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Assessment Of Endotracheal Tube Cuff Pressure Among Intubated Patients In Emergency Department, Operating Rooms, And Icus

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Abstract

Background: *Tracheal intubation constitutes a routine part of anesthetic practice both in the operating theatre as well as in the care of critically ill patients. Maintain the Endotracheal Tube Cuff Pressure (ETCP) within safe ranges, which ensures airway patency and provides positive pressure ventilation, is a complex circumstance due to many factors. Although there are recommendations for the prevention of excessive or insufficient ETCP, there is still no consensus based on affecting factors. Establishing and maintaining a secure airway using a cuffed endotracheal tube (E[1]TT) is an important step in management of intubated patients. Out-of-range ETT cuff pressure is associated with various complications which could lengthen the hospital stay.* ***The study aims:*** *To evaluate ETT cuff pressure in intubated patients in the emergency department (ED), operating rooms (ORs), and Intensive Care Units (ICUs).* ***Methods:*** *A cross-sectional study was conducted among intubated patients admitted to ED, ICUs, and ORs of Hospital, Jeddah, KSA from January to July 2022. The ETT cuff pressure of 153 patients was measured using a standard manometer. Demographic data and duration of intubation were recorded. The data were analyzed using the SPSS software version 28. P values less than 0.05 were considered significant.* ***Results:*** *The ETT cuff pressure exceeded the recommended range in 125 out of 153 patients (81.7%). The mean cuff pressure (67.29 cmH2O) was significantly higher than the recommended range ($p<0.001$). The cuff pressure was higher in patients in the ORs compared to patients in the ED and ICU (OR=8.46, $p<0.001$).* ***Conclusion:*** *Intubation in the OR can be considered a risk factor for higher-than-normal ETT cuff pressure and subsequent complications. The ETT cuff pressure monitoring by means of a manometer is recommended.*

Keywords: *Anesthesia; Intubation; Endotracheal tube;Cuff pressure*

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Introduction

Endotracheal intubation is an effective way to provide rapid and safe airway patency and respiratory support in the intensive care unit (ICU), emergency department (ED) and operating rooms (OR) [1]. Endotracheal intubation allows effective isolation of the trachea by inflating the balloon (cuff) of the endotracheal tube (ETT) just below the vocal cords. The inflatable cuff is an important part of endotracheal tube management, which ensures airway patency and positive pressure ventilation. The endotracheal tube cuff pressure (ETCP) should be between 20-30 cmH2O to safely close the airway [2]. It has been reported that excessive inflation of the endotracheal cuff (>30 cmH2 O) causes hoarseness, sore throat, inadequate swallowing of secretions, tracheal stenosis, tracheal wall damage and ischemia due to decreased mucosal capillary blood flow. It has been shown that these effects can occur even in a very short time under high pressure [3].

In contrast, inadequate inflation of the endotracheal cuff (below 20 cmH2 O) causes ventilator associated pneumonia (VAP) due to ineffective ventilation and micro aspiration of gastric secretions and leakage of oropharyngeal and subglottic secretions into the lungs [7]. Keeping ETCP within safe ranges is a complex situation due to many factors [8, 9]. These factors are mainly; patient movements, different neck and head positions, sedation, type of surgical intervention, presence of nasogastric tube, intubation time and intubation tube position [8, 10, 11]. A cuffed endotracheal tube (ETT) with a proper size filled in appropriate pressure (20-30 cmH2O) is the mainstay of securing airway. The cuff is filled with air to provide a barrier against mucosal secretions of the trachea [2].

This barrier facilitates positive pressure ventilation and decreases the chance of aspiration of gastric and pharyngeal contents. Filling a high-volume low-pressure cuff with a low volume of air prevents air leak during positive pressure ventilation and decreases the odds of mucosal ischemia due to long-term pressure on the tracheal wall [12]. However, all stages of tracheal intubation may cause injury to the trachea and larynx; for example, destruction of the respiratory cilia mostly occurs just below the cuff two hours after intubation and by a pressure on the tracheal wall of less than 25 mmHg [13]. Other noteworthy complications related to ETT cuff pressure include tracheal stenosis, tracheal rupture, trachea-esophageal fistula, trachea-innominate fistula, and tracheal mucosal injury resulting from ETT cuff hyperinflation [12, 13]. The benefits of a properly placed ETT outweigh the risks associated with intubation. However, if attention is not paid to its complications, hazardous and sometimes irreversible problems may occur [12, 13].

An ETT cuff pressure more than 30 cmH2O decreases the tracheal mucosal perfusion while blood flow completely disrupts in pressures more than 50 cmH2O. On the other hand, the minimum ETT cuff pressure required for prevention of micro aspiration and ventilator-associated pneumonia is 20 cmH2O. Cuff pressure control at the lower limit of the normal range during the operation decreases postoperative sore throat significantly while suboptimal cuff pressure is associated with micro aspiration, ventilator-associated pneumonia, and ventilation insufficiency [14-18]. There is little knowledge about ETT cuff function and its related injuries [19-20], which can be associated with being extremely low or high pressures. Various factors such as change in patients' position may affect proper maintenance of cuff pressure. On the other hand, the cuff pressure decreases over time [21-23], and ETTs equipped with pressure control systems are expensive [24].

Although inflating the cuff pressure with normal saline produces a more stable pressure, it is not recommended because the cuffs are designed for inflation with air [25, 26]. Studies have shown that cuff pressure control using conventional methods like listening to air leak noise and palpation of the ETT cuff lack the desired efficiency in producing optimal cuff pressures. The experience of the intubating person alone is not enough for controlling ETT cuff pressure [21, 27]. Several studies suggest that cuff pressure exceeds the normal range in many patients admitted to the ICU, OR, ED, and even patients transferred to emergency centers via patient transfer services including air medical services. It is, therefore, logical to measure the ETT cuff pressure after intubation and maintain it in the range of 20-30 cmH2O [16, 26, 28- 36]. The complications of endotracheal intubation have become more apparent because of the increase in the number of endotracheal intubations; moreover, the complications associated with the use of cuff have not been eliminated despite the use of high-volume low- pressure cuffs.

Since tertiary centers usually admit critically ill patients requiring intubation, a cuff pressure more than the optimal range leads to sore throat, stridor, cough, and shortness of breath that could lessen patient satisfaction. Tracheomalacia and trachea-esophageal fistula are complications associated with long-term intubation. Considering the results of previous studies indicating that the cuff pressure is not in the optimal range in most cases and since these studies have not introduced modifiable risk factors, it seems necessary to evaluate the ETT cuff pressure and its determinants in different medical centers [16, 20, 37- 42]. ETT cuff pressure of the patients admitted to the Intensive Care Units (ICUs), Operating Rooms (ORs), and Emergency Department (ED) of Hospital, Jeddah, KSA were evaluated and the possible risk factors were determined to lower the risks associated with low and high ETT cuff pressures in order to better the patient safety and management and devise better plans to decrease complications and length of hospital stay attributed to high cuff pressures.

Methods

This descriptive-analytical study was conducted after obtaining the approval of the Ethics Committee of University. The target population of this study was intubated patients admitted to ED, ICUs, and ORs of Hospital, Jeddah, KSA from January to July 2022. Convenience sampling was done to select the patients. Every intubated patient whose record contained demographic data, intubation time, and intubating person's data was included in the study. The patients who were intubated for surgery were identified in the OR, the ETT cuff pressure was evaluated, and the data were recorded. The patients admitted to the head and neck surgery were not included in the study due to Interference with the surgical field. The sample size was 153 subjects.

