

Effects of Open and Closed Tracheal Suctioning on Pain in Mechanically Ventilated Patients

Abstract

Background: Painful care procedures are the most common cause of stress in patients admitted to Intensive Care Units (ICUs). Tracheal suctioning is the most painful experience for ICU patients. The present study was conducted to compare open and closed endotracheal suctioning in terms of their effect in pain in mechanically ventilated patients. **Materials and Methods:** The present clinical trial recruited 70 mechanically ventilated patients with tracheostomy in 2019. The eligible patients were randomly divided into open and closed suctioning groups. The pain was measured in the patients using the Critical Pain Observational Tool (CPOT) before and during suctioning as well as 10 and 30 min later. The data were analyzed using the repeated measures Analysis Of Variance (ANOVA), paired t-test, and Chi-squared test. **Results:** The pain score was significantly higher in the open suctioning group during ($t = 2.59, p = 0.01$) and 10 min after suctioning ($t = 3.02, p = 0.004$). No significant differences were observed in the pain score between the two groups 30 min after suctioning ($t = 0.32, p = 0.75$). The post hoc Least Significant Difference (LSD) test showed that the CPOT scores 10 min after suctioning was significantly higher than that before suctioning and significantly lower than that during suctioning ($p = 0.001$). The CPOT score 30 min after suctioning was also significantly lower than that 10 min after suctioning ($p < 0.001$). **Conclusions:** The present findings suggested a lower pain in the patients with closed suctioning compared to those with open suctioning.

Keywords: Interactive ventilatory support, pain, suction

Introduction

The International Association for the Study of Pain (IASP) describes the pain as an unpleasant sensation and an emotional experience associated with actual or potential damage to tissues. Research suggests pain and agitation in most of the adult Intensive Care Unit (ICU) patients cause psychophysical complications that may last many years after their discharge.^[1] As the subject of many years of research, identifying, explaining, and managing pain are crucial in patients admitted to ICUs^[2]; nevertheless, pain is never controlled yet in at least 50% of ICU patients. Endotracheal suctioning is commonly used by nurses in ICUs to maintain gas exchange, adequate oxygenation, and alveolar ventilation in mechanically ventilated patients.^[3]

Open endotracheal suctioning is performed after removing the mechanical ventilation circuit from the patient, whereas closed endotracheal suctioning is conducted while

the patient is connected to the mechanical ventilation device.^[4,5] As a means of clearing secretions and keeping the airway open, tracheal suctioning can cause numerous complications. Suction-induced pain is described by patients as a bad memory. Approximately 64% of the patients reported moderate-to-severe pain during suctioning.^[1] Mechanically ventilated patients find suctioning a painful and upsetting process during which they feel as if their lungs are being actually pulled into a catheter.^[6]

Comparing the two methods cited in terms of physiological disorders, oxygenation, and ventilation changes have shown the advantages and disadvantages of different types of endotracheal suctioning in literature. Open suctioning is reportedly associated with inadequate arterial saturation, inability to maintain a Positive End-Expiratory Pressure (PEEP), an increased heart rate, hypertension, and

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cardiac arrhythmias. Open suctioning also exposes the staff to infectious discharges from patients and artificial airways to microbial contamination. Moreover, closed suctioning was found to cause fewer physiological complications than those caused by open suctioning.^[7-9] To the best of the authors' knowledge, either open or closed suctioning has rarely been addressed in literature in terms of pain in mechanically ventilated patients. Given suctioning as a repetitive procedure in ICUs, examining and comparing open and closed methods of suctioning in terms of pain is crucial. The present study sought to compare open and closed endotracheal suctioning in terms of their effect in pain in mechanically ventilated patients. The aim of this study was to compare changes in the pain of endotracheal suctioning with open and closed suctioning systems.

Materials and Methods

This clinical trial (IRCT20180108038267N1) was conducted in the ICU of Al-Zahra Hospital in Isfahan, Iran from spring to winter, 2017. All patients who met the inclusion criteria were recruited. According to Figure 1, the sample size was calculated as 35 patients per group using Altman's monogram at a confidence interval of 95% and a power of 80%.

