

Effectiveness of pressure adjustment on attaining a safe cuff pressure inflation in elderly critically ill patients

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Abstract:

Background: The endotracheal tube (ETT) cuff pressure must be in a safe range that ensures delivery of the prescribed mechanical ventilation tidal volume, reduces the risk for aspiration of secretions that accumulate above the cuff, and does not compromise tracheal perfusion. Maintaining the ETT cuff pressure within an optimal range is challenging because many factors influence the pressure, such as the patient's position and suctioning, so monitoring and maintaining ETT cuff pressure within normal and safe range considered as one of the important roles of the critical care nurses.

Aim: to examine the effectiveness of pressure adjustment on attaining a safe cuff inflation pressure in elderly critically ill patients.

Subjects and Methods: A Quasi experimental study was conducted on 33 elderly critically ill patients admitted to CCU department in the selected hospital. Data were collected using endotracheal tube cuff Pressure record (ETT cPR) designed by the researchers.

Results: Cuff pressure readings changed in both the control and study days overtime. The number of cP adjustments ranged from 2 to 3 times per patient (mean, 2.09; SD, .89), and 81.16 % of these were to add air to the cuff. Addition of air was the only intervention for 22 patients, whereas air removal was the only intervention for 4 patients.

Conclusion: Cuff pressure readings were fluctuating in both the control and study days overtime. Cuff pressure adjustments were effective in attaining safe cuff inflation pressure as there was improvement in cuff pressure readings with cuff pressure adjustment in the study day comparing with the readings in the control day.

Recommendation: Frequent cuff pressure monitoring is needed for all intubated patients and nurses should be trained on cuff pressure inflation to maintain the cuff pressure within safe and normal range.

Keywords: Critical care, Elderly, Endotracheal Tube, Cuff Pressure.

I. Introduction

There is a huge increase in the elderly population worldwide. Most of critically ill patients are elderly, and the increased number of persons aged more than 65 years will lead to increase health-care costs. Aging affects a number of parameters of lung function, such as gas exchange, ventilation, and compliance, as well as pulmonary defense mechanisms. Thus, the consequences are early collapse smaller distal airways, dilated alveolar ducts, and fewer gas exchange surfaces. Air trapping and gas exchange problems appear as manifestations from these changes⁽¹⁻³⁾.

Elderly critically ill patients with impaired ventilatory function often need invasive mechanical ventilation (MV) to maintain adequate pulmonary ventilation. The artificial airways most often used in MV are the endotracheal tubes (ETT) and tracheostomy tube⁽¹⁾. Nurses play an important role in the management of the artificial airway. Maintenance of an adequate pressure in the ETT cuff is an important aspect of airway management. ETT The cuff is inflated to seal the airway to deliver MV. A cuff pressure (cP) between 20 and 30 cm H₂O is recommended to provide an adequate seal and decrease complications risk. Survey results indicate that cP is usually monitored and adjusted every 8 to 12 hours Cuff pressure readings were fluctuating in both the control and study days overtime⁽⁴⁾.

ETT cP differs and may be out of range during the interval between intermittent measurements, increasing the risk for complications. Therefore, the safety margin of ETT cP is determined between under-inflation and over-inflation. Under-inflation causes leakage of air, which reduces the effect of mechanical ventilation. In addition, ETT cP below 20 cmH₂O increasing the risk factor of ventilator associated pneumonia (VAP). However, over-inflation of the ETT cuff causes a serious injury and affect blood flow to the tracheal mucosa, causing tracheal stenosis, tracheal rupture, or tracheoesophageal fistula^(5,6).

The ETT cP must be in a range that does not compromise tracheal perfusion ensures delivery of the prescribed MV, tidal volume and decreases the risk for aspiration of secretions that accumulate above the cuff. Studies recommend a minimal ETT cP of 20 cm H₂O to prevent aspiration and VAP. In a study of 83 subjects,

and found a 4-fold risk for VAP when the ETT cP was less than 20 cm H₂O. The amount of air needed to achieve a pressure of 20 cm H₂O is small, ranging from 2.6 mL for a 7.0-mm ETT to 3.3 mL for an 8.5-mm tube. The pressure needed to seal the airway has not been extensively studied⁽⁷⁾.

