



## Endotracheal tube cuff pressure during laparoscopic bariatric surgery: highs and lows

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**Background:** Gastric calibration tubes (GCTs) are a unique component of bariatric surgery. This study aimed to assess changes in the endotracheal tube (ETT) cuff pressure during laparoscopic bariatric surgery.

**Methods:** This was a prospective observational study consisting of 124 American Society of Anesthesiologists class I–III morbidly obese patients (body mass index > 40 kg/m<sup>2</sup>) undergoing elective laparoscopic bariatric surgery under general anesthesia. The baseline ETT cuff pressure was 28 cmH<sub>2</sub>O. Cuff pressure, peak airway pressure, and hemodynamic changes were observed during various steps of bariatric surgery. Immediate postoperative complications during the first 24 h were recorded.

**Results:** ETT cuff pressure increased significantly from the baseline (28 cmH<sub>2</sub>O) after insertion of GCT (36.3 ± 7.3 cmH<sub>2</sub>O) and creation of carboperitoneum (33.3 ± 3.8 cmH<sub>2</sub>O). Cuff pressure decreased significantly on GCT removal (24.0 ± 3.0 cmH<sub>2</sub>O) and release of carboperitoneum (24.7 ± 3.0 cmH<sub>2</sub>O). Peak airway pressure increased from the initial baseline value of 25.1 ± 3.7 to 26.5 ± 4.5 after GCT insertion, creation of carboperitoneum (32.6 ± 4.4), attainment of reverse Trendelenburg position (32.3 ± 4.0), and subsequent return to supine position 32.5 ± 4.8.

**Conclusions:** The endotracheal cuff pressure significantly varies during the intraoperative period. Routine monitoring and readjustment of cuff pressure are advisable in all laparoscopic bariatric surgeries to minimize the possibility of postoperative complications.

**Keywords:** Adult; Bariatric surgery; Calibration; Laparoscopic surgical procedures; Manometry; Morbid obesity; Trachea.

## INTRODUCTION

Obesity can be defined as a “disease,” which is prevalent in both developing and developed nations. Currently, laparoscopic bariatric surgery is an efficient method of weight reduction and is generally associated with low morbidity and mortality [1]. General anesthesia in patients with morbid obesity presents a challenging task.

Laparoscopic surgery is performed under general anesthesia with mechanical ventilation. A high-volume, low-pressure cuffed endotracheal tube (ETT) with a sealing cuff pressure of approximately 20–30 cmH<sub>2</sub>O is commonly used for proper sealing and avoidance of over-inflation [2]. The main symptoms associated with tracheal intubation are sore throat, hoarseness, and dysphagia [3]. Although the exact pathophysiology of post-intubation airway symptoms is not fully known,

mucosal damage at the cuff level is thought to be an important cause of tracheal morbidity [4].

Insertion of gastric calibration tubes (GCTs) is required during bariatric surgery, especially sleeve gastrectomy, to drain and remove gastric fluid and provide calibration for gastric pouch and leak testing. The complications associated with GCT insertion include pharyngeal and esophageal tears, which increase morbidity and cost in these patients [5,6]. Another important aspect of GCT insertion, which is usually ignored, is the pressure exerted on the trachea, with the resultant increase in cuff pressure of the ETT in situ. Hence, this study aimed to observe the changes in cuff pressure during various steps of laparoscopic surgery and the complications arising from it.

