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Effect of various body positions on the measurement of endotracheal tube cuff pressure among critical patients

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Abstract: **Nurses in intensive care unit should monitor endotracheal tube (ETT) cuff pressure regularly using a cuff pressure manometer which should be the standard of care for each ETT inserted. The main aim of this study was to assess the effect of various body positions on the measurement of endotracheal tube cuff pressure among critical patients. A correlation study was carried out in trauma intensive care unit (ICU) at Minia University hospital of Egypt, including 210 orally intubated patients and attached with positive pressure mechanical ventilation. Patients of the study were turned to 6 different positions (Dorsal recumbent , Lower fowler, High fowler, Left lateral . Right lateral and prone position). The patient's cuff pressure reading was taken after spending (20) minutes in the position every 2 hours. Result: (58.1 %) of the sample were male their mean age between (40.6 ± 8.9) years. (50.5 %) admitted with head trauma. (70.0 %) and (78.6 %) of the patient's cuff pressure measurements was above (30 cmH_2O) when they were in the dorsal recumbent position and Prone position. Also (50.5 & 51 %) their cuff pressure was above (30 cmH2O) when they were in the high fowler and left lateral rotation of the head. But (58.6 % and 41.9 %) had below (20 cmH2O) cuff pressure when they were in the right lateral rotation of the head and lower fowler position. Conclusion: To adjust the cuff pressure for ICU patients, nurses should monitor it using a cuff pressure manometer, because any change in patient's head and body position affect the ETT cuff measurements.**

Keywords: **body positions, measurement, endotracheal tube, cuff pressure, critical & patients.**

1. INTRODUCTION

Endotracheal tube (ETT) cuff pressure adjustment and measuring are a life-saving nursing intervention for trauma patients and any intubated critical ill patients. Trauma was the leading cause of morbidity and mortality in the age group (18-65) years. Traumatic cases need intensive care units (ICU) admission and immediate intubation to protect the airway from obstruction and restoring hemodynamic status [(1).]

After ETT insertion critical care nurse (CCN) fixes it using a syringe filled with (5 cm to 10 cm) of air injected into the pilot balloon to inflate its cuff. Most modern tubes are made from polyvinyl chloride which has a high-volume, low-pressure cuff. Its cuff pressure should be adjusted carefully using a cuff pressure manometer [(2)].

Endotracheal tube cuff pressure presents the relation between the trachea and the tube cuff which prevents any air leak and aspiration. Nurses in ICU should monitor ETT cuff pressure regularly using a cuff pressure manometer which should be the standard of care for each ETT inserted [(3)].

Many ICU nurses and doctors consider the pilot balloon palpation as an indicator of low or high cuff pressure but recent reviews did not support that and consider using an ETT cuff pressure manometer for monitoring its pressure [4].

Endotracheal tube standard cuff pressure should be maintained between (20 to 30 cm) of water (cmH2O) which is the optimal pressure that will prevent any air leak and aspiration. Endotracheal tube cuff pressure affected by varieties of factors as patient body position, head alignment, body temperature, therapeutic interventions, patients hemodynamic status and nitrous oxide anesthesia [5].

Positioning change for critical patients is one of the routine daily nursing interventions in ICU that applied to prevent complications of immobility. Body position change had an effect on a patient's ETT cuff pressure which should be readjusted and monitored carefully. Nseir S., et al [6] showed that ICU patients who had a normal ETT cuff pressure were only about (18%) and (82 %) of them had under or overpressure that affected by the daily routine nursing management.

Endotracheal tube cuff pressure lower than (20 cmH2O) places critical patients at risk for air leak which reduces the actual volume required for lung inflation. Lower ETT cuff pressure leads to micro-aspiration of secretions. This micro-aspiration of secretions from the upper and lower airways facilitates bacterial colonization and ventilator-associated pneumonia [7].

Increasing ETT cuff pressure more than (30 cmH2O) was more common after ETT fixation with a fixed (5 to 10 cm) of air, if persisted for a long period of time it will cause tracheal ischemia from decreasing capillary perfusion, tracheal stenosis and hemorrhage or necrosis. Endotracheal tube cuff pressure rises by the addition of positive pressure ventilation ([8]).

