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Effect of deep and superficial endotracheal suctioning on hemodynamic parameters and pain in neurosurgical intensive care patients

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ABSTRACT

Objective: This study aimed to determine the effects of deep and superficial endotracheal suctioning on hemodynamic parameters and pain level in mechanically ventilated neurosurgical patients.

Patients and Methods: This prospective, randomized, controlled experimental study was conducted on 37 patients who underwent deep endotracheal suctioning and 37 patients who underwent superficial endotracheal suctioning using open endotracheal suctioning system. The arterial blood pressure, heart rate, body temperature, respiratory rate, oxygen saturation levels and pain status of the patient were compared before and after endotracheal suctioning at 1 min, 5 min and 30 min.

Results: There was no statistically significant difference between the effects of deep and superficial endotracheal suctioning methods ($p > 0.05$). However, there was less change in systolic and diastolic arterial blood pressure and heart rates in patients who underwent superficial endotracheal suctioning before and 30 min after endotracheal suctioning ($p > 0.05$).

Conclusion: Superficial endotracheal suctioning caused fewer changes in hemodynamic parameters and pain levels of patients compared to deep endotracheal suctioning. For this reason, nurses should first prefer the superficial endotracheal suctioning method during the suctioning practices of neurosurgery patients.

Keywords: Endotracheal suctioning, Neurosurgery, Intensive care, Hemodynamic parameters, Nurse

1. INTRODUCTION

Endotracheal suctioning is the process of taking out the respiratory system secretions using a vacuum device operating with negative pressure. Endotracheal suctioning, which is used to remove these tracheal and intraoral secretions in intensive care patients, can be applied in two ways: deep and superficial. Deep endotracheal suctioning is the insertion of a suction catheter until resistance is met in the patient's trachea and lower airway. Superficial endotracheal suctioning is cleaning process by aspirating only intratubal and intraoral spaces with a catheter without advancing it to the patient's intrathoracic cavity [1,2].

A limited number of studies in the literature investigated the effects of deep and superficial endotracheal suctioning. These studies reported that deep and superficial endotracheal suctioning protected patients from respiratory complications, besides affecting hemodynamic parameters and causing pain [3-9]. Haddad and Arabi reported that neurosurgical patients were not hemodynamically stable. They also stated that endotracheal suctioning increased intracranial pressure (ICP) and led to secondary complications. Therefore, they emphasized that endotracheal suctioning should be short and atraumatic [4]. Irajpour et al., investigated the cardiovascular effects of deep and superficial suctioning and found that both suctioning methods increased arterial blood pressure and heart rate and no statistically significant difference was found between these two groups [5]. In addition, it was emphasized in the literature that patients experienced severe pain in the 1st and 5th min after

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superficial and deep endotracheal suctioning. Although, it was stated that the intensity of pain decreases in the 30th min, the pain intensity experienced by the patients during this period was undeniable [10-13].

Endotracheal suctioning, which has important effects on the hemodynamic parameters and pain conditions of the patients, is important to be applied in the least traumatic way in neurosurgery patients whose health conditions are adversely affected, especially in the smallest changes in brain perfusion. However, although there are many studies comparing open (endotracheal suctioning method in which patients are separated from the mechanical ventilator) and closed (endotracheal suctioning method in which patients are applied without leaving the mechanical ventilator) endotracheal suctioning methods in the literature, the number of studies comparing both neurosurgery patients and deep and superficial endotracheal suctioning techniques is quite low. In the literature, the number of studies reporting the superiority of these two different endotracheal suctioning techniques over each other is quite low. In addition, there is insufficient evidence on which endotracheal suctioning method is the most appropriate in neurosurgery patients without impairing cerebral perfusion. For this reason, the study was conducted to determine the effects of deep and superficial endotracheal suctioning on arterial blood pressure, heart rate, body temperature, respiratory rate, oxygen saturation level (SpO_2), and pain in postoperative neurosurgical patients dependent on a mechanical ventilator.

2. PATIENTS and METHODS

Design and Setting

The study is a prospective, randomized controlled experimental study. Data were collected between September 1, 2015 and November 11, 2016. The patients were divided into two groups as control (deep endotracheal suction patients) and experimental group (superficial endotracheal suction patients). Patients who met the research criteria were randomized over hospital protocol numbers (simple randomization using the randomizer.org address). Afterwards, deep endotracheal suctioning was applied to 37 patients in the control group, and superficial endotracheal suctioning was applied to 37 patients in the experimental group. The study was conducted with neurosurgery patients treated in the intensive care units of a university hospital and a public hospital. Surgical patients were followed up in six intensive care units in total. An average of fifteen intensive care nurses work in each intensive care unit, and a responsible intensive care specialist or anesthesiologist of these intensive care units.

Sample

In this prospective, randomized observational study, postoperative neurosurgery patients with 74 epidural, subdural, intracranial hemorrhage and intracranial masses in intensive care unit were studied according to the sample size ($d = 6.8$, $\sigma = 10.47$, $\alpha = 0.05$, $\beta = 0.8$) [5,14].

Inclusion criteria for the study; volunteer, over 18 years old, intubated (between 2 and 7 days on the day of intubation), on mechanical ventilator, without extraventricular drainage, had not infiltrates, not sedated, not unconscious, monitored, with radial artery catheter, arterial blood pressure between 160/90 mmHg and 110/70 mmHg , heart rate between 60-100/min, respiratory rate between 16-22/min, body temperature not higher than 38° C, no cyanosis (SpO_2>86%), hourly urine output more than 30 ml, thrombolytic, not have thrombotic-lung disease and rhythm problems, did not need blood transfusion, and laboratory blood values of sodium, potassium and chlorine were within normal limits. When sodium, potassium and chlorine values are above the normal values, the patients may experience problems in cardiovascular and respiratory functions in addition to fluid-electrolyte disorders, so these values were considered to be within the normal range.

Patients who did not meet any of these criteria were not included in the study. Further, 24 patients who did not meet sampling inclusion criteria and volunteer to participate were excluded from the study.

In order to start the study, ethical committee approval was obtained (date/number: 2015-10-20/05) and implementation permission was received from the institution where the study would be conducted. Later, informed consent was obtained after the supervisor physicians and nurses in the intensive care units, patients or their relatives (for confused or lethargic patients) were informed about the study. The principles of the Helsinki Declaration were followed in the study.

Data Collection Tools

Data were collected using a data collection form, Behavioral Pain Scale (BPS) developed by Payen et al. for intensive care patients and the adaptation of the scale to Turkey was carried out by Vatansever and the Glasgow Coma Scale (GCS) developed by Teasdale and Jennett [8,15,16].

Data collection form consisted of two parts. The first part of the questionnaire comprised a total of nine questions, including eight open-ended questions and one close-ended question on patient information. The questions in the first section were related to gender, age, diagnosis, days spent in the intensive care unit, the GCS score, number of days spent by the patient under intubation, mechanical ventilator mode, hourly urine volume, and the procedure applied to the patient. The second part comprised a chart, in which the pain level measured according to the BPS and the hemodynamic parameters measured and evaluated just before and at 1 min, 5 min, and 30 min after deep and superficial endotracheal suctioning were recorded.

Behavioral Pain Scale: The behavioral pain scale was developed by Payen et al. for intensive care patients [8]. Cronbach's alpha coefficient was found to be 0.64-0.72. The adaptation of the scale to Turkish was carried out by Vatansever in 2004, and the internal discrepancy coefficient (Cronbach alpha value) was found to be 0.71-0.93 [8,15]. It consisted of three subscales, including facial expression, upper limb movements, and ventilation compliance. Each subscale had 4 sub items,

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totaling 12 items. Each subscale was scored between 1 (no pain response) and 4 (full pain response). The lowest score obtained from the scale was 3 and the highest score was 12. A score over 5 indicated that the patient experienced pain. The first items in each subscale showed the absence of pain, the second items mild pain, the third items moderate pain, and the fourth items increased pain level [15]. In a study, it is reported that the use of BPS is useful in evaluating the pain status of neurosurgery patients [17].

***Glasgow Coma Scale*:** GCS is a scale developed by Teasdale and Jennett in 1974. Patients' level of consciousness was determined according to the score taken on a scale that assessed the best eye-opening, motor, and verbal responses. The lowest score from the GCS was 3, which represented bad prognosis, and the highest score was 15, which represented good prognosis. Patients who scored 8 or below on the scale were considered to be in coma [16].