## MATERIALS AND METHODS

This prospective observational study was conducted for 4 months in a tertiary, high-volume bariatric center after obtaining Institutional Ethics Committee approval (no. SAIMS/IEC/16/02) and written informed consent. A total of 289 patients underwent surgery during the study period, comprising 182 morbidly obese patients (body mass index [BMI] > 40 kg/m<sup>2</sup>) who were admitted for laparoscopic bariatric surgery. One hundred and twenty-four American Society of Anesthesiologists grade I, II, and III morbidly patients of both the sexes taken in the operating theater with bispectral index monitor (BIS) monitoring under the same anesthesiologist and consenting to be a part of the study were included in the study (Fig. 1). Patients who did not fulfill the inclusion criteria, American Society of Anesthesiologists grade IV patients, and those with predicted difficult intubation or tracheostomy

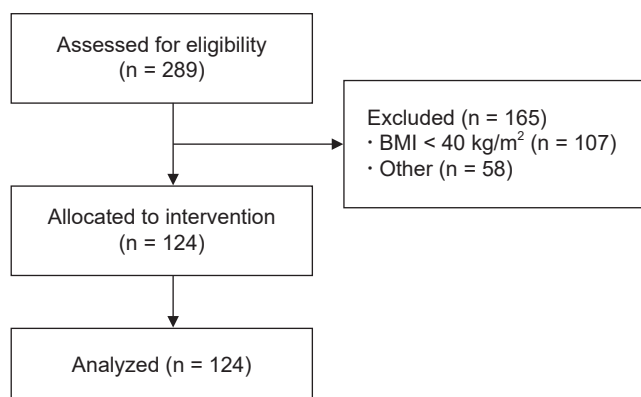
in situ were excluded from the study.

After being transferred to the operating theater, all patients were administered general anesthesia using a standard protocol. Pre-oxygenation with 100% oxygen for 3 min was carried out. Induction of anesthesia was started with IV glycopyrrolate 0.2 to 0.4 mg, IV fentanyl 30–40 µg, and IV propofol 1% 7.5–12.5 ml (BIS guided). Endotracheal intubation with a cuffed ETT was facilitated by the neuromuscular blocker cisatracurium IV, 0.15 mg/kg as per total body weight. For female patients, a size 7 cuffed ETT was used, and for males, a size 8 cuffed ETT was used. Anesthesia was maintained with oxygen and air (60:40) along with desflurane and controlled mechanical ventilation with cisatracurium injection. A high-volume, low-pressure ETT (Rüsch®, Teleflex Medical, Malaysia) was placed in situ, and the ETT cuff pressure was adjusted to 28 cmH<sub>2</sub>O using a manometer (Posey®, Portex, Germany). We ensured that there was no leakage by stethoscopic auscultation. After induction, a 38 Fr (12.7 mm) GCT (Ethicon Endo-Surgery, Germany) was inserted blindly in a slightly head-up position. Abdominal insufflation of carbon-dioxide was performed in the supine position. The patients were placed in the reverse Trendelenburg position to facilitate surgery and consequent cuff pressure changes, and changes in peak airway pressure were recorded at the following steps of surgery: 2 min after insertion of GCT, creation of carboperitoneum in supine position, reverse Trendelenburg position, final removal of GCT, return to supine position, and release of carboperitoneum. The cuff pressure recordings were performed at the end of expiration.

Immediate postoperative complications during the first 24 h such as sore throat, cough, hoarseness of voice, and aspiration pneumonia were also recorded. The target cuff pressure was set at 28 cmH<sub>2</sub>O and adjusted after each recording at various surgical steps. The manometer was calibrated every month. It was kept attached to the pilot balloon throughout surgery. Intra-abdominal pressure was maintained between 14 and 16 mmHg during the carboperitoneum. Measurements were taken with the patient's head and neck in the neutral position and occiput on the same type of pillow.

## Statistical analysis

The results obtained were collected, tabulated, and analyzed using appropriate statistical tests. Statistical analysis was performed using IBM SPSS 20 version (IBM Co., USA). Normality of distribution was assessed using the Kolmogorov-Smirnov test. Continuous variables were expressed as



**Fig. 1.** CONSORT flow chart of the study. CONSORT: consolidated standards of reporting trials, BMI: body mass index.

mean  $\pm$  standard deviation or range, while non-continuous variables were expressed as the number of occurrences and percentages. The ETT cuff pressure and peak pressure at various surgical steps were compared using multiple paired *t*-tests. Statistical significance was set at  $P < 0.05$ .

## RESULTS

In total, 124 patients were included in this study (Fig. 1). In the study population, mean age was  $44.5 \pm 12.6$  years and mean BMI was  $46.1 \pm 6.0$  kg/m<sup>2</sup>. Majority of the patients belonged to the age group of 40–60 years (51.7%), with a preponderance of females (55%). The mean duration of surgeries was 1.2 h. Most patients underwent sleeve gastrectomy, Roux-en-Y gastric bypass, or mini-gastric bypass (Table 1).

The baseline cuff pressure was set to 28 cmH<sub>2</sub>O. Mean ETT cuff pressure was found to be significantly increased from the baseline after insertion of GCT ( $36.3 \pm 7.3$  cmH<sub>2</sub>O;  $P < 0.001$ ) and creation of carboperitoneum ( $33.3 \pm 3.8$  cmH<sub>2</sub>O;  $P < 0.001$ ). ETT cuff pressure was frequently higher than 30 cmH<sub>2</sub>O after GCT insertion, which may lead to impaired tracheal mucosal blood flow. Clinically significant increase in cuff pressure ( $> 35$  cmH<sub>2</sub>O) was observed in 55 of 120 patients (45.8%). We also found that there was an approximately two-fold increase in endotracheal cuff pressure in 3 out of 120 patients (2.5%). In addition, cuff pressure significantly decreased from the baseline after GCT removal ( $24.0 \pm 3.0$  cmH<sub>2</sub>O;  $P < 0.001$ ) and release of carboperitoneum ( $24.7 \pm 3.0$  cmH<sub>2</sub>O;  $P < 0.001$ ). No significant changes were observed in cuff pressure after giving reverse Trendelenburg position ( $28.0 \pm 1.4$  cmH<sub>2</sub>O) and return to supine position ( $27.9 \pm 1.3$  cmH<sub>2</sub>O) (Table 2).

There was a significant increase ( $P < 0.05$ ) in peak airway pressure from the initial baseline value of  $25.1 \pm 3.7$  to  $26.5 \pm 4.5$  cmH<sub>2</sub>O ( $P < 0.001$ ) after GCT insertion, creation of carboperitoneum ( $32.6 \pm 4.4$ ) ( $P < 0.001$ ), attainment of reverse Trendelenburg position ( $32.3 \pm 4.0$ ) ( $P < 0.001$ ), and subse-

quent return to supine position  $32.5 \pm 4.8$  ( $P < 0.001$ ). Furthermore, peak airway pressure decreased and returned to baseline values after the release of the carboperitoneum (Table 3). Only 2 of the patients had hoarseness of voice as a postoperative complication, while 10 patients had sore throat and discomfort. No other complications such as aspiration were noted in this study (Table 2).

## DISCUSSION

Our study emphasizes the importance of intraoperative ETT cuff pressure monitoring, particularly in laparoscopic bariatric surgery. We found that cuff pressure not only increases with GCT insertion and creation of the carboperitoneum but also decreases significantly with GCT removal and release of carboperitoneum. Both scenarios can prove harmful if adequate measures are not taken.

Laparoscopy in bariatric surgery is associated with lower morbidity and mortality than the traditional surgical approach [7]. The physiological changes associated with laparoscopic bariatric surgery include those associated with tilting the patient to facilitate instrumentation and surgical exposure, pressure effects of instilled gas into a closed cavity

**Table 2.** Comparison of Cuff Pressure between Baseline and Various Steps During Surgery

Steps during surgery	Cuff pressure (cmH <sub>2</sub> O)
Baseline	28
GCT insertion	$36.3 \pm 7.3$
Creation of carboperitoneum	$33.3 \pm 3.8$
Reverse Trendelenburg position	$28.0 \pm 1.4$
Final removal of GCT	$24.0 \pm 3.0$
Return to supine	$27.9 \pm 1.3$
Release of carboperitoneum	$24.7 \pm 3.0$

Values are presented as mean  $\pm$  SD. Cuff pressure was adjusted to 28 cmH<sub>2</sub>O at each step. GCT: gastric calibration tube.

