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ORIGINAL RESEARCH **AIRWAY MANAGEMENT**

A prospective, observational study of changes in endotracheal tube cuff pressure according to different patient positions in neurosurgery

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ABSTRACT

Objective: Underinflation of the cuff of endotracheal tube (ETT) used during general anesthesia can cause complications such as air leakage and aspiration during ventilation. At the same time, overinflation can lead to serious complications such as postoperative sore throat, tracheomalacia, and tracheal rupture. In this study, we aimed to evaluate the effect of different surgical positions, e.g., prone, supine, and semi-fowler positions, on ETT cuff pressure and the effect of cuff pressure changes on postoperative sore throat in neurosurgical operations.

Methodology: We included a total of 150 patients (50 patients each in two groups) undergoing neurosurgery in prone, supine, and semi-fowler positions in this prospective and observational study**.** After intubation, ETT cuff pressure was adjusted to 25 cmH_2O with a manometer (T0), and continuous monitoring was provided by connecting to the transducer via a three-way tap. We recorded the cuff pressure immediately after positioning the patient (T1), before correcting the position (T18), and after correcting the position (T19). We evaluated patients for sore throat using the Visual Analog Scale (VAS) after extubation and at the 1st, 12th, and 24th postoperative hours.

Results: After positioning, cuff pressure increased only in the pronated group, whereas it decreased in the other groups. The difference between the prone and semi-fowler groups was statistically significant ($P = 0.042$). During the follow-up period, it was determined that the cuff pressure decreased over time in the prone and semi-fowler groups and increased from time to time in the supine group, but the cuff pressures before extubation in all three groups were significantly lower than the initial values ($P < 0.001$). The supine group had the highest sore throat VAS score at the 24th postoperative hour, and this difference was statistically significant ($P = 0.017$).

Conclusion: To ensure patient safety, we recommend making continuous cuff pressure monitoring a routine practice, given that ETT cuff pressure may vary depending on the patient position.

Keywords: Position, Prone, Supine, Semi-Fowler, Endotracheal Cuff Pressure, Sore Throat

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1. INTRODUCTION

After tracheal intubation, postoperative sore throat (POST) is the most common and widespread postoperative complication. The incidence of POST ranges from 20% to 70%. It is highest in the early postoperative period, especially between 2 and 6 hours after extubation, but decreases rapidly over time. Reports indicate that 11% of patients still experience residual symptoms after 96 hours. Risk factors for POST in patients undergoing tracheal intubation include female gender, younger age, smoking, previous or current lung disease, prolonged intubation time, and bloody tracheal tube during extubation. There are also factors like the size and type of endotracheal tube (ETT), double lumen tubes, high intracuff pressure, and intubation without neuromuscular blockade that may play a role in the occurrence of POST.[1, 2]

Monitoring and limiting ETT cuff pressure plays an important role in reducing the incidence of POST. According to a study by Liu et al., even during short intubation times (1-3 hours), maintaining the ETT cuff pressure in the appropriate range with a manometer reduced postoperative symptoms such as sore throat, cough, and hoarseness.[3]

Patients may require different positions depending on the type of surgical intervention. Each position may cause changes in the ventilation/perfusion (V/P) ratio and hemodynamics. Different positions may also cause changes in the ETT cuff pressure. There is also a risk of complications such as nerve damage or pressure sores due to compression, stretching, or ischemia in any position. Anesthesiologists should be careful against such complications.[4] Athiraman et al. looked at ETT cuff pressure in 70 patients who had neurosurgery while they were lying on their back, on their side, on their stomach, or while they were sitting. They found that the pressure dropped significantly in the supine and prone patient groups from positioning to extubation.[5] When the ETT cuff pressure fell below 20 cmH_2O, the cuff was inflated by intervention. They emphasized the importance of measuring ETT cuff pressure continuously or at frequent intervals in neurosurgical patients, and ensuring it stays within the determined value range after positioning.

This study aimed to evaluate the effect of different surgical positions (prone, supine, semi-fowler) on ETT cuff pressure and the effect of cuff pressure changes on postoperative sore throat in neurosurgical operations.