In a study of 50 intubated patients with a 7.0-mm ETT, the mean cP required for an adequate seal was 19.1 cm during pressure control ventilation⁽⁸⁾. Some newer ETTs are made with a thin-walled polyurethane cuff, which may seal at a pressure as low as 9.5 cm H₂O. The ETT cP associated with impaired tracheal capillary perfusion ranges between 30 and 50 cm H₂O. Persistent over-inflation of the ETT cuff increases the risk for tracheal damage: fistula, damage of the tracheal wall, subglottic stenosis or scarring, hoarseness and nerve damage⁽⁸⁻¹⁴⁾.

Maintaining ETT cP within an optimal range is challenging. 54% to 75% of ETT cuff measurements were between 15 and 30 cm H₂O in observational studies that used continuous monitoring of pressure. Nseir et al⁽⁹⁾ studied cP in 101 patients for 808 hours. ETT cP was adjusted to 25 cm H₂O and continuous monitoring was started. Under-inflation was noted in more than half of patients, while over-inflation occurred in three quarters of patients. One-third of patients sustained under-inflation or over-inflation for more than 30 minutes. Under-inflation was associated with longer duration of intubation and no specific adverse outcomes for over-inflation were reported⁽⁹⁾.

Specialized endotracheal tubes and different devices have been developed to maintain ETT cP. These tubes and devices maintain the cP better than intermittent adjustment; however, a reduction in complications has not yet been shown. In a crossover study, Duguet et al⁽⁸⁾ tested an air-controlled device in patients receiving MV. During the control day, cP was adjusted and monitored twice a day to maintain an ETT cP within the safe range. During the intervention day, the pressure was regulated with the device. The device maintained the cP in the desired range of 15 to 30 cm H₂O for 95% of the time, compared with 56% of the time that pressures were in the desired range during the control condition. However, the outcome data were not collected. Valencia et al⁽⁶⁾ did a trial using an automatic device to regulate the ETT cP. Subjects were randomized to either usual care or the device within 24 hours of intubation. Under-inflation was observed in 45% of the measurements during the control condition versus 0.7% in the automatic group. There were not any differences in VAP rate, causative organisms, or mortality⁽⁶⁾.

ETT cP often changes over time. Sole et al⁽¹⁰⁾ noted decreases in ETT cP within 4 to 12 hours after adjustment of the pressure to 20 cm H₂O. In the same line, Sridemma et al⁽¹⁴⁾ noted that cP decreased to 20 cm H₂O in 4 to 5 hours after initial adjustment to 25 cm H₂O. Similar findings were reported when cP was monitored continuously. Longer duration of intubation was associated with greater decreases in pressure over time⁽¹⁴⁾.

Many studies recommend that ETT cP above 30 cmH₂O should be avoided⁽¹¹⁻¹⁵⁾. An experimental study reported that maintaining cP under 30 cmH₂O is safe as there is no injury in the mucosa associated with these pressures. Other research by Jain et al.⁽¹⁶⁾ reported complications of over-inflation of ETTcuff include nerve palsy, tracheoesophageal fistula, tracheal wall damage, subglottic scarring or pressure including; stenosis and hoarseness. Under-inflation of ETT is associated with inadequate delivery of prescribed tidal volume and aspiration of secretions⁽¹⁰⁾. No study about this topic was conducted in the Arabic nations.

II. Significance of the study

There is an increasing demand for critical care services in Kingdom of Saudi Arabia (KSA) and globally, this demand is attributable to the increasing population age and longer survival. Increased rate of elderly admission to intensive care units due to many causes such as the physiological changes that occur overtime in their systems, mainly changes in their immune and respiratory systems that may require an immediate intubation for ventilation and oxygenation. One method of intubation is inserting an ETT, and critical care nurses play an important role to keep monitoring and adjusting the ETT cP to facilitate adequate ventilation and oxygenation, maintain it in the normal and safe range of cP.