Data Collection

Patients who met the research criteria were randomized over hospital protocol numbers (simple randomization using the randomizer.org address). Afterwards, deep endotracheal suctioning was applied to 37 patients in the control group, and superficial endotracheal suctioning was applied to 37 patients in the experimental group.

The patients were rested without painful stimuli 30 min before the endotracheal suctioning. After the necessary materials were brought to the bedside and placed on a clean and easily accessible area, the procedure was performed in accordance with the superficial and deep endotracheal suctioning application procedures by open system [3]. In accordance with the suctioning application procedures, in patients; endotracheal suctioning procedures were performed in the presence of wheezing, hyperventilation, tachycardia, rhythm problems, increased blood pressure, cough, cyanosis, sweating, restlessness and secretion in the tube. Patients were hyperoxygenated for 2 min with 100% oxygen before both procedures. The patients were suctioned with a 14 Fr x 500 mm catheter (Bıçakcılar, Istanbul, Turkey) for 10 sec. In the neurosurgery patients, intracranial pressure should not exceed 20 mmHg. However, intracranial pressure may be as high as 50 mmHg during suction. At the same time, the vital parameters of neurosurgical patients can return to their original state 10 min after suction. Therefore, the depth and duration of suction and the need for a second suction are important in these patients. The suction time should not exceed 10 seconds and if possible a second suction is required until the vital parameters are restored. After suctioning, the patients were hyperoxygenated again with 100% oxygen for 1 min. Patients' arterial blood pressure, heart rate, body temperature, SpO_2 level, and respiratory rate were measured just before endotracheal suctioning and at 1, 5 and 30 min after both suction procedures. The patients' pain levels were assessed at the same time intervals according to the BPS. The previous settings of the mechanical ventilator with lowered alarm sound were restored. All applications were applied by the same researcher (Figure 1).

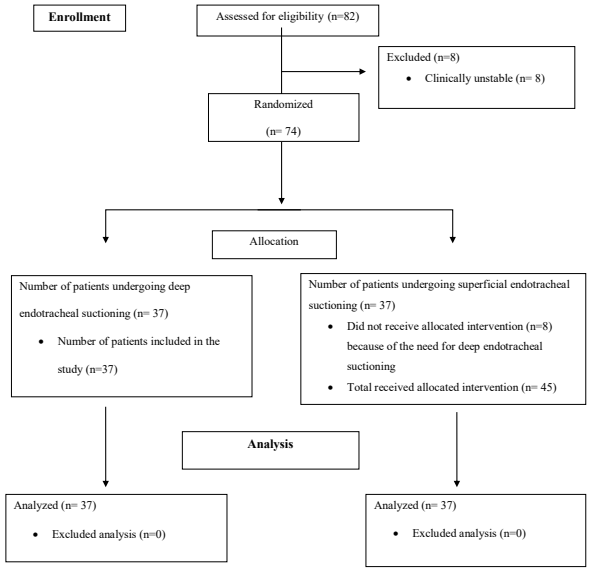

Figure 1. *Diagram showing the flow patients*

Statistical Analysis

Demographic and clinical characteristics of patients and measurement results were defined using numbers, percentages, and arithmetic mean and standard deviation tests. Chi-square and independent-sample *t* tests were used to compare the demographic and clinical characteristics of patients. Similarly, *t* test was used to compare the independent variables in deep and superficial endotracheal suctioning. Two-way analysis of variance (ANOVA) test was used to compare patients' repetitive measurements according to the endotracheal suctioning types. Greenhouse-Geisser statistical test was used in the case of a statistically significant difference in Mauchly sphericity test ($p<0.05$). A p value<0.05 was considered as statistically significant in all statistical analyses in the study.

3. RESULTS

The mean age of the patients was 62.21±1.69 years, most of whom were female (62%, n=46). Patients were in intensive care hospitalized 3.9±2.5 days. Patients had 8.72±1.17 GCS score and 89.1% of the patients had intracranial bleeding diagnosis (n=66). A comparison of the demographic and clinical characteristics of the patients who underwent deep or superficial suctioning showed that the groups were homogeneously distributed (p> 0.05) (Table I).