2. METHODOLOGY

This prospective and observational study was conducted between February 2022 and April 2022 in patients electively operated in different positions, e.g., prone, supine, and semi-fowler, under general anesthesia for neurosurgery. The study included patients between the ages of 18 and 70 years, ASA class I, II, and III, anesthesia and who signed an informed consent. We excluded patients with ASA classification above IV, patients with previous tracheostomy or tracheal stenosis, patients with expected difficult intubation, patients with multiple intubation attempts, pregnant women, patients requiring emergency intervention, patients who had difficulty understanding the Visual Analog Scale (VAS) scores, patients with language/communication barriers, and patients who did not give consent.

The work-up form recorded demographic characteristics such as age, gender, body mass index (BMI), comorbidities, ASA score, type of operation, and the patient position. Patients underwent routine monitoring, e.g., 3-lead electrocardiogram (ECG), peripheral oxygen saturation (SpO_2), and non-invasive blood pressure (NIBP). Additionally, we performed bispectral index (BIS) monitoring using a Covidien bispectral index (BIS) monitor. Depending on the type of operation, a suitable sized intravenous (IV) line or central catheter was opened, and 0.9% NaCl infusion was started. We also performed invasive arterial monitoring on patients who needed it. We administered 1 mg/kg lidocaine, 2-3 mg/kg propofol, 1-2 µg/kg fentanyl, and 0.6 mg/kg rocuronium for induction, followed by orotracheal intubation using high volume, low pressure cuffed tubes with an internal diameter (ID) of 7 mm for female patients and ID 7.5 mm for male patients after achieving adequate muscle relaxation.[6]

After intubation, the tube cuff was inflated to 25 cmH_2O with an analog cuff manometer (VBM Medizintechnik®, GmbH, Germany). We connected a pressure line to the pilot balloon using a three-way tap, fixed the transducer at the level of the cricoid cartilage, and provided continuous pressure monitoring on the anesthesia monitor.[7,8] Throughout the cases, cuff pressure was measured from the patient's pilot balloon and verified with a manometer. Cuff pressure was recorded after intubation (T0), immediately after the patient was positioned (T1), just before the patient was placed in the neutral (supine) position (T18), and before extubation after the patient was placed in the neutral position (T19). Patients were placed on mechanical ventilator support in volume-controlled mode with 6-8 ml/kg tidal volume, 5 cmH_2O PEEP, 10-12/min respiratory rate, 35-40 mmHg $EtCO_2$ and 50% FiO_2 according to ideal weight.

Anesthesia maintenance was achieved with propofol 50-200 µg/kg/min and remifentanil 0.05-2 µg/kg/min with BIS values between 40-60. Neuromuscular blockade was reversed with 2 mg/kg sugammadex. Patients were extubated after they became fully responsive to commands. After extubation and at the 1st, 12th, and 24th hours postoperatively, sore throat was evaluated by VAS score.

Statistical Evaluation:

Data analysis was performed using the statistical package program IBM SPSS 25.0 (Armonk, NY: IBM Corp.). In addition to descriptive statistical methods (frequency, percentage, mean, standard deviation, median, min-max), the Chi-Square ($\chi 2$) test was used to compare qualitative data. In cases where a difference was detected, post-hoc Bonferroni correction was applied to determine the source of the difference. The Kolmogorov-Smirnov test, skewness-kurtosis, and graphical methods (histogram, Q-Q plot, stem and leaf, boxplot) evaluated the data's conformity to a normal distribution. The study employed the one-way ANOVA test for intergroup comparisons of

Table 1: Demographic characteristics of the patients included in the study (n = 150)

