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Effects of Maintaining Cuff Pressure on the Occurrence of Ventilator Associated Pneumonia at a University Hospital in Egypt

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Research Article

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Abstract

Background: Pneumonia is the second most common nosocomial infection and a leading cause of death. Furthermore, the risk for pneumonia increases 3 to10 fold in patients receiving mechanical ventilation.

Aim of this Study: Is to investigate effect of maintaining the tracheal cuff pressure on the occurrence of ventilator associated pneumonia in critically ill patients.

Material and Methods: a comparative study was used to carry out the research on one hundred and ten patients in pulmonary Intensive Care Unit at Mansoura University Hospital. Two tools were used to collect data about correlation between maintaining the tracheal cuff pressure and the occurrence of ventilator associated pneumonia.

Results: High significant statistical difference was found between the study and control groups regarding CPIS score on the seventh day. ($X2 = 10.53$, $p < 0.001$). So, most of study group has got CPIS <7 (96.4%) when compared to control group (74.5%). Moreover, significant differences were found between both groups regarding length of hospital stay and intubation. So, the study group demonstrated shorter length in both hospital stay and intubation than the control group.

Conclusion: Maintaining cuff pressure between 20-30 cm H_2O have decreased occurrence of VAP and have a significant reducing effect on the length of hospital stay and endotracheal intubation.

Recommendation: Replication of the study on a large probability sample selected from different critical care units in Egypt. Furthermore, studying the barriers that hinder the nurses to maintain endotracheal cuff pressure.

Keywords: Maintaining; Endotracheal tube; Cuff pressure; Ventilator associated pneumonia

Introduction

Ventilator-associated pneumonia (VAP) is defined as pneumonia that occurs 48-72 hours following endotracheal intubation. It contributes to approximately half of all cases of hospital-acquired pneumonia. VAP is estimated to occur in 9-27 % of all mechanically ventilated patients, with the highest risk being early in the

course of hospitalization. It is the second most common nosocomial infection in the intensive care unit [1]. Endotracheal tubes cuffs are used to prevent the leak of gas and also pulmonary aspiration in mechanically ventilated patients. However, the use of high cuff inflation volumes may cause tracheal damage [2].

Leakage of fluid around the cuff of the endotracheal tube (ETT) into the airway is an important cause for the occurrence of micro aspiration. The cuff is designed to provide a seal with the airway, allowing airflow through the ETT but preventing passage of air or fluids around the ETT. When this seal is compromised, micro aspirations contaminated with gastric contents or bacterially colonized oral secretions can occur that leave the patient susceptible to many problems, such as hypoxia, pneumonitis, and respiratory infections. Hypoxic events have been shown as a result of the aspiration in mechanically ventilated patients. Aspiration of gastric contents can lead to Pneumonitis and ventilator-associated tracheobronchitis. To prevent gas leakage and aspiration, an endotracheal tube (ETT) with a cuff is generally used for mechanically ventilated patients. Because excessive cuff pressure decreases tracheal capillary perfusion, and insufficient cuff pressure leads to aspiration of oropharyngeal contents. Loss of cuff pressure is known to increase the risk of complications cuff pressure below 20 cmH2O is associated with the development of ventilator-associated pneumonia [3].

Aim of the Study

The aim of this study is to assess the effect of maintaining the tracheal cuff pressure between 20-30 cm H2O on the occurrence of ventilator associated pneumonia in critically ill patients.

Research Hypothesis

The patients who will be exposed to maintaining tracheal cuff pressure will decrease occurrence of ventilator associated pneumonia than patients who will not be exposed.

Subjects and Methods

Research Design

Quasi-experimental research design was used in the current study. It identifies a comparison group that is as similar as possible to the treatment group in terms of baseline (pre-intervention) characteristics. The comparison group captures what would have been the outcomes if the programme / policy had not been implemented. Hence, the programme or policy can be said to have caused any difference in outcomes between the treatment and comparison group [4]. The current research utilized quasi-experimental design because the study conducted to assess the effect of maintaining the tracheal cuff pressure on the occurrence of ventilator associated pneumonia in critically ill patients. This information was used as starting point in assessment of ventilator associated pneumonia in intensive care unit, facilitates validation of results and provides efficient patient management based on accurate assessment.

Setting

This study was carried out at pulmonary ICU at Mansoura University Hospital. The hospital included two ICUs. Each ICU contained 6 beds, 6 cardiac monitors, 6 mechanical ventilators, ECG machine and DC machine, the nurse patient ratio was 1:3.

