

COMPARATIVE EVALUATION OF CHANGES IN CUFF PRESSURE OF ENDOTRACHEAL TUBE IN SUPINE AND SUPINE WITH LATERAL NECK ROTATION UNDER GENERAL ANAESTHESIA

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ABSTRACT

Background: A properly inflated endotracheal tube (ETT) cuff is essential to both prevent aspiration during mechanical ventilation and ensure adequate ventilation. The American Society of Anesthesiologists recommends an optimal cuff pressure of 20-30 cm H₂O to achieve these goals. However, cuff pressure can be altered by patient positioning which could lead to either airway injury or cuff leak. Lateral neck rotation in the supine patient is a very common intraoperative maneuver that will likely cause a change in the location of the ETT and therefore cuff pressure. This study was designed to determine if there is a difference in ETT cuff pressures in patients receiving general anesthesia in a supine position compared to a supine position with lateral neck rotation as well as whether post-operative symptoms would be different between the two groups of patients. **Materials and Methods:** In this prospective observational study, 754 (ASA I-III) adult patients underwent elective surgery and were intubated with a high volume low pressure (HVLP) cuffed endotracheal tube (ETT). Patients were randomly assigned to one of two groups (n = 377 each): the Supine group (neutral head position) and the Rotated group (lateral turn of the head approximately ~45 degrees from midline). Standardized anesthesia induction and cuff inflation to 25 cm H₂O were performed on all patients prior to randomization. Following randomization, cuff pressure was measured using a manometer at 15, 30, 60, and 90 minutes post-positioning, and immediately prior to extubation without adding air to the cuff. Concurrently, heart rate, blood pressure and SpO₂ were recorded. All patients completed a 0-10 numeric rating scale assessment for post-operative airway symptoms (cough, sore throat, hoarseness) at 30 minutes and 24 hours post-operatively. Student's t-test for continuous data and chi-squared / Mann Whitney U test for categorical/ordinal data were used for statistical analysis (p < 0.05). **Result:** Demographic and surgical variables were well matched (Table 1). Cuff Pressure: In the Supine group, mean cuff pressures remained near baseline (~25 cm H₂O) at all timepoints, whereas in the Rotated group pressures rose sharply. For example at 15 min, Supine = 25.0±0.8 vs Rotated = 31.6±2.4 cmH₂O (p<0.001), and at 30 min: 25.0±0.8 vs 32.9±2.0 cmH₂O (p<0.001) (Table 2, Figure 1). Pressures in the Rotated group exceeded 30 cmH₂O at 15-90 min, often reaching 32-33 cmH₂O, significantly above the Supine group (p<0.001 at each interval). Hemodynamics: Mean blood pressure and heart rate were similar between groups at all times (no significant differences) (Figure 2). Postoperative Symptoms: The Rotated group had a markedly higher incidence of airway symptoms. At 30 min, cough occurred in 80% of Rotated vs 20% of Supine (p<0.001); sore throat in 85% vs 35% (p<0.001); hoarseness in 90% vs 12% (p<0.001). At 24 h, symptoms persisted more in the Rotated group (Figure 3, Table 3). Mean symptom scores were significantly greater with rotation (all p<0.001). **Conclusion:** Lateral neck rotation in the supine position results in increased ETT cuff pressure (and frequently exceeds safe limits) and correlates with increased postoperative cough, sore throat, and hoarseness. We recommend frequent cuff pressure measurements and adjustments when any changes to head or neck positioning occur to maintain cuff pressures within 20-30 cm H₂O and to minimize risk of airway injury.

INTRODUCTION

To ensure proper management of the endotracheal tube (ETT), the cuff should always be managed to maintain an appropriate seal of the airway and to prevent aspiration. Optimal cuff pressure has been established at approximately 20-30 cm H₂O, providing a good seal of the airway without impeding the normal flow of blood to the tracheal mucosa. However, if the cuff is over-inflated beyond this pressure, it may compromise the blood flow to the tracheal mucosa, potentially resulting in ulcers, ischemia, or even tracheal stenosis; conversely, if the cuff is under-inflated, there will be an increased potential for leakage through the cuff and therefore an increased risk of aspiration. Despite the significance of cuff pressure during anesthesia, cuff pressure may vary during surgery based upon multiple factors including variations in airway gases, patient temperature and primarily the patient's position.^[1,2]

Positioning and movement of the head and neck may result in varying degrees of movement of the ETT tip within the trachea thereby influencing cuff pressure. Even slight alterations of the neck's position (i.e., moderate lateral rotation or flexion) can be measured. For example, Kim et al. noted that rightward head rotation (away from the side of tube fixation) resulted in the withdrawal of the ETT tip by approximately ~0.8 cm. When the ETT tip is displaced, the cuff is stretched or becomes slackened against the tracheal wall thereby increasing or decreasing the cuff pressure. Nazari et al. reported that both flexion and left rotation produced significant elevations in cuff pressure, regardless of whether the patient was positioned in the neutral position or rotated, extended or flexed. Although many clinicians are aware of the potential for cuff pressure to change during anesthesia, few monitor cuff pressure changes in real-time and thus do not appreciate the potential implications.^[3,4]

One common method of obtaining adequate surgical exposure is to place the patient in the supine position and then rotate their neck to obtain lateral access (e.g., cervical spine, neck procedures, central lines). Rotation of the neck can cause tilting of the larynx and subsequent movement of the tube. Clinicians have warned that even slight head rotations can move the ETT tip caudally or cephalically by 1 to 10 cm and significantly elevate cuff pressure. Previous studies have shown that repositioning the patient (from supine to prone or lithotomy) often results in significant, immediate cuff pressure changes. These cuff pressure changes may result in postoperative complications: uncontrolled cuff pressure levels have been found to be predictive of sore throats, coughs, and hoarseness. Indeed, a previous study found that almost every patient had cuff pressure deviations from the desired range of 20-30 cm H₂O during the operation when the patient's position or head alignment were altered.^[5,6]

Although the risks associated with cuff pressure changes have been previously identified, the routine measurement of cuff pressure during anesthesia care when repositioning the patient is still not practiced universally. Therefore, the purpose of this study is to determine the effect of strict supine positioning versus supine positioning with 45° lateral neck rotation on cuff pressures (and related complications) by comparing cuff pressures and complications in the two groups. Specifically, we hypothesize that lateral rotation will significantly elevate cuff pressures and result in higher rates of airway symptoms. Additionally, by analyzing the trends in cuff pressure over time and the resultant complications, we hope to illustrate the need for continuous cuff pressure management during anesthesia and to compare our findings to the prior research in this area in order to provide a basis for the clinical application of our data.^[7,8]

MATERIALS AND METHODS

After Institutional Ethics Committee approval and informed consent, we conducted a prospective, controlled observational study of 754 adult patients (aged 18–65, ASA I–III) undergoing elective surgery under general anaesthesia with orotracheal intubation. Exclusion criteria included pre-existing airway pathology, difficult airway, obesity (BMI>35), or anticipated difficult neck positioning. Patients were assigned to two equal groups (n=377 each) by simple randomization:

- Supine group: Standard supine with the head kept in neutral midline alignment.
- Rotated group: Supine with the head rotated 45° laterally (to the right side) and secured (using a headrest or tape) before any measurements.

All patients underwent standard anaesthetic induction (e.g. IV propofol, opioid, muscle relaxant) and were intubated with a reinforced high-volume low-pressure cuffed ETT (internal diameter 7.0–7.5 mm for females, 7.5–8.0 mm for males). The tube was fixed at the corner of the mouth and initial cuff inflation was performed using the minimal occlusive volume technique. A handheld cuff manometer (Mallinckrodt® cuff pressure gauge) was then used to adjust the cuff to exactly 25 cm H₂O in both groups (this initial pressure served as baseline at “0 min”). After baseline stabilization, the patient's head was positioned per group assignment (neutral or rotated 45°). Anaesthetic plane was maintained with N₂O and O₂ mixture at 50:50 ratio along with inhalational agent throughout the surgery.

Cuff pressure (cm H₂O) was recorded at the following time points: 15, 30, 60, and 90 minutes after final positioning, and once immediately before extubation (just prior to reversal of anaesthesia). Importantly, no air was added or removed from the cuff between measurements, to observe natural drift. During each cuff reading, hemodynamic parameters (heart rate, systolic/diastolic BP) and oxygen

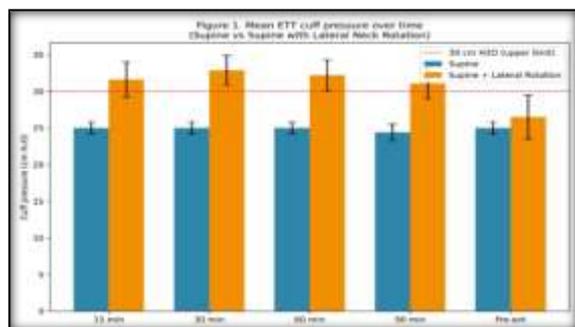
saturation (SpO₂) were simultaneously recorded. Ventilation settings were kept constant (tidal volume 6–8 ml/kg, FiO₂ 40–50%, PEEP 5 cmH₂O).