A comparison of hemodynamic parameters and pain scores of the patients at different measurement according to endotracheal suctioning types is shown in Table II. The mean systolic blood pressure and heart rates of the patients measured just before suctioning increased at 1 and 5 min and decreased in the 30 min after both suctioning methods. The increase was higher at 1 min after deep endotracheal suctioning. The

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mean diastolic blood pressure measured at 1 min after deep and superficial endotracheal suctioning was higher than 5th min after the suctioning. The mean diastolic blood pressure of patients who underwent deep suctioning was higher in all measures than the value before suctioning. The diastolic blood pressure values of the patients who underwent superficial endotracheal suctioning were lower than the values measured 30 min after suctioning, compared to the values measured before suctioning. The SpO_2 levels measured at 1, 5, and 30 min after both suctioning types were continuously higher when compared with values just before suctioning. The patients' pain scores showed the greatest increase in the first min after deep suctioning. In addition, the pain values that increased after deep and superficial endotracheal suctioning started to decrease after 5 min. In particular, it was determined that the values measured at 30 min after deep endotracheal suctioning fell below the pain values determined before the application (Table II). However, no statistically significant difference was found between the results of two suctioning types (p> 0.05) (Table II).

Table I. *Comparison of demographic and clinical features of the patients*

	Deep Endotracheal Suctioning	Superficial Endotracheal Suctioning	
	Number Percent (%)	**Number Percent (%)**	**Statistical test**
Ventilator mode			
SIMV	33 55.0	27 45.0	c^2=3.171, *P*=0.075
CBAP	4 28.6	10 71.4	
Sex			
Female	12 42.9	16 57.1	c^2=0.919, *P*=0.338
Male	25 54.3	21 45.7	
Diagnosis			
Intracranial bleeding	32 48.5	34 51.5	c^2=0.561, *P*=0.454
Intracranial tumor	5 62.5	3 37.5	
	X±SD	**X±SD**	
Age	65.21±15.05	59.21±18.33	*t*= –1.538 *P*=0.128
Hospitalization day	4.13±2.61	3.67±2.39	*t*= –0.788 *P*=0.433
Glasgow Coma Scale score	8.70±1.24	8.75±1.11	*t*= –0.197 *P*=0.845
Number of days with intubation	3.59±1.80	3.13±1.43	*t*= –1.213 *P*=0.229
Sodium	140.08±2.88	139.65±2.53	*t*= –0.686 *P*=0.495
Potassium	4.14±0.42	4.06±0.53	*t*= –0.674 *P*=0.502
Chloride	103.61±3.32	103.92±3.56	*t*= –0.398 *P* =0.692
Hemoglobin	12.30±1.14	11.97±0.96	*t*= –1.337 *P*=0.185
Hematocrit	38.40±2.19	37.99±2.08	*t*= –0.831 *P*=0.409

Values are presented as numbers and percentage (%). %95 CI: %95 confidence interval. SD: standard deviation; SIMV: Synchronized Intermittent Mandatory Ventilation; CPAP: Continious Positive Airway Pressure

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Table II. *Comparison of hemodynamic parameters and pain situations of patients at different measurement times according to endotracheal suctioning types*

Measurements	Type of endotracheal suctioning	Before the application	1 min after the application	5 min after the application	30 min after the application	Two-way ANOVA in repeated measurements	
		X±SD	X±SD	X±SD	X±SD	According to suctioning types	According to measurement types
Systolic blood pressure	DES	130.27±17.60	146.81±18.15	135.57±18.51	128.89±17.24	*F*=0.823[a]	*F*=64.971[a]
	SES	122.11±12.65	136.78±12.70	127.59±13.06	116.95±11.70	*P*=0.482	***P*=0.000**
Diastolic blood pressure	DES	74.51±10.75	83.51±11.33	78.16±10.54	75.27±13.06	*F*=0.520[a]	*F*=13.827[a]
	SES	70.91±11.30	78.54±12.32	71.54±12.20	68.10±9.17	*P*=0.669	***P*=0.000**
Heart rate	DES	86.75±10.25	103.19±13.18	97.00±14.86	91.94±13.82	*F*=1.253[a]	*F*=54.444[a]
	SES	83.89±11.09	96.56±12.62	94.29±13.58	86.29±14.55	*P*=0.291	***P*=0.000**
Body temperature	DES	36.73±0.43	36.77±0.44	36.80±0.44	36.78±0.46	*F*=0.450[b]	*F*=1.952[b]
	SES	36.65±0.43	36.68±0.44	36.68±0.45	36.70±0.47	*P*=0.629	*P*=0.148
Respiratory rate	DES	19.00±2.96	23.75±4.99	21.56±5.41	18.86±3.77	*F*=0.709[b]	*F*=54.819[b]
	SES	17.86±1.87	22.43±3.50	21.40±4.92	18.21±3.08	*P*=0.526	***P*=0.000**
SpO_2	DES	95.62±2.34	96.32±2.83	97.78±2.18	98.48±1.34	*F*=0.121[a]	*F*=52.096[a]
	SES	95.37±2.31	96.34±2.64	97.59±2.03	98.45±1.81	*P* =0.947	***P*=0.000**
Pain score	DES	3.27±0.50	5.45±1.06	3.86±0.91	3.18±0.46	*F*=0.991[b]	*F*=134.958[b]
	SES	3.21±0.58	5.24±0.89	4.05±1.10	3.24±0.64	*P*=0.383	***P*=0.000**

