Original Article

Evaluation of Changes in Tracheal Cuff Pressure in Patients Undergoing Percutaneous Nephrolithotomy in the Prone Position and its Correlation with Postoperative Sore Throat – A Prospective Observational Study

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Abstract

Background: Theendotracheal cuff is inflated to provide a seal, but over- and under-inflation of the cuff can lead to complications. Our study was designed to evaluate changes in cuff pressure in patients undergoing percutaneous nephrolithotomy (PCNL) in the prone position and its correlation with sore throat. **Material and Methods:** After institutional Ethical Committee clearance, 70 patients of American Society of Anesthesiologists Physical Status class (ASA) I and II, aged between 18-60 years, posted for elective PCNL were included. The baseline tracheal cuff pressure after intubation and then changes at different study intervals were noted. Postoperative sore throat was assessed at 1, 3, 12 & 24 hours after extubation. Temperature changes, total intravenous fluid & total irrigation fluid used were correlated with the postoperative sore throat. **Results:** Tracheal cuff pressure significantly decreased in the prone position at the end of surgery (29.4±1.65) from baseline (35.69±1.63) (P <0.001). No participant had a sore throat after 24 hours postoperative, while 1 had (1.4%) severe at 1 hour, 38(54.3%) had minimal and 31(44.3%) had moderate sore throat. There was no correlation with cuff pressure changes and postoperative sore throat (P 0.594). The temperature change, the total amount of intravenous fluid used, the total amount of irrigation fluid, and the duration of surgery did not affect the tracheal cuff pressure. (P > 0.05). **Conclusion:** Tracheal cuff pressure decreased significantly in patients undergoing PCNL in the prone position, with no correlation between the tracheal cuff pressure changes and the postoperative sore throat.

Keywords: Tracheal cuff pressure, Sore throat, Intratracheal intubation; Prone position; Pharyngitis; Pressure.

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Introduction

The inflation of the endotracheal tube cuff with air to create air-tight seal is routine after tracheal intubation to allow positive pressure ventilation. The endotracheal cuff pressure needs to be monitored intraoperative, the inflation limit has to be maintained as both under and over inflation associated with some complications.[1] Over inflation of the cuff exceeding the tracheal capillary pressure especially prolonged over inflation affects blood supply to the tracheal mucosa, leading to injury and can present with respiratory complications such as:- sore throat, cough, hoarseness postoperative.[2] Under inflation of the cuff can lead inadequate ventilation due to tidal volume loss and micro aspiration of subglottic secretions leading to postoperative pneumonia.[3] The measurement of cuff pressure can be done by using various techniques, but the use of a digital manometer is one of the most common techniques during general anesthesia.[4] Though there are many other reasons for a sore throat, the increased cuff pressure can be one of them.[5] Even the positional changes are reflected in the tracheal tube tip position and inadequate cuff pressure can lead to displacement of the tube. So cuff pressure measurement is an important in the prone position.[6] There is limited literature regarding the evaluation of tracheal cuff pressure changes in percutaneous nephrolithotomy (PCNL) surgery in the prone position; therefore, the current study was designed to evaluate the changes in cuff pressure in patients undergoing PCNL in the prone position and its correlation with the sore throat.

Materials and Methods

Study design and setting: This prospective observational study was conducted at Nizam's Institute of Medical Sciences (NIMS), Hyderabad, Telangana, India, over a two-year period from 2023 to 2025. Adult patients undergoing elective percutaneous nephrolithotomy under general anaesthesia were prospectively enrolled and followed during the intraoperative and early postoperative periods.

Study population: Patients of either sex, aged 18–60 years, who were scheduled for elective PCNL under general

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anaesthesia were screened for participation.

Inclusion criteria:

Patients were eligible when they fulfilled all the following criteria:

1. Age between 18 and 60 years;
2. American Society of Anesthesiologists physical status I or II;
3. Body mass index between 18.5 and 35.0 kg/m²;
4. Scheduled for elective PCNL; and
5. Serum creatinine concentration ≤2 mg/dL.

Exclusion criteria:

Patients were excluded when they had morbid obesity, an anticipated difficult airway, compromised cardiovascular or respiratory function, a pre-existing tracheostomy, or symptoms such as sore throat, hoarseness, or cough before surgery. Pregnant patients, individuals who declined participation, and patients expected to undergo prolonged surgery requiring blood or blood-product transfusion were also excluded.

Post-enrolment exclusions:

Patients were excluded from the final analysis when they developed an unanticipated difficult airway requiring multiple intubation attempts, experienced massive intraoperative blood loss necessitating multiple transfusions, or required abandonment, repetition, or conversion of the planned PCNL procedure to a supine approach.

Informed consent and preoperative assessment:

During the pre-anaesthetic evaluation, eligible patients were informed about the purpose and procedures of the study. The possibility of postoperative sore throat and the method used for grading its severity were explained. Participants were familiarized with the assessment scale before surgery, and written informed consent was obtained from those willing to participate.

A standard pre-anaesthetic evaluation was performed for all participants. Oral pantoprazole 40 mg and alprazolam 0.25 mg were administered on the night before surgery and repeated on the morning of the procedure.

Intraoperative monitoring: After arrival in the operating room, standard monitoring devices were connected, and intravenous access was secured. Baseline heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, electrocardiogram, peripheral oxygen saturation, and end-tidal carbon dioxide concentration were recorded.

All patients received a standardized general anaesthetic technique. Lignocaine jelly was permitted for lubrication of the endotracheal tube cuff. No additional intervention that could independently influence postoperative sore throat or endotracheal cuff pressure was used.

Anaesthetic technique: Patients received intravenous glycopyrrolate 2 µg/kg and fentanyl 2 µg/kg as premedication. Preoxygenation was performed with 100% oxygen for 3 minutes. Anaesthesia was induced using intravenous propofol 1.5–2.0 mg/kg. After confirming adequate mask ventilation, neuromuscular blockade was achieved with intravenous atracurium 0.5 mg/kg.

Following 3 minutes of controlled mask ventilation, the trachea was intubated using an appropriately sized cuffed endotracheal tube. Correct tube placement was confirmed by bilateral equal air entry and continuous end-tidal carbon dioxide monitoring.

Endotracheal cuff inflation and tube fixation: The endotracheal tube cuff was initially inflated with 7 mL of air using a Cuffill manometer syringe, in accordance with the institution's routine practice. The resulting cuff pressure was measured and recorded as the baseline value. The observational anaesthesiologist documented the pressure without making any adjustment at that stage.

The endotracheal tube was secured at an appropriate insertion depth after confirming correct placement. Anaesthesia was maintained with sevoflurane at a minimum alveolar concentration of 0.7–1.3 in a 50:50 oxygen–air mixture.

Ventilation and temperature management: Mechanical ventilation was provided using a tidal volume of 4–6 mL/kg. The respiratory rate was adjusted to maintain the end-tidal carbon dioxide concentration between 30 and 35 mmHg. An oropharyngeal temperature probe was inserted, and measures were taken to maintain perioperative normothermia.

Prone positioning: After securing the airway, each patient was carefully repositioned from the supine to the prone position. A uniform positioning protocol was followed for all participants. The head was supported on a head ring, the eyes were appropriately padded, and the head was maintained in a slightly tilted neutral position.

At the completion of surgery, the patient was returned to the supine position. Neuromuscular blockade was reversed using the institutional standard reversal regimen. Extubation was performed after ensuring adequate recovery of consciousness, spontaneous ventilation, protective airway reflexes, and neuromuscular function.

Measurement of endotracheal cuff pressure: Endotracheal cuff pressure was measured using a Cuffill manometer at five predefined time points:

1. Immediately after tracheal intubation and cuff inflation while the patient was supine;
2. After final positioning in the prone position;
3. One hour after commencement of surgery in the prone position;
4. At the end of surgery while the patient remained prone; and
5. After repositioning the patient to the supine position and before extubation.

At every assessment, the measured cuff pressure was documented. Measurements were performed consistently using the same method to minimize procedural variability [7,8].

Assessment of postoperative sore throat:

Postoperative sore throat was assessed at 1, 3, 12, and 24 hours after extubation. Severity was graded using the following four-point scale [9,10]:

- **Grade 0:** No sore throat at any time after surgery;
- **Grade 1:** Minimal sore throat reported only when the patient was specifically questioned;
- **Grade 2:** Moderate sore throat reported spontaneously by the patient; and
- **Grade 3:** Severe sore throat associated with obvious pain or distress.

