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Variations in Endotracheal Tube Cuff Pressure During Laparoscopic Surgery in Head-Up and Head-Down Positions

Dr. Adithya M[*1], Dr. Dikshapreet[2], Dr. Shrikant[3], Dr. Murali Manohar A[4] & Dr. Prasad CGS[5]

[1,2,3,4,5]Department of Anaesthesiology and Critical Care, ESIC MC PGIMSR & Model Hospital, Rajajinagar, Bengaluru

HIGHLIGHTS

1. Cuff pressure fluctuates with position changes.
2. Head-up increases endotracheal tube pressure.
3. Head-down reduces cuff pressure slightly.
4. Monitoring ensures optimal airway safety.
5. Position impacts cuff pressure during surgery.

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ABSTRACT

The study evaluates the variations in endotracheal tube (ETT) cuff pressure during laparoscopic surgeries, focusing on the head-up and head-down positions. Laparoscopic procedures often involve creating a pneumoperitoneum, which, in conjunction with patient positioning, can influence respiratory mechanics and cause significant changes in cuff pressure. Maintaining ETT cuff pressure within the optimal range of 20-30 cm H_2O is crucial to prevent complications such as mucosal ischemia and aspiration. This prospective observational study, conducted at ESIC Medical College, Bangalore, from March 2021 to August 2022, included 70 patients undergoing elective laparoscopic surgeries. Patients were divided equally into two groups based on the position: head-up (35 patients) and head-down (35 patients). ETT cuff pressure, intra-abdominal pressure, and peak airway pressure were measured at various intervals during surgery, starting from carbon dioxide insufflation and continuing throughout the procedure. Results indicated a statistically significant increase in cuff pressure in the head-down group, with values reaching 32.57 ± 1.07 cm H2O at the 60-minute mark, compared to 31.22 ± 1.56 cm H_2O in the head-up group ($p = 0.012$). However, changes in intra-abdominal pressure and peak airway pressure between the groups were not significant. These findings highlight the influence of patient positioning, particularly in the head-down position, on ETT cuff pressure during laparoscopic surgeries. Although intra-abdominal and peak airway pressures also increased in both groups, the changes were not statistically significant. The study underscores the importance of continuous intraoperative monitoring and adjustment of ETT cuff pressure, particularly in the head-down position, to reduce the risk of airway-related complications. By focusing on the physiological changes associated with different patient positions, the study contributes valuable insights into airway management during laparoscopic procedures.

* Corresponding author.
Dr. Adithya M, Department of Anaesthesiology and Critical Care, ESIC MC PGIMSR & Model Hospital, Rajajinagar, Bengaluru
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INTRODUCTION

Laparoscopic surgery is typically conducted under general anesthesia with mechanical ventilation, utilizing a high-volume, low-pressure endotracheal tube (ETT)[1]. These tubes have a sealing cuff pressure maintained at around 20-30 cm H_2O to ensure a proper seal and prevent overinflation. Despite the widespread use of these ETT cuffs designed to minimize pressure on the trachea, complications related to overinflation still frequently occur[2]. Such complications range in severity, with transient sore throat, hoarseness, and tracheal mucosal ulcers being some of the most common outcomes. Even when cuff pressures are carefully set within safe limits immediately after tracheal intubation, they can rise significantly due to various factors, including patient movement, positioning during surgery, changes in body temperature, and the degree of neuromuscular blockade[3].

During laparoscopic procedures, the creation of a pneumoperitoneum-where the abdominal cavity is inflated with gas-and positioning the patient in head-up or head-down tilt can lead to significant physiological changes[4]. These include decreased lung compliance, increased intrathoracic pressure, and elevated peak airway pressure, all of which can affect the pressure inside the ETT cuff. Specifically, the Trendelenburg position (where the patient is tilted head-down) induces notable hemodynamic and respiratory changes. It reduces functional residual capacity and increases pulmonary compliance, potentially contributing to alterations in cuff pressure. Understanding how these physiological changes interact during surgery is crucial for patient safety and minimizing complications related to airway management[5].

Research has been conducted to explore some of these interactions. For example, Kwon Y et al. studied changes in EIT cuff pressure and airway pressure during pneumoperitoneum in patients undergoing laparoscopic cholecystectomy in the head-up position[6]. Another study by Rosero EB et al. focused on the same parameters in obese patients undergoing pelvic laparoscopic surgery. Despite such studies, there remains a gap in comprehensive understanding of the physiological effects of pneumoperitoneum and various patient positions on ETT cuff pressur[7]. The combined effects of these factors-particularly in different surgical positions like head-up and head-down tilt-have not been fully clarified or studied in detail.

