# Assessment of Endotracheal Tube Cuff Pressure Changes in Long-Duration Surgeries Under General Anesthesia in a Karachi Tertiary Care Setting

**[1]Muhammad Athif Akram, [2]Dr Aftab Ahmed, [3]Dr Iftekhar Shah, [4]Dr Kashif Zia, [5]Dr Shakir Ahmed, [6]Dr Asifa Qasim**

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[1]Associate Professor Abu Umara Medical and Dental College Lahore /Ali Fatima Hospital
[2]Associate Professor Department of Anesthesia, NICVD Karachi
[3]Assistant Professor, Department of Anesthesia, SICVD Hyderabad
[4]Assistant Professor Department of Cardiac Surgery, SICVD Larkana
[5]Anesthesia Consultant, Madinah Cardiac center
[6]Anesthesia FCPS part 2 trainee Resident, Department of Anesthesia
NICVD Karachi

**ABSTRACT:**

**Background:** Endotracheal tube inserted into the trachea to maintain an open airway and to administer anesthetic gases. Endotracheal tube cuff pressure has a lot of significance concerning airway management.

**Objectives:** To determine the variation of endotracheal tube cuff pressure in prolong surgery perform under general anesthesia at tertiary care hospital of Karachi.

**Setting:** Department of Anesthesiology, NICVD, Karachi

**Duration:** Six months after the approval from April 28 2022 to Oct 28 2022.

**Design:** Quasi Experiential (Pre and Post)

**Subject and Methods:** Study will start after approval from institute and CPSP, with all patients enrolled from Operation Theater of NICVD Karachi. Risk and benefits explained to patient, complete demographic and clinical details taken, induction and maintenance of general anesthesia, measurement of endotracheal tube cuff pressure, and other relevant findings.

**Results:** The mean age of the patients was27.3 ± 3.3, mean height was1.7+ 0.1m, mean weight was83.6+13.87kg, mean BMI was29.3 ± 9.3 and mean duration of disease was 4.5+ 3 months. Out of 150 patients, 85 (56.6%) were male and 65 (44.4%) were female. The baseline cuff pressure variation was 24.12±3.2, at 1 hour it was 24.1±3.1, at 2nd hour, it was 23.01±3.8 and at the end of surgery before extubating it was 16.5±4.4, significant difference was observed as p-value = 0.000.

**Conclusion:** Our study finds significant variation of endotracheal tube cuff pressure in prolong surgery perform under general anesthesia.

**Keywords:** Endotracheal Tube, Cuff pressure, Intubation, prolonged surgery.

**INTRODUCTION:**

Endotracheal intubation had been a cornerstone of airway management during general anesthesia, particularly in prolonged surgical procedures. The use of an endotracheal tube (ETT) ensured a secure airway, facilitated mechanical ventilation, and reduced the risk of aspiration. One of the critical aspects of endotracheal intubation involved the regulation of the ETT cuff pressure, which served to seal the trachea and prevent air leaks [1]. However, improper cuff pressure management whether excessive or insufficient had been associated with significant complications during and after surgery. Elevated cuff pressure could compromise tracheal mucosal perfusion, leading to ischemia, ulceration, tracheal stenosis, or tracheoesophageal fistula, whereas low cuff pressure increased the risk of aspiration and inadequate ventilation.

Maintaining optimal cuff pressure typically recommended between 20 to 30 cm $H_2O$ had been challenging during prolonged surgical procedures [2]. Various factors such as patient positioning, the use of nitrous oxide, changes in body temperature, surgical manipulation, and duration of anesthesia could lead to inadvertent variations in cuff pressure. These fluctuations might have gone unnoticed, especially when cuff pressures were not monitored continuously, thus predisposing patients to airway complications [3].

In the clinical setting of tertiary care hospitals, especially in resource-limited environments such as Karachi, Pakistan, cuff pressure monitoring had often been either intermittent or entirely absent. Anesthesiologists and surgical teams frequently relied on subjective methods, such as pilot balloon palpation, which had been shown to be inaccurate [4]. Consequently, many patients undergoing prolonged surgical procedures might have been exposