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Relation Between Endotracheal Tube Cuff Pressure Measurements and The Incidence of Ventilator Associated Pneumonia

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Abstract
The importance of cuff pressure in endotracheal tube management cannot be overstated. Guidelines recommend that a cuff pressure should be in a range of 20 to 30 cm H_2O. Low cuff pressure increase risk for micro-aspiration of subglottic secretions. This micro-aspiration is considered the major pathogenic mechanism for ventilator-associated pneumonia, complication with marked morbidity and mortality. **Aim:** This study was carried out to determine the relation between endotracheal tube cuff pressure and the incidence of ventilator-associated pneumonia. **Design:** Descriptive research design. **Setting:** In two critical care units at Assiut Main University Hospital: Trauma ICU and general ICU. **Subjects:** A convenience sample of 60 critically ill patients. **Tools:** Three tools were utilized to collect data of study, **Tool I:** Patient assessment sheet. **Tool II:** Endotracheal tube cuff pressure measurements. **Tool III:** Ventilator- associated pneumonia assessment sheet. **Method:** The researcher used preparatory, implementation and evaluation phases to implement this study. **Results:** Finding of the present study revealed that there was significant statistical relationship between endotracheal tube cuff pressure and incidence of ventilator associated pneumonia with (P value < 0.05). **Conclusion:** There is a significant statistical relation between endotracheal tube cuff pressure and incidence of ventilator-associated pneumonia. **Recommendations:** Endotracheal tube cuff pressure measurements should be standardized as a basic part of care provided to all critically ill patients in intensive care units.

Keywords: Cuff pressure, Endotracheal tube & Ventilator associated pneumonia.

Introduction
Most patients in intensive care units require endotracheal intubation. Endotracheal tubes are used for intubation of the airway. This is done orally or nasally to facilitate the passage of gases into the lung, and to protect the airway. There are many types of endotracheal tubes with varying cuffs, various methods of inflating cuffs and a variety of ideal ranges for maintaining cuff pressure. Tubes have cuffs that exert pressure against the tracheal mucosa. The purpose of these cuffed tubes is to form a seal against the tracheal wall to prevent air leaking around the tube, as well as to protect against aspiration of any secretions**. (Ommid et al., 2021)**

Cuff pressure is the pressure generated by the inflated cuff of endotracheal tubes. The ETT cuff pressure must be kept in a range that deliver the prescribed mechanical ventilation tidal volume, reduces the danger for aspiration of secretions that accumulate above the cuff without altering the tracheal perfusion. It is recommended that a cuff pressure should be maintained between 20–30 cm of water. Endotracheal tube cuff pressure can change drastically by several effects exerted on the cuff. This may lead to side effects due to under-inflated or over-inflated cuffs. Over-inflation of the cuff can cause changes in the tracheal mucosa, granuloma, rupture of the trachea, tracheo-esophageal fistulae or tracheal stenosis and total blockage of tracheal mucosal blood flow. Under inflation may cause air leakage, risk of pulmonary aspiration and accidental extubation. Precise measurement allows tighter control of cuff pressures within normal range thus minimizing the negative effects of over- and under-inflation of the cuff **(Aeppli et al., 2019)**

The devices that invade the body can cause complications and even death. When the patient is intubated, one of the major complications of intubation is ventilator-associated pneumonia (VAP). VAP is associated with high mortality, morbidity rates and medical costs. The mortality rate of VAP is the highest of all nosocomial infections. Medical cost increase when patients develop VAP, due to the increased use of antibiotics and other medications, cross contamination with other patients and longer stay in the intensive care unit and hospital day increase. **(Bloria, 2019)**

VAP subdivided into two groups, firstly early-onset pneumonia, within 48 to 72 hours after intubation, as a result of aspiration during intubation, and late onset

pneumonia after 72 hours. Two processes have to occur to develop VAP, namely, bacterial colonization of the oropharynx and tracheobronchial tract and ensuing aspiration of these secretions to the lower respiratory tract. **(Wen et al., 2019)**