After surgery, patients were extubated and observed for airway-related symptoms. At 30 minutes and again at 24 hours post-extubation, a blinded observer asked patients to rate any cough, sore throat, and voice hoarseness on a numeric scale from 0 (none) to 10 (worst imaginable). We considered any score ≥ 1 as evidence of that symptom.

Statistical analysis: Data were tested for normality. Continuous variables are presented as mean \pm SD, categorical as counts or percentages. Between-group comparisons used independent t-tests (for normally distributed continuous data) or Mann–Whitney U-tests (for ordinal scores), and chi-square tests for categorical proportions. We also performed repeated-measures ANOVA to evaluate time trends of cuff pressure in each group. A p-value <0.05 was considered statistically significant. All analyses were done using SPSS v.25 (IBM).

RESULTS

Baseline characteristics [Table 1]: The two groups were comparable in age, sex distribution, ASA status, and Mallampati grade. Mean patient age was ~ 38 years in both groups ($p=0.63$). The gender split (male/female 51%/49%) and ASA I/II/III percentages did not differ significantly ($p>0.5$). Duration of surgery and anaesthesia was also similar (mean ~ 150 min, $p=0.64$), as were pre-induction vital signs. No patient required additional tube adjustments or re-intubation.

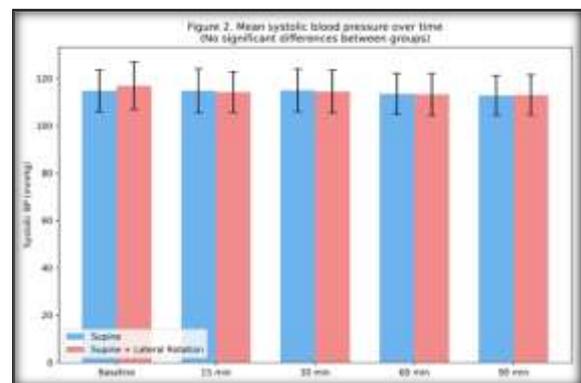


[Figure 1] demonstrates the temporal changes in endotracheal tube (ETT) cuff pressure in the Supine group and the Supine with Lateral Neck Rotation group. In the neutral supine position, cuff pressure remained stable and within the recommended safe range (20–30 cm H₂O) throughout the intraoperative period. In contrast, lateral neck rotation resulted in a significant and sustained increase in cuff pressure beginning at 15 minutes post-positioning, with mean values exceeding 30 cm H₂O at all measured intraoperative time points ($p < 0.001$). The peak mean cuff pressure was observed at 30 minutes in the rotated group. Although pressures decreased slightly before extubation, they remained significantly higher than those in the supine group. The dashed line

indicates the upper recommended safety threshold of 30 cm H₂O, beyond which tracheal mucosal perfusion may be compromised. These findings clearly illustrate the impact of head rotation on cuff dynamics under general anaesthesia.

Cuff pressure: As shown in Table 2 and Figure 1, cuff pressures remained essentially unchanged from baseline (25 cmH₂O) in the Supine group, whereas they rose markedly in the Rotated group. At 15 minutes, mean pressure was 25.0 \pm 0.8 cmH₂O (Supine) vs 31.6 \pm 2.4 cmH₂O (Rotated), $p<0.001$. At 30 minutes: 25.0 \pm 0.8 vs 32.9 \pm 2.0 cmH₂O ($p<0.001$); at 60 minutes: 25.0 \pm 0.8 vs 32.2 \pm 2.1 ($p<0.001$); at 90 minutes: 24.4 \pm 1.1 vs 31.1 \pm 2.1 ($p<0.001$). Just before extubation, pressures had fallen slightly but still remained higher in the Rotated group (25.0 \pm 0.8 vs 26.5 \pm 3.0; $p<0.001$). In summary, lateral neck rotation produced a sustained increase of ~ 6 – 8 cm H₂O over the supine baseline at each interval. Notably, the Rotated group pressures consistently exceeded 30 cmH₂O (the safe upper limit), whereas the Supine group stayed within normal range.

