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A comparative study of endotracheal tube cuff pressure changes in patients undergoing open abdominal and laparoscopic surgeries

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ABSTRACT

Background: Laparoscopic surgeries are routinely performed because it's minimally invasive and early recovery for patients. The preferred mode of anesthesia is general anesthesia with an endotracheal tube (ETT). The creation of the pneumoperitoneum and various positions cause cuff pressure (CP) changes. **Aims and Objectives:** We aim to study the CP changes and post-operative complications related to it. The secondary objective was to observe the post-operative complications such as sore throat, hoarseness of voice, and blood-streaked expectoration after extubation at 12 h, and at the time of discharge from the post-anesthesia care unit. **Materials and Methods:** One hundred and fifty patients undergoing elective open abdominal and laparoscopic surgeries were enrolled. Three groups (open abdominal [group A], n = 50; lap head up [group B], n = 50; and lap head down [group C], n = 50) were compared for CP changes before and after pneumoperitoneum and position change. CP changes and post-operative complications were recorded and analyzed with Statistical Package for the Social Sciences version 19. **Results:** Mean differences in CP after intubation at 5 min were similar in all three groups. At 45 min onward, the mean CP in group C was found to be elevated and continued to increase till the end of surgery. However, at 90 min, group B also showed some increase in CP. There was a mild increase in CP in groups B and A. The mean difference between groups was found to be remarkable. During the post-operative period, there were 0.7% and 3.3% of cases with throat pain in group B and group C, and 2% of patients in group C had blood streak expectoration. **Conclusion:** In laparoscopic surgery, especially in a head-down position, a considerable increase in CP is associated with post-operative complications.

Key words: Endotracheal tube cuff pressure; Laparoscopic surgery; Pneumoperitoneum; Head-down position; Head-up position

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INTRODUCTION

Laparoscopic surgeries are preferred because of several advantages they offer. However, there is insufflation of CO_2 during laparoscopic surgeries to create pneumoperitoneum, and general anesthesia (GA) is the mode of anesthesia during laparoscopic surgeries. This insufflated CO_2 can cause pressure changes in the endotracheal tube (ETT) cuff pressure (CP).[1] In addition, various positions (head up and head down) during the surgical procedure can also cause pressure changes. The purpose of cuff inflation after endotracheal intubation is to prevent aspiration of pharyngeal content into the trachea and prevent air leakage.[2] This ensures adequate ventilation and reduces leakage of inhalational anesthetic. Another significant but less evident function of the ETT cuff is to keep the tube central in the trachea and guard against mucosal irritation from the tube's tip.[3]

The increase in high volume-low pressure ETT that are routinely used during GA can lead to more severe problems such as temporary hoarseness, sore throat, tracheal mucosal

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ulcer, nerve palsy, tracheal rupture, or fistula, and subglottic stenosis.[4] High CP >30 cmH_2O is the leading cause of these complications due to tracheal mucosa ischemia on the anterolateral trachea wall. In an animal model, tracheal mucosal damage occurs within 15 min of high CP; all laparoscopic surgeries take longer duration than this.[5] The degree of neuromuscular blockade, patient position, and temperature can all impact CP, even if they are constantly monitored following tracheal intubation. In addition, commonly used medical gases, especially nitrous oxide, and volatile breathing agents, might affect CP.[6]

This study was conducted to know the effect of pneumoperitoneum and various positions used during laparoscopic surgeries on the ETT CP and compared with open abdominal surgeries and to correlate between ETT CP changes and post-operative symptoms such as throat pain, sore throat, and difficulty in swallowing.

Aims and objectives

The Primary aim and objective of this research is to observe the changes in ETT cuff pressure in open and laparoscopic abdominal surgeries in accordance to pneumoperitoneum and various changes in position. The secondary objective is to correlate the ETT cuff pressure changes and post-operative complaints like throat pain, sore throat, hoarseness and blood streaked expectoration.

MATERIALS AND METHODS

This prospective observational comparative study was conducted for 2 years after getting permission from the Institutional Ethics Committee. After obtaining informed written consent, 150 patients were recruited for this study.