Significance of the study:

The unmonitored ETT cuff pressure places the trauma patients in the ICU at great risk of uncontrolled cuff pressure that will occur during providing patient's nursing care as positioning, hygiene, suctioning and maintenance of the mechanical ventilator. The researchers observed during real-time practice that the majority of trauma patients whom are intubated did not receive any ETT cuff pressure monitoring by the ICU nurses or doctors.

It was noticed that many ICU nurses did not understand the value of monitoring the ETT cuff pressure. These circumstances may be due to the ICU nurses' do change in patient position but they did not monitor or readjust the ETT cuff pressure after that procedure. But a few numbers of them monitors patient's tube position, airway and hemodynamic after providing their nursing care to them. So this study aimed to assess the effect of various body positions for intensive care patients on the measurement of endotracheal tube cuff pressure.

Aim of study: is to assess the effect of various body positions on the measurement of endotracheal tube cuff pressure among critical patients.

Research question:

Is there a correlation between changing body positions among critical patients and measurement of endotracheal tube cuff pressure?

2. METHODOLOGY

A correlation study was carried out in trauma intensive care unit (ICU) at Minia University hospital of Egypt at the period from (June 2018 to January 2019). A convenient sample of (210) intubated trauma patients was selected conveniently during period of (6 month). The inclusion criteria included all trauma patients, ages between (18years - 60years), from both genders (male and female), orally intubated and attached with positive pressure mechanical ventilation. The patient should be under sedation according to the ICU regimen (as doctor order) with stable hemodynamic circulation.

Data were collected by the researchers using two tools were prepared by the researchers after reviewing the related literature [9]. **First tool: general patient's assessment sheet** included two parts

Part I: included data as patients age, sex, date of admission and medical diagnosis. **Part II: included** Patient's intubation parameters as ETT size in cm, tube fixation at the corner of the patient's mouth in cm, tube position checks, mode of mechanical ventilation, presence of positive end-expiratory pressure (PEEP) in cmH2O.

Second tool: ETT cuff pressure measurements in every patient's position included chart of the measurements of the ETT Cuff pressure monitoring at the six different patient's position every two hours. the ETT Cuff pressure manometer name is (VBM cuff-manometer Medi-zintechnik, Sulz, Germany in cm H_2O with a pressure range from 0 to 120 cm H_2O.

Validity of the study: was tested by a jury panel of 7 experts in the field of nursing and medicine. **The reliability**: was done using Cronbach' alpha test it was (90 %) for first tool and (85 %) for the second tool.

A pilot study: was done on 10 % (21) of patients to test the feasibility of the study and applicability of the tool and there are no modifications done.

Ethical consideration: An official permission from the research ethics committee of the faculty of nursing, Minia University, Egypt was obtained to conduct the study. Official permissions were granted from the head nurse of the ICU to conduct the study. Written informed consent was obtained by the researchers from the patient's family after explaining the aim of the study. confidentiality of data, privacy, voluntary participation and right to refuse to participate in the study were informed to them by the researchers through personal communication.

Study pprocedure:

Patient's demographic data, medical data and intubation parameters were obtained firstly from the patients' family and medical records (first tool). The researchers assessed every intubated patient included in the study after spending 24 hours of intubation at the ICU to be sure from the stability of patient's medical and clinical conditions. The patient's endotracheal tube insertion was done according to the ICU protocol via specialist physician in anesthesiology and intensive care unit. The ETT was inserted while wearing personal protective equipment as (sterile mask, gown and gloves) to prevent ICU infection. The ETT insertion was done using sterile ETT and Laryngoscope (to visualize the vocal cords). The ETT cuff was check for its efficiency before inserting it by deflating it and re-inflation again using syringe filled with 5to 10 cm of air injected through its pilot balloon [(9)]. The tube was inserted while the head is extended and the neck is flexed (sniffing of the head). For trauma patient: Maintain in-line cervical spinal spine immobilization during entire process of intubation. After insertion of the sterile ETT the researchers used a sterile hand-held resuscitation bag device attached to 100% oxygen for 3 minutes providing frequent and gentle breaths to confirm the ETT placement and providing oxygen support to reduce hypoxemia.

Endotracheal tube size was assessed and the correct ETT position was confirmed by auscultation of the bilateral breathing sounds and sometimes performing chest radiography. The ETT securing pattern using the adhesive tape method or cotton gauze technique at the corner of the mouth was assessed (first tool). The patient was under sedation drugs to prevent him from breathing against the machine which will cause the ETT cuff pressure to rise. Midazolam sedation drug (Loading dose: 0.03–0.3 mg/kg in increments of 1–2.5 mg. Maintenance dose: 0.03–0.2 mg/kg/h) using continues intravenous infusion typically in combination with analgesics (as ordered by ICU doctors) [(10).]

Routine nursing care as suctioning, oral hygiene and endotracheal tube position change to the corner of the patient's mouth was done before procedure time. The 1st ETT cuff pressure reading was taken after 20 minutes of the routine nursing care to ensuring that the ETT was in place and patent and to not affect the patient's hemodynamic and oxygenation status (second tool). The 1st ETT cuff pressure reading was documented and considered basic data that will be used for comparison with the other measurements (second tool).

Patient started to be turned to the first routine ICU position change which is the Dorsal recumbent position. After spending 20 minutes in the previous position the 2nd cuff pressure reading was taken (second tool).

and documented in the patient's chart. After that The 1st cuff adjustment was done to be (20-30cm H2O) using the cuff pressure manometer and a stethoscope to auscultate the tracheal sounds, then left the patients spend the rest of the two hours in position. At the end of the two hours 3rd cuff pressure reading was taken (second tool).

After that patients were turned to the second position change which is the Lower Fowler's position. The 4th cuff pressure reading was taken and documented in the patient's chart (second tool). after spending 20 minutes in this position. After that the 2nd cuff adjustment (20-30cm H2O) was done to left the patients spend the rest of the two hours in position. The previous listed steps were repeated again for every patient's position. All Patients of the study (210) were turned to 6 different positions according to the ICU routine every 2 hours by the researchers and the assistance of the ICU nurses to

ensure that every patient turned to the optimal position and suitable body alignment to not harm the patients during positioning change.

The 6 applied body positions included in the study as shown in the following table

The sequences of the 6 applied body positions included in the study

Stages	Preposition change reading	Position		Post position reading	cuff pressure adjustment
		Type of applied Position	Position action		
1st stage	Reading ETT cuff pressure after 2minutes of the routine nursing care. **(Base data).**	**Dorsal recumbent**	dorsal recumbent body position with backrest of the bed at zero levels and the head in a neutral alignment of body positions.	Reading ETT cuff pressure after 20 minutes using manometer.	cuff pressure adjusted to: (20–30 cmH_2O) using manometer.
After 2 hours from the applied position					
2nd stage	Reading ETT cuff pressure using manometer.	**Lower fowler**	Lower fowler position with the back elevated at 30 ° degree.	Reading ETT cuff pressure after 20 minutes using manometer.	cuff pressure adjusted to: (20–30 cmH_2O) using manometer.
After 2 hours from the applied position					
3rd stage	Reading ETT cuff pressure using manometer.	**High fowler**	High fowler position with 45°back and head up.	Reading ETT cuff pressure after 20 minutes using manometer.	cuff pressure adjusted to: (20–30 cmH_2O) using manometer.
After 2 hours from the applied position					
4th stage	Reading ETT cuff pressure using manometer.	**Left lateral**	Left lateral rotation of the body and head with 30° head up.	Reading ETT cuff pressure after 20 minutes using manometer.	cuff pressure adjusted to: (20–30 cmH_2O) using manometer.
After 2 hours from the applied position					
5th stage	Reading ETT cuff pressure using manometer.	**Right lateral**	Right lateral rotation of the body and head with 30° head up.	Reading ETT cuff pressure after 20 minutes using manometer.	cuff pressure adjusted to: (20–30 cmH_2O) using manometer.
After 2 hours from the applied position					
6th stage	Reading ETT cuff pressure using manometer.	**Prone position**	Prone position with the head facing the bed linen and at one side position.	Reading ETT cuff pressure after 20 minutes using manometer.	cuff pressure adjusted to: (20–30 cmH_2O) using manometer.

Statistical analysis:

Data entry and data analysis were done using SPSS version 20 (Statistical Package for Social Science). Data were presented as number, percentage, mean, standard deviation. Chi-square test P-value considered statistically significant when $P < 0.05$.

3. RESULT

Table (1): shows that about half of the patient's sample (58.1 %) were male and (41.9 %) were female. In relation to age, their mean was between (40.6 ± 8.9) years. Regarding medical diagnosis (50.5 %) of patients admitted with head trauma. Only (31.9 %) and (17.6%) had chest and abdominal trauma. Patients mean oxygen saturation was between (95.1 ± 2.3). Patients mean heart rate was (93.6 ± 7.5) b/m and mean body temperature was (37.7± 0.6) °C.

Table (2): shows the intubation parameters of the studded patient sample. It was observed that (40 %) of the studied patients were intubated with an ETT size (7cm). (100 %) of the studied patients, remained attached to the mechanical ventilator on SIMV mode. The majority of them (80 %) were on PEEP (5 cmH_2O).

Table (3): shows the effect of the patient's body position on ETT cuff pressure. It was observed that the majority of patients (70.0 %) and (78.6 %) their ETT cuff pressure was more than normal (above 30 cmH2O) when they were in the dorsal recumbent position and the prone position, with mean cuff pressure (43.6 ± 23.8) and (64.6 ± 30.1) respectively. Also, it was observed that (50.5 & 51 %) their ETT cuff pressure moved above (30 cmH2O) when they were turned to the high fowler position and left lateral rotation of the body and head. But it was observed that more than half of the sample (58.6 %) had Less than normal (below 20 cmH2O) cuff pressure when they were in the right lateral rotation of the body and head with mean pressure (38.2 ± 32.6).

Table (4): shows the effect of the patient's body position on ETT cuff pressure. It was observed that the mean cuff pressure after 20 minutes in the position was significantly high in all patients when compared with the adjusted cuff pressure one and the cuff pressure after spending 2 hours in the position. There was high statistical significant difference between all cuff pressure readings in the different routine ICU patient's position change presented by P value (0.000*).

Table (5): evident that, there were a strong positive correlation between adjusted cuff pressure and left lateral position (R=0.843). in addition, the same table denoted that, there were a weak positive correlation between adjusted cuff pressure and lower fowler position and right lateral position (R=0.133, R=0.187**).

Table (1): Demographic and medical data of the studded sample (No.210)

Personal data	No.	%
Sex		
Male	122	58.1
Female	88	41.9
Age / Year		
25-35	70	33.3
36- 45	84	40.0
46- 55	56	26.7
Mean ± SD	40.6 ± 8.9	
Medical data		
Diagnosis		
Head trauma	106	50.5
Chest trauma	67	31.9
Abdominal trauma	37	17.6
Oxygen Saturation		
90- 94	70	33.3
95- 100	140	66.7
Mean ± SD	95.1 ± 2.3	
Heart Rate (b/m) (Mean ± SD)	93.6 ± 7.5	
Body Temperature (°C) (Mean ± SD)	37.7± 0.6	

Table (2): Frequency distribution of the patient's intubation parameter (No.210)

Intubation parameter	NO.	%
ETT size		
6 cm	14	6.7
6.5 cm	70	33.3
7 cm	84	40.0
7.5 cm	42	20.0
Tube fixation at the corner of the patient's mouth		
22 cm	28	13.3
23 cm	70	33.3

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24 cm	112	53.3
Mode of mechanical ventilation		
SIMV	210	100.0
PEEP		
5 cmH2O	168	80.0
10 cmH2O	42	20.0

N.B. ETT: Endotracheal tube, PEEP: Positive end-expiratory pressure.

