Relationship between Body Position and Endotracheal Tube Cuff Pressures among Critically Ill Patients

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Abstract

Background: *Management of the endotracheal tube cuff pressure is an important part of the care given by critical care nurses for critically ill patients. Over-inflation of the endotracheal tube cuff can cause serious injury and affects blood flow to tracheal mucosa. Under-inflation may cause air leakage which decreases the effect of mechanical ventilation and increases the risk of pulmonary aspiration and accidental extubation. Changes in the patient's position can cause variation in endotracheal tube cuff pressure.* ***Objective:*** *to identify the relationship between body position and endotracheal tube cuff pressures among critically ill patients.* ***Settings:*** *The study was carried out in Damanhur Medical National Institute General ICU, and Damanhur Chest Hospital ICU, Egypt.* ***Subjects:*** *A convenient sample of 75 adults; orally intubated critically ill patients who are newly admitted to the previously mentioned ICUs* ***Methods:*** *Patients' endotracheal tube cuff pressure was measured at semi-fowler position 45 which was considered the starting position and the cuff pressure was adjusted using the minimum occlusive volume technique and the reading was recorded using a cuff manometer to be the baseline measurement. Then the body position was changed every two hours and the cuff pressure was measured in three different positioned-fowler 30, left lateral, and right lateral positions) immediately, 15 minutes, 30 minutes, 1 hour, and 2 hours after each patient's body position change. The observed cuff pressures were compared with the basic cuff pressure at the starting position.* ***Results:*** *Significant difference was found (P= 0.000) between ETT cuff pressure mean scores measured immediately and 15 minutes after different body position changes in relation to the baseline measurement. However, a significant difference was found (P= 0.000) only between ETT cuff pressure mean scores measured 30 minutes, 1 hour, and 2 hours after body position change to semi-fowler and right lateral positions in relation to the baseline measurement.* ***Conclusion:*** *The cuff pressure measurements were significantly changed with changing the patients' body positions at different timing.* ***Recommendations:*** *Cuff pressure monitoring using a cuff pressure manometer is mandatory before and after critically ill patients' body position changes. A protocol for the ETT cuff pressure measurement should be developed.*

Keywords: Endotracheal tube, cuff pressure, body position

Introduction

Tracheal intubation (TI) and mechanical ventilation (MV) are considered the most common reason for critically ill patients' admission to intensive care units (ICUs). Cuffed endotracheal tubes (ETT) are used for adult intubation. The new endotracheal tubes are characterized by the presence of high-volume low-pressure cuffs, either made of polyvinyl chloride or polyurethane. The tubes enable positive-pressure ventilation and minimize the risk of aspiration of upper airway secretions. Increased ETT cuff pressure can cause dangerous complications such as decreased blood flow to tracheal mucosa, which in turn may be complicated by rupture of the trachea or formation of tracheoesophageal fistula. Decreased ETT cuff pressure also can lead to air leakage, ineffective MV, pulmonary aspiration, accidental extubation with difficulty in re-intubation, arrhythmias, and sudden cardiac arrest (Feng et al., 2015; Jordan et al., 2012; Nseir et al., 2009) .

It is recommended that the ETT cuff pressure should be between 20- 30 cm H2O or 18- 22 mmHg to provide an adequate seal and reduce the risk of complications related to over- or under-inflation of the ETT cuff (Hamilton, & Grap, 2012; Sole et al., 2011). Several factors were found to cause over and under-inflation. The CCNs also have a critical role in identifying the factors affecting the cuff pressure. Multiple factors were found to increase ETT cuff pressure (Bessereau et al. 2010; Koyama et al., 2018; Tennyson et al., 2016) or decrease cuff pressure (Mogal et al., 2018; AR et al., 2013) .

Previous studies reported that tracheal tube cuff pressure could be changed over time and in other different situations such as patient movement, bed position, head extension, and patient effort to speak (Godoy et al., 2008; Lizy et al., 2014; Sole et al., 2010). Moreover, it was proven that head and neck mobility can affect ETT placement which in turn can affect cuff pressure. (Alcan et al., 2017; Athiraman et al., 2015; Kim et al.,2015; Tailleur et al., 2016). Based on previous findings, close monitoring of cuff pressure is recommended.