Cuff pressure measurement was done using the VBM manometer (Germany) by a trained person. In patients admitted to the OR, cuff pressure was measured after intubation and stability of the patient's status. The manometer was calibrated before and after each measurement. In the ICU, demographic characteristics (age, sex, and weight, duration of intubation, and indication for intubation) were extracted from the patients' records. In all subjects, cuff pressure measurement was done in the supine position with the head aligned with the trunk. Data normality was assessed using the Kolmogorov- Smirnov test. Independent t-test, ANOVA, Spearman correlation coefficient, Pearson correlation coefficient, and generalized linear model were applied to analyze the data. SPSS version 28 was used for data analysis. The results are presented as mean ± standard deviation (SD) and frequency. P values less than 0.05 were considered significant.

Results

One hundred and fifty-three patients admitted to the ED, OR, and ICU were evaluated. Eighty-seven patients (56.9%) were female, and 66 patients (43.1%) were male. (**Table 1**) shows the frequency distribution of the patients in different wards and (**Table 2**) presents the frequency distribution and mean values of the variables. In some cases, cuff pressure had been set by the experience of care giver.

ETT cuff pressure was divided to three groups:

- Group 1: ETT cuff pressure less than the normal range (0-19 cmH2O) (n=11, 7.19%)

- Group 2: ETT cuff pressure within the normal range (20- 30 cmH2O) (n=17, 11.11%)
- Group 3: ETT cuff pressure more the normal range (more than 30 cmH2O) (n=125, 81.7%).

ETT cuff pressure more than 30 cmH2O was further divided to two groups: 31-50 cmH2O and more than 50 cmH2O (**Table 3**). The difference between the mean ETT cuff pressure of the patients (67.2 ±33.6) and the normal (recommended) values was 42.29 cmH2O, which was statistically significant (P<0.001, t-test). ETT cuff pressure did not have a significant correlation with age and weight (p>0.05). (**Table 4**) shows the mean cuff pressure in patients admitted to the ICU, OR, and ED. Considering the significant difference in the mean ETT cuff pressure between patients admitted to different wards, pairwise comparison of the mean cuff pressure was done. The order of mean ETT cuff pressure in different wards was as follows: OR>ED>ICU.

There was a difference of 33.63 cmH2O in the mean ETT cuff pressure between patients admitted to the OR and ICU, which was significant (p<0.001). The difference in the mean ETT cuff pressure between patients admitted to OR and ED was 23.56 cmH2O, which was significant (p=0.003). The odds ratio of the cuff pressure of the patients admitted to these two wards was 6. The difference in the mean cuff pressure between patients admitted to the ICU and ED was 10.07 cmH2O (95% CI- 6.08-26.17), indicating no significant difference (p>0.05). There was a difference of 11.62 cmH2O in the ETT cuff pressure between men and women, which was statistically significant (p<0.05). The odds ratio of cuff pressure between men and women was 1.7, but the p value calculated for this value was 0.05; therefore, sex was not a significant risk factor (**Table 5**).

Table (1): Distribution of patients in different wards

Hospital ward	Frequency (%)
ED	18(11.8%)
ICU	69(45.1)
OR	66(43.1)
Total	153

Table (2): Descriptive data

Variable	Cuff pressure (cmH2O)	Age (year)	Weight (kg)	Duration of intubation (day)
Mean± SD	67.2 ±33.6	64.9±18.6	67.2±10.7	9.98 ±7.5

Table (3): Frequency distribution of ETT cuff pressure

ETT cuff pressure		Frequency	(%)
More than normal range	31-50 cmH2O	29	18.95%
	> 50 cmH2O	96	62.75%
Within or less than normalrange		28	18.30%
Total		153	100%

Table (4): Comparison of ETT cuff pressure between three wards

Hospital ward	Number of patients	Mean ± SD	P value (ANOVA)
ED	18	61.67±31.25	<0.001
ICU	69	51.59±30.43	
OR	66	85.23±28.74	
Total	153	67.29±33.64	

SD: Standard Deviation.