Parameter	Total	Group P	Group S	Group SF	P value
Age (y)	49.7 ± 14.1	50.5 ± 13.3	47.8 ± 13.8	50.7 ± 15.4	0.508
Female Gender	92 (61.3)	26 (52.0)	33 (66.0)	33 (66.0)	0.252
BMI (kg/m^2)	28.0 (4.8)	27.9 (4.5)	28.0 (5.2)	27.9 (4.6)	0.990
Comorbidities	125 (83.3)	47 (94.0)	36 (72.0)	42 (84.0)	0.013
Cigarette smoking	31 (20.6)	17 (34.0)	4 (8.0)	10 (20.0)	0.006
Obese	41 (27.3)	16 (32.0)	14 (28.0)	11 (22.0)	0.528
ASA					
I	25 (16.6)	3 (6.0)	14 (28.0)	8 (16.0)	0.017 (Difference between Group P and S)
II	80 (53.3)	34 (68.0)	19 (38.0)	27 (54.0)	
III	44 (29.3)	12 (24.0)	17 (34.0)	15 (30.0)	
IV	1 (0.6)	1 (2)	0 (0.0)	0 (0.0)	
Duration of anesthesia (min)	213.6 ± 95.7	217.8 ± 109.4	205.8 ± 71.2	217.2 ± 103.5	0.781

Data presented as mean ± SD or n (%);

normally distributed quantitative data, and the repeated measures ANOVA test for intragroup comparisons. In cases where a difference was detected, the significance level was accepted as $\alpha = 0.05$.

Power Analysis:

Power analysis according to the comparison of sore throat VAS scores at 24 hours postoperatively was performed using the statistical package program G*Power 3.1.9.7 (Franz Faul, Universitat Kiel, Germany); $n_1 = 50$, $n_2 = 50$, $n_3 = 50$, Effect size (f) = 0.29, $\alpha = 0.05$; power = 89%.

3. RESULTS

Fifty patients from each group (prone, supine, semi-fowler) who met the inclusion criteria were included in the study. 92 (61.3%) of the patients were female and the mean age was 49.74 ± 14.1 years. 125 (83.3%) of the patients had at least one chronic disease; 25 (16.6%) patients were ASA I, 80 (53.3%) patients were ASA II, 44 (29.3%) patients were ASA III, and one (0.6%) patient was ASA IV. The mean duration of anesthesia was 213.6 ± 95.7 min.

In the comparisons between the groups, it was found that there was no statistically significant difference between the groups in terms of gender, age, BMI values and duration of anesthesia ($P > 0.05$).

There was a statistically significant difference ($P < 0.05$) between the groups in terms of comorbidity and smoking status. It was found that comorbidity and smoking rates were higher in Group P patients. A statistically significant difference in terms of ASA status was found ($P < 0.05$). The number of ASA-II

Table 2: Intragroup and intergroup comparison of ETT cuff pressure

ETT cuff pressure	Group P1 (n = 50)	Group S 2 (n = 50)	Group SF 3 (n = 50)	P*	Difference
T0	25.0 ± 0.0	25.0 ± 0.0	25.0 ± 0.0	1.000	--
T1	26.4 ± 4.3	24.9 ± 4.4	24.4 ± 3.2	0.042	1 to 3
T18	22.8 ± 4.3	24.0 ± 4.9	20.9 ± 4.7	0.005	2 to 3
T19	22.6 ± 4.8	22.9 ± 4.4	20.9 ± 4.7	0.067	--
P	< 0.001	< 0.001	< 0.001		
Difference	With T0-T1 T18-T19	T19 with T0-T1	With T0-T1 T18-T19		

Group P: Prone, Group S: Supine, Group SF: Semi-Fowler,
Note: Data are expressed as Mean ± Standard Deviation.
T0: ETT cuff pressure before positioning,
T1: ETT cuff pressure immediately after positioning,
T18: ETT cuff pressure immediately before position correction,
T19: ETT cuff pressure after position correction
**: One-Way Anova Test*

patients in Group P, and ASA-I in Group S was higher (P = 0.017).

ETT cuff pressure (T1) measured immediately after positioning was higher in Group P patients than in Group SF patients, and ETT cuff pressure measured immediately before positioning was corrected (T18) was higher in Group S patients than in Group SF patients. There was no statistically significant difference between the groups in other simultaneous measurements (P > 0.05).