Excessive cP increases the risk of tracheal injury and stenosis, and insufficient cP can result in air leakage, aspiration, and unplanned extubation. In hospital routine, it is noted that many nurses neglect measurement of cP. When verification is carried out, it usually is made by digital palpation of the external cuff (pilot) which is not a reliable measurement⁽¹⁾.

The importance of ETT cP monitoring is to assess the accuracy and feasibility of continuous monitoring of cP, describe changes in cP over time, and identify clinical factors that influence cP. There is no local researches conducted in KSA to maintain safe cP inflation and /or to monitor changes in ETT cP. Therefore, **this study aimed** to examine the effectiveness of pressure adjustment on attaining a safe cuff inflation pressure in elderly critically ill patients. **Hypothesis;** the intervention is effective in maintaining cP within an optimal range, and cP decrease over time without intervention. **Cuff pressure adjustment is** adding or removing air to maintain cP readings within safe range (20 - 30 cmH₂O).

III. Subject and method

Study Design:

This study was quasi-experimental research design in which a randomized, repeated measures crossover design. Subjects were randomly assigned to either the intervention or the control group on day 1 with a crossover to the other condition on day 2. In this design, subjects serve as their own controls.

Setting:

The present study was conducted at two selected hospitals in Makkah in KSA. Subjects were recruited from two intensive care units (general intensive care unit in each hospital). Subjects were under the care of either a medical or surgical intensivist team.

Subject:

A convenience sample of 33 elderly critically ill patients were enrolled in the study between November 2014 and June 2015. Inclusion criteria were age 50 years or older, oral endotracheal intubation, and conventional mechanical ventilation. Tracheostomy, high-frequency oscillatory ventilation, and prone positioning were exclusion criteria. The statistician estimated the sample size needed to assess the ability of the intervention to maintain the ETT cP within an optimal range. A sample of 24 patients who experienced both the control and intervention conditions was needed to detect a large effect (1.00) at an α of .05 with at least 80% power. Based on estimated attrition between days 1 and 2 of data collection, the target enrollment was 33 patients. Data were collected during both control and intervention conditions for 32 patients.

The data collection instrument was "Endotracheal tube cuff pressure record" (ETT cPR). This tool was developed by the researchers after reviewing the related literatures⁽⁸⁻¹⁴⁾ to record readings of ETT cP. This record will include three parts:

- Part 1; Demographic data and patients' characteristics as age, sex, level of consciousness, diagnosis, height, weight, body mass index (calculated as the weight in kilograms divided by the height in meters squared), APACHE III score and length of hospital stay. All these data were collected from the medical record and via direct observation of physiological variables and ventilator settings.
- Part 2; Hemodynamic parameters as, heart rate (beats per minute), temperature (°C) and respiratory rate (breaths per minute).
- Part 3; Ventilator parameters; as Fraction of inspired oxygen (FiO₂), Positive end-expiratory pressure (cmH₂O), Oxygen saturation (%) and Mean airway pressure (cmH₂O).
- Part 4; Endotracheal tube care: Position of endotracheal tube, size of endotracheal tube (mm), cP monitoring using cP manometer (cmH₂O), activity data (for example, turning and suctioning is recorded as done / not done) and intubated days.

Scoring System:

Cuff pressure (cP) value is considered normal when it is from 20 to 25 cm H₂O. Below 20 cm H₂O is considered under-inflation (low cuff pressure value) and above 25 cm H₂O is considered over-inflation (high cuff pressure value).

IV. Tools validity and reliability:

The current study tool was submitted to five academic nursing experts in the critical care & emergency nursing and the nursing education fields to test the face and content validity of the tool, the necessary modifications were carried out according to the academic nursing experts' judgment on clarity of sentences and the appropriateness of the content. Tool reliability was tested using internal consistency methods (Alpha Cronbach test). Its result was 0.93 which indicates that the tool is highly reliable to be used for the study.

Pilot Study

A pilot study was conducted on 4 (12%) patients. They were selected from the previously mentioned study settings according to inclusion criteria to assess the current study tools for its clarity, validity, applicability and the time required to fill the tool. Necessary modifications of the tool were done according to pilot results to reach the finalized form. The subjects who included in the pilot study were excluded from the total study sample.

