Original Article

Effects of shallow and deep endotracheal tube suctioning on cardiovascular indices in patients in intensive care units

Alireza Irajpour[1], Mohammad Abbasinia[2], Abbas Hoseini[3], Parviz Kashefi[4]

Abstract

Background: Clearing the endotracheal tube through suctioning should be done to promote oxygenation. Depth of suctioning is one of the variables in this regard. In shallow suctioning method, the catheter passes to the tip of the endotracheal tube, and in deep suctioning method, it passes beyond the tip into the trachea or brunches. This study aimed to evaluate the effect of shallow and deep suctioning methods on cardiovascular indices in patients hospitalized in the intensive care units (ICUs).

Materials and Methods: In this clinical trial, 74 patients were selected among those who had undergone mechanical ventilation in the ICU of Al-Zahra Hospital, Isfahan, Iran using convenience sampling method. The subjects were randomly allocated to shallow and deep suctioning groups. Heart rate (HR) and blood pressure (BP) were measured immediately before and 1, 2, and 3 min after each suctioning. Number of times of suctioning was also noted in both the groups. Data were analyzed using repeated measures analysis of variance (ANOVA), Chi-square and independent *t*-tests.

Results: HR and BP were significantly increased after suctioning in both the groups ($P < 0.05$). But these changes were not significant between the two groups ($P > 0.05$). The suctioning count was significantly higher in the shallow suctioning group than in the deep suctioning group.

Conclusions: Shallow and deep suctioning were similar in their effects on HR and BP, but shallow suctioning caused further manipulation of patient's trachea than deep suctioning method. Therefore, in order to prevent complications, nurses are recommended to perform the endotracheal tube suctioning by the deep method.

Key words: Airway clearance, cardiovascular system, intensive care unit, nursing, suction

Introduction

Most of the patients hospitalized in the intensive care unit (ICU) due to acute respiratory failure require endotracheal intubation and mechanical ventilation.[1] In patients with an endotracheal tube, keeping the airway open is one of the important goals of care.[2] Cleaning methods and, thus, keeping the airway open include frequent change of patient position, moisturizing the air entering the lungs, chest physiotherapy, and endotracheal tube suctioning.[3] Endotracheal suctioning is one of the duties of nurses in ICUs.[4] Endotracheal suctioning for removing secretions, and thereby keeping the airway open and saving the lives of patients is necessary. However, failure to meet the standards in the implementation of these procedures can have numerous effects.[5] Possible complications of endotracheal suctioning include hypoxia, bronchospasm, atelectasis, tracheal tissue injury, pneumonia associated with ventilator, increased intracranial pressure, and cardiac dysrhythmia.[6,7] Therefore, updating endotracheal suctioning practices to reduce the incidence of these complications is to be considered.[4,8-10]

Depth of endotracheal suctioning is one of the topics considered to reduce its side effects. Nursing experts have disagreements on the fewer side effects and efficiency of each of the shallow and deep suctioning methods. Few studies were conducted in this area and reported conflicting results. Results of Youngmee and Yonghoon[11] and Gillies and Spence[12] showed that the heart rate (HR) during and after endotracheal suctioning in both shallow and deep suctioning did not have a significant difference. Van de Leur *et al*. found that shallow suctioning against routine suctioning caused significantly minor increase in arterial

[1]Department of Critical Care Nursing, Faculty of Nursing and Midwifery, Isfahan, Iran, [2]Department of Critical Care Nursing, Faculty of Nursing and Midwifery, Isfahan, Iran, [3]Department of Adult Nursing, Faculty of Nursing and Midwifery, Isfahan, Iran, [4]Department of Anesthesia and Intensive Care, Isfahan University of Medical sciences, Isfahan, Iran

Address for correspondence: Mr. Mohammad Abbasinia, Department of Critical Care Nursing, Faculty of Nursing and Midwifery, Isfahan, Iran.
E-mail: abbasyniamohammad@yahoo.com

blood pressure (16.8% vs. 24.5%) and minor increase in pulse rate (0.9% vs. 1.4%).[13] Due to the controversy of the evidence and documents related to the selection of the more effective method of shallow and deep suctioning, this study aimed to compare the effects of these methods on cardiovascular indices of patients in ICUs; the results would help to introduce the best practice to nurses and nursing students, so that this procedure is performed with minimal complications.

Materials and Methods

This was a single-blinded clinical trial on patients undergoing mechanical ventilation in the ICU of Al-Zahra Hospital, Isfahan, Iran. The study was approved by the Ethics Committee of Isfahan University of Medical Sciences. Convenience sampling was performed for enrolling the patients in the study. Assigning the subjects to the shallow and deep suctioning groups was done randomly. An informed consent was obtained from the participants, and for anesthetized patients, the consent was obtained from their relatives. The inclusion criteria included the absence of thrombotic diseases, minimum of 2 days and maximum of 7 days should have passed after 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/min), arrhythmia, cyanosis, extreme loss of arterial oxygen ($SpO_2 < 86\%$).