Table 3: Frequency distribution of endotracheal tube cuff pressure measures during each patient position (No.210)

The ETT cuff pressure during different positions	NO	%
Dorsal recumbent position		
Normal pressure (20-30 cmH2O).	40	19.0
Less than normal (below 20 cmH2O).	23	11.0
More than normal (above 30 cmH2O).	147	70.0
Cuff pressure Mean ± SD	43.6 ± 23.8	
Lower Fowler position		
Normal pressure (20-30 cmH2O).	32	15.2
Less than normal (below 20 cmH2O).	88	41.9
More than normal (above 30 cmH2O).	90	42.9
Cuff pressure Mean ± SD	37.4 ± 25.5	
High fowler position		
Normal pressure (20-30 cmH2O).	37	17.6
Less than normal (below 20 cmH2O).	67	31.9
More than normal (above 30 cmH2O).	106	50.5
Cuff pressure Mean ± SD	24.5 ± 19.8	
Left lateral rotation of the body and head		
Normal pressure (20-30 cmH2O).	0	0.0
Less than normal (below 20 cmH2O).	103	49.0
More than normal (above 30 cmH2O).	107	51.0
Cuff pressure Mean ± SD	42.2 ± 31.4	
Right lateral rotation of the body and head		
Normal pressure (20-30 cmH2O).	0	0.0
Less than normal (below 20 cmH2O).	123	58.6
More than normal (above 30 cmH2O).	87	41.4
Cuff pressure Mean ± SD	38.2 ± 32.6	
Prone position		
Normal pressure (20-30 cmH2O).	0	0.0
Less than normal (below 20 cmH2O).	45	21.4
More than normal (above 30 cmH2O).	165	78.6
Cuff pressure Mean ± SD	64.6 ± 30.1	

Table 4 Comparison between different cuff pressure reading after each change in patient's position according to time

Cuff pressure	Mean ± St. deviation	T value	P. value
1st cuff pressure after 20 minutes of routine nursing care (base data)	64.3 ± 19.5	47.77	**0.000***
2nd Cuff pressure after 20 minutes in dorsal position	43.5 ± 23.8	26.47	**0.000***
2nd Adjusted cuff pressure between (20-30 cmH2O)	27.6 ± 2.1	186.1	**0.000***
3rd Cuff pressure after 2 hours	28.15 ± 3.06	133.3	**0.000***
4th Cuff pressure after 20 minutes in low fowler position	37.4 ± 25.4	21.29	**0.000***
3rd Adjusted cuff pressure between (20-30 cmH2O)	27.5 ± 2.3	170.9	**0.000***
5th Cuff pressure after 2 hours	27.8 ± 3.7	108.3	**0.000***

6th Cuff pressure after 20 minutes in high fowler position	24.5 ± 19.8	18.8	**0.000***
4th Adjusted cuff pressure between (20-30 cmH2O)	27.6 ± 2.19	182.3	**0.000***
7th Cuff pressure after 2 hours	28.1± 3.2	125.2	**0.000***
8th Cuff pressure after 20 minutes in left lateral position.	42.2 ± 31.4	19.56	**0.000***
5th Adjusted cuff pressure between (20-30 cmH2O)	27.5 ± 2.2	182.52	**0.000***
9th Cuff pressure after 2 hours	28.5 ± 3.5	116.6	**0.000***
10th Cuff pressure after 20 minutes in right lateral position.	38.2 ± 32.6	16.97	**0.000***
6th Adjusted cuff pressure between (20-30 cmH2O)	27.4 ± 2.2	181.9	**0.000***
11th Cuff pressure after 2 hours	27.6 ± 7.2	55.3	**0.000***
12th Cuff pressure after 20 minutes in Prone position.	64.6 ± 30.1	31.4	**0.000***
7th Adjusted cuff pressure between (20-30 cmH2O)	27.4 ± 2.2	181.9	**0.000***
13th Cuff pressure after 2 hours	27.3 ± 6.5	61.8	**0.000***

Table (5): The correlation between adjusted cuff pressure and different position among study patients (N= 210)

Variable	adjusted cuff pressure	
	R	P
Supine position	**.061**	**.379**
Lower fowler position	**.133**	**.054**
High fowler position	**.009**	**.894**
Left lateral rotation	**.843**	**.534**
Right lateral rotation	**.187****	**.007**
Prone position	**.019**	**.783**

4. DISCUSSION

Cuffed endotracheal tube used in critical units to maintain adequate distribution of tidal volume and to prevent the risk of aspiration of secretion. [11] The present study observed that any change in the patient's head or whole body position will have an effect on the ETT cuff pressure.