Subjects

A purposive sample of 110 mechanically ventilated patients was chosen. The sample was chosen according to inclusion criteria and estimated according to the following statistical formula: Considering the mean bacterial concentration in cuff pressure patients (2.4±1.6) and non-continues cuffed pressure patients (3.7±3.1) [5] and using DSS.research.com sample size calculation at 5% ∝ error (95% significance) and 20% β error (80% power of the study). Moreover, 53. 5% for incomplete data was added. So, the sample size would be 110 and divided randomly to study and control group; 55 patients in each group. The exclusion criteria included Patients who have severe immune deficiency, hematologic disorder, undergoing long term immunosuppressive/ chemotherapy therapy, radiation therapy and Patients with lung fibrosis.

Tools of Data Collection

- **Tool I: patient's demographic and health relevant data**

This tool was developed by the researcher after reviewing recent related literature. It included patient's demographic data and health relevant data such as age, sex, date of admission, date of discharge, diagnosis, method of nutrition, time of intubation, time of extubation, duration of intubation, tube size, mode of ventilator, and Glasgow Coma Score.

- **Tool II: Clinical Pulmonary Infection scale (CPIS)**

This scale was adopted from the practice of emergency and critical care neurology [6]. Clinical Pulmonary Infection scale was calculated from the first five variables (temperature, leukocytes count, tracheal secretions, chest

x-ray infiltrates, Pao2/Fio2). The CPIS culture were calculated from the CPIS base line score by adding two more points when gram stains or culture were positive. A score of more than seven at baseline or after incorporating the gram stains (CPIS gram) or culture (CPIS culture) results was considered suggestive of pneumonia and and less than seven free from pnueumonia [6]. The minimum score was zero and the maximum score was 14.

Validity and reliability of the tools

The tools were tested for content- related validity by a panel of 5 experts in Critical Care and Emergency Nursing Department, Medical-Surgical Nursing Department, Anesthesia and Intensive Care Department Faculty of Medicine, Mansoura University and Cairo University who reviewed the tool for clarity, relevance, understanding, and the feasibility for implementation. According to their opinion's modifications were made. Internal consistency reliability was assessed and tested whether all items in an instrument measure the same variable and internal consistency reliability was tested and retested via Cronbach's Alpha to indicate how well the items in an instrument fit together conceptually. The CPIS tool has been established and analyzed by Cronbach's Alpha test and found to be =0.84.

Pilot Study

A pilot study was carried out on 5 patients (10% of the total sample) to test the feasibility, objectivity and applicability of the tools, estimate the time needed to fill data collection tools. Based on result of the pilot study, necessary modifications were done accordingly prior to data collection. Some items have been rephrased to be clear and understood.

Protection of Human Rights

An Ethical approval was obtained from the research Ethical Committee. As well, an official letter to conduct the study was obtained from the hospital administrative authority was attained. Informed consent was obtained from the patients. Anonymity and Confidentiality were assured through coding of all data, subjects were assured that this data will not be reused in another research without their permission; the data collected was used in the purpose of the research.

Procedure

The current study was conducted through two phases: preparation and implementation phase:

Preparation phase

This phase involved developing of the study tools through reviewing of related literature. Later, tool 1 was fulfilled from the patients' records. Later, after 7 days of maintaining the cuff pressure between 20-30 cm H_2O for the study group. At the same time the control group subjects underwent the routine cuff pressure monitoring. Next, the CPIS was calculated for both groups. This phase lasted from May till September 2016.

Implementation phase

110 mechanically ventilated patients were randomly allocated into two groups by means of block randomization (block size of 4) using the concealed envelope mode. Later, they were divided into study and control group. The study group that consisted of 55 patients has undergone adjustment of cuff pressure between 20-30 cm H_2O. This phase was achieved after training the nurses on the technique of cuff pressure measuring, its maintenance and the way for recording it in the observation notes. On the other hand, the control group had undergone random inflation of endotracheal cuff by other nursing staff. Modified Clinical Pulmonary Infection scale was calculated on admission, after 3 days and 7 days of intervention in both groups. The minimum score is (0) and the maximum score is (14). After implementation nurses' checklist for monitoring cuff pressure among critically ill patients with the manometer every 8 hours between 20- 30 cm H_2O for 7 days. A comparison was done between study and control groups to determine the occurrence of VAP for both groups by using Modified Clinical Pulmonary Infection scale (tool II). This phase lasted from October 2016 to January 2017.