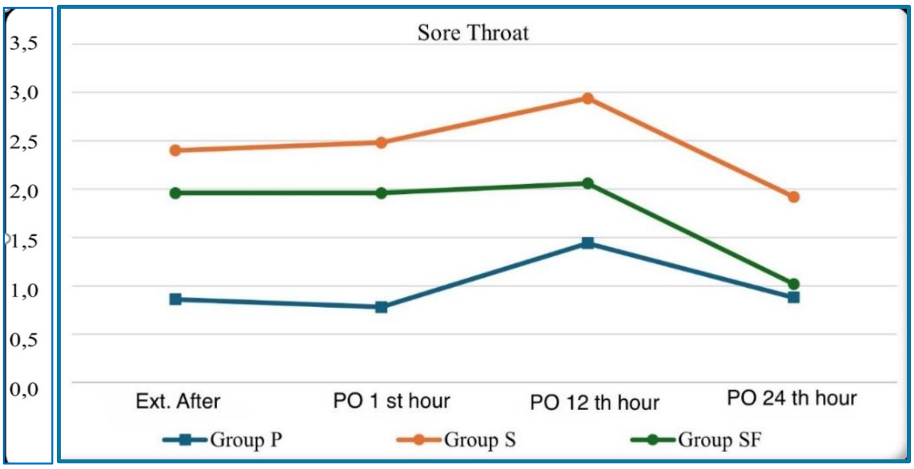

Figure 1: Comparison of VAS scores between and within groups in the evaluation of sore throat

In intragroup comparisons, ETT cuff pressure after position correction (T19) was found to be significantly lower than ETT cuff pressure before positioning (T0) in all three groups. In Group P and Group SF patients, ETT cuff pressure before positioning (T0) and ETT cuff pressure immediately after positioning (T1) were higher than ETT cuff pressure immediately before position correction (T18) and after position correction (T19). In group S patients, the ETT cuff pressure values after position correction (T19) were lower than the ETT cuff pressure values measured before positioning (T0) and immediately after positioning (T1).

There was a statistically significant difference (P < 0.05) between the groups in frequency of sore throat in all measurements. Immediately after extubation and at the postoperative 1st hour, VAS scores of Group P were lower than Group S and Group SF, at the 12th hour, VAS scores of Group P were lower than Group S, and at postoperative 24th hour, VAS score values of Group S were higher than Group SF and Group P.

4. DISCUSSION

In our study, an increase in ETT cuff pressure was detected only in the prone group after positioning, and a decrease was observed in the other groups. This difference between prone and semi-fowler groups was statistically significant. During the follow-up period, it was observed that ETT cuff pressure decreased over time in the pronated and semi-fowler patient groups. In the supine patient group, the ETT cuff pressure increased from time to time compared to the baseline value, but the cuff pressures before extubation in all three groups were significantly lower than the baseline values. It was determined that the highest postoperative 24th hour sore throat VAS score was in the supine patient group, and this difference was statistically significant.

In this study, it was concluded that ETT cuff pressure may affect postoperative sore throat, may change depending on the position, and decreases over time. The reason for the gradual decrease in ETT cuff

Table 3: Comparison of VAS scores between and within groups in the evaluation of sore throat

Sore Throat	Group P [1] (n = 50)	Group S [2] (n = 50)	Group SF[3] (n = 50)	P*	Difference
After extubation	0.86 ± 1.74	2.40 ± 2.70	1.96 ± 2.52	**0.004**	1 to 2-3
PO 1st hour	0.78 ± 1.49	2.48 ± 2.43	1.96 ± 2.36	**0.000**	1 to 2-3
PO 12th hour	1.44 ± 2.45	2.94 ± 2.88	2.06 ± 2.69	**0.021**	1 to 2
PO 24th hour	0.88 ± 1.61	1.92 ± 2.21	1.02 ± 1.98	**0.017**	1-3 with 2
P**	0.069	**0.022**	**0.002**		
Difference	--	PO with the 12th hour PO 24th hour	PO with 24th hour Ext. Post, PO 1, 12 hours		

Group P: Prone, Group S: Supine, Group SF: Semi-Fowler,
PO -: Postoperative
Note: Data are expressed as Mean ± Standard Deviation.
**: One-Way ANOVA Test, **: Repeated Measures Anova Test,*

pressure in all groups over time may be gravity, loss of consciousness due to appropriate depth of anesthesia, and loss of tonus in the neck muscles as a result of neuromuscular blockade and posterior displacement of the structures forming the airway.