V. Procedure

The study was achieved through three phases namely; assessment, implementation, and evaluation. This study started from November 2014 to the end of June 2015. The researchers began with introducing themselves and providing clear explanation about the nature, aim and purpose of the current study to the patients

and/or patients' surrogates. They informed that sharing in this study is voluntary. The research ethical committee at both the university and the hospital approved the study. Informed consent was obtained from surrogates of critically ill patients who met the eligibility criteria. If the patient was alert and responsive, consent was also obtained at the time of data collection. Trained nurses collected all data, and delivered the intervention. They demonstrated competency in setting up the equipment, recording observational data, recording cuff pressure data, and implementing the intervention. Interrater reliability was established for all procedures. The principal investigator did ongoing observation of adherence to data collection procedures.

Data were collected during the 8:00 AM to 8:00 PM shift for two days. During both control and intervention conditions, monitoring of ETT cP was initiated and the pressure was adjusted to 20 cm H₂O in all patients or higher (less than 30 cm H₂O) if needed to achieve a seal (as intensivist instructions). *Regardless of group, air was added to the cuff if a leak was audible or a ventilator alarm for low exhaled tidal volume indicated an inadequate cuff pressure (clinical trigger)*. Hemodynamic parameters and ventilator parameters data were recorded hourly, while cP measurement was recorded three times, each time every 4 hours and observations of patient care and activities (e.g., suctioning, positioning, turning) were recorded on the Endotracheal tube cuff pressure record" (ETT cP R) by the research assistant as they occurred. Nursing and respiratory care staff delivered usual care to all patients in both conditions. The routine care for patients in the units is measuring cuff pressure once on ETT intubation. Patients were randomly assigned to either the intervention or the control day on day 1 with a crossover to the other condition on day 2. In this design, subjects serve as their own controls.

Assessment phase

The purpose of this phase was to collect baseline data regarding ETT cP in elderly critically ill patients. Demographic data and patients' characteristics, hemodynamic parameters, ventilator parameters and endotracheal tube care including position of endotracheal tube, size of endotracheal tube (mm), cP monitoring using cP manometer (cm H₂O), activity data (for example, turning and suctioning) and intubated days were collected for all patients in both conditions using the tool of the study.

Technique of measurement; the cP manometer is attached to the pilot balloon port and the cP is read as shown in the manometer. Ideal pressure (known as minimal occlusive volume) is lowest amount needed to seal airway. Studies recommend maintaining the cP lower than venous perfusion pressure-usually about 20 to 30 cm H₂O. (More than 30 cm H₂O may exceed venous perfusion pressure.) The connection between measuring device and pilot balloon port should be kept tight to avoid an air leak that could compromise cP. The cP value is documented for both control and intervention conditions.

Implementation phase

After 4 hours of the baseline measurement, cP was measured using cP manometer and recorded for both control and intervention conditions.

Intervention condition; If ETT cP is low (below 20 cmH₂O) or high (30 cmH₂O), a quick assessment of the potential causes was done. The researcher places the diaphragm of the stethoscope over the trachea and listens for an air leak. A smooth, hollow sound indicates a sealed airway; a loud, gurgling sound indicates an air leak. In case that an air leak is not heard, the button of the manometer is pressed under the dial of the cP to slowly release air from the balloon on the tracheal tube and auscultation for an air leak should be done. As soon as an air leak is heard, the manometer button is released and the handle of the cP manometer is squeezed gently to inflate the cuff. Adding air to the cuff should be continued until an air leak is no longer heard. When the air leak ceases, the dial on the cP manometer is read. This measurement is the minimal pressure required to effectively occlude the trachea around the tracheal tube. The pressure value should be within the green area (20 to 25 cm H₂O) on the manometer dial. Then the cP manometer is disconnected from the pilot balloon port and the pressure value is documented using the study instrument.

Therefore, if a low cP is sustained, air is added to the ETT cuff and adjustments were made until a pressure of at least 20 cmH₂O is achieved. If a high cP is sustained, air is removed from the ETT cuff until the pressure is sustained below 30 cmH₂O.