Data collection sheet consisted of two parts. The first part included demographic and clinical information and the second part included HR, systolic, diastolic, and mean arterial blood pressure, and the frequency of required suction for effective airway cleaning. Data collection sheet was developed by relevant literature, and its content and face validity was examined by the experts.

All endotracheal suctioning procedures, measurements, and data recordings were performed by a single researcher. Central suctioning system was used for all the subjects. Measurement of HR and blood pressure values was also performed noninvasively using vital signs monitoring system with the brand name of Sa'a: dat, made in Tehran, Iran.

Having randomly chosen the samples and assigning them to shallow and deep suctioning groups, according to the information in the hospital records, the researcher extracted all the demographic and clinical information of the patients and entered them in the first section of data sheet. Then, in the second part of the study, he evaluated the patients' requirement to use endotracheal tube for suctioning. Both shallow and deep suctioning groups were hyperoxygenated 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 come in contact with 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.[14]

After each suctioning of the endotracheal tube, patient's airway was heard to ensure effective cleaning. If the airway secretions were not cleaned properly, endotracheal suctioning was performed again. This procedure was continued until all the airway secretions were cleaned.

The cardiovascular indices of the patients were only recorded and measured in the first endotracheal suctioning. If the condition of any of the subjects was deteriorating (bradycardia: HR < 60 min), arrhythmia, cyanosis, extreme drop in arterial oxygen ($SpO_2 < 86\%$), cardiopulmonary resuscitation procedure was performed on them and they were excluded from the study. Patients' HR immediately before, immediately after, and 1 and 3 min after endotracheal suctioning and the values of systolic, diastolic, and mean blood pressure in the patients immediately before, immediately after, and 2 min after endotracheal suctioning were measured and entered in the second part of the data sheet. The number of suctions needed to effectively clear the airway was also calculated and entered in the second part of the data sheet.

For data analysis, SPSS software version 19 (SPSS Inc., Chicago, IL, USA) was used. To examine whether the age of the subjects in both the groups matched, independent *t*-test was used. To check the similarity of gender, reason of admission, patient's records, and mode of mechanical ventilation of the two groups, Chi-square test was used, and to compare the effects of endotracheal suctioning on the cardiovascular indices of patients in both the groups, repeated measures analysis of variance (ANOVA) was performed. To compare the number of times suctioning was required for effective cleaning of the airway of patients in both groups, Chi-square test was used.

Results

In the present study, 74 subjects in the two groups of shallow suctioning (37 people) and deep suctioning (37 people) were studied. During the study, neither 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. 40% of the participants were women and 60% 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. Also, 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].

The findings showed that the changes in the mean HR in the stages immediately after, 1 min after, and 3 min after endotracheal suctioning compared to the stage immediately before it were 7.13 ± 5.70, 4.08 ± 4.20, and 1.54 ± 2.80 in the shallow suctioning group and 9.05 ± 8.10, 4.27 ± 5.90, and 0.67 ± 4.80 in the deep suctioning group, respectively. Results of repeated measures ANOVA showed that increase in HR in each stage of both groups of patients (shallow and deep suctioning) was statistically significant. But there was no statistically significant difference between the two groups in different stages [Table 2].

In the shallow suctioning group, the mean changes of systolic, diastolic, and mean arterial blood pressure in patients immediately after endotracheal suctioning compared to immediately before it were 6.64 ± 8.20, 5.54 ± 6.60, and 6.05 ± 6.50 mmHg, respectively; at 2 min after endotracheal suctioning compared to before it, the changes were 5.16 ± 5.00, 3.27 ± 4.60, and 3.83 ± 4.4 mmHg, respectively.

In the deep suctioning group, the mean changes in systolic, diastolic, and mean arterial blood pressure after endotracheal suctioning of the patient compared to immediately before it were 7.62 ± 8.50, 6.37 ± 6.70, and 7.02 ± 7.00 mmHg,

Table 1: Demographic and clinical comparison of the patients in the studied groups

Groups	Deep suctioning (number (%))	Shallow suctioning (number (%))	χ^2, *P* value
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	6 (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)	

$P<0.05$ was considered significant. SIMV: Ventilation, CPAP: Continuous positive airway pressure, ASV: Adaptive Support Ventilation, AC: Assist-control Ventilation, PCV: Pressure-controlled ventilation

Table 2: Comparison of the differences of mean heart rates immediately before endotracheal suctioning and immediately after, 1 min after, and 3 min after endotracheal suctioning in the studied groups

Groups	The difference immediately after and immediately before (Mean±SD)	The difference 1 min after and immediately before (Mean±SD)	The difference 3 min after and immediately before (Mean±SD)	ANOVA and repeated measures	
				Among the groups	Different levels of measurement
Shallow suctioning	5.70±7.13	4.20±4.08	2.80±1.54	*P*=0.695	*P*<0.001
Deep suctioning	8.10±9.05	5.90±4.27	4.80±0.67		

ANOVA: Analysis of variance, $P<0.05$ was considered significant respectively; at 2 min after endotracheal suctioning compared to before it, the changes were 4.29 ± 8.00, 2.89 ± 5.20, and 3.48 ± 6.20 mmHg, respectively.