DES, Deep Endotracheal Suctioning SES, Superficial Endotracheal Suctioning
[a]*Mauchlysphericity test.* [b]*Greenhouse-Geisser test.*

4. DISCUSSION

In this current study, an increase in systolic and diastolic arterial blood pressures immediately after suctioning suggested that patients' bodies were responding to the stress experienced during endotracheal suctioning. This is because adrenaline and noradrenaline hormones released in response to stress increase the heart's contraction strength and speed by stimulating beta 1 receptors. As a result, systolic and diastolic blood pressures also increase [18].

Jongerden et al., reported that both open and closed endotracheal suctioning caused significant changes in arterial blood pressure of the patients; however, no significant differences in arterial blood pressure were observed between these two methods [18]. Also, Irajpour et al., investigated the cardiovascular effects of deep and superficial suctioning in 74 patients and reported an increase in arterial blood pressures using both methods; these changes did not show any significant difference between the groups [5]. Dastdadeh et al., to determine the effect of open and closed endotracheal suctioning system on pain and agitation, they reported significant differences in heart rate, systolic blood pressure and diastolic blood pressure variables in different time periods [7]. Christopher et al., explored the physiological effects of closed endotracheal suctioning in mechanically ventilated patients. In their study, closed endotracheal suctioning caused a significant change in the blood pressure, but this change was not clinically important [19]. The results of these previous studies were compatible with the results of the present study.

In this study, the observed increase in heart rate after suctioning compared to the rate just before endotracheal suctioning was thought to be a stress response similar to arterial blood pressures. This finding is supported by many studies [5,11,14,19,20]. These results showed that the type of endotracheal suctioning and the stress experienced did not have a statistically and clinically significant effect on the patients' bodies. On the other hand, Abbasinia et al., reported that respiratory rates of patients increased significantly during deep and superficial endotracheal suctioning [6]. However, in parallel with the results of this study, they could not find a statistically significant difference between

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endotracheal suctioning methods. Bousarri et al., reported that respiratory rates of patients increased during endotracheal suctioning and returned to normal levels after administration [21].

Hyperventilation and hypoxia can cause significant complications in neurosurgical patients [22]. Therefore, oxygenation should be at an optimal level. Rao noted that complications occurring secondary to brain trauma (such as hypoxia, hypercapnia, hypotension, and hypo-hyperglycemia) might cause an increase in the intracranial pressure and intracranial hypertension in the brain [23]. Therefore, in the study, hyperventilation with 100% oxygen for 1 min was applied to the patients 2 min before and after endotracheal suctioning to prevent the development of hypoxia. It was found that SpO_2 levels increased continuously in patients who did not develop hypoxia after deep and superficial endotracheal suctioning. This increase was statistically and clinically significant ($p<0.05$). The increase in the obtained SpO_2 levels did not show significant difference according to the suctioning type ($p> 0.05$). These findings suggested that both endotracheal suctioning types were effective in clearing secretions in airways. However, these findings were in contradiction with the results of previous studies showing that SpO_2 levels were reduced immediately after endotracheal suctioning. Özden and Görgülü determined a decrease in SpO_2 levels during and 2 min after open and closed endotracheal suctioning [11]. They reported that SpO_2 levels of patients increased in 5 and 15 min after suctioning. The SpO_2 levels were found to be significantly different in studies by Faraji et al. and Mazhari et al. investigating the effects of open and closed systems. They found that this difference was more evident in the open system suctioning [14,24].