Evaluation phase

Variation of ETT cP values in the control day were reported. A comparison was made between the baseline measurements and the subsequent readings in both control and intervention conditions.

Administrative design and ethical considerations

The study conducted over a period of 8 months from November 2014 to the end of June 2015. An official letter clarifying the purpose and setting of the study was obtained from the ethical committee and the hospital authority to conduct the study. Written informed consent was obtained from each conscious patient or from the responsible person (if unconscious patient). It included the aim of the study, potential benefits, risks and discomforts from participation. The anonymity, confidentiality and privacy of responses, voluntary participation and right to refuse to participate in the study were emphasized to subjects.

Statistical analysis

Statistical Package for Social Sciences (SPSS) version 17.0 was used for quantitative data analysis. Data were presented using descriptive statistics in the form of frequencies and percentages for qualitative variables and means and standard deviations and medians for quantitative variables. Cronbach alpha coefficient was calculated to assess the reliability of the developed tool through their internal consistency. Quantitative data were compared using independent samples t-test. A significant P-value was considered when p less than .05 and highly significant when P-value less than or equal .01.

VI. Results

Sample

Demographic data and baseline characteristics for all subjects are summarized in tables 1,2. Most of the patients were at age group 60-74 years old with 25(75.75%) patients, male and female groups were nearly equal as male; 17 (51.5%) patients and 16 (48.5%) patients were female. The mean height of the patients was 160.81 cm (SD, 13.21). The mean weight of the patients was 65.92 Kgm (SD, 14.18). The mean of body mass index (BMI) of the patients was 24.09 (SD, 4.91). The mean length of stay of the patients was 6 days (SD, 5.68). The mean APACHI III score of the patients was 49.54 (SD, 19.77). Patients had been intubated a mean of 4 days (SD, 2.83) at the beginning of the study (Table 1).

Nearly ninety percent of patients admitted to the critical care unit respiratory disorders. Turning was performed every 2 hours and suctioning every 4 hours for all patients as unit policy. All patients had a standard 7.5- or 8.0-mm tube. Nearly all subjects were treated with synchronized intermittent mandatory ventilation (95% on the control day; 97% on the intervention day). The others were on assist-control ventilation. The patients' physiological characteristics were nearly stable and did not change significantly between the control and intervention conditions (Table 2).

Table (1) Distribution of elderly critically ill patients according to their basic characteristics:

Variable	N	%
Age /years		
60-	25	75.75
75-	4	12.12
85- older	4	12.12
Mean age = 67.76		
Gender		
Male	17	51.5
Female	16	48.5
Characteristics		
Items	Mean	SD
Height/cm	160.81	13.21
Weight /kgm	65.92	14.18
BMI	24.09	4.91
Length of stay/days	5.96	5.68
APACHI III score	49.54	19.77
Intubated days/ days	4.29	2.83
Diagnosis		
	N	%
Respiratory disorder	29	87.9
Endocrine/metabolic disorder	11	33.3
Cardiovascular disorder	9	27.3
Infectious disorder	8	24.2
Renal disorder	6	18.2
Neurological disorder	5	15.2
Gastrointestinal disorder	3	11.5
Others (trauma)	3	9.1

Table 2 Hemodynamic parameters of the subjects in the control and intervention days.

Parameter	Control day		Intervention day		t. value	p. value
	Mean	SD	Mean	SD		
Temperature	37.12	0.70	37.15	0.18	0.19	0.85
Pulse Rate	99.86	4.22	96.36	10.56	1.57	0.12
Respiration Rate	20.07	0.50	22.37	2.11	5.41	0.001
Blood Pressure	130.10	9.12	131.35	12.79	0.41	0.69
Mean arterial pressure	101.58	10.29	92.49	15.95	2.44	0.02
SpO2	98.92	1.18	93.81	8.30	3.11	0.01

ETT cP readings changes in the control day over time

Data collected during the control day were analyzed to assess whether ETT cP readings decreased over time without intervention. Obvious changes; increases/ decreases in pressure data were noted in the control day. A simple linear model of cP on time for all patients in this day was done. The t test statistic was 3.94 (P = 0.001), indicates changes in ETT cP over time that necessitate ETT cP monitoring frequently however; these changes were not statistically significant.