The inclusion criteria comprised admission to the ICU, an age of 18–70 years, a Glasgow coma score of at least 7, not taking high-dose sedatives or tranquilizers (deep sedation) during the previous six hours, no severe facial traumas, normal hearing and speaking ability according to medical records and statements of the patient's family, no neurological damage affecting breathing such as quadriplegia, no history of psychological diseases, severe neurological problems, or cardiac diseases, no neuromuscular diseases, no primary pulmonary pathophysiology, ventilation with synchronized intermittent mandatory ventilation,

PEEP = 3–5 cmH₂O, tidal volume = 8–10 mL/kg, the fraction of inspired oxygen = 40%–60%, pressure support ventilation = 8–10 cm, no coagulation disorders or thrombocytopenia and a Richmond Agitation Sedation Scale (RASS) score of 0 or -1. The exclusion criteria consisted of tracheal extubation, need for repeated suctioning at least every 20 min, reduced levels of consciousness during suctioning, hemodynamic instability, dysrhythmia, reductions of over 10% in SpO₂ levels during suctioning, and the dose of tranquilizers and painkillers required exceeding that of the treatment protocol. The eligible patients selected with convenience sampling were randomly divided into an open suctioning group and a closed suctioning group using a minimization software package.

Prior to suctioning, written consent was obtained from the patients' legal guardians. Pain in the patients was recorded by a trained assistant who was blinded to the study allocation and objectives to avoid measurement bias. Before suction three times, every 20 min, and their mean was used as the baseline status of the patient for further examinations. The patients' pain was then measured with the Critical Pain Observational Tool (CPOT) and recorded 10 and 30 min after suctioning.^[10] Rijkenberg *et al.* examined the Behavioral Pain Scale (BPS) and compared it with the CPOT in assessing pain in mechanically ventilated patients and suggested that the BPS score increased even with nonpainful stimuli and recommended the CPOT for pain assessment in nonconscious mechanically ventilated patients.^[11] Suctioning was performed in the present study according to the 2014 guidelines of the Agency for Clinical Innovation^[12] and a central suction system was used if needed. Before and after the open and closed suctioning, the patients were hyper oxygenated with 100% oxygen. The maximum suction pressure was 120 mmHg, and open suctioning was performed using suction catheters numbers 14 and 16. The patients were assessed for arrhythmia and hemodynamic changes during suctioning.

The data collection tools included a two-part form whose first part comprised demographic characteristics, including age, gender, body mass index (BMI), the cause of admission, length of stay, duration of mechanical ventilation, ventilator specifications, and patient mode, which were matched with the minimization software. The second part included the patients' pain record table based on the CPOT whose validity and reliability were approved with a Cronbach's alpha of 0.78.^[13,14] This tool examined four criteria, namely facial expression, body movements, compliance with the ventilator in ventilated patients, and muscle tension. Each step was scored 0–2, and the maximum CPOT score of 8 showed excessive pain. The data were analyzed in SPSS-16 (SPSS Inc., Chicago, Ill., USA) using the Chi-squared test, t-test, Mann-Whitney U test, and repeated measures ANOVA.