Risk factors for VAP had been occurred among old age, patients with severe of injury or illness, or who with pulmonary disease, neurologic injury and trauma as well as prior administration of corticosteroids or prior inappropriate antibiotic treatment, administration of H_2 blocking agents, also the intubation route, or patient who re-intubated. Also, from the predisposing factors; duration of the patient on mechanical ventilation, low intra cuff pressure length of hospital stay before ICU admission, length of ICU stay, and supine body position of the patients. **(Green et al., 2017)**

VAP is diagnosed when the patient has a new infiltrate on chest x-ray along with fever and increase in white blood cell count after 48 hours of invasive mechanical ventilation. To diagnose a VAP episode, the presence of clinical signs of pneumonia plus microbiological confirmation by quantitative cultures is required. It can be obtained from either tracheal aspirate, Broncho-alveolar Lavage (BAL), Mini-BAL or Protected Brush Specimens (PBS), each having sensitivity and specificity. **(Beccaria et al., 2017)**

Positioning of the endotracheal tube is usually the responsibility of the physician, but in the intensive care units, nurses are overwhelmed to care for the endotracheal tube that will include the management of secretions, maintaining the position of the endotracheal tube, ensuring correct cuff pressures, prevention of complications and managing complications when they do occur after consulting the responsible physician. **(Wen et al., 2019)**

The intensive care nurse has always been occupied with the prevention of ventilator-associated pneumonia. VAP cannot totally be prevented, in spite of training about the infection control principles and vigorous measures to implement these principles. Factors, other than the transgression of infection control principles, may be lead to VAP, as it remains a problem in nursing practice, so that the present study investigate the relation between endotracheal tube cuff pressure measurements, and incidence of ventilator-associated pneumonia. **(Bloria, 2019)**

Significance of the study:

Inappropriate endotracheal tube cuff pressure can cause a potential complications, which could significantly affect the health outcomes of patients, as this need a competent nursing care offered. So this study developed to determine the occurrence percentage of VAP. In **A**ssuit 2017, at Trauma Intensive Care Unit of Assuit Main University Hospital it was found that 59 % of adult cases were on cuffed endotracheal tube. (**Assuit university hospital records, 2017**).

Aim of the study:

To assess the relation between endotracheal tube cuff pressure measurements and the incidence of ventilator-associated pneumonia through:

- Measuring the endotracheal tube cuff pressure in patients admitted to intensive care unit
- Identifying the percentage of cuffs inflated to the correct pressure among patients admitted to intensive care unit.
- Identifying the relation between endotracheal tube cuff pressure and the incidence of ventilator-associated pneumonia

Hypothesis:

The following research hypothesis was formulated in an attempt to achieve the aim of the study.

A relationship will be found between the endotracheal tube cuff pressure measurements and incidence of ventilator-associated pneumonia.

Patients and Method

Research design:

Descriptive research design was used to conduct this study.

Variables:

- **Independent variable**: Endotracheal tube cuff pressure measurements.
- **Dependent variable**: Incidence of ventilator-associated pneumonia.

Setting:

This study was conducted in two critical care units at Assiut Main University Hospital, namely: Trauma ICU and general ICU.

Patients:

A purposeful sample of 60 critically ill patients who were newly intubated within 24 hours in the previously mentioned intensive care units

Inclusion criteria:

The study included patients who had the following criteria:

- Adult patients
- Patients receiving invasive mechanical ventilation.
- Patient intubated with cuffed endotracheal tube.

Exclusion criteria:

The study excluded patients with the following criteria:-

- Patients intubated prior to ICU admission
- Patients diagnosed with pneumonia at admission

Tools of data collection:-

Three tools were used to collect the necessary information for the study, as the following**:-**

Tool one: - Patient assessment sheet:

The tool was developed by the researcher after reviewing literatures **(Taslimi et al., 2016**) **(Craven and Hirnle, 2007) to** assess patients' characteristics and divided into two parts:

Part I: Bio-socio demographic and clinical data of patients

- Bio-socio demographic data includes patient's code, age and sex
- Clinical data; such as diagnosis, prescribed medications, invasive devices date of admission, date of discharge, length of stay in ICU

Part II: Mechanical ventilation data:

This part was developed by the researcher after reviewing of literatures **(Pierce, 2007)**. This part used to assess parameters of mechanical ventilation such as mode of mechanical ventilation, fraction of inspired oxygen (FIO_2), Tidal volume (Vt), mandatory& spontaneous respiratory rate, positive end expiratory pressure (PEEP), pressure support (Ps) , and duration of mechanical ventilation.