In patients in the semi-fowler position, the head and neck support are removed from the table due to the use of the studded headgear, and the head is supported only by the pins of the studded headgear. Since the neck is free, resistance to the table is eliminated and tension in the posterior airway is reduced. Therefore, we think that the most significant decrease in ETT cuff pressure from intubation to extubation was in the semi-fowler group. In the study conducted by Kim and colleagues on 55 patients who underwent lumbar vertebra surgery,[9] it was reported that endotracheal tube (ETT) cuff pressure was examined in the supine and prone positions without head movement (in a neutral position). In the study, it was demonstrated that transitioning from the supine to the prone position increased the ETT cuff pressure, and head flexion elevated the ETT cuff pressure in both the supine and prone positions, while head extension increased this pressure only in the prone position. Therefore, the importance of monitoring ETT cuff pressure in every patient positioned in the prone position was emphasized.

In the study conducted by Minonishi and colleagues on 132 patients who underwent lumbar vertebra surgery, changes in ETT cuff pressure were examined in patients transitioning from the supine to the prone position.[10] It was found that in 91.7% of the patients, the ETT shifted and the ETT cuff pressure decreased when the head was rotated to the right and placed in flexion. In the study, it was concluded that ETT position may change with head and neck movement, and accordingly, there may be differences in ETT cuff pressure.

In our study, we observed a decrease in the mean ETT cuff pressure after positioning in the semi-fowler and supine groups and an increase in the prone group, and this increase was found to be significant compared to the semi-fowler group. In addition, in our study, the head was kept in a neutral position, and no flexion, extension, or rotation was applied to the head. Although the reason for the increase in cuff pressure in the prone position is not fully explained, it is thought that the trachea may be compressed from behind by the cervical vertebrae, muscles, and vessels due to the effect of gravity. In the prone position, gravity-induced pressure on the chest and anterior abdominal wall may lead to an increase in intraabdominal and intrathoracic pressure, which may cause an increase in ETT cuff pressure during mechanical ventilation.[9]

Liu and colleagues divided 120 patients under general anesthesia into groups by measuring ETT cuff pressure using different methods and identified a positive correlation between postoperative sore throat (POST) and ETT cuff pressure.[14] This correlation was reported to be strongest after the 24th postoperative hour. In a meta-analysis conducted by Hu and colleagues, it was demonstrated that postoperative sore throat (POST) at 24 hours could be significantly reduced with lower ETT cuff pressure.[15]

In our study, the POST VAS values of the prone group were significantly lower than the supine and semi-fowler groups after extubation and at the 1st postoperative hour. In addition, the postoperative sore throat VAS values of the supine group were significantly higher than the prone and semi-fowler groups at the 24th postoperative hour. In addition, dysphagia after extubation and at 1 and 24 hours postoperatively was significantly higher in the supine group than in the prone group. Considering that 12 patients in the supine group underwent anterior cervical surgery and used retractors in the cervical region, it is thought that this contributed to the increase in POST symptoms.

5. CONCLUSION

In conclusion, different positions of patients during surgery have a significant effect on the endotracheal tube cuff pressure, and it is recommended that the pressue is measured with a manumeter, either continuously ot internittently, to avoid complications of high pressure.

6. Data availability

The numerical data generated during this research is available with the authors.

7. Acknowledgement

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8. Conflict of interest

The study utilized the hospital resources only, and no external or industry funding was involved.

9. Ethical approval

The study was approved by No. 2 Clinical Research Ethics Committee of Ankara City Hospital on February 2, 2022..

10. Authors' contribution

SSO: Writing the article, manuscript editing, translating the article

MS: Conduction of study work, translating the article

AB: Concept, manuscript editing

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