Data Analysis

Upon completion of data collection, data were tabulated and analyzed using the Statically Package for Social Sciences version 16 (SPSS, Inc., Chicago, IL, USA). 0.05 level was used as the cut off value for statistical significance and the following statistical measure were used. Number and percentage were used for describing and summarizing qualitative data. While chi square test was used as measure of central tendency and dispersion respectively for normally distributed quantitative data. The level of significant was adopted at $p<0.05$.

Results

Table 1 shows frequency distribution of study and control groups by their demographic characteristics. It is apparent that half of patients (50.9%) in both study and control groups, their age was more than 60 years.

However, no significant differences were found among them. In relation to gender, nearly two thirds of the study groups were females (61.8%) and half of males is present in control group (52.7%). However, no significant differences were found between them (X2 =2.3, p =0.126). Regarding the body mass index (BMI), it was observed that half of patients in both groups were overweight (58.2% & 52.7% respectively for the control and study group). In relation to smoking status, the current findings revealed that the smokers were slightly higher in the control group (45.5%) than the study group (30.9%). However, no significant differences were found between them (X2 =2.46, p =0.1).

Variable	Control group		Study group		Chi square test	
	n	%	n	%	X^2	p
Age						
20 – 29	4	7.3	0	0	4.151	0.042
30 – 39	3	5.5	10	18.2	4.274	0.039
40 – 49	13	23.6	7	7.3	2.2	0.138
50 – 59	7	12.7	13	23.6	2.2	0.138
>60	28	50.9	28	50.9	0	1
Gender						
Females	26	47.30%	34	61.80%	2.347	0.126
Males	29	52.70%	21	38.20%	2.347	0.126
BMI						
Normal	15	27.30%	10	18.20%	1.294	0.255
Overweight	32	58.20%	29	52.70%	0.331	0.565
Obese	8	14.50%	16	29.10%	3.411	0.065
Smoking status	25	45.50%	17	30.90%	2.465	0.116

Table 1: Frequency distribution of study and control groups by their demographic characteristics (n=110).

Variable	Control group		Study group		Chi square test	
	n	%	n	%	X2	p
Past medical history						
Respiratory diseases	36	65.50%	35	63.60%	2.037	0.154
Cardiac diseases	39	71%	37	67.20%	0.374	0.541
DM	31	65.40%	39	70.90%	1.387	0.239
Renal failure	0	0%	3	5.50%	3.084	0.079
Present diagnosis						
COPD	12	21.80%	7	12.70%	1.591	0.207
Pulmonary edema	8	14.50%	4	7.30%	1.497	0.221
Lung abscess	4	7.30%	7	12.70%	0.909	0.34
Pulmonary Embolism	4	7.30%	9	16.40%	2.181	0.14
Others	4	7.30%	7	12.70%	0.909	0.34
Chest auscultation						
Wheezes	51	92.70%	46	83.60%	2.181	0.14
Crackles	4	7.30%	9	16.40%	2.181	0.14
Method of feeding						
No	5	9.10%	0	0%	5.238	0.022
Nasogastric feeding	44	80.00%	47	85.50%	0.573	0.449
Parenteral feeding	6	10.90%	8	14.50%	0.327	0.567
Sedative drug use	32	58.20%	34	61.80%	0.152	0.697

Table 2: Comparison between control and study groups in relation to baseline health relevant data.

Table 2 illustrates comparison between control and study groups in relation to health relevant data. Two third of patients had past history of respiratory diseases (65.5% versus 63.6% in the control and study groups

respectively), cardiac diseases (71% versus 67.2% respectively) and diabetes (65.4% versus 70.9% respectively). In relation to the current diagnosis, COPD and pulmonary edema, lung abscess and pulmonary embolism were found in both groups but slightly higher in control group than study group except pulmonary embolism. Moreover, nearly half of subjects in both groups were complaining of wheezing. Concerning the type of nutrition, half of both groups administered feeding through nasogastric tube (44% versus 47% in the control and study groups respectively). However, no significant differences were detected among them.

CIPS score	Control group		Study group		Chi square test	
	n	%	n	%	X2	p
At baseline (before intervention)						
<7	55	100%	55	100%	0	1
≥7	0	0%	0	0%	0	1
After 3 days						
<7	52	94.50%	55	100%	3.084	0.079
≥7	3	5.50%	0	0%	3.084	0.079
After 7 days						
<7	41	74.50%	53	96.40%	10.53	<0.001
≥7	14	25.50%	2	3.60%	10.53	<0.001

Table 3: Comparison of the clinical pulmonary infection score (CPIS) between the control group and study group at the baseline, three and seven days after maintaining cuff pressure intervention (n=110).