**Table 3.** Comparison of Peak Airway Pressure between Baseline and Various Steps During Surgery

Steps during surgery	Peak airway pressure (cmH <sub>2</sub> O)
Baseline	$25.1 \pm 3.7$
GCT insertion	$26.5 \pm 4.5$
Creation of carboperitoneum	$32.6 \pm 4.4$
Reverse Trendelenburg position	$32.3 \pm 4.0$
Final removal of GCT	$31.7 \pm 4.5$
Return to supine	$32.5 \pm 4.8$
Release of carboperitoneum	$25.3 \pm 3.9$

Values are presented as mean  $\pm$  SD. GCT: gastric calibration tube.

**Table 1.** Demographic Data

Variable	Value (n = 124*)
Age (yr)	$44.5 \pm 12.6$
Sex, F/M (%)	55/45
BMI (kg/m <sup>2</sup> )	$46.1 \pm 6.0$
Duration of surgery (min)	$83.0 \pm 15.6$
Type of surgery, sleeve/gastric bypass/mini gastric bypass	66/23/35

Values are presented as mean  $\pm$  SD or number only. BMI: body mass index. \*Total patients.

further increasing the gastric pressure, systemic effects of carbon dioxide, and pressure effect associated with GCT. Thus, endotracheal intubation is mandatory in obese patients. Studies conducted to date have assessed cuff pressure changes during one aspect of laparoscopic surgery, such as position or carboperitoneum [3,8]. This study evaluated changes in cuff pressure during various steps of laparoscopic bariatric surgery.

The ETT cuff pressure must be adjusted to ensure delivery of the prescribed mechanical ventilation tidal volume and reduce the risk of aspiration of secretions that accumulate above the cuff without compromising tracheal perfusion [9]. A minimal pressure of 20 cmH<sub>2</sub>O is recommended to prevent aspiration and ventilator-associated pneumonia [10,11]. There is a lack of uniformity in the desired value of cuff pressure, but a range of 20–30 cmH<sub>2</sub>O can be considered safe. Lomholt [12] recommended selecting a cuff pressure of 25 cmH<sub>2</sub>O as the safe minimum cuff pressure to prevent aspiration and leakage of ventilator gases. The cuff pressure was adjusted to 28 cmH<sub>2</sub>O to ensure safety.

Hung [13], in their study on patients undergoing laparoscopic bariatric surgery, had concluded that after insertion of the calibrating orogastric tube, the median tracheal cuff pressure increased from 28 to 36 cmH<sub>2</sub>O ( $P < 0.001$ ) and was greater than 35 cmH<sub>2</sub>O in 30 of 60 patients (50%). Our study showed that cuff pressure increases not only at the time of GCT insertion but also at the time of creation of the carboperitoneum. Fifty-five percent of the patients had ETT cuff pressure greater than 35 cmH<sub>2</sub>O on GCT insertion, and 17.5% patients had increased cuff pressure at the time of pneumoperitoneum creation. Kim et al. [14] observed a similar increase in cuff pressure after insertion of a transesophageal echocardiography probe.

Wu et al. [8] evaluated ETT cuff pressure changes in the head-up or head-down position during laparoscopic surgery. They found that the head-up position in laparoscopic cholecystectomy causes no significant change in cuff pressure, which is similar to our results. BMI did not show any correlation with an increase in cuff pressure in our study, similar to the aforementioned study. The peak airway pressure did not change significantly in their study. In our study, a significant increase was seen from the baseline value, but when compared with the value of peak pressure at the time of creation of the carboperitoneum, no significant change was observed (Table 3). The reverse Trendelenburg position reduces breathing by shifting the abdominal viscera caudally away from the diaphragm. Hence, it is expected that the airway

pressure should decrease, but this was not observed. The increase in compliance with the reverse Trendelenburg position could have been nullified by the carboperitoneum. Carboperitoneum decreases thoracopulmonary compliance by 30–50% in healthy and obese patients [15].