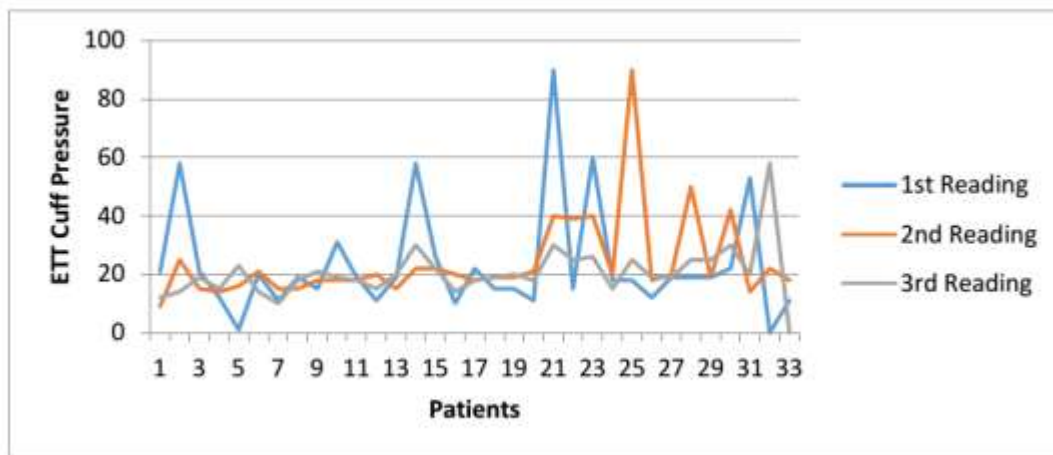


Fig. 1: ETT cP readings changes in the control day over time

Effectiveness of ETT cP adjustment

Thirty-three patients had data collected during the intervention condition. The number of cP adjustments ranged from 2 to 3 per patient (mean, 2.09; SD, .89), and 81.16 % of these were to add air to the cuff. Addition of air was the only intervention for 22 patients, whereas air removal was the only intervention for 4 patients. Six patients required both addition and removal of air and only one patient who does not need any adjustments. The mean total amount of air added to the cuff was 10.06 (SD, 4.66) mL. The mean amount of air removed from the cuff was 28.41 (SD, 8.12) mL. After the first and second readings, adjustment were done. However, cP readings changed in the second and third readings.