Inclusion criteria

ASA I and II physical status, aged 18–60 years of either gender, scheduled for elective open abdominal surgeries (group A), laparoscopic surgeries in the head-up (group B), and laparoscopic surgery in the head-down position (group C) were included.

Exclusion criteria

Patients with abnormal airways having anticipated difficult intubation, lung diseases such as chronic obstructive pulmonary disease and bronchial asthma, more than two attempts of laryngoscopy, and change in the plan of surgery from laparoscopy to laparotomy were excluded.

The sample size was calculated using power analysis (α=0.05, power=0.9) based on a previous study. Forty-five subjects were required in each group and a total of 50 subjects were to be recruited in each group by considering mean CP changes from previous studies. A total of 150 subjects, with 50 in each group were included in this study.

All patients received general anesthesia under standard ASA monitoring care; patients were pre-medicated with an injection glycopyrrolate 0.005 mg/kg iv, injection ondansetron 0.15 mg/kg iv, and injection fentanyl 2 mcg/kg iv. Pre-oxygenated with 100% oxygen for 3 min. Induced with injection propofol 2–2.5 mg/kg iv and relaxed with injection succinylcholine 2 mg/kg iv. They were intubated with polyvinyl chloride (PVC) high volume low pressure cuffed ETT of proper size**,** adult female 7/7.5 ID**,** adult male 8/8.5 ID. Patients were ventilated with O2:N_2O ratio 1:1, sevoflurane 1–2 MAC with a tidal volume of 6–8 mL/kg and respiratory rate of 12–14/min. Muscle relaxant injection atracurium 0.4–0.5 mg/kg iv loading dose and 0.08–0.1 mg/kg iv maintenance dose (every 30 min). ETT CP is adjusted to 25 cm H_2O using an aneroid cuff manometer (PORTEX), considered baseline CP, and CP was measured by connecting the aneroid cuff manometer to the pilot balloon and reading to be noted as reflected on the manometer dial. CP is to be measured every 5 min, after CO_2 insufflation, after the change in position, and until the end of surgery till the patient is extubated.

At the end of the surgery, with the return of spontaneous ventilation, the neuromuscular block was reversed with injection glycopyrrolate 0.008 mg/kg iv+injection neostigmine 0.05 mg/kg iv. When the patient was fully awake and had adequate tone and power present, thorough oral suctioning was done. CP at extubation was measured, the cuff was deflated, and ETT was removed. Post-operative complications such as sore throat, hoarseness of voice, and blood-streaked expectoration were to be recorded post-extubation at 12 h and discharge from the post-anesthesia care unit.

Data analysis was performed using Statistical Package for the Social Sciences (version 19). For quantitative variables, descriptive statistics were generated, including mean, standard deviation, and proportions (percent). To verify the theory of Chi-square, independent sample t-tests, and ANOVA were applied. Statistics were judged significant at $P<0.05$.

RESULTS

A total of 150 patients were enrolled in this study 50 patients in three groups. There was no significant difference in age, weight, body mass index (BMI), or sex between the three groups. The demographic characteristics of all groups are shown in Table 1.

In the present study, in group A, there were (15) 10%, (21) 14%, and (14) 9.3% of cases who underwent hernia repair, hysterectomy, and colorectal carcinoma surgeries, respectively, and in group B, there were (40) 26.7%, and (10) 6.7% of cases who underwent laparoscopic cholecystectomy and diagnostic laparoscopy, respectively. Similarly, in group C, there were (39) 26% and (11) 7.3% of cases underwent laparoscopic appendicectomy and diagnostic laparoscopy, respectively.

The difference in the mean duration of surgery, baseline CP, and CP after the change in position in the three groups was found to be statistically insignificant (Table 2).

Mean differences in CP after starting at 5 min intervals were found to be elevated in all three groups and it was statistically insignificant till the 40 min of surgery. At 45 min onwards the mean CP pressure in three groups was found to be elevated and at 60 min the mean CP pressure in group A, group B, and group C were 25.2, 28.2, and 30.2, respectively, the mean difference between groups was found to be significant with a P=0.004 and it was statistically significant.