Given the incomplete understanding of how these surgical factors impact cuff pressure, this study was designed to changes in ETT cuff pressure during laparoscopic surgery when patients are placed in both head-up and head-down positions[8]. By focusing on these positions, this research contribute to a more thorough understanding of the physiological interactions during laparoscopic procedures and improve the management of airway pressure to reduce the risk of complications associated with ETT overinflation[9].

The study aims to compare endotracheal tube cuff pressure during laparoscopic surgeries after carbon dioxide insufflation and in head-up and head-down positions. The secondary objective is to measure intra-abdominal and peak airway pressures following carbon dioxide insufflation and changes in patient positioning during laparoscopic procedures.

MATERIAL AND METHODS

Data was collected from consenting patients scheduled for elective laparoscopic surgery under general anesthesia with endotracheal intubation at ESIC-Medical College-PGIMSR, Bangalore. The sample size, based on Wu CY et al., was calculated at 35 patients per group (head-up and head-down positions). The study, conducted from March 2021 to August 2022, was a prospective observational design. Inclusion criteria included ASA status 1 and 2, aged 18-60 years, while exclusion criteria involved ASA status 3 and 4, airway disease, and traumatic intubation.

RESULT

The mean age of subjects undergoing laparoscopic surgeries in head-up and head-down positions, which were 31.91±13.11 years and 30.17±10.18 years, respectively, with a p-value of 0.149, indicating no significant difference. In the head-up group, there were 9 males (25.7%) and 26 females (74.3%), while the head-down group had 20 males (57.1%) and 15 females (42.9%). The mean weight for the head-up group was 55.68±6.51 kg and for the head-down group, 53.65±5.65 kg, with a p-value of 0.385, showing no significant difference. Similarly, the mean height was 157.4±5.43 cm in the head-up group and 157.2±5.91 cm in the head-down group, with a p-value of 0.933, indicating no significant difference between the groups in terms of height.

Table 1: Showing the Mean BMI in Both the Groups

Demographic parameters	Head up	Head down		Mean difference		P value	Remarks
	Mean	SD	Mean	SD			
BMI(kg/m^2)	22.51	2.73	21.67	1.72	0.84	0.126	Not significant

The table show the mean BMI of subjects undergoing laparoscopic surgery in head-up and head-down positions, which were 22.51±2.73 kg/m² and 21.67±1.72 kg/m², respecti-vely. The p-value was 0.126, indicating no statistically significant difference between the two groups.

Table 2: Showing the Mean Pulse Rate in Both the Groups

Demographic parameters	Head up		Head down		Mean difference	P value	Remarks
	Mean	SD	Mean	SD			
PR(bpm)	71.34	3.39	71.71	1.88	-0.37	0.573	Not significant

The table show the mean pulse rate of subjects undergoing laparoscopic surgeries in head-up and head-down positions, which were 71.34±3.39 bpm and 71.71±1.88 bpm, respective-ely. The p-value was 0.573, indicating no statistically significant difference between the groups.

Table 3: Showing the Mean SBP in Both the Groups

Demographic parameters	Head up		Head down	Mean difference		P value	Remarks
	Mean	SD	Mean	SD			
SBP(mmHg)	121.4	8.82	125.14	9.81	-3.74	0.098	Not significant

The table and figure show the mean systolic blood pressure (SBP) of subjects in laparoscopic surgeries, which was 121.4±8.82 mmHg in the head-up position and 125.14±9.81 mmHg in the head-down position. The p-value of 0.098 indicates no statistically significant difference.

Table 4: Showing the Mean DBP in Both the Groups

Demographic parameters	Head up		Head down		Mean difference	P value	Remarks
	Mean	SD	Mean	SD			
DBP(mmHg)	78.03	10.14	78	8.68	0.03	0.989	Not significant

The table and figure show the mean diastolic blood pressure (DBP) of subjects undergoing laparoscopic surgeries in head-up and head-down positions, which were 78.03±10.14 mmHg and 78±8.68 mmHg, respectively. The p-value of 0.989 indicates no statistically significant difference between the groups.

Table 5: Showing the Mean Respiratory Rate of in Both the Groups.

Demographic parameters	Head up		Head down		Mean difference	P value	Remarks
	Mean	SD	Mean	SD			
Respiratory rate (cpm)	16.91	1.62	17.65	1.87	-0.74	0.081	Not significant

The table show the mean respiratory rate of subjects in laparoscopic surgeries, which was 16.91±1.62 cpm in the head-up position and 17.65±1.87 cpm in the head-down posit-ion. The p-value of 0.081 indicates no statistically significant difference.