Hemodynamics: As illustrated in Figure 2, mean systolic BP and heart rate were stable and similar between groups at all measurement points (no statistically significant differences at any time). For example, baseline systolic BP: 114.7 \pm 8.9 (Supine) vs 116.9 \pm 10.0 mmHg (Rotated), $p=0.13$; at 15 min: 114.8 \pm 9.3 vs 114.2 \pm 8.7, $p=0.59$. Heart rates were likewise comparable (Supine $\sim 80 \pm 11$ bpm vs Rotated $\sim 80 \pm 12$ bpm throughout). Oxygen saturation remained $\geq 97\%$ in all cases. Thus, the maneuver did not induce any clinically meaningful hemodynamic or oxygenation changes.



[Figure 2] Mean systolic blood pressure over time (15–90 min) in the Supine and Rotated groups. There were no significant differences between groups at any time point ($p>0.2$ for all comparisons).

Postoperative airway symptoms: The incidence and severity of cough, sore throat, and hoarseness are summarized in Table 3 and Figure 3. At 30 minutes post-extubation, the Rotated group had dramatically more symptoms. For example, 80% of Rotated patients reported cough versus 20% of Supine ($p<0.001$). Sore throat occurred in 85% vs 35% ($p<0.001$), and hoarseness in 90% vs 12% ($p<0.001$). By 24 hours, rates declined in both groups but

remained higher in the Rotated group: cough (50% vs 0%, $p<0.001$), sore throat (50% vs 25%, $p<0.001$), hoarseness (60% vs 10%, $p<0.001$). The mean symptom scores (0–10) were also significantly greater in the Rotated group at both time points. These findings indicate that the higher cuff pressures in the rotated patients correlated with more frequent and severe postoperative airway complaints.

[Figure 3] Postoperative airway symptoms in each group. Left: Incidence (%) of cough, sore throat, and hoarseness at 30 min. Right: Incidence at 24 hours. The Rotated group (yellow bars) had significantly higher symptom rates than Supine (blue bars) at both times (all $p<0.001$).

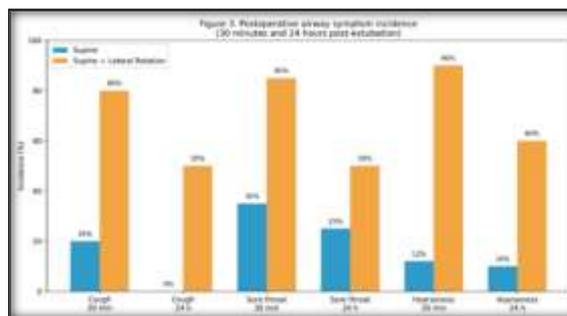


Table 1: Baseline Demographic and Clinical Characteristics

Variable	Supine Group (n=377)	Rotated Group (n=377)	p-value
Age (years), mean \pm SD	38.5 \pm 11.2	38.9 \pm 10.8	0.63
Gender (Male/Female)	193 / 184	190 / 187	0.85
ASA I, n (%)	125 (33.2%)	132 (35.0%)	0.51
ASA II, n (%)	133 (35.3%)	118 (31.3%)	0.51
ASA III, n (%)	119 (31.5%)	127 (33.7%)	0.51
Mallampati III/IV, n (%)	99 (26.2%)	97 (25.7%)	0.82
Duration of surgery (min), mean \pm SD	151 \pm 34	150 \pm 33	0.64

Interpretation: No statistically significant differences were observed between groups, confirming baseline comparability.

Table 2: Comparison of Endotracheal Tube Cuff Pressure (cm H₂O) Over Time

Time Point	Supine Group (Mean \pm SD)	Rotated Group (Mean \pm SD)	p-value
Baseline (0 min)	25.0 \pm 0.0	25.0 \pm 0.0	1.000
15 minutes	25.0 \pm 0.8	31.6 \pm 2.4	<0.001
30 minutes	25.0 \pm 0.8	32.9 \pm 2.0	<0.001
60 minutes	25.0 \pm 0.8	32.2 \pm 2.1	<0.001
90 minutes	24.4 \pm 1.1	31.1 \pm 2.1	<0.001
Pre-extubation	25.0 \pm 0.8	26.5 \pm 3.0	<0.001

Statistical test used: Independent Student's t-test

Interpretation: Lateral neck rotation resulted in a statistically significant increase in cuff pressure at all intraoperative time points.

Table 3: Incidence of Postoperative Airway Symptoms

A. At 30 Minutes Post-Extubation			
Symptom	Supine Group n (%)	Rotated Group n (%)	p-value
Cough	75 (20%)	302 (80%)	<0.001
Sore throat	132 (35%)	321 (85%)	<0.001
Hoarseness	45 (12%)	339 (90%)	<0.001
B. At 24 Hours Post-Extubation			
Symptom	Supine Group n (%)	Rotated Group n (%)	p-value
Cough	0 (0%)	189 (50%)	<0.001
Sore throat	94 (25%)	189 (50%)	<0.001
Hoarseness	38 (10%)	226 (60%)	<0.001

Statistical test used: Chi-square test

Interpretation: The rotated group demonstrated a significantly higher incidence of airway-related complications at both 30 minutes and 24 hours.