Results of repeated measures ANOVA showed that the mean increases in systolic, diastolic, and mean arterial blood pressure in both groups of patients at different stages of shallow and deep suctioning were statistically significant. However, no significant difference between the two groups at different stages was observed [Table 3].

For effective airway cleaning 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 done. But 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. Chi-square test showed that the number of needed suctions to effectively clear airway in the shallow suctioning group was significantly higher than that required in the deep suctioning group ($P < 0.05$).

Discussion

The results of this study indicated that the mean HR of patients in the stages immediately after, 1 min after, and 3 min after endotracheal suctioning compared to the HR immediately before it had significantly increased in both groups of shallow and deep suctioning ($P < 0.05$). Mean HR in both shallow and deep 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 very close to the value at the stage immediately after suctioning. Seyyed Mazhari *et al*. concluded that HR of the patients after endotracheal suctioning compared to the value immediately before it was significantly increased, and until 5 min after suctioning, it returned to the original levels found before suctioning.[15]

Results showed that difference in changes of patients' HR values between the shallow and deep suctioning groups was not statistically significant. Increase in HR of patients in the deep suctioning group was slightly more than in the shallow suctioning group. Youngmee and Yonghoon showed that infant HR in both shallow and deep suctioning groups increased during and after endotracheal suctioning, but the difference between the groups was not significant.[11] On the other hand, results of Van de Leur *et al*.'s study indicated that shallow suctioning compared with routine suctioning significantly caused a slight increase in patients' HR (9% vs. 1.4%).[13] 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 findings of the present study also showed that mean arterial blood pressure of the patients in the stages immediately after and 2 min after endotracheal suctioning compared to immediately before it significantly increased in both shallow and deep suctioning groups. Mean arterial blood pressure of the patients in both the groups in the stage immediately after endotracheal suctioning compared to immediately before it was increased; then, in the stage 2 min after suctioning, it decreased, but not to the level immediately before it. Zolfaghari *et al*. showed that arterial blood pressure values significantly increased in patients 2 min after endotracheal suctioning and returned to the levels found before suctioning at 5 min after endotracheal suctioning.[16] It seems that the increase in HR and arterial blood pressure values in patients occurred due to hypoxia during suctioning, and after suctioning with hyperoxygenation, they returned to the levels found prior to suctioning. Therefore, the nursing staff can prevent these

Table 3: Comparison of the differences of mean systolic blood pressure, diastolic, and mean arterial blood pressure (in mmHg) immediately before endotracheal suctioning and immediately after and 2 min after endotracheal suctioning in both shallow and deep suctioning groups

Blood pressure	Groups	The difference immediately after and immediately before (Mean±SD)	The difference 2 min after and immediately before (Mean±SD)	ANOVA and repeated measures	
				Among the groups	Different levels of measurement
Systolic	Shallow suctioning	8.2±6.64	5.0±5.16	F=2.145, *P*=0.147	F=14.698, *P*<0.001
	Deep suctioning	8.5±7.62	8.0±4.29		
Diastolic	Shallow suctioning	6.6±5.45	4.6±3.27	F=0.977, *P*=0.326	F=21.890, *P*<0.001
	Deep suctioning	6.7±6.37	5.2±2.89		
Mean	Shallow suctioning	6.5±6.05	4.4±3.83	F=1.114, *P*=0.295	F=21.046, *P*<0.001
	Deep suctioning	7.0±7.02	6.2±3.48		

ANOVA: Analysis of variance, P<0.05 was considered significant complications by hyperoxygenating the patients before and after endotracheal suctioning.

The results suggested that the changes in the arterial blood pressure values between the shallow and deep suctioning groups were not statistically significant. The increase in mean arterial blood pressure values in patients of the deep suctioning group was slightly more than that in the shallow suctioning group. The results of Van de Leur *et al*.'s study, unlike the present study, showed that shallow suctioning significantly caused a slightly increased systolic blood pressure of patients, compared with routine suctioning (16.8% vs. 24.5%).[13]

The present results also showed that the number of suctions needed for efficient airway cleaning in the shallow suctioning group was significantly higher than that in the deep suctioning group. This means that in order to effectively clear the airway, using shallow suctioning method requires more endotracheal modification. This can lead to further complications such as hypoxia, bronchospasm, atelectasis, endotracheal tissue injury, pneumonia associated with ventilator, increased intracranial pressure, and cardiac dysrhythmia.[6,7] It seems that deep endotracheal suctioning procedure with less complications can lead to more effective airway cleaning.