Patients admitted to the ICU are seriously ill and require specialized care, and they are frequently immobile for long periods. Positioning every two hours is recommended (Ahtiala, Soppi & Tallgren, 2018). More than one study found that changes in a patient’s positions cause variation in ETT cuff pressure which may lead to serious complications in critically ill patients. (Khalil, N. S. et al., 2018; Beccaria LM. et al., 2017; Feng et al., 2015; Jordan, P. et al., 2012; Sole et al., 2o11; Nseir et al., 2009). They indicated that ETT cuff pressure measurement is routinely measured every 8-12 hours or it may be measured once at the beginning of the nursing shift while changing patient positioning occurs every 2 hours (Ahtiala, Soppi & Tallgren, 2018). For that reason, these studies recommended that CCNs should measure and adjust ETT cuff pressure after changing the patient’s position. On the other hand, other studies recognized that variation in cuff pressure after position changes is transient and ETT cuff pressure returns to normal within 15 minutes after patients' position changes (Godoy et al., 2008; Sole et al., 2010; Lizy et al., 2014).

The previously mentioned studies were limited by the small patients' number and the frequency of cuff pressure monitoring; hence it was measured once after patients' positions change. In the current study, the ETT cuff pressure was measured five times, immediately after the patients' position change, 15, 30 minutes, one hour, and two hours throughout the 2 hours of the patients' position change.

Aims of the Study

This study was conducted to explore the relationship between body position and ETT cuff pressures among critically ill patients.

Research hypotheses

There is a significant relationship between the cuff pressure measurements and changing the patients' body position.

Materials and Method

Materials

Design: A descriptive correlational research design was used to conduct this study.

Settings: This study was conducted in the Damanhur Medical National Institute General ICU, and Damanhur Chest Hospital ICU.

Subjects: The study sample comprised 75 adult newly orally intubated critically ill patients. On admission to the ICU, all critically ill patients were assessed to identify if they have the inclusion criteria for the study. Patients whose ages were between 18 and 60 years old, and who had high-volume, low-pressure cuff tubes were included. Patients who were agitated or irritable (RASS level 1 to 5), had unstable spinal cord injury, difficult intubation, morbid obesity (body mass index > 35), laryngeal edema, hemodynamically and respiratory instability such as (tachycardia, bradycardia, unrecorded blood pressure, hypertension and tachypnea) and patients with tracheostomy tube were excluded from the study.

<u>Tools:</u> One tool was used to collect the data in this study **"Endotracheal tube cuff pressure measurement record"** This tool was developed by the researcher after reviewing the relevant literature. It was used to record the ETT cuff pressure at the different times in different body positions. It consists of two parts:

Part I: Patient's sociodemographic and baseline clinical data.

This part included: patients' age, sex, unit, date of ICU admission, patients' diagnosis, date of intubation, causes for intubation, length of mechanical ventilation, past medical history, BMI and RASS level.

Part II: Endotracheal tube cuff pressure measurements.

This part was used to record the following;

- Hemodynamic parameters; Heart rate (HR), temperature, Blood pressure (BP).
- Respiratory& ventilators parameters; respiratory rate (RR), body peripheral oxygen saturation (SPO2), Mode of mechanical ventilation, positive end expiratory pressure (PEEP) level, peak inspiratory pressure (PIP) level.
- Patients' ETT cuff pressure measurements.
- In addition, this part included the patients' different body position (semi fowler 450 (baseline position), semi fowler 300, the right lateral and the left lateral position) and the different timing for documentation the previous mentioned parameters (immediately, 15 minutes, 30 minutes, 1 hour and 2 hours).

Method

Approval of the ethics committee of the faculty of nursing was obtained. Official permission was obtained from the Faculty of Nursing Alexandria University to the administrative authorities of Damanhur Medical National Institute, and Damanhur Chest Hospital. Official approval to carry out the study was obtained from the hospital administrative authorities to collect the necessary data from the selected settings after an explanation of the aim of the study. Data collections started at the beginning of January and were completed by June 2018.

The study tool was tested for content validity by five experts in the field of critical care and emergency nursing and all the necessary modifications were done accordingly. The reliability of the tool was tested using Cronbach's alpha, and the reliability coefficient was (0.720) which was accepted. A pilot study was carried out on 10 patients that were not included in the study sample in order to test the clarity, feasibility, and applicability of the research tool.