The present study investigated (210) intubated trauma patients attached to mechanical ventilation. (58.1 %) of them were male and their mean age (40.6 ± 8.9 years). The present study finding agreed with Khalil et al. [12] and Athiraman et al. [13] who reported in their studies that male patients were at higher risk for trauma and intubation than females.

The present research found that any change in the patient's head and neck or whole body position while providing the routine nursing care at the ICU had an effect on the ETT cuff pressure reading if it is not monitored and readjusted by a cuff pressure manometer.

It was noticed that when measuring the ETT cuff pressure by cuff manometer, the majority of the studied sample had high than normal pressure (above 30 cmH2O) after turning them to the supine and the prone position. On the other hand, about half of patients their ETT cuff pressure were also above (30 cmH2O) when they were in the high fowler and left lateral rotation of the body and head. But right lateral position and the lower fowler position were the most common position that had lower cuff pressure readings below (20 cmH2O).

The present research finding prove that any patient's head and neck flexion or rotation will lead to tracheal muscle wall pressure against the wall of the cuff which leads to its increase if not monitored and readjusted. On the other hand, many ICU nurses inflated the ETT pilot balloon using a fixed number of cm of air as (5 cm or 10 cm of air) without any consideration of air leak or over inflation of the cuff and they did not monitor it using a cuff pressure manometer. Many ICU nurses did not aware of the importance of monitoring and readjusting the ETT cuff pressure of the intubated patients, and they did not have enough knowledge about the harmful effect of the increase or decrease in its pressure.

Nurses in ICU used the pilot balloon palpation method to estimate the efficiency of the ETT cuff pressure during its securing. But the current practices of the ICU nurses did not prove its efficacy in our study and also in another study that conducted by Giusti D.G., et al. [14]) who examined how accurate the cuff pressure monitoring by manual palpation in intubated patients?, they found that using pilot balloon palpation as a method to examine the normal cuff pressure was incorrect in (68%) of the patients, and only correct in (10%) of them whom received the manual pilot balloon palpation monitoring.

Soleimani M., & Ashrafi. [15] agreed with the present study and mentioned that all intubated mechanically ventilated patient will have a change in the ETT cuff pressure after body position change, their mean pressure increased to be (29.12±0.41 cmH2O) when placed in the lateral position and reached (27.6±0.38 cmH2O) when the head of the bed decreased to the zero level (supine position).

The present study was in line with Ziyaeifard et al. [16] in a study that investigated the effect of different patient positions on endotracheal tube cuff pressure after adult cardiac surgery, they found (43. 6%) of the measurements were greater than the upper target limit (30 cmH2O) after positioning change. Letvin A., et al. [17] & Sharifi et al. [18] were in line with the present study and found that the majority of the orally intubated patients with an ETT their cuff pressure measurements were higher than the recommended range (above 30 cmH2O) after changing the body position.

On the other hand, the present study found that more than half of the studded sample their ETT cuff pressure were lower than normal (below 20 cmH2O) when they were in right lateral rotation of the body and head. The present finding was in line with Alcan et al., [19] who demonstrated a reduction in the ETT cuff pressure after changing position to lateral position. Also, the same author emphasized that high sedation doses is one of the most important things that lead to a significant decrease in the ETT cuff pressure (below 20 cmH2O) and it will increase after sedation withdrawal.

Godoy AC, et al., [20] reported that (47.3%) of the intubated patients had an ETT cuff pressure more than (30 cmH2O) after the fixed amount of air injected in the tube pilot balloon (about 10 cm of air). Godoy et al., [20] suggested that any change in patient body position could affect the ETT cuff pressure. Alcan et al., [19] emphasized that ETT cuff pressure monitoring and compliance on it is one of the most important items of VAP bundle prevention guidelines that should be done at regular intervals to prevent micro-aspiration of secretion or tracheal ischemia that will result from its un adjustment.

5. CONCLUSION

The endotracheal tube cuff pressure should be monitored at a regular interval and after patient's body position change. Positioning affects the ETT placement and its cuff pressure because of the head movement and neck flexion. To adjust the ETT cuff pressure the ICU nurse should do it using a cuff pressure manometer.

Limitation of the study

The study need to be repeated on a large sample with different types of diagnosis other than the traumatic patients and modes of mechanical ventilator to reach more publication and evidence.

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