Tool two: - Endotracheal tube cuff pressure measurements

This tool was developed by the researcher after reviewing the related literature **(Lizy et al., 2014)** to assess endotracheal tube cuff pressure measurements of patients whether high , low or within the normal range. It includes size of endotracheal tube, cuff pressure measurements ; in which cuff pressure measured every 8 hours daily until occurrence of early or late onset of ventilator associated pneumonia throughout 5 days, no correction made to cuff pressure even high or low.

Tool three:- ventilator-associated pneumonia assessment sheet

This tool was developed by the researcher after reviewing the related literature **(Lima et al., 2017)** to assess the occurrence of ventilator-associated pneumonia such as presence of a new or progressive radiographic chest infiltrate, high or low temperature, white blood cell count.

Method of data collection

The study was conducted throughout three main phases, which were preparatory phase, implementation phase and evaluation phase:-

Preparatory phase

The study tools were designed after extensive literature review

Content validity

Content validity of the developed tools done by five experts in the related field: three professors of anesthesia, faculty of medicine, Assiut University, one professor of adult surgical nursing, faculty of nursing, Assiut University, one lecturer of critical care and emergency nursing ,faculty of nursing , Assiut University and the necessary modifications were done accordingly.

Reliability

- Tools were tested for its reliability by using Cronbach`s coefficient alpha and was 0.87
- A written approval obtained from the hospital administrative authority to collect the necessary data.

Ethical considerations

- Research proposal approved from Ethical Committee in the Faculty of Nursing, Assiut University
- There is no risk for study subject during application of the research
- The study follow common ethical principles in clinical research
- Written consent obtained from patients or guidance that are willing to participate in the study after explaining the nature and purpose of the study
- Patient assured that the data of this research will not be refused without a second permission.
- Confidentiality and anonymity assured.
- Patients have the right to refuse to participate and \or withdraw from the study without any rationale at any time.

The pilot study

A pilot study was carried out on 10% of patients to test the feasibility and applicability of the tool and the necessary modifications were done and data were excluded from the study.Also, to estimate the time needed to answer the study tools.

Implementation phase for study group:-

Data was collected as follows:

- Following Ethics Committee permission , 60 critically ill patients who required endotracheal intubation and mechanical ventilator support for more than 48 hours hospitalized in 2 intensive care units (ICUs) were studied
- Patients' demographic data were recorded included sex, age
- Clinical data was recorded includes date of admission, reason for ICU admission ,prescribed medications, invasive devices, date of discharge, and length of stay in ICU
- size of the endotracheal tube was recorded for each patient
- The endotracheal tube cuff pressure measured by Intermittent method
- The endotracheal tube cuff pressure measured by a cufflator; is intermittent method; by a method in which the manometer is connected to the inflation valve of pilot balloon of endotracheal tube and the cuff pressure is shown on the screen and then the manometer disconnected from the inflation valve of the pilot balloon.