Study protocol:

Patients' endotracheal tube cuff pressure was measured and recorded using the cuff pressure manometer (Pressure Gauge Universal Germany) at semi-fowler position 45 which is considered the starting position. After recording the cuff pressure, the ETT cuff was deflated and then re-inflated and the cuff pressure was adjusted using the minimum occlusive volume technique to be within the normal range according to the individual differences (Burns 2014). After that, the reading was recorded to be the baseline measurement. Then the body position was changed every two hours based on the ICU schedule. The cuff pressure was measured in three different positions (semi-fowler 30, left lateral, and right lateral positions) immediately, 15 minutes, 30 minutes, 1 hour, and 2 hours after each patient's body position change. The observed cuff pressures were documented and compared with the recorded cuff pressure before position change. After 2 hours of each position the patient was returned to the starting position again (semi-fowler 450) and the cuff pressure was recorded and returned to the baseline value before changing to the next position. Immediately after each body position change both hemodynamic parameters and ventilator parameters were obtained and recorded.

Ethical considerations:

Critically ill patients or their relatives signed Informed written consent before enrollment in the study after explaining the aim of the study and the right to refuse to participate in the study and/ or withdraw at any time. The patient's privacy was respected. Data confidentiality was during the implementation of the study.

Statistical Analysis

SPSS software version 22 was implemented to investigate data. The patients' sociodemographic and medical data were explored by descriptive statistics namely frequency, percentage, mean and standard deviation. In order to compare the patients' endotracheal cuff pressure, ANOVA with repeated measures and paired t-tests were applied. Cohen's d was implemented to calculate the effect size considering the effect size ≥ 0.8 to be large.

Results

Table 1 illustrates the distribution of the studied patients according to their socio-demographic characteristics. The study sample was composed of 75 newly orally intubated critically ill patients and more than half of them were from the chest hospital ICU. According to patients 'age, 65.3% were between 51- 60 years and 62.7% of the studied patients were males.

Table 2 shows the first measurements of the ETT cuff pressures for the studied patients. It was observed that the ETT cuff pressure measurements of the most of studied patients were out of the normal range as follows: 70.7% were high above 30 cmH2O while 17.3% of them their ETT cuff pressure measurements were low < 20 cmH2O.

Table 3 shows the relationship between the mean scores of ETT cuff pressure measurements and the different body positions in relation to the baseline measurement. Concerning the ETT cuff pressure measurements in the semi-fowler 300, it was found that the mean scores for the ETT cuff pressure measurements significantly increased above the baseline measurements the different timing immediately, 15 minutes, 30 minutes, 1 hour, and 2 hours. It was noted that the highest mean scores for the ETT cuff pressure measurements were about 29 ± 6 cm H2O after 1 hour and p was 0.000. Regarding the ETT cuff pressure measurements in the right lateral position, it was found that the mean scores for the ETT cuff pressure measurements also significantly increased above the baseline measurement immediately, 15 minutes, 30 minutes, 1 hour, and 2 hours. It was observed that the highest mean scores for the ETT cuff pressure measurements were about 31 ± 4 cm H2O after 2 hours and p was 0.000. Concerning the ETT cuff pressure measurements in the left lateral position, it was noted that the mean scores for the ETT cuff pressure measurements were increased above the baseline measurement only immediately, 15 minutes and 30 minutes. The mean values were about 29 ± 4 cm H2O, 28 ± 4 cm H2O, 27 ±3 cm H2O respectively and p were 0.000, 0.000, and 0.100 respectively. While the ETT cuff pressure significantly decreased below the baseline measurements after 1 hour and 2 hours and the mean scores were about 26 ± 5 cm H2O and 26 ± 6 cm H2O respectively and p were 0.826, 0.470 respectively.

Table 4 revealed the effect of different body positions on the mean scores of ETT cuff pressure measurements. It was found that the different body positions (the semi-fowler position 30 °, the right lateral position, and the left lateral position) had a large Cohen's d effect size on the mean scores of the ETT cuff pressure measurements immediately. Moreover, it was noted that the right lateral position had the highest Cohen's d effect size followed by the left lateral position than the semi-fowler position at 30 °.