In continuation, from 65 min onward, the mean CP in group C continued to increase till the end of the surgery; however, group A and group B also showed some increase in CP, and the mean difference between groups was found to be significant (Figure 1).

In continuation, 125 min, the mean CP of group C continued to increase the most, followed by group B and group A, the mean difference between groups was found to be remarkable (Figure 2).

At extubation (Figure 3), the mean CP was found to be higher in group C (32.6±1.4) followed by group B

Table 1: Demographic characteristics of patients

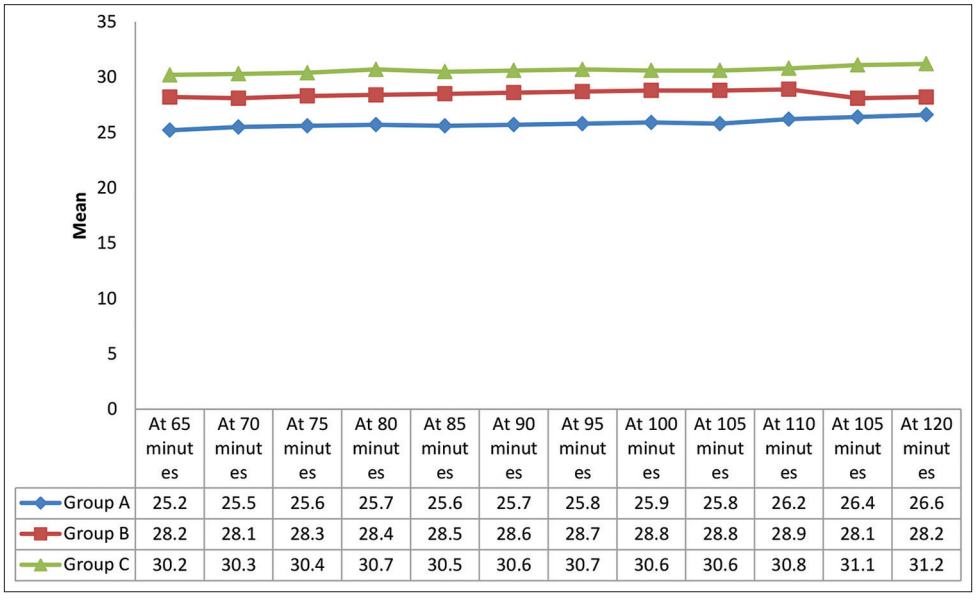
Variables	Range	Group A (n=50)	Group B (n=50)	Group C (n=50)	P-value
Age (years)	18–60	44.7±10.4	39.9±13.1	42.0±13.1	0.144
Gender (M/F)		28/22	31/19	3/19	0.799
Weight (kg)	40–100	75.7±14.2	78.3±13.4	76.9±16.2	0.680
BMI	16–40	24.7±2.4	25.3±1.9	24.6±2.1	0.371

Data are presented as mean±SD or number of patients. BMI: Body mass index

Table 2: Comparison of mean duration of surgery, baseline CP, and CP after the change in position in different groups

Time intervals	Group A	Group B	Group C	P-value
Mean duration of surgery	122.7±31.7	109.5±28.3	116.7±27.9	0.084
Baseline CP	25±0.0	25±0.0	25±0.0	1.000
CP after the change in position	25.3±0.4	27.2±1.2	28.4±1.5	0.231

CP: Cuff pressure



	At 65 minutes	At 70 minutes	At 75 minutes	At 80 minutes	At 85 minutes	At 90 minutes	At 95 minutes	At 100 minutes	At 105 minutes	At 110 minutes	At 105 minutes	At 120 minutes
Group A	25.2	25.5	25.6	25.7	25.6	25.7	25.8	25.9	25.8	26.2	26.4	26.6
Group B	28.2	28.1	28.3	28.4	28.5	28.6	28.7	28.8	28.8	28.9	28.1	28.2
Group C	30.2	30.3	30.4	30.7	30.5	30.6	30.7	30.6	30.6	30.8	31.1	31.2

Figure 1: Cuff pressure in the 2nd h

(29.4±0.8) and then group A (27.01±0.2), which was found to be statistically significant P<0.001.