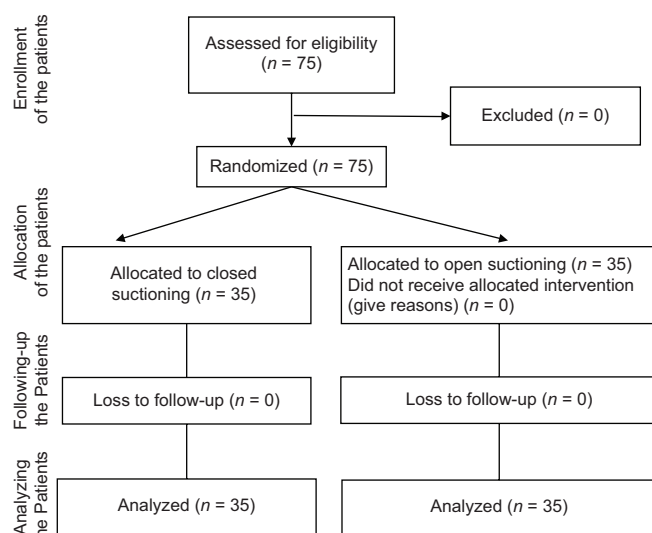


Figure 1: CONSORT flow diagram

Ethical considerations

This study was funded by Isfahan University of Medical Sciences and approved by the Ethics Committee of Isfahan University of Medical Sciences (IR.MUI.REC.1394.3.976). The legal guardians of all the patients were briefed on the study objectives, and those who were willing to participate in the study signed informed consent forms.

Results

This study assessed 75 mechanically ventilated patients. According to the results of the independent t-test and Chi-squared test presented in Table 1, the intervention group and the control group were not significantly different in terms of demographic characteristics. According to Table 2, the repeated measures ANOVA showed significant differences in the mean CPOT score between the two groups at the three time points. The independent t-test showed insignificant differences in the mean presuction scores of pain based on the CPOT between the two groups. The pain score in the open suctioning group was, however, significantly higher during and 10 min after suctioning, whereas it was not significantly different between the two groups 30 min after suctioning. Moreover, the Least Significant Difference (LSD) test showed that the CPOT mean score was significantly higher in both groups during and 10 min after suctioning compared to that before suctioning, and the score 30 min after

suctioning was significantly lower than that 10 min after suctioning [Table 3].

Discussion

The present findings showed that both open and closed suctioning methods caused pain and the patients' pain increased respectively by approximately 50% and below 40% in the open and closed suctioning groups during compared to before suctioning. Despite the pain decrease in the patients 10 min after compared to during suctioning, it was still higher compared to that before suctioning. Thirty min after suctioning, the patients' pain almost reached the baseline before suctioning. Given that the recurring procedure of suctioning should be performed even 17–18 times in some patients, even negligible decreases in pain are clinically significant.^[1] The present study found closed suctioning to generally cause less pain than that caused by open suctioning, which is inconsistent with the results of Dastdadeh *et al.* who investigated and compared the effects of open and closed suctioning on pain and agitation in ICU patients, they used the BPS to assess pain while CPOT was used in the present study. Moreover, Dastdadeh *et al.* failed to investigate the effects of the duration of mechanical ventilation and length of stay.^[15] According to a physiological rule, unlike most sensory receptors in the body, pain receptors scarcely or almost never adapt to repeated stimuli. In fact, under

Table 1: Comparing demographic and physical characteristics between the two groups

Variable		Mean (SD)		Independent t-test		
		Open suctioning group	Closed suctioning group	t	df	p
Age (year)		42.90 (14.40)	43.10 (11.40)	0.07	68	0.94
Weight (kg)		76.70 (13.20)	75.60 (12.40)	0.35	68	0.73
BMI*		23.70 (2.70)	24.60 (2.90)	1.29	68	0.20
Length of stay (day)		358 (1.30)	3.11 (1.90)	1.13	68	0.26
Duration of mechanical ventilation (day)		1.90 (1)	1.70 (1.20)	0.94	68	0.35
		Frequency (percentage)		Chi-squared test		
				χ^2	df	p
Gender	Female	17 (47.17)	12 (35.28)	1.02	68	0.31
	Male	19 (52.77)	22 (64.67)			
Cause of hospitalization	Trauma	17 (47.18)	18 (52.87)	0.23	68	0.63
	Surgery	19 (52.78)	16 (47.10)			