Table (5): Comparison of ETT cuff pressure between male and female patients

	Number	ETT cuff pressure(cmH2o)mean ± SD	Odds Ratio(95% CI)	P value
Men	66	60.68±35.14	1.7 (0.77 – 3.94) P value > 0.05	0.03
Women	87	72.30±31.76		

Discussion

This study was conducted to determine the ETT cuff pressure in patients admitted to the OR, ED, and ICU and compare it with recommended pressure. The mean cuff pressure of the study population was 67.29±33.64 cmH2O, which exceeded the recommended pressure of 20-30 cmH2O. The ETT cuff pressure significantly exceeded the normal upper limit in 81.7% of the patients (p<0.001). This finding was consistent with previous studies [33-34]. Like previous research, this study showed that the cuff pressure could not be maintained in the recommended range by palpation, and it was necessary to use a manometer although cuff palpation is the most common method for ETT cuff pressure evaluation [27, 31, 32, 43-45].

In this study, not only the cuff pressure exceeded the recommended range in many of the patients (81.7%), but the cuff pressure was also more than 50 cmH2O in 76.8% of the patients. A possible reason for this finding could be inattention of the intubating person to cuff pressure and ignoring the importance of this pressure and its consequences. It seems that lack of training and measurement tools like cuff manometer also play a role in this regard [30, 46, and 37]. The cuff pressure was less than recommended range (less than 20 cmH2O) in 7.19% of the patients. On the other hand, cuff pressure less than 20 cmH2O is associated with aspiration of pharyngeal secretions and is a risk factor of ventilator associated pneumonia (VAP) [48, 49].

Regarding these ratios, many patients would require endotracheal. Therefore, inattention to the recommended cuff pressure may impose a heavy burden on the health system in terms of complications and costs, which underlines the importance of the continuous cuff pressure monitoring. While some studies found no apparent risk factor for cuff pressure exceeding the recommended range, some other studies found that the duration of intubation and lack of patient sedation were independently associated with a low ETT cuff pressure. The potential risk factors of high cuff pressure include agitation, coughs, patient- ventilator asynchrony, and head position change. However, the present study found no significant risk factor for the high ETT cuff pressure [30, 34].

The correlation of high cuff pressure with age, sex, weight, duration of intubation, and ward was assessed in the present study. None of them had a significant correlation with ETT cuff pressure. Although the ETT cuff pressure was significantly higher in women than in men (p=0.03) with an odds ratio of 1.7 (95% CI 0.77-3.94), the calculated odds ratio was not significant considering its p value (>0.05); therefore, sex was not a risk factor for high ETT cuff pressure in this study. Further studies may be required to investigate the relationship between sex and ETT cuff pressure.

The order of mean ETT cuff pressure was as follows OR>ED>ICU with a significant difference. Intubation in the OR was a risk factor for cuff pressure more than the recommended range. A possible explanation for this finding is that the cuff pressure decreases over time and due to the longer duration of intubation in patients admitted to ICU and ED compared to OR, the rate of detecting high cuff pressure was higher in the OR, which was consistent with previous studies [30]. Another explanation may be the wrong assumption that because the duration of being intubated is short in the OR, cuff pressures exceeding the recommended range are not a significant threat. It should be noted that the short duration of intubation might not prevent cuff pressure damage to the airway because injury to the airway mucosa starts 15 minutes after intubation [46, 47].

Manometers are not available in some ORs and the ETT cuff is inflated based on experience, which may be another reason for this difference. The adverse effects of high cuff pressure reduce over time with a gradual decrease in the cuff pressure while in the OR, due to the short duration of exposure to high cuff pressure (compared to ED and ICU); the adverse outcomes may be significant in the long term. Therefore, manometers should be available in ORs and ICUs as a vital component of the anesthesia equipment.

Conclusion

Pilot balloon palpation or a fixed volume of air routinely used for cuff pressure modulation lacks the required precision and the best way to achieve an appropriate cuff pressure is continuous cuff pressure measurement with a manometer. Intubation in the OR may be associated with a higher risk of high cuff pressure. Considering the adverse consequences of high ETT cuff pressure, more attention should be paid to maintaining the cuff pressure in the recommended range.

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