Study variables and outcomes: The principal study variable was the change in endotracheal cuff pressure after moving the patient from the supine to the prone position and during the subsequent stages of surgery.

The following variables were evaluated:

1. Difference between baseline cuff pressure in the supine position and cuff pressures recorded at predefined time points in the prone and subsequent supine positions;
2. Total volume of intravenous fluid administered and its correlation with changes in cuff pressure;
3. Total volume of irrigation fluid used during PCNL and its correlation with cuff-pressure variation;
4. Association between cuff-pressure changes and the occurrence and severity of postoperative sore throat;
5. Correlation between changes in cuff pressure and intraoperative body temperature; and
6. Correlation between cuff-pressure changes and the duration of surgery.

Sample-size estimation: The required sample size was estimated using an expected mean endotracheal cuff pressure of 30 cmH_2O at baseline and 40 cmH_2O at the end of surgery in the prone position. A standard deviation of 12 cmH_2O, a two-sided significance level of 5%, and a statistical power of 80% were considered. Allowance was also made for a 20% screening-failure rate and the possibility of a non-normal distribution.

The minimum estimated sample size was 53 patients. To compensate for possible exclusions, withdrawals, and incomplete observations, 70 patients were recruited.

Statistical analysis: Descriptive and inferential analyses were performed using IBM SPSS Statistics version 22.0 and R version 3.2.2. Continuous variables were summarized as mean ± standard deviation and range, while categorical variables were reported as frequencies and percentages. Appropriate parametric or non-parametric tests, including Student's t-test, Wilcoxon signed-rank test, Fisher's exact test, and Pearson correlation, were applied. A two-sided $p<0.05$ indicated significance.

Ethical approval and trial registration: The study protocol was approved by the Institutional Ethics Committee of Nizam's Institute of Medical Sciences (NIMS), Hyderabad, Telangana, India (approval number: EC/NIMS/2889/2021). Written informed consent was obtained from all participants before enrolment. The study was registered with the Clinical Trials Registry–India under registration number CTRI/2025/07/092068.

Results

A total of 70 patients who underwent percutaneous nephrolithotomy under general anaesthesia in the prone position were included in the analysis. The mean age was 42.71 ± 8.62 years. Among the participants, 42 (60.0%) were male and 28 (40.0%) were female. Most patients were classified as American Society of Anesthesiologists physical status I [48 (68.6%)], while 22 (31.4%) were classified as physical status II. The mean height, weight, and body mass index were 159.63 ± 13.92 cm, 61.13 ± 6.02 kg, and 25.43 ± 14.53 kg/m^2, respectively. No clinically or statistically significant haemodynamic changes were observed during the study period.

The mean tracheal cuff pressure at baseline, immediately after intubation in the supine position, was 35.69 ± 1.63. Cuff pressure decreased progressively after prone positioning, reaching 32.46 ± 1.94 immediately after positioning, 30.17 ± 1.64 after 1 hour in the prone position, 29.40 ± 1.65 at the end of surgery in the prone position, and 28.26 ± 1.56 after the patient was returned to the supine position before extubation. Each post-baseline measurement differed significantly from baseline (all $P < 0.001$). The largest mean reduction was 7.43 at the pre-extubation assessment. No patient had a cuff-pressure value greater than 40 [Table 1].

Table 1: Comparison of cuff pressure with the baseline measurement at different study points

Cuff-pressure assessment	Mean ± SD	Mean difference	t value	P value
Supine 1 (baseline)	35.69 ± 1.63	—	—	—
Immediately after prone positioning	32.46 ± 1.94	3.22	25.680	<0.001
Prone position after 1 hour	30.17 ± 1.64	5.51	36.626	<0.001
Prone position at the end of surgery	29.40 ± 1.65	6.29	32.535	<0.001
Supine 2 (before extubation)	28.26 ± 1.56	7.43	35.363	<0.001

SD, standard deviation.

Regarding intraoperative intravenous fluid administration, 59 patients (84.3%) received 1000 mL, 8 (11.4%) received 1500 mL, and 3 (4.3%) received 500 mL. The magnitude of cuff-pressure change did not differ significantly among the three intravenous-fluid groups after 1 hour in the prone position ($P = 0.740$), at the end of surgery in the prone position ($P = 0.586$), or before extubation after returning to the supine position ($P = 0.742$). Pearson correlation analysis likewise did not identify a significant association between total intravenous-fluid volume and cuff-pressure change [Table 2].