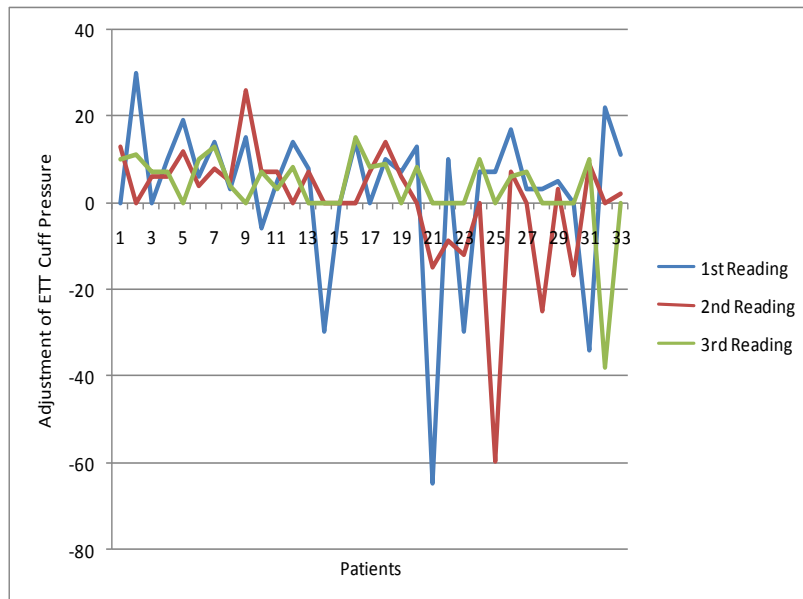


Fig. 2 ETT cP adjustment in the intervention day

Variability of ETT CP

The ETT CP adjustment was effective in maintaining the CP within safe range as table (3) shows that 10 (30.3%) patients in the control day had under-inflation in the first reading and they increased to 12 (36.4%) patients by the third reading. In the intervention day, 5 (15.2%) patients had over-inflation in first reading and improved by cP adjustments to be only 1 (3.0%) patient in the third reading. In addition, 5 (15.2%) patients in the intervention day were at normal level in first reading and increased by cP adjustments to be 14 (42.4%) patients in the third reading. However, the differences in CP readings between patients in the control and intervention days were not statistically significant (p 0.70).

Table (3) Relationship between control and study group in ETT cuff pressure readings:

Level/reading	Control day			Study day			P
	1 st	2 nd	3 rd	1 st	2 nd	3 rd	
Over-inflation	7 (21.1%)	4 (12.1%)	4 (12.1%)	5 (15.2%)	6 (18.2%)	1 (3.0%)	0.70
Normal	16 (48.5%)	16 (48.5%)	17 (51.5%)	5 (15.2%)	9 (27.3%)	14 (42.4%)	
Under-inflation	10 (30.3%)	13 (39.4%)	12 (36.4%)	23 (69.6%)	18 (54.5%)	18 (54.5%)	

VII. Discussion

Endotracheal tubes have become essential for securing the airway especially in elderly critically ill patients with MV. Large volume cuffs are ideal for generating low seal pressures. High volume low-pressure endotracheal tube cuffs are able to achieve minimal lateral tracheal wall pressure by affecting a clinical airtight seal at low intra-cuff pressures allowing delivery of predetermined tidal volumes into the lungs. However, these cuffs can also generate high intra-cuff and lateral tracheal wall pressures when inflated beyond the seal pressure. Cuff pressures greater than 30 cm H₂O are known to obstruct tracheal capillary blood flow with total occlusion of flow occurring at pressures above 50 cm H₂O (8-10).

Both over- and under-inflation of ETT cuffs have adverse complications. ETT cP must be maintained within a therapeutic range (25 - 30 cmH₂O) that is high enough to ensure delivery of MV and prevention of aspiration, but low enough to ensure perfusion to the tracheal capillaries without causing injury. Unfortunately, most nurses give little attention to inflation pressure of the ETT cuff, and simply determine the cP by estimation techniques according to their experience (5,13-15). Ensuring patients' safety is becoming increasingly important role for critical care nurses and monitoring and maintain cP within the safe range is one of the ways to ensure

this safety. Therefore, the aim of this study was to examine the effectiveness of pressure adjustment on attaining a safe cP inflation in elderly critically ill patients.

The subjects of the study were elderly population as the physiological changes that occur in that period of life, they are more prone to complications in CCU and they need special nursing care. *From the result of the current study, increases/ decreases in ETT cP were noted in the control day over time. Even in the intervention day, after the first and second readings, adjustment were done. However, cP readings changed in the second and third readings.* These results validate findings reported by many studies. Sole et al. ⁽¹⁰⁾ stated that some patients required intervention within the first hour after the pressure was adjusted to 22 cm H₂O at the beginning of data collection. Sridermma et al ⁽¹⁴⁾ reported a decrease to 20 cm H₂O within 4 to 5 hours after adjustment to 25 cm H₂O. Nevertheless, patients in the current study were in the same age group, with slight differences in their diagnoses, nearly the same number in both genders and the same severity level on APACHE III scoring system. So the variation in ETT cP could be related to time factor.

Similar to the findings of the current study, Nseir et al ⁽⁹⁾ studied the occurrence of variations in ETT cP in intubated critically ill patients. The researchers performed continuous recording of cP for 8 hours in 101 patients after manual adjustment of ETT cP and reported under-inflation in 54% and over-inflation in 73% patients, and 44% patients developed both. In addition, Nseir et al ⁽⁹⁾ reported that One third of patients had under-inflation or over-inflation for more than 30 minutes. In a study of Sole et al ⁽¹¹⁾, which aimed to evaluate an intervention to maintain endotracheal tube cP within therapeutic range, the researchers noted that ETT cP decreased over time and 51.7% of cP values were out of range during 12 hour shift.