During the post-operative period, there were 0.7% and 3.3% of cases with throat pain in group B and group C, respectively, and none were reported in group A, there were 0.7% and 5% of cases with sore throat in group B and group C, respectively, and none reported in group A and there were 0.7% and 2.7% of cases with hoarseness of voice in group B and group C, respectively, and none reported in group A. This shows that post-operative airway complications were higher in group C followed by group B and none in group A (Table 3).

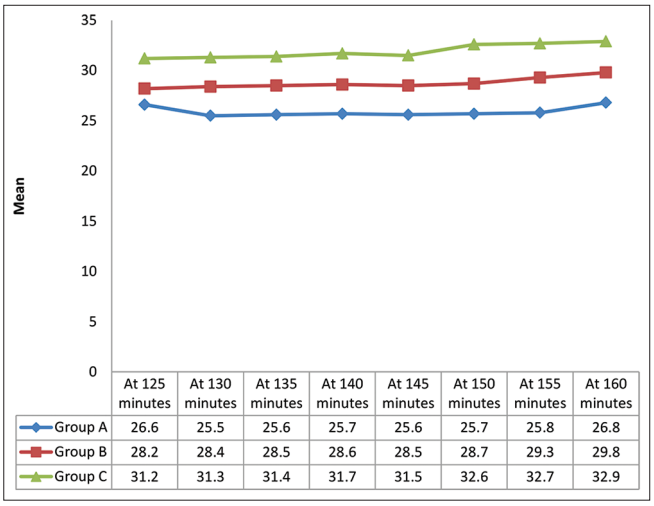


Figure 2: Cuff pressure in the 3rd h

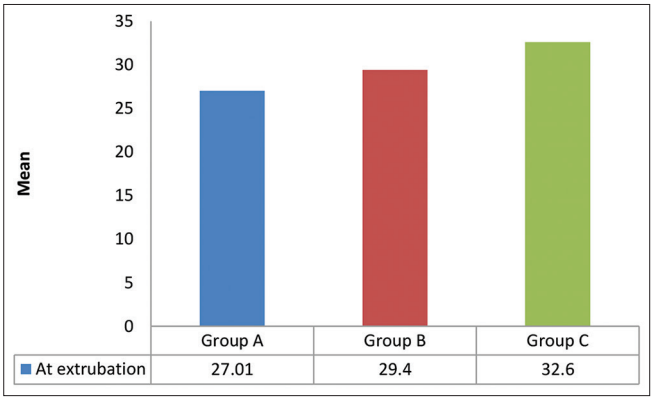


Figure 3: Cuff pressure at extubation

DISCUSSION

The significant finding of the present study is that ETT CP was increased in laparoscopic surgery (more in head-down than head-up position) when compared with open abdominal surgeries. This increase in ETT CP was also directly associated with post-operative respiratory complications such as throat pain, sore throat, hoarseness, and blood-streaked expectoration.[7,8]

The primary purpose of the ETT cuff and maintaining adequate pressure within the cuff is to avoid aspiration into the trachea, to prevent ventilatory leak during mechanical ventilation, and to fix ETT in position.[9,10] If CP is inadequate, air leak and aspiration preferentially occur through the longitudinal folds in the HVLP cuff wall and trachea.[11,12]

A study by Kwon et al.[13] investigated the differences in CP for laparoscopic cholecystectomy because of pneumoperitoneum and the interrelation between BMI, pneumoperitoneum time, and CP changes. They concluded that CP and BMI are not interrelated, but CP and pneumoperitoneum time are directly related, directly correlating with the present study.