When the effect of deep and superficial endotracheal suctioning on the pain intensity experienced by patients was evaluated, the level of pain decreased in 1 min and 5 min after both suction methods and the pain intensity reduced below the pre-procedural level at 30 min after endotracheal suctioning. However, the decrease in the 5th min of superficial endotracheal suctioning was greater than that in deep endotracheal suctioning. Statistical analysis revealed no statistically significant difference between the methods in terms of pain levels ($p> 0.05$). This result showed that both endotracheal suctioning methods were painful procedures for the patients. In addition, the superficial endotracheal suctioning was considered a less painful procedure because the pain level in 5th min of the superficial endotracheal suctioning was closer to that during the pre-procedural period. Dastdadeh et al., reported that repeated measures after suctioning showed significant difference areas of facial expression, upper limbs, and compatibility with the ventilator after open and closed suctioning [7]. Yava et al., also detected that the highest pain intensity was felt during endotracheal suctioning before and after the interventions [10]. Many previous studies also showed that endotracheal suctioning was an extremely painful procedure causing changes in the hemodynamic parameters of the patients [7,10-12].

In conclusion, the study showed that clinically and statistically significant difference was not found on comparing the effect of two endotracheal suctioning methods. As well, superficial endotracheal suctioning caused fewer changes in systolic and diastolic arterial blood pressures and heart rate in patients compared with deep endotracheal suctioning. Moreover, it had more positive effects on the oxygenation level and caused less pain in the patient. Superficial endotracheal suctioning was less traumatic compared with deep endotracheal suctioning for the patients. So, for the purpose of clearing the airway secretions of neurosurgical patients, the superficial endotracheal suctioning technique should be used first, unless deep endotracheal suctioning is indicated. We believe that this way, the quality of care of patients will increase. Also, when patients are aspirated with appropriate technique, their risks will be reduced in terms of complications.

It is important that nurses should monitor patients closely because endotracheal suctioning causes changes in the hemodynamic parameters of the patients. It is need to perform more experimental studies on the effects of deep and superficial endotracheal suctioning on patients' hemodynamic parameters and pain level.

Limitations of the Study

The study was conducted in two centers to reach the number of samples. In addition, it was long to reach the number of samples because the inclusion criteria for the patients to be studied were too high. Patients who did not meet the sampling criteria were excluded from the study, which increased the duration even longer.

Compliance with Ethical Standards

Ethical Approval: Ethical committee approval was obtained (approval number: 2015-10-20/05) and implementation permission was received from the institution where the study conducted. Later, written informed consent was obtained after the supervisor physicians and nurses in the intensive care units, patients or their relatives (for confused or lethargic patients) were informed about the study. The principles of the Helsinki Declaration were followed in the study.

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Conflict of Interest: There are no conflicting interests.

Author contributions: SC and SK: Planning the research, determining the method, SC obtaining all necessary permits, SK and EK Collecting the data, SC: Analyzing the data. All authors were involved in the interpretation and reporting of the research results.

REFERENCES

[1] Credland N. How to perform open tracheal suction via an endotracheal tube. Nurs Stand 2016; 30:30-8. doi: 10.7748/ns.30.35.36.s46.

[2] Elsaman SA. Effect of application of endotracheal suction guidelines on cardiorespiratory parameters of mechanically ventilated patients. IOSR-JNHS 2017; 6:41-8. doi:10.9790/1959.060.1014148.

[3] AARC Clinical Practice Guidelines Endotracheal suctioning of mechanically ventilated patients with artificial airways. Respir Care 2010; 55:758-64.

[4] Haddad SH, Arabi YM. Critical care management of severe traumatic brain injury in adults. Scand J Trauma Resusc Emerg Med 2012; 20:1-15. doi.org/10.1186/1757-7241-20-12.

[5] 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. Iran J Nurs Midwifery Res 2014; 19:366-70.

[6] Abbasinia M, Irajpour A, Babaii A, Shamali M, Vahdatnezhad J. 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. J Caring Sci 2014; 3:157-64. doi: 10.5681/jcs.2014.017.

[7] Dastdadeh R, Ebadi A, Vahedian-Azimi A. Comparison of the effect of open and closed endotracheal suctioning methods on pain and agitation in medical icu patients: a clinical trial. Anesth Pain Med 2016; 6:1-8. doi: 10.5812/aapm.38337.