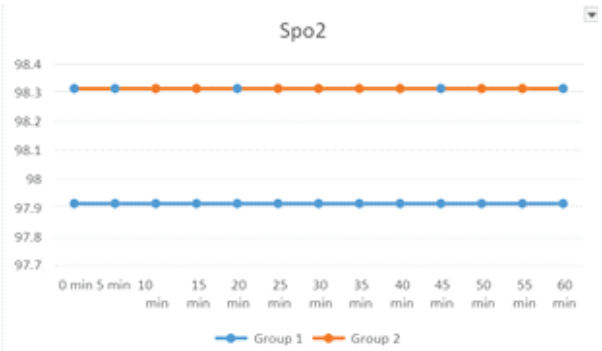

Figure 1: Showing the Mean Spo2 in Both the Groups

The figure show the mean SpO_2 of subjects in laparoscopic surgeries, with 97.91±1.62% in the head-up position and 98.31±1.64% in the head-down position. The p-value of 0.038 indicates no statistically significant difference.

Table 6: Showing the Mean Duration of Surgery in Both the Groups

Demographic parameters	Head up		Head down		Mean difference	P value	Remarks
	Mean	SD	Mean	SD			
Duration(minutes)	49.71	14.55	55	12.24	-5.29	0.105	Not significant

The table and figure show the mean duration of surgery for subjects in head-up and head-down positions, which was 49.71±14.55 minutes and 55±12.24 minutes, respectively. The p-value of 0.105 indicates no statistically significant difference.

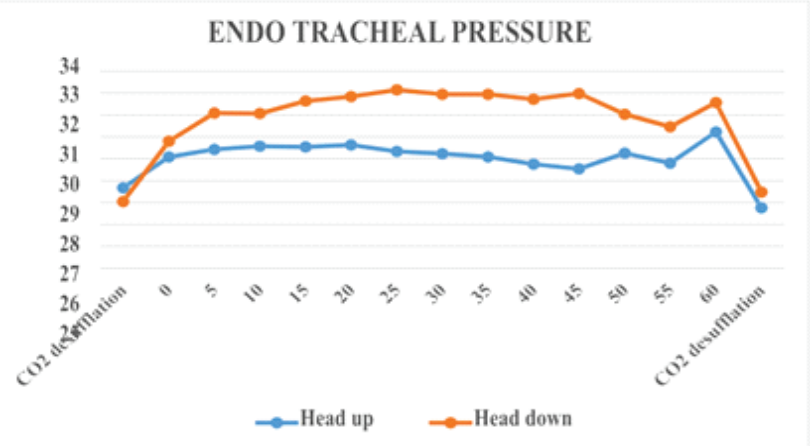

Figure 2: Showing the Mean Endo tracheal Cuff Pressure Measurement in Both the Groups.

The table and figure show mean endotracheal cuff pressure in laparoscopic surgeries. A significant difference was observed between head-up and head-down positions from 0 to 60 minut-es ($p < 0.05$). No significant differences were noted at CO2 insufflation and desufflation ($p = 0.155$ and 0.071).

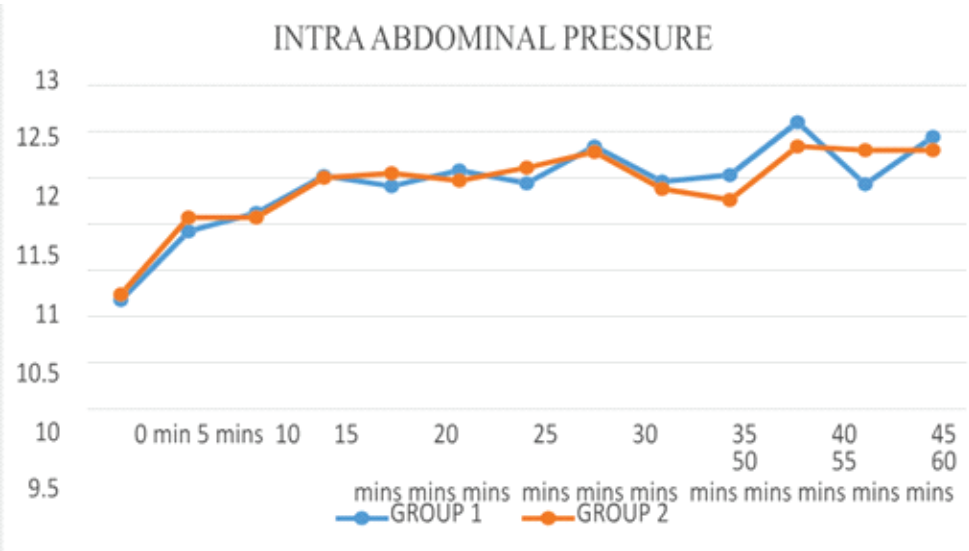

Figure 3: Showing the Mean Intra-Abdominal Pressure in Both the Groups

The table and figure display the mean intra-abdominal pressure in laparoscopic surgeries for head-up and head-down positions. There was no statistically significant difference between the two positions at any time point.