Table 5 shows the relationship between ETT cuff pressure measurements and the different body positions at different timing. This table shows a significant relationship between the ETT cuff pressure measurements and the three positions (semi-fowler 30, right lateral, and left lateral position) at different timing immediately, 15 minutes, 30 minutes, 1 hour, and 2 hours an F test were 9.997; 3.788; 5.885 respectively and the p was <0.001 for each position.

Discussion

Proper management of the cuff pressure is crucial in intubated and mechanically ventilated patients. The endotracheal cuff pressure is recommended to be less than 30 cm H2O. In this context, previous studies showed that high cuff pressure of more than 30 cm H2O threatens tracheal blood flow, and more than 50 cm H2O completely occludes the tracheal wall blood flow. If increased cuff pressure continues for 15 min, superficial damage to the tracheal mucosa will occur (Hoffman et al., 2009; Tobii et al., 2017). Moreover, it was documented that columnar epithelium was destroyed, and the basement membrane was exposed (Liu et al.,2010; Lim et al., 2012). On the other hand, low cuff pressure can be a risk factor for ventilator-associated pneumonia (Lorente et al., 2014).

Despite the obvious risks associated with improper pressure, close monitoring of cuff pressure is not a priority in ICUs (Sole et al., 2009). Results of the current study show that the ETT cuff pressure measurements of most of the studied patients were above 30 cm H2O (over inflation) at the first time of measurement. This observation may be related to limited resources in the selected settings and the absence of the cuff pressure manometer. These results are consistent with Nesir et al. (2009) who indicated that assessing cuff pressure is not often a routine in some ICUs and variations in the ETT cuff pressure are common among ICU patients. Previous studies emphasized the value of using the cuff pressure manometer (Maddumage et al., 2017; Bulamba et al., 2017). It is mandatory for critical care nurses to be sure that the ETT cuff pressure value remains within the optimal range to avoid related complications (Beccaria et al., 2017; Grant, 2013) .

The present study found a large effect of the different body positions immediately on the mean scores of the ETT cuff pressure measurements. It was observed that most of the ETT cuff pressures in the studied patients were significantly increased above the baseline measurements after changing patients' body positions. These findings agree with previous studies (Lizy et al., 2014; Gody et al., 2008; Kim et al., 2009; and Ziyaeifard et al., 2017). These findings can be explained as follows: the position of ETT can be affected by head rotation, flexion, and extension and this may alter the ETT cuff pressure value. However, Sole et al. (2009) findings indicated that the effect of body position on cuff pressure often was temporary and terminates after 15 minutes. The results of the present study demonstrate that the ETT cuff pressure measurements significantly changed from the baseline measurement not only immediately after changing the patient's body position but also continue until 2 hours after changing the patient's body position .

The current study revealed that a significant relationship between a patient's body position and ETT cuff pressure values is present. Based on this finding, it is mandatory for the critical care nurse to check and recheck the cuff pressure via the ETT cuff manometer after any changes in body position for the intubated patients. The ETT cuff pressure should be kept within the prescribed limits of 20-30 cm H2O, to avoid the occurrence of complications resulting from over or underinflation of the ETT cuff.

Conclusion

The current study revealed that the cuff pressure measurements were significantly changed with changing the patients' body position at different timing. Most patients were found to have high cuff pressure measurements before and after body positioning which can threaten the patients' safety.

Recommendations

Regarding the findings of the study, the following recommendations are made:

- Cuff pressure monitoring using a cuff pressure manometer is mandatory before and after critically ill patients' body position changes.
- A protocol for the ETT cuff pressure measurement should be developed.
- The adequate number of cuff pressure measurement equipment must be available

Limitation of the study

The researcher did not use the supine position to identify its effect on the ETT cuff pressure because most of the studied patients exhibited discomfort in this position.

Table (1): Distribution of the studied patients according to their Sociodemographic characteristics

Sociodemographic characteristics	No.	%
Unit		
Chest ICU	38	50.7
Damanhur GICU	37	49.3
Age (in years)		
18–30	2	2.7
31–40	2	2.7
41–50	22	29.3
51–60	49	65.3
Sex		
Male	47	62.7
Female	28	37.3

Table (2): Distribution of the studied patients according to the first reading of the ETT cuff pressure measurements.