[8] Vatansever HE. Investigation of pain behaviors in patients with mechanical ventilation in surgical intensive care unit. (Unpublished master's thesis), Higher Education Council, National Thesis Center Database (Thesis no: 156336), 2004. (Original work published in Turkish)

[9] Hawthorne C, Piper I. Monitoring of intracranial pressure in patients with traumatic brain injury. Front Neurol 2014; 5:1-16. doi.org/10.3389/fneur.2014.00121.

[10] Yava A, Koyuncu A, Pusat N, Yıldırım V, Demirkılıç, U. Invasive and noninvasive interventions and postoperative pain in cardiac surgery intensive care unit. GKDAYB Journal 2013; 19:184-90. (Original work published in Turkish)

[11] Özden D, Görgülü RS. Effects of open and closed suction systems on the hemodynamic parameters in cardiac surgery patients. Nurs Crit Care 2014; 20:118-25. doi: 10.1111/nicc.12094.

[12] Galbiati G, Paola C. Effects of open and closed endotracheal suctioning on intracranial pressure and cerebral perfusion pressure in adult patients with severe brain injury: a literature review. J Neurosci Nurs 2015; 47:239-46. doi: 10.1097/JNN.000.000.0000000146.

[13] Khayer F, Ghafari S, Saghaei M, Yazdannik A, Atashi V. Effects of open and closed tracheal suctioning on pain in mechanically ventilated patients. Iran J Nurs Midwifery 2020; 25:426-30. doi: 10.4103/ijnmr.IJNMR_135_18.

[14] Mazhari SM, Pishgou'ei A, Zareian A, Habibi H. Effect of open and closed endotracheal suction systems on heart rhythm and arterial blood oxygen level in intensive care unit patients. Iran. J. Crit. Care Nurs 2010; 2:133-7.

[15] Payen J, Bru O, Bosson J, et al. Assessing pain in critically ill patients by using a behavioral pain scale. Crit Care Med 2001; 29:2258-63. doi: 10.1097/00003.246.200112000-00004.

[16] Teasdale G, Jennett B. Assessment of coma and impaired consciousness. a practical scale. Lancet 1974; 2:81-4. doi.org/10.1016/S0140-6736(74)91639-0.

[17] Ribeiro CJN, Fontes Lima AGC, de Araújo SRA, et al. Psychometric properties of the behavioral pain scale in traumatic brain ınjury. Pain Manag Nurs 2019; 20:152-7. doi: 10.1016/j.pmn.2018.09.004.

[18] Jongerden IP, Kesecioglu J, Speelberg B, Buiting AG, Leverstein-van Hall MA, Bonten MJ. Changes in heart rate, mean arterial pressure, and oxygen saturation after open and closed endotracheal suctioning: a prospective observational study. J Crit Care 2012; 27:647-54. doi: 10.1016/j.jcrc.2012.02.016.

[19] Seymour CW, Cross BJ, Cooke CR, Gallop RL, Fuchs BD. Physiologic impact of closed-system endotracheal suctioning in spontaneously breathing patients receiving mechanical ventilation. Respir Care 2009; 54:367-74.

[20] Yousefi H, Vahdatnejad J, Yazdannik AR. Comparison of the effects of two levels of negative pressure in open endotracheal tube suction on the physiological indices among patients in intensive care units. Iran J Nurs Midwifery Res 2014; 19:473-77.

[21] Bousarri MP, Shirvani Y, Agha-Hassan-Kashani S, Nasab NM. The effect of expiratory ribcage compression before endotracheal suctioning on the vital signs in patients under mechanical ventilation. Iran J Nurs Midwifery Res 2014; 19:285-89.

[22] Köstekli S, Çelik S, Keskin E. Evaluation of the effect of endotracheal aspiration at different head heights on oxygenation of the brain by non-invasive method in intensive care patients. J Clin Nurs 2022; 00:1-12. doi: 10.1111/jocn.16314.

[23] Umamaheswara Rao GU. Cerebral perfusion pressure based management of traumatic brain injury. Internet J Anesthesiol 2007; 12:1-8.

[24] Faraji A, Khatony A, Moradi G, Abdi A, Rezaei M. Open and closed endotracheal suctioning and arterial blood gas values: a single-blind cross over randomized clinical trial. Crit Care Res Pract 2015; 1:1-5. doi.org/10.1155/2015/470842.