*Body Mass Index

Table 2: The mean (SD) CPOT* score of pain at different times in the two groups

Time	Mean (SD)		Independent t-test		
	Open suctioning group	Closed suctioning group	t	df	p
Before suctioning	1.58 (1.04)	1.75 (1.30)	0.53	(2,34)	0.59
During suctioning	5.50 (1.88)	4.38 (1.60)	2.59	(2,34)	0.01
10 min after suctioning	3.20 (1.38)	2.18 (1.40)	3.02	(2,34)	0.004
30 min after suctioning	1.60 (1)	1.70 (1.30)	0.32	(2,34)	0.75
Repeated measures ANOVA					
F	55.20	41.66			
p	<0.001	<0.001			

*Critical pain observational tool

Table 3: Comparing the mean CPOT* score of pain between every two time points in the two groups using the LSD test

Time	p	
	Open suctioning group	Closed suctioning group
Before and during suctioning	<0.001	<0.001
Before and 10 min after suctioning	<0.001	0.001
Before and 30 min after suctioning	1	0.16
During and 10 min after suctioning	<0.001	<0.001
During and 30 min after suctioning	<0.001	<0.001
10 min and 30 min after suctioning	<0.001	<0.001

*Critical Pain Observational Tool

certain conditions, prolonged application of pain stimuli through increasing the length of stay and duration of mechanical ventilation and repeating suctioning affects the pain perceived by patients.^[14,16] The present study found the mean (SD) duration of mechanical ventilation to be 1.90 (1) days and the mean (SD) length of stay to be 3.60 (1.30) days. Considering agitation a dependent variable and a Richmond Agitation-Sedation Scale (RASS) score of 0 and -1 an inclusion criterion, Dastdadeh *et al.* found all the patients to be in a sedatory status and a patient with a high RASS score to perceive pain differently from the perception of those with an RASS score of 0 and -1.

Mohammad Pour *et al.* compared the effects of open and closed tracheal suctioning on pain and oxygenation in 130 mechanically ventilated patients after undergoing coronary artery bypass grafting and observed no statistically-significant differences between the higher pain during open suctioning and the pain during closed suctioning.^[17] Using the neonatal-pain agitation sedation scale, Acikgoz *et al.* found closed suctioning to cause an insignificantly-lower pain in newborns compared to that caused by open suctioning,^[18] which is consistent with the present study. The instrument used in Acikgoz' study was Neonatal- Pain Agitation Sedation Scale (N-PASS). They suggested that although there is no statistically significant difference in pain between open and closed suction, newborns felt a little more pain in open suction.^[18]

The eradication of any weak points due to the detachment of the mechanical ventilation device from the patient has been demonstrated to be the most important advantage of the closed suctioning system; nevertheless, little information is available about the effects of the closed suctioning system on hemodynamic parameters.^[4] Evans *et al.* found closed suctioning to be performed more often during the day and nurses to spend less time performing closed suctioning than performing open suctioning. Compared to open suctioning, the closed suctioning procedure requires less time and fewer nurses and causes fewer physiological complications in patients.^[10] Corley *et al.* found the end-expiratory lung volume to improve more slowly in

closed suctioning compared to in open suctioning at all the time points. Although closed suctioning reduced the lung volume lost during suctioning, its postsuction rate of recovery of the volume was lower. Closed suctioning was, therefore, not recommended for protecting the lung volume after suctioning.^[19] Although the two methods of suctioning have been compared in literature, their effects on pain have rarely been investigated. Further research is recommended to be conducted with a larger population to select the best suctioning method, maintain safety, and improve the quality of patient care.

The present study limitations included the nurses' incomplete knowledge of closed suctioning, which caused their tendency to perform closed suctioning. To solve this problem, nursing education is recommended to be provided on different types of suctioning methods and their advantages and disadvantages.

Conclusion

The results of this study showed that closed suctioning is less painful for the patients. ICU nurses are recommended to be trained and provided with more information about closed suctioning to extend its application. The present findings showed gradual changes in the level of pain in the two groups receiving open or closed suctioning, and pain levels in the mechanically ventilated patients were found to be affected by the type of the suctioning system used. Catheterization for suctioning with the closed system was also found gentler and hence less painful.

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Conflicts of interest

Nothing to declare.

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