ETT cuff pressure	Frequency of the Patients (N=75)	Percent (%)
< 20 cmH_2O	13	17.3
20-30 cmH_2O	9	12.0
>30 cmH_2O	53	70.7
Total	75	100.0

Table (3): The relationship between the mean scores of ETT cuff pressure and the different body positions in relation to the baseline measurement.

Semi fowler 30^0						Paired t-test	P
Baseline Mean± S. D	Immediate Mean± S. D	15 min Mean± S. D	30 min Mean± S. D	1 hr Mean± S. D	2 hr Mean± S. D		
26.03 ± 1.90	28.61 ± 3.86					5.847	0.000*
26.03 ± 1.90		27.80 ± 4.07				3.741	0.000*
26.03 ± 1.90			28.51 ± 5.43			3.886	0.000*
26.03 ± 1.90				29.12 ± 6.19		4.237	0.000*
26.03 ± 1.90					28.81 ± 5.21	4.569	0.000*
Right Lateral							
Baseline Mean± S. D	Immediate Mean± S. D	15 min Mean± S. D	30 min Mean± S. D	1 hr Mean± S. D	2 hrs Mean± S. D		
26.03 ± 1.90	31.25 ± 4.58					10.786	0.000*
26.03 ± 1.90		28.99 ± 3.59				7.913	0.000*
26.03 ± 1.90			29.29 ± 4.44			6.508	0.000*
26.03 ± 1.90				30.17 ± 3.69		11.487	0.000*
26.03 ± 1.90					31.28 ± 4.91	10.214	0.000*
Left Lateral							
Baseline Mean± S. D	Immediate Mean± S. D	15 min Mean± S. D	30 min Mean± S. D	1 hr Mean± S. D	2 hrs Mean± S. D		
26.03 ± 1.90	29.24 ± 4.44					6.679	0.000*
26.03 ± 1.90		27.65 ± 3.61				4.177	0.000*
26.03 ± 1.90			27.15 ± 3.99			2.631	0.100
26.03 ± 1.90				25.91 ± 5.04		-0.221	0.826
26.03 ± 1.90					25.55 ± 5.92	-0.726	0.470

t- paired – t-test *: Statistically significant at $p \leq 0.05$ Baseline reading; at semi-fowler 450 and ranged between 25- 27 according to patients' variability.

Table (4): The effect of different body positions on the mean scores of ETT cuff pressure measurements.

ETT Cuff Pressure Mean Scores		Cohen's d Effect Size
Baseline ETT pressure cuff mean score	Immediate ETT pressure cuff mean score	
Semi fowler position		
26.03±1.90	28.61±3.86	0.848*
Right lateral position		
26.03±1.90	31.25±4.58	1.489*
Left lateral position		
26.03±1.90	29.24±4.44	0.939*

Small effect Cohen's d = 0.2- <0.5, Medium effect Cohen's d = 0.5<0.8, Large effect Cohen's d = ≥ 0.8 *

Table (5): The relationship between the ETT cuff pressure measurements and the different body positions at different timing

Patient positions	ETT cuff pressure measurements							
	Baseline reading	Immediately	15 minutes	30 minutes	after 1h	after 2hrs	F	P
Semi fowler 30^0 position								
Mean ± SD.	26.03 ± 1.90	28.61 ± 3.86	27.80 ± 4.07	28.51 ± 5.43	29.12 ± 6.19	28.81 ± 5.21	4.385	0.001*
Right lateral position								
Mean ± SD.	26.03 ± 1.90	31.25 ± 4.58	28.99 ± 3.59	29.29 ± 4.44	30.17 ± 3.69	31.28 ± 4.91	17.928	0.000*
Left lateral position								
Mean ± SD	26.03 ± 1.90	29.24 ± 4.44	27.65 ± 3.61	27.15 ± 3.99	25.91 ± 5.04	25.55 ± 5.92	7.713	0.000*

F: ANOVA test *: Statistically significant at $p \leq 0.05$ **Baseline reading;** at semi-fowler 45^0 before changing patient's body position and ranged between 25- 27 according to patients' variability

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