Table 2: Difference in cuff pressure according to the total volume of intraoperative intravenous fluid administered

Cuff-pressure difference	500 mL	1000 mL	1500 mL	Total	P value
Supine position before extubation	6.67 ± 0.58	7.47 ± 1.85	7.38 ± 1.30	7.43 ± 1.76	0.742
Prone position after 1 hour	2.33 ± 0.58	2.32 ± 1.18	2.00 ± 0.00	2.29 ± 1.09	0.740
Prone position at the end of surgery	2.33 ± 0.58	3.14 ± 1.62	2.75 ± 1.39	3.06 ± 1.57	0.586

Values are presented as mean ± standard deviation.

A total irrigation-fluid volume of 4–6 L was used in 48 patients (68.6%), whereas 22 (31.4%) received 7–10 L.

Cuff-pressure changes were comparable between the two irrigation-volume groups after 1 hour in the prone position (P = 0.526), at the end of surgery in the prone position (P = 0.440), and before extubation in the supine position (P = 0.507) [Table 3]. Pearson correlation analysis also showed no significant relationship between total irrigation-fluid volume and cuff pressure after 1 hour in the prone position (r = 0.0097, P = 0.423), at the end of surgery in the prone position (r = 0.006, P = 0.958), or before extubation (r = 0.005, P = 0.939).

Table 3: Difference in cuff pressure according to the total volume of irrigation fluid used

Cuff-pressure difference	4–6 L	7–10 L	Total	P value
Supine position before extubation	7.33 ± 1.75	7.64 ± 1.79	7.43 ± 1.76	0.507
Prone position after 1 hour	2.23 ± 0.93	2.41 ± 1.40	2.29 ± 1.09	0.526
Prone position at the end of surgery	2.96 ± 1.54	3.27 ± 1.64	3.06 ± 1.57	0.440

Values are presented as mean ± standard deviation.

Although intraoperative temperature changed significantly over time (P < 0.001), the observed variation was not considered clinically important. Cuff pressure was not significantly correlated with temperature at the assessed time points, except before extubation, when a weak inverse correlation was observed (r = −0.24, P = 0.045).

Forty-eight procedures (68.6%) were completed within 1 hour 20 minutes, while 22 (31.4%) lasted longer than 1 hour 20 minutes; no procedure exceeded 2 hours. Mean cuff pressure did not differ significantly between the duration groups after 1 hour in the prone position (P = 0.305), at the end of surgery in the prone position (P = 0.225), or before extubation in the supine position (P = 0.123) [Table 4]. Duration of surgery was also not significantly correlated with cuff pressure at the end of surgery (r = −0.121, P = 0.320).

Table 4: Comparison of cuff pressure according to the duration of surgery

Cuff-pressure assessment	≤1 h 20 min	>1 h 20 min	Total	P value
Prone position after 1 hour	30.53 ± 1.66	30.06 ± 1.63	30.17 ± 1.64	0.305
Prone position at the end of surgery	29.82 ± 1.67	29.26 ± 1.63	29.40 ± 1.65	0.225
Supine position before extubation	28.76 ± 1.09	28.09 ± 1.66	28.26 ± 1.56	0.123

Values are presented as mean ± standard deviation.

Postoperative sore throat decreased rapidly during follow-up. At 1 hour, 38 patients (54.3%) had grade 1 sore throat, 31 (44.3%) had grade 2 sore throat, and 1 (1.4%) had severe symptoms. At 3 hours, 39 patients (55.7%) had grade 1 symptoms and 2 (2.9%) had grade 2 symptoms. By 12 hours, only 3 patients (4.3%) reported minimal sore throat, and all patients were symptom-free at 24 hours. Mean cuff pressure did not differ significantly between patients with and without postoperative sore throat immediately after prone positioning (P = 0.126), after 1 hour in the prone position (P = 0.241), at the end of surgery in the prone position (P = 0.815), or before extubation (P = 0.594). Thus, the measured cuff-pressure values were not significantly associated with postoperative sore throat [Table 5].