DISCUSSION

Laparoscopic surgeries under general anesthesia utilize a cuffed endotracheal tube, with intra-cuff pressure maintained between 20 to 30 cmH_2O to prevent aspiration and ensure pro-per ventilation. Overinflation above 30 cmH_2O decreases mucosal perfusion, while pressures below 20 cmH_2O heighten aspiration risk. During laparoscopy, cuff pressure increases due to factors like pneumoperitoneum, head and neck position changes, and the use of nitrous oxide. Studies by Wu CY and Kwon Y examined intraoperative cuff pressure variations in different positions and body mass index correlations. This study evaluates changes in cuff pressure during laparoscopic cholecy-

-stectomy (head-up) and appendectomy (head-down) positions post-pneumoperitoneum. Demographic variables, including age, gender, BMI, pulse rate, and surgery duration, were comparable between groups[10][11][12].

Post-intubation, the endotracheal cuff pressure was inflated to 25 cmH_2O, and intra-abdominal pressure was limited to 10-15 mmHg in both study groups. Baseline cuff pressures after pneumoperitoneum were 28.68 ± 1.81 cmH_2O (head up) and 28.05 ± 1.84 cmH_2O (head down), with a p-value of 0.155, indicating no significant difference. Cuff pressure was monitored every 5 minutes for an hour, with a greater increase in the head-down position, peaking at 60 minutes. At this point, pressure reached 31.22 ± 1.56 cmH_2O (head up) and 32.57 ± 1.07 cmH_2O (head down), with a significant p-value of 0.012. Wu CY's study also reported significant increases in cuff pressure during laparoscopic surgery, particularly in head-down positions. Similarly, Kwon Y's study on patients with different BMI levels during laparoscopic cholecystectomy found no significant difference in cuff pressure changes between groups, with a baseline increase of approximately 5 cmH_2O in both[10][12][13].

After desufflation, mean cuff pressure changes were 1.7 ± 1.9 cmH_2O in the study group and 1.4 ± 1.6 cmH_2O in the control group, with no statistical significance. Cuff pressure changes correlated with pneumoperitoneum time but were unaffected by BMI. Lizy C's study in 12 critically ill patients showed significant cuff pressure deviations across 16 different positions. Yildirim Z B's research in 40 patients demonstrated that laparoscopic surgeries, especially in the head-down position, caused cuff pressures to exceed 30 cmH_2O, correlating with pneumoperitoneum. These findings support the observation that head-down positions result in higher cuff pressures[14][15][16].

Following intubation, peak airway pressures were 18.45 ± 2.06 cmH_2O in both head-up and head-down positions, with a non-significant p-value of 1.00. After pneumoperitoneum, pressures rose slightly to 19.22 ± 1.45 cmH_2O (head-up) and 19.37 ± 1.51 cmH_2O (head-down), with a p-value of 0.689. At the 60th minute, peak pressures reached 21 ± 2.34 cmH2O (head-up) and 22.6 ± 0.87 cmH_2O (head-down), again non-significant (p = 0.501). After desufflation, pressures returned to 18.20 ± 2.11 cmH_2O (head-up) and 18.37 ± 1.39 cmH_2O (head-down), with no significant difference (p = 0.501). Other studies, such as those by Renders T A L et al. and Wu CY et al., showed significant increases in airway pressure with pneumoperitoneum, especially in Trendelenburg positions. However, in this study, peak airway pressure changes were insignificant, potentially due to variations in intra-abdominal pressure, the use of air or N_2O, or patient BMI[10][17][18].

CONCLUSION

In our study on endotracheal tube cuff pressure during laparoscopic surgery, we found that cuff pressure increased in both head-up and head-down positions, with a greater rise in the head-down position. Although intra-abdominal and peak airway pressures also increased, the changes were not statistica-lly significant.

In conclusion, elevated intracuff pressure during laparoscopic surgery may affect mucosal perfusion, leading to postoperative complications. Thus, intraoperative monitoring of cuff pressure is crucial to prevent such complications. Further research is needed to explore the clinical impact of increased intra-abdominal and peak airway pressures.

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