Hemodynamic parameters were also recorded during the various surgical steps. Heart rate did not vary much with GCT insertion, carboperitoneum, reverse Trendelenburg position, return to supine position, or release of carboperitoneum. However, in the reverse Trendelenburg position, systolic and diastolic blood pressure fell significantly below baseline. Hence, it is vital for patients to be adequately hydrated to prevent adverse outcomes due to hypotension, such as stroke.

The drop in ETT cuff pressure observed when the GCT was removed in the present study can be explained by the removal of an external force on the posterior membranous tracheal wall exerted by the GCT into the esophagus. The cuff pressure also decreases significantly when the carboperitoneum is released. These periods of insufficient pressure leave the patient susceptible to micro-aspiration as secretions or hemorrhagic acidic gastric content pooled on top of the ETT cuff as the GCT is removed, may move past it, and trickle down into the lungs. Accumulating evidence suggests that obesity is associated with complications due to longstanding reflux, such as erosive esophagitis, Barrett's esophagus, and esophageal adenocarcinoma [16]. Thus, microaspiration or frank aspiration of gastric contents intraoperatively, especially when the GCT is pulled out, is a serious risk in these patients. Therefore, proper suctioning as the GCT is removed is recommended.

Fluid leakage around the ETT cuff into the airway is a potentially serious form of microaspiration. The cuff is designed to seal the airway, allowing airflow through the ETT, but preventing the passage of air or fluids around the ETT. When this seal is compromised, microaspiration contaminated with gastric contents or bacterially colonized oral secretions can occur, leaving the patient susceptible to a host of problems, such as hypoxia, pneumonitis, and respiratory infection.

In our study, 9.7% of the patients had throat pain or hoarseness of voice. Liu et al. [17] had found the incidence of sore throat to be 44% when cuff pressure was not monitored, whereas adjustment of cuff pressure reduced the incidence to 33%. However, this study was not specific to laparoscopic bariatric surgeries. Hung [13] did not consider the postoperative complications. None of the patients in our study had severe complications such as aspiration. This may be the result of

cuff pressure adjustment to 28 cmH<sub>2</sub>O at every step. If this is not done, the increase or decrease in cuff pressure and the subsequent complication rate can be quite high.

A major limitation of our study is that at each step, the endotracheal cuff pressure was readjusted to 28 cmH<sub>2</sub>O. If the pressure was not adjusted, the incidence of complications may have been higher. Neuromuscular monitoring was not performed in this study.

Sengupta et al. [18] concluded in their study that there is a tendency to overinflate the cuff by manual palpation, and increased training does not improve cuff management. Thus, in this study, we conclude that there is a significant increase in cuff pressure at the time of GCT insertion, as well as creation of pneumoperitoneum, while a significant drop is seen at the time of GCT removal and release of pneumoperitoneum. ETT cuff pressure monitoring using a manometer is a simple and effective method of decreasing tracheal mucosal injury and aspiration-related complications. Its use is recommended not only in bariatric surgery but also in all laparoscopic surgeries.

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## CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

## DATA AVAILABILITY STATEMENT

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

## AUTHOR CONTRIBUTIONS

Conceptualization: Dipti Saxena, Atul Dixit. Data curation: Dipti Saxena, Jyoti Raghuwanshi, Subodh Chaturvedi. Formal analysis: Dipti Saxena, Jyoti Raghuwanshi. Methodology:

Atul Dixit, Subodh Chaturvedi. Project administration: Dipti Saxena, Atul Dixit. Writing - original draft: Dipti Saxena. Writing - review & editing: Atul Dixit. Investigation: Jyoti Raghuwanshi, Subodh Chaturvedi. Resources: Jyoti Raghuwanshi, Subodh Chaturvedi. Software: Jyoti Raghuwanshi, Subodh Chaturvedi. Supervision: Atul Dixit, Subodh Chaturvedi.

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