- The reading of the endotracheal tube cuff pressure observed in all patients.
- The endotracheal tube cuff pressure measured every 8 hours daily throughout 5 days.
- Cuff pressure was recorded in centimeter of water.
- The ETT cuff pressure of 20–30 cm of H2O was considered as standard
- No correction made to cuff pressure even high or low
- The data acquired from the patients included in the study was evaluated on a daily basis for the occurrence of VAP
- Axillary body temperature measured for all patients on admission and repeated every day for five days.
- Result of WBC recorded for all patients on admission and repeated every day for five days.
- Assessment of the sputum color done for all patients on admission and repeated every day for five days
- Endotraceal aspirates were collected with a sterile catheter. The catheter
- was introduce via the endotracheal tube .They were obtained from all patients
- Sputum from the patients was collected from the tip of the suction catheter and transported to the laboratory in a sterile tube.
- Chest X-ray was done for all patients in the third day of admission to observe the presence of pneumonia shadow.
- A diagnosis of ventilator-associated pneumonia is suspected when the patient has a new infiltrate on chest x-ray along with fever and raised leucocyte count after 48 hours of invasive mechanical ventilation
- The end point of the study was the incidence of early or late -onset clinical and microbiological criteria for VAP
- VAP was divided into two categories: early-onset type (within 48 hour) and late-onset type within (3-5 days).

Phase III: Evaluation phase

The patients evaluated after endotracheal tube cuff pressure measurements were done for occurrence of ventilator associated pneumonia by chest radiograph , sputum culture, laboratory findings (increase or decrease of white blood cells), with fever throughout 5 days

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 and standard deviation. quantitative variables. P-value was considered statistically significant when $P < 0.05$.

Results

Table (1): Patients' demographic data

Item	Descriptive "n=60"
1-Age:	
• 18-<40 yrs.	20(33.33%)
• 40-60 yrs.	40(66.67%)
Mean±SD	47.83±17.25
2-Sex:	
• Male	42(70.0%)
• Female	18(30.0%)

Table (2): Patients' clinical data

Item	Descriptive "n=60"
1-Diagnosis:	
• Trauma	30(50.0%)
• Post-operative	15(25.0%)
• Stroke	15(25.0%)
2-Prescribed medications :	
• Antibiotics	60(100%)
• Stress ulcer prophylaxis	60(100%)
• Sedatives	20(33.33%)
• Steroids	6(10.0%)
3-Invasive devices:	
• Endoteracheal tube	60(100%)
• Central venous catheter	60(100%)
• Nasogatric tube	57(95.0%)

Table (3): Patients' distribution in relation to mechanical ventilator parameters

Respiratory parameters	Developed (VAP) "n=17"	Not developed (VAP) "n=43"	P-value
	Mean ± SD	Mean ± SD	
Respiratory rate (RR)			
1st day	22.30 ± 5.47	21.81 ± 5.94	0.243n.s
2nd day	23.10 ± 5.97	21.94± 6.19	0.468n.s
3rd day	24.79 ± 6.27	22.10 ± 5.87	0.0.04*
4th day	26.33 ± 6.49	22.27 ± 6.57	0.02*
5th day	27.07 ± 7.92	23.51 ± 5.22	0.003*
Tidal volume (V_t)			
1st day	461.41± 97.73	458.12 ± 79.43	0.246n.s
2nd day	468.94 ± 68.73	471.56± 78.59	0.238n.s
3rd day	487.46 ± 79.43	481.79 ± 82.73	0.624n.s
4th day	498.48± 114.83	487.89± 112.79	0.533n.s
5th day	502.45± 142.27	503.52± 114.73	0.443n.s
Fraction of oxygen(Fio_2)			
1st day	48.70 ± 10.06	47.46 ± 13.46	0.673n.s
2nd day	46.24 ± 11.29	48.19 ± 12.78	0.468n.s
3rd day	44.18 ± 12.49	50.57 ± 15.07	0.497n.s
4th day	44.73 ± 13.56	48.76 ± 16.49	0.376n.s
5th day	48.79 ± 18.49	47.84 ± 17.49	0.884n.s
SpO_2			
1st day	98.24 ± 1.84	97.89 ± 2.04	0.237n.s
2nd day	97.02 ± 1.24	97.86 ± 1.88	0.564n.s
3rd day	95.43 ± 1.29	98.11 ± 2.24	0.371n.s
4th day	93.22 ± 1.89	98.04 ± 2.17	0.02*
5th day	92.08 ± 2.07	97.77 ± 2.71	0.01*
Positive end Expiratory Pressure (PEEP)			
1st day	7.28 ± 2.83	7.39 ± 2.73	0.340n.s
2nd day	7.30 ± 2.89	7.71 ± 2.56	0.447n.s
3rd day	7.58 ± 3.27	7.76 ± 3.22	0.524n.s
4th day	8.00 ± 3.27	8.00 ± 3.18	0.496n.s
5th day	7.25 ± 2.82	7.52 ± 2.87	0.549n.s
Pressure Support Ventilation (PSV)			
1st day	15.79 ± 10.79	15.66 ± 8.76	0.449n.s
2nd day	15.62 ± 9.46	16.24 ± 9.17	0.582n.s
3rd day	15.23 ± 7.84	15.73 ± 8.02	0.663n.s
4th day	15.17 ± 8.16	15.65 ± 7.87	0.473n.s
5th day	14.76 ± 8.17	15.73 ±7.04	0.376n.s
Duration on M.V: • <7 days • >7 days	 2(11.76%) 15(88.23%)	 33(76.74%) 10(23.25%)	P<0.01*