Similarly, Chauhan et al.[14] compared the differences in ETT CP between open and laparoscopic cholecystectomy under GA. They claimed that laparoscopic surgery caused more significant changes in hemodynamic parameters than open surgery. Due to reduced thoracic compliance, abdominal insufflation during laparoscopic surgery causes a considerable increase in CP. ETT CP is impacted by position change during laparoscopic surgery. They concluded that during laparoscopic surgery, pneumoperitoneum, and positioning differences significantly enhance ETT CP, which is linked to a higher frequency of post-operative problems. This directly correlates with the findings of the current study.

To further support the findings of the current study, a study by Wu et al.,[15] on CP changes in laparoscopic surgeries and associated positions stated that patients undergoing laparoscopic cholecystectomy and laparoscopic colorectal tumor resection experienced an increase in CP during

Table 3: Association between the proportion of cases with post-operative complications in three groups

Complications	Group A (n=50)	Group B (n=50)	Group C (n=50)	P-value
Throat pain	00	1 (0.7)	5 (3.3)	0.026*
Sore throat	00	1 (0.7)	6 (5)	0.010*
Hoarseness	00	1 (0.7)	4 (2.7)	0.068
Blood-streaked sputum	00	00	3 (2)	0.047*

P-value of <0.05 is considered statistically significant.

insufflation from 26±3 to 32±6 and 27±3 to 33±5 cmH_2O, respectively (both P<0.001). The head-down tilt led to a further rise in CP from 33±5 to 35±5 cmH_2O (P<0.001), and there was no correlation between CP and intra-abdominal pressure (10–15 mmHg) used in laparoscopic surgery. They concluded that during laparoscopic surgery, the ETT's CP increased, especially when the patient was lying head-down.

Liu et al.[16] conducted a study on controlled ETT CP and post-procedural complications, and 500 patients were divided into a control group without measuring ETT CP and a study group with ETT CP measured and adjusted using a manometer. They concluded that CP measured by the classical finger palpation method was usually higher, and CP estimated and adjusted using a manometer was associated with a lower number of ETT-related post-procedural respiratory complications.

Narendra et al.,[6] in observational analysis of ETT CP, changes in laparoscopic surgeries, stated that when N_2O was used, the CP increased (31.4+12.54 cm of H_2O), especially right after insufflation (35.54+12.06 cm of H_2O), and even more so when the head low (36.28+12.13 cm of H_2O). With pneumoperitoneum, mean airway pressure (Ppeak) similarly increased (22.60+4.38 cm of H_2O). Regularly checking the pressure in the ETT cuff should be a component of safe anesthetic practice, and using a simple tool like a hand pressure gauge should be standard procedure when N_2O is utilized.

The findings of the current study are again supported by a study on N_2O diffusion across tracheal cuff by Dullenkopf et al.,[17] stated that when exposed to nitrous gas, the ultra-thin polyurethane tube cuff showed higher nitrous oxide permeability than traditional PVC cuffs and quickly increased CP. The frequency of CP checks was more crucial than the tube's brand.

Limitations of the study

Limitations of our study are the non-blinding nature of this study and the use of N_2O in our study, as N_2O is already known to increase the ETT CP and is a confounding factor. The study design could not correlate CP with specific post-operative respiratory complications because they may be associated with multiple outcomes such as the number of intubation attempts, type of lubricants used, use of a stylet, etc., and ETT size is not standardized, which may affect the outcome.

CONCLUSION

Our study concludes that ETT CP increases more in laparoscopic surgeries in the head-down position in comparison with laparoscopic surgeries in the head-up position and open abdominal surgeries. Post-operative respiratory complications are directly associated with elevated ETT CP of more than 30 cm H_2O. Continuous monitoring of ETT CP is required in all laparoscopic cases to prevent post-operative complications related to CP.

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Author's Contributions:
HBJ- Definition of intellectual content, literature survey, prepared the first draft of a manuscript, implementation of the study protocol, data collection, data analysis, manuscript preparation, and submission of the article; **SE-** Concept, design, clinical protocol, manuscript preparation, editing, and manuscript revision; **RPC-** Design of study, statistical analysis, and interpretation.

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