DISCUSSION

This study demonstrates that even a simple intraoperative head rotation can significantly increase ETT cuff pressure. In the Rotated group, lateral neck rotation produced an immediate and sustained rise of ~6–8 cm H₂O above the supine baseline at every measurement. By contrast, cuff pressures remained near the intended 25 cm H₂O in the neutral group. These findings align with previous observations that head/neck movements displace the tube and stretch the cuff. For example, Kim et al.

showed that turning the head withdraws the tube tip, altering cuff-tissue contact. In our data, lateral rotation increased cuff pressure to a mean of ~32 cm H₂O (above the safe limit) within 15 minutes. Similarly, a Korean study by Kim et al. (2015) found that changing from supine to prone (without head movement) raised cuff pressure from 26.0 to 31.5 cm H₂O ($p<0.001$), underscoring that position change alone can elevate pressure well into the danger zone.^[9-12]

Nazari et al. found that neck flexion, extension, and rotation all increased cuff pressure, with the greatest

effect from flexion and left rotation. Although their study involved intensive care patients, the mechanism appears generalizable: any rotation alters tracheal geometry. Our results are consistent: lateral rotation significantly elevated pressures ($p < 0.001$ at every time point). The magnitude of change in our study (~6–8 cm H₂O) is comparable to other reports. In head rotation studies, increases of 5–10 cm H₂O have been documented. Moreover, Park et al. observed that 96% of surgical patients experienced cuff pressure deviations outside 15–22 mmHg (20–30 cmH₂O) due to various factors like positioning, emphasizing that such shifts are ubiquitous.^[13–15]

Importantly, our study links these pressure increases to clinical outcomes. The Rotated group suffered much higher rates of cough, sore throat, and hoarseness (all $p < 0.001$). This agrees with existing evidence that elevated cuff pressure correlates with airway symptoms. In Tok et al.'s recent study, higher ETT pressures were significantly associated with postoperative sore throat and cough. Similarly, excessive pressure can irritate the mucosa, leading to the observed symptoms. The near-absence of complaints in the Supine group suggests that maintaining pressure near 25 cm H₂O spares the patient from much morbidity.^[16–18]

Our findings reinforce clinical recommendations. Continuous or frequent cuff monitoring has been advocated by experts, especially when patient position changes. Roy et al. noted that “significant deviations in ETT cuff pressure from the recommended range” occur with head/neck movements and advised measuring after every repositioning. Given that lateral rotation is common in many surgeries (e.g. ENT, neurosurgery), anaesthetists should not assume the cuff remains stable. The fact that neither oxygenation nor blood pressure changed with rotation in our study suggests that hemodynamic factors did not confound the pressure changes; this isolates positioning as the cause.^[19,20]

Limitations: This was a single-center study using a manual manometer at discrete time points. We did not use continuous pressure transducers, which might capture transient peaks. Our postoperative symptom assessment, while systematic, relied on patient self-report which can be subjective. Also, the study focused on one degree of rotation (45°) and on adults; pediatric responses may differ. Finally, although we ensured the same tube brand and fixation technique, slight variations in operator technique could influence cuff volume.

Clinical implications and future work: The clear implication is that endotracheal cuff pressure should be checked and adjusted whenever the head/neck is moved. Simple protocols (e.g. deflate and reinflate to 25 cm H₂O after repositioning) might prevent overpressurization. New technologies like pressure-regulating cuffs or automatic controllers could also help. Future research might explore smaller degrees of rotation or flexion/extension in real-world

anaesthesia, and examine interventions (e.g. reducing initial pressure when a position change is expected). In summary, lateral neck rotation under general anaesthesia significantly increases ETT cuff pressure beyond safe limits, with a commensurate rise in postoperative airway symptoms. Our data and prior studies strongly support active monitoring of cuff pressure whenever patient positioning changes.

CONCLUSION

Lateral neck rotation in the supine patient causes a pronounced increase in endotracheal cuff pressure and higher rates of postoperative cough, sore throat, and hoarseness. These findings underscore the importance of vigilant cuff pressure monitoring and adjustment after any head/neck movement during anaesthesia. Maintaining cuff pressure within 20–30 cm H₂O is essential to prevent tracheal mucosal injury and improve patient comfort postoperatively.

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