** Statistically significant difference (p<0.05)*

Table (4): Patients' Endotracheal tube cuff pressure measurements

Item	Descriptive "n=60"
ETT size • 7mmID • 7.5mmID	 18(30.0%) 42(70.0%)
Cuff pressure measurements • <20 cmH2O • 20-30 cmH2O • >30 cmH2O	 39(65.0%) 7(11.67%) 14(23.33%)

mmID: millimeter Internal Diameter

Table (5): Frequency of Ventilator Associated Pneumonia (VAP) among patients

Item	Descriptive "n=60"
• Developed (VAP) • Not developed (VAP)	17(28.33%) 43(71.67%)
• Early onset VAP • Late onset VAP	6(35.30%) 11(64.70%)

Table (6): Relation between Frequency of Ventilator Associated Pneumonia (VAP) with patient's characteristics

Item	Developed (VAP) "n=17"	Not developed (VAP) "n=43"	P-value
1-Age:			
• <40yrs. • >40yrs.	3(17.64%) 14(82.35%)	17(39.53%) 26(60.46%)	X=12.36 P<0.03*
2-Sex:			
• Male • Female	2(11.76%) 15(88.23%)	33(76.74%) 10(23.25%)	X=6.14 P<0.01*

** Statistically significant difference (p<0.05) Using Chi-Square test*

Table (7): Relation between Ventilator Associated Pneumonia (VAP) with cuff pressure among Patients

Item	Developed (VAP) "n=17"	Not developed (VAP) "n=43"	P-value
• <20 cmH_2O • 20-30 cmH_2O • >30 cmH_2O	15(88.23%) 2(11.76%) 0	24(55.841%) 5(11.62%) 14(32.55%)	X=8.42 P<0.001**

** Statistically significant difference (p<0.05) Using Chi-Square test*

Table (8): Relation between Frequency of Ventilator Associated Pneumonia (VAP) with ICU stay among Patients

Item	Developed (VAP) "n=17"	Not developed (VAP) "n=43"	P-value
ICU stay:			
• <10 days • >10 days	4(23.52%) 13(76.47%)	16(37.20%) 27(62.90%)	X=10.15 P<0.02*

** Statistically significant difference (p<0.05) Using Chi-Square test*

Table (1): Shows patients' demographic data. There was (66.67%) of patients in age, more than 40years with mean value of age 47.83years. Also there was (70.0%) of patients were male.

Table (2): Shows patients' clinical data. With (50.0%) of patients was post traumatic, also all the patients (100%) were using Antibiotics & Stress ulcer prophylaxis. All the patients (100%) were having endotracheal tube & Central venous catheter, also there was (95.0%) of the patients were having Nasogatric tube

Table (3): Shows patients' distribution in relation to Mechanical ventilator parameters. It was noticed that (88.23%) of the patients with VAP have duration on M.V more than 7 days. With significance difference between VAP and duration on M.V (P<0.01)

Table (4): Shows patients' endotracheal tube cuff pressure measurements. In relation to endotracheal tube size, there was (70.0%) of patients were intubated with 7.5mmID of endotracheal tube .There was (65.0%) of patients were in pressure <20 cmH2O

Table (5): Shows frequency of Ventilator Associated Pneumonia (VAP) among Patients. There was (28.33%) of patients developed VAP. and (64.70%) of patients who developed VAP have late onset VAP.