In addition, the results of the current study shows that cP adjustment was effective in attaining a safe cP inflation in elderly critically ill patients. Most of the adjustments were adding air. There were improvement in cP readings in the intervention day after cP adjustments and there were differences in cP readings between patients in the control and intervention day. Patients are the same in the control and intervention days, nearly the same diagnosis, same severity score, and same ventilation and hemodynamic parameters. Therefore, this result may be attributed to the adjustment and the continuous monitoring of cP. In addition, the lower starting ETT cP (20 cm H₂O) may be other reason (in some studies, the starting ETT cP was 25 cm H₂O)

The results of the current study are similar to the reported 95% to 98% of values that are within range when devices are used to maintain the cP⁽¹⁰⁾. Duguet et al ⁽⁸⁾ used a cuff manometer twice a day, and after each intervention on the ETT, cP was in the safe range in 56% and in the high range in 29% of the time. In the same line, Maboudi at al ⁽⁵⁾ studied the accuracy of ETT cP adjustment by trained ICU nurses and reported that the adjustment of out of range pressures could decrease the rate of ETT cP over- and under-inflation.

In the same line, Sole et al ⁽¹²⁾ studied cP in patients with mean age, 61.6 years. The researchers noted that during the control day, more than fifty percent of cP values were out of range compared with only eleven percent during the intervention day. In addition, the researchers reported that the intervention was mostly to add air to the ETT cuff ⁽¹⁷⁻²²⁾. In addition, Valencia et al. ⁽⁶⁾ recommended in their study that ETT cP adjustment was effective in maintaining appropriate inflation cP.

Critical care nurses are responsible for care of ETT and one of the important aspects of care is monitoring and maintaining cP within the safe range to promote ventilation and prevent complications ^(5,23). Hedberg et al ⁽²²⁾ conducted a study to describe whether critical care nurses and anesthesiologists identified a very high cP by manual palpation of the external cuff balloon on an ETT. The researchers found that there was no significant relationship between profession and skill in identifying a very high cP or between work experience and skill in terms of identifying a very high cP. Furthermore, the study findings indicated that 10% of patients are at risk of tracheal erosion because of a high cP and recommended continuous ETT cP monitoring.

VIII. Conclusion

It was obvious from the study that there were changes in the cuff pressure monitoring as the cuff pressure readings were fluctuating in both the control and study days overtime. Cuff pressure adjustments were effective in attaining safe cuff inflation pressure, as there was improvement in cuff pressure readings with cuff pressure adjustment in the study day comparing with the readings in the control day.

IX. Recommendations

For practice; critical care nurses assume the responsibility to manage the ETT, therefore, critical care nurses should ensure adequate management of ETT cuff pressure. Cuff pressure values vary over time. It is difficult to maintain cuff pressures within the therapeutic range without continuous monitoring. Since cuff pressure fluctuates, it is important to incorporate procedures for oropharyngeal suctioning and oral care as part of airway management to prevent VAP.

For research, Future research should address the optimal ETT cuff pressure and frequency of cuff pressure measurement for preventing outcomes such as VAP and tracheal damage. Commercial. Additional research is

needed for identification of variables that influence cuff pressure, such as type of tube and duration of intubation. Knowledge of these variables may assist in designing additional interventions to maintain the cuff pressure within an optimal range.

Some limitations were identified in the current study. Collection of data were done only in one shift to assess the interventions that are done routinely. Findings may be different on the night shift. Collection of data were for a small portion of a patient's total time on mechanical ventilation. The effect of the intervention on outcomes, such as VAP, was not assessed because of the limited data collection duration. A comprehensive cuff pressure assessment throughout the mechanical ventilation duration may provide greater evidence of the relationship of cuff pressure to outcomes of mechanical ventilation.

The study also has some strengths. Each patient serve as his /her own control, which counters the problem of nonequivalence between an experimental and a control group. In addition, factors that might influence the cP were eliminated as much as possible by the selection process (exclusion criteria).

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