes trend of the mean RR and SpO₂ of the patients in the stages immediately after, 1 min after, and 3 min after endotracheal tube suctioning compared to the stage immediately before was significant by different in the both shallow and deep endotracheal tube suctioning groups ($P < 0.05$). However, trend changes were not significant between the two groups ($P > 0.05$). Consistent with the findings of this study, Youngmee and Yonghoon also concluded that infant's SpO₂ in both shallow and deep suctioning groups significantly decreased during and after endotracheal tube suctioning ($P < 0.05$), but the difference between the groups was not significant ($P > 0.05$).²⁰ Also, Van de Leur *et al.*, have found that shallow suctioning compared with deep suctioning significantly caused a slight decrease in patient's SpO₂ 2% vs. 2.7%.²¹ Youngmee and Yonghoon's study was performed on infants; therefore, the results cannot be generalized to adults. The difference in the results of Van de Leur *et al.*'s study with the results of the present study is because in the former study, besides the two groups being different regarding the depth of suctioning, in the shallow suctioning group,

normal saline and hyperoxygenation were not used.

The results of this study also revealed that the number of suctionings needed for efficient airway cleaning in the shallow suctioning group was significantly higher than that in the deep suctioning group. According to the results of this study, both shallow and deep endotracheal tube suctioning methods have similar effects on RR and SpO₂. However, the number of suctionings in the deep suctioning group was lower than that in the shallow suctioning group.

This study has two limitations. Different people have different psychological and mental conditions; against invasive procedures such as endotracheal tube suctioning have different physiological reactions. These two factors might have affected our findings.

Conclusion

The overall results of this study showed that changes of RR and SpO₂ were similar in both shallow and deep endotracheal tube suctioning methods. However, the number of suctionings in the deep suctioning group was significantly lower than that in the shallow suctioning group. Therefore, it seems that deep endotracheal tube suctioning method can be used to clean the airway with lesser manipulation of the trachea. According to the effects of both shallow and deep endotracheal tube suctioning on the respiratory indices, it is for nurses recommended to monitor the RR and SpO₂ of patients with more attention during and after deep endotracheal tube suctioning.

According to the results of this study, it is recommended that comparison of the effects of shallow and deep suctioning on the intubation time and the incidence of ventilator-associated pneumonia investigated in the future studies.

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Ethical issues

None to be declared.

Conflict of interest

The authors declare no conflict of interest in this study.

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