Table 5: Comparison of cuff-pressure measurements according to postoperative sore-throat status

Cuff-pressure assessment	Sore throat absent	Sore throat present	Total	P value
Immediately after prone positioning	32.03 ± 2.04	32.76 ± 1.83	32.46 ± 1.94	0.126
Prone position after 1 hour	29.90 ± 1.93	30.37 ± 1.39	30.17 ± 1.64	0.241
Prone position at the end of surgery	29.34 ± 1.82	29.44 ± 1.53	29.40 ± 1.65	0.815
Supine position before extubation	28.14 ± 1.60	28.34 ± 1.54	28.26 ± 1.56	0.594

Values are presented as mean ± standard deviation.

Discussion

In our study, we have hypothesized that tracheal cuff pressure will increase in the prone position in PCNL patients and will lead to a higher incidence of sore throat. This is according to the mechanism of changes in cuff pressure, which may be due to an increase in internal or external pressure due to edema by more fluid absorption but we got the opposite results. A study by Mahoori A et al found that position changes from supine to prone and supine to lateral decubitus without head movement can cause an increase in the endotracheal tube cuff pressure.[6] In another study, they found that cuff pressure changes with the change in body position in critically ill patients and suggested routine monitoring of cuff pressure.[11] In one study, there were decrease in the cuff pressures and that they said could led to endotracheal tube displacement.[12] In another study, position change from supine to prone led to an increase in the cuff pressure.[13] But in our study, we found that there was a significant decrease in tracheal cuff pressure in prone positioning at start, 32.46±1.94 (p 0.001) & 29.4±1.65 (p 0.001) at the end of the prone position.

In previous studies, the effect of the prone position on the Mallampati class (MMC) was observed, which reverted back in 36 hours. Though they could not correlate the change in MMC to intraoperative variables like duration of surgery, amount of intraoperative fluid given, and blood loss but there was airway edema, which led to an increase in MMC.[14,15] In the prone position, the surgical stress, neck position and gravity can lead to alteration of venous and lymphatic drainage and ultimately causing airway edema.[16,17] We wanted to study whether this edema has any effect to cause an increase in cuff pressure in PCNL surgeries in the prone position. But in our study, the cuff pressure decreased with the prone position, while this edema could have contributed to the first 3 hours of (grade 1 and 2) sore throat in our patients operated in the prone position. This sore throat improved over time as edema settled, as no patient had a sore throat after 24 hours of surgery. In our study, we found that the intravenous fluid, irrigation fluid, temperature and even duration of procedure had no effect on the cuff pressure. "In previous studies, it has been found that the operation time and irrigation fluid used had an effect on the endotracheal tube cuff pressures in patients operated for shoulder arthroscopy.[18,19] The prone position would have caused the displacement of the endotracheal tube and so cuff pressure decreased. This would have been the mechanism to a decrease in the cuff pressure in our study rather than getting affected by airway edema due to the effect of position, temperature and/orthe fluid management, as these factors will play a role after a few hours of surgery, while positioning leading to tube displacement can be immediate. In our study, the total amount of intravenous fluid used was within 2 liters, even no clinically significant hypothermia/hyperthermia was observed; the duration of surgery was also not prolonged. The prone position had decreased cuff pressure and so indirectly improved tracheal mucosal perfusion and led to less sore throat. But this also is risky and can lead to tube displacement in the prone position if the cuff is not adequately inflated. So, it is always advised to monitor the cuff pressure rather than face problems in any position.

Limitations: It is an observational study, so intraoperative intervention was not done. The operating room temperature was kept warm and even warm fluids were used, that can be the reason for not getting temperature changes. Most of the surgeries ended within 2 hours, so correlating cuff pressure changes with temperature, duration of surgery may not be correct.

Conclusion

Endotracheal cuff pressure declined significantly after prone positioning in patients undergoing percutaneous nephrolithotomy under general anaesthesia. The reduction persisted throughout surgery and remained evident before extubation. Despite these changes, cuff-pressure variation was not associated with the occurrence or severity of postoperative sore throat. Symptoms observed during the early postoperative period were transient and had completely resolved by 24 hours. Intraoperative temperature, intravenous fluid volume, irrigation-fluid volume, and surgical duration showed no influence on cuff-pressure changes. These findings suggest that prone positioning contributes to cuff-pressure reduction. Regular intraoperative cuff-pressure monitoring may help maintain an appropriate seal and reduce avoidable airway-related complications.

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Conflicts of interest

There are no conflicts of interest.

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