Table (6): Shows relation between Frequency of Ventilator Associated Pneumonia (VAP) with patient's characteristics. There was significance difference between VAP and age of patients (P<0.05) with (82.35%) of patients with VAP were age more than 40 years, also about gender, there was significance difference between VAP and sex of

patients (P<0.05) with (88.23%) of patients with VAP were male.

Table (7): Shows relation between Ventilator Associated Pneumonia (VAP) with cuff pressure among Patients. There was significance difference (P<0.001) with high percentage (88.23%) in patients with VAP have cuff pressure <20 cmH_2O .

Table (8): Shows relation between Frequency of Ventilator Associated Pneumonia (VAP) with ICU stay among Patients. (76.47%) of patients with VAP have ICU stay more than 10 days. With significance difference between VAP and ICU stay (P<0.02*)

Discussion

Endotracheal intubation and mechanical ventilation are sole life-saving treatments for many critically ill patients. Cuff pressure is golden in endotracheal tube management. Endotracheal cuff pressure should be in a weight to balance the risk of mucosal damage and the risk of ventilator-associated pneumonia **(Aeppli et al., 2019)**

So, the aim of this study was to assess the relation between endotracheal tube cuff pressure measurements and the incidence of ventilator-associated pneumonia

This discussion will cover the main result findings as follow:

Demographic and clinical data of patients

In relation to age, it was noticed that the majority of patients who developed VAP were in age of more than 40 years old this due to the fact that elderly people have diminished cough and gage reflexes, impaired immune system and increased frequency of serious comorbidities ,this results agree with a study done by **Ommid et al., (2021**) which revealed that the incidence of VAP was highest in patients of age between 31-60 years old. Reason could be that the majority of admitted patients were in this age group. The number of people between 31 –60 years old accounts for 58% of the total number of patients admitted at this time.

Regarding to sex, the majority of patients who developed VAP were male in study group, this may be due to that males are heavy smokers than females, and exposed to some occupational hazards. These findings are in the same line with results of **Ommid et al., (2021)** study in which revealed that (66.66%) out of the patients with VAP in the study were males and (32.33%) were females.As Patients developing VAP were predominately males in the study.

As regards to the medical diagnosis, half of patients had trauma. This finding was supported by **Green et al., (2017)** who mentioned that risk factors for VAP have been described, including old age, severity of injury or illness, underlying pulmonary disease, neurologic injury and trauma as well as prior to the administration of corticosteroids and prior inappropriate antibiotic treatment.

In relation to medications prescribed for the patients, all patients administered antibiotics and stress ulcer prophylaxis, this increase risk of VAP. This finding was in line with **Ali (2007),** who found that there was a significant relation between occurrence of oropharyngeal colonization and the use of antibiotics with increases number of positively cultured patients who received antibiotic therapy. Also was in the same line with **Green et al., (2017)** who stated that risk factors for VAP including old age, severity of injury or illness, neurologic injury and trauma as well as the prior administration of corticosteroids ,prior inappropriate antibiotic treatment ,use of H_2 blocking agents, and intubation route.

As regards to the presence of the invasive devices the most common devices in all patients were cuffed endotracheal tube, central venous catheter, and the vast majority had nasogastric tube. This may be attributed to that nasogastric tube, enables bacteria to migrate to and from the oropharnex and facilitate the reflex of bacteria from gut, which increase oropharyngeal colonization and stagnation of oropharyngeal secretions. Endotracheal intubation compromises the nature barrier between the oropharynx and trachea ,facilitate the entry of bacteria into lower airway during intubation or by pooling and leakage of secretion around the endotracheal tube cuff.