Table 3 shows comparison of the clinical pulmonary infection score (CPIS) between the control group and study group. High significant statistical difference was found between the study and control groups regarding CPIS score on the seventh day. (X_2 = 10.53, p <0.001). So, most of study group has got CPIS <7 (96.4%) when compared to control group (74.5%).

Variable	Control group		Study group		Chi square test	
	n	%	n	%	X2	p
Duration of hospital stay*						
1 – 7 days	18	38.30%	31	58.50%	4.064	0.044
> 7 days	29	61.70%	22	41.50%	4.064	0.044
Duration of intubation						
1 – 7 days	28	50.90%	36	65.50%	2.391	0.122
8 – 14 days	19	34.50%	19	34.50%	0	1
> 14 days	8	14.50%	0	0%	8.627	0.003
Deaths	8	14.50%	2	3.60%	3.96	0.047

Table 4: Comparison of duration of hospital stay, duration of intubation and mortality rate between the control and study groups (n=110).

Table 4 shows comparison of duration of hospital stay, duration of intubation and mortality rate between the control and study groups. Two third of patients in control group stayed at hospital for more than 7 days (61.7%). On the contrary, nearly half of patients (58.5%). In study group stayed at 1-7 days in hospital (X2 = 4.064, P = 0.044). Also, more than two thirds of study group have been intubated from (1-7) days (65.5%) versus the control group (50.9%). Moreover, 14.5% of the control group stayed more than 14 days when compared to nothing in the study group (0%). Regarding incidence of mortality rate, it was observed that it was about 14.5% in control group versus 3.6% in study group and showed significant statistical different (X2 = 3.960, P = 0.047).

Discussion

The current study aimed to assess the effect of maintaining the tracheal cuff pressure on the occurrence of ventilator associated pneumonia in critically ill patients. Therefore, the researchers hypothesized that the patients who will be exposed to maintaining tracheal cuff pressure between 20-30 cm H_2o will reduce the occurrence of ventilator associated pneumonia than patients who will

not be exposed. The findings of this study showed a highly significant reducing effect on the incidence of VAP when compared to traditional endotracheal cuff pressure that maintained by palpation for cuff inflation among the control group. This finding may have relevance to that continuous control of endotracheal tube cuff pressure is associated with decreased micro-aspiration of gastric content that may reduce significantly the occurrence of ventilator-associated pneumonia [7].

This result is supported by Sole ML, et al. [8] who investigated the effect adding or removing air on the proportion of time that cuff pressure was between 20 and 30 cm H2O and evaluated the changes in cuff pressure over time. That study revealed that intervention was effective in maintaining cuff pressure within an optimal range, and cuff pressure decreased over time without intervention. When using palpation for cuff inflation operators rarely achieved optimal intracuff pressures. Moreover, experience had no effect on this skill and, as such, a cuff manometer is recommended [9].

Similarly, a similar study done by Othman HA, et al. [10] at the emergency intensive care unit at Zagazig University Hospitals in Egypt utilized a simplified version of the clinical pulmonary infection score (CPIS) to diagnose the presence of VAP. They revealed a high significant statistical difference among the studied patients on the 7th day. Therefore, this finding motivated to utilize that approach utilizing this scale to detect pneumonia as early as possible.

Additionally, Jansson M [11] stated that ventilator-associated pneumonia (VAP) causing a two-fold increase in mortality rates and extra costs, in addition to the prolonged use of ventilators and extended stays in intensive care units. The current study findings showed high statistical differences in the hospital stay lengths between the study and control group. So, the patients who stayed at hospital up to seven days represented more than two thirds of the study group. While, patients who stayed at hospital more than seven days constituted more than half in control group. From the researcher point of view, the risk of VAP is not only related to length of stay in the ICU setting, but it may have relevance to the length of stay, the number and type of invasive procedures done. This view is in line with a study done by Eagye KJ, et al. [12] who studied the impact of super infection on the hospital length of stay and costs in patients with ventilator-associated pneumonia and found that the extra use of antibiotics for patient management exaggerate the costs and increasing the hospital stay. Furthermore , other study done by Rosenthal VD, et al. [13] supported our study findings and reported that the incidence of VAP prolonged Length of stay by an average of two days, and increased the risk of death by 14 %.

Conclusion

The current findings that the patients in the study group who exposed to maintaining endotracheal cuff pressure between 20:30 cm H2O showed decreased occurrence of VAP, decreased length of intubation and hospital stay when compared with the control group.

Recommendations

Replication of the study on a large probability sample selected from different geographical areas of Egypt and in general ICU. Furthermore, studying the barriers facing the nurses to maintain endotracheal cuff pressure.

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