Conclusions

The overall results of this study showed that deep suctioning compared with shallow suctioning is more effective in airway cleaning. However, the increase in HR and arterial blood pressure values in patients with deep suctioning was slightly more than that in the shallow suctioning group, and this increase, even to a small degree, can have adverse clinical effects on cardiac patients. Therefore, nurses should monitor the HR and arterial blood pressure values in patients with more attention during and after deep endotracheal suctioning.

According to the results, it is recommended that further studies be conducted to compare the effects of shallow and deep suctioning on respiratory parameters and also on the incidence of pneumonia associated with ventilator.

Acknowledgment

This article is a result of an approved thesis in Isfahan University of Medical Sciences and Health Services, with the number 392015. The recorded code in the registration center of clinical trials is IRCT2012123111954N1. Appreciation goes to the research deputy of Isfahan University of Medical Sciences and the hard-working staff of the ICUs of Isfahan Al-Zahra Hospital who helped us in conducting this study.

References

1. Suri HS, Li G, Gajic O. Epidemiology of Acute Respiratory Failure and Mechanical Ventilation. Yearbook of Intensive Care and Emergency Medicine. Berlin Heidelberg: Springer; 2008. p. 193-202.
2. Tusman G, Bohm SH, Warner DO, Sprung J. Atelectasis and perioperative pulmonary complications in high-risk patients. Curr Opin Anaesthesiol 2012;25:1-10.
3. Brunner LS, Smeltzer SC, Bare BG, Hinkle JL, Cheever KH. Brunner and Suddarth's Textbook of Medical-Surgical Nursing. Philadelphia: Lippincott Williams and Wilkins; 2009. p. 658.
4. Urden LD, Stacy KM, Lough ME. Critical care nursing: Diagnosis and management. Philadelphia: Mosby/Elsevier; 2010. p. 602.
5. Caramez MP, Schettino G, Suchodolski K, Nishida T, Harris RS, Malhotra A, *et al*. The impact of endotracheal suctioning on gas exchange and hemodynamics during lung-protective ventilation in acute respiratory distress syndrome. Respir care 2006;51:497-502.
6. Williams L, Wilkins. Fundamentals of Nursing Made Incredibly Easy! Philadelphia: Lippincott Williams and Wilkins; 2006. p. 319.
7. American Association for Respiratory Care. AARC Clinical Practice Guidelines. Endotracheal suctioning of mechanically ventilated patients with artificial airways 2010. Respir care 2010;55:758-64.
8. Ugras GA, Aksoy G. The effects of open and closed endotracheal suctioning on intracranial pressure and cerebral perfusion pressure: A crossover, single-blind clinical trial. J Neurosci Nurs 2012;44:E1-8.
9. Vanner R, Bick E. Tracheal pressures during open suctioning. Anaesthesia 2008;63:313-5.
10. Bourgault AM, Brown CA, Hains SM, Parlow JL. Effects of endotracheal tube suctioning on arterial oxygen tension and heart rate variability. Biol Res Nurs 2006;7:268-78.
11. Youngmee A, Yonghoon J. The effects of the shallow and the deep endotracheal suctioning on oxygen saturation and heart rate in high-risk infants. Int J Nurs Stud 2003;40:97-104.
12. Gillies D, Spence K. Deep versus shallow suction of endotracheal tubes in ventilated neonates and young infants. Cochrane Database Syst Rev 2011;(7):CD003309.
13. Van de Leur JP, Zwaveling JH, Loef BG, Van der Schans CP. Endotracheal suctioning versus minimally invasive airway suctioning in intubated patients: A prospective randomised controlled trial. Intensive Care Med 2003;29:426-32.
14. White GC. Basic clinical lab competencies for respiratory care: An integrated approach. New York: Delmar Cengage Learning; 2012. p. 447.
15. Seyyed Mazhari M, Pishgou'ei AH, Zareian A, Habibi H. Effect of open and closed endotracheal suction systems on heart rhythm and artery blood oxygen level in intensive care patients. Iranian Journal of Critical Care Nursing 2010;2:1-2.
16. Zolfaghari M, Nasrabadi AN, Rozveh AK, Haghani H. Effect of open and closed system endotracheal suctioning on Vital Signs of ICU patients. Hayat 2008;14:13-20.

How to site: Irajpour A, Abbasinia M, Hoseini A, Kashefi P. Effects of shallow and deep endotracheal tube suctioning on cardiovascular indices in patients in intensive care units. Iranian Journal of Nursing and Midwifery Research 2014;19:366-70.

Source of Support: Isfahan University of Medical Sciences, **Conflict of Interest:** Nil.