This result supported by **Ali (2007),** who found that oropharyngeal colonization was higher among patients with nasogartric feeding. This result was in agreement with **Zahran (2005),** who found that endotracheal facilitate the entry of bacteria into lower airway during intubation or by pooling and leakage of secretion around the endotracheal tube cuff. Showed the increase the risk for ventilator associated pneumonia 7 folds. Also the current study finding was in the same line with **Bloria (2019)** who reported that the devices that enter the body can cause complications and even death. When the patient is intubated, one of the major complications of intubation is ventilator-associated pneumonia.

Regarding to endotracheal tube cuff pressure measurements, the present study revealed that two thirds of patients had low endotracheal tube cuff pressure, this may be attributed to that endotracheal tube cuff pressure is not measured absolutely for any patient by any health care personnel, endotracheal tube cuff pressure evaluated rarely by pilot balloon palpation plus endotracheal tube cuff pressure is decreased over time

This finding was in contradiction with a study done by **Lorente et al., (2014)** in which revealed that intermittent pressure cuff (Pcuff) control by using a manometer is widely used in ICUs to overcome to complications that related to high or low tracheal cuff, but its accuracy in maintaining Pcuff in normal range is not optimal as inaccurate in continuously maintaining Pcuff in normal range. In addition to frequent measurements of Pcuff represent a workload for nurses and may result in aspiration of contaminated secretions pooled above the cuff, as each connection of the manometer to the pilot balloon is associated with transient decrease of Pcuff. Also a study done by **Rajan et al., (2018)** supported that Pcuff decreased over time in mechanically ventilated patients. **Aeppli et al., (2019)** hypothesized that a decrease in pressure could be resulted from shortage of nursing staff which may have bad effects on patient care, and can result significant under inflation time durations with manual inflations.

Regarding the incidence of ventilator associated pneumonia, it was noticed that about one third of patients developed VAP .this may be attributed to patient factors such as presence of endotracheal intubation and nasogastric tube and two thirds of patients had low endotracheal tube cuff pressure. In addition factors such as lack of skilled staff with ICU knowledge, skills and experience, lack of guidelines in the ICU, lack of knowledge about VAP disease process are factors that hinder the implementation of VAP Prevention strategies amongst the intensive care nurses. Also the shortage of the intensive care nurses causes burn out amongst staff, increased workload and poor productivity in the ICU, which in turn hinder the implementation of VAP prevention strategies.This finding is supported by a study done by **Lorente et al., (2014**) that revealed that pressure lower than 20 cmH_2O increases the incidence of VAP from 11.2% to 22.0% .

As regard the Frequency of Ventilator Associated Pneumonia (VAP) with duration on M.V among Patients. Most patients who developed VAP has longer duration on mechanical ventilation. this Similar with a study done by **Rajan et al., (2018)** The study reported that the duration of mechanical ventilation in patients with ventilator associated pneumonia was prolonged compared with those without Ventilator associated pneumonia.

In Relation to the Frequency of Ventilator Associated Pneumonia (VAP) with ICU stay among Patients. It was noticed that three quarters of patients with VAP have ICU stay more than 10 days With significance difference between VAP and ICU stay (P<0.02*).this finding is in agreement with finding of **Bloria (2019)** which revealed that patients who develop a ventilator-associated pneumonia, increased consumption of antibiotics and other medications, cross contamination of other patients and longer stay in the intensive care unit and hospital

Conclusion

Based on the results of this study, it could be concluded that there is a significant statistical relationship between endotracheal tube cuff pressure and incidence of ventilator associated pneumonia

Recommendations

- Endotracheal tube cuff pressure measurements should be standardized as the golden element of care provided to all critically ill patients in intensive care units.
- Re- application of this research on a larger probability sample acquired from different geographical areas in Egypt for generalization of the finding.
- In ICUs with overburdened nursing staff automatic cuff pressure control manometer is a better option than manual .
- Continuous endotracheal tube cuff pressure control system and other VAP prevention bundle components should be set as essential part of care provided to all critically ill patients
- A poster about Ventilator Associated Pneumonia preventative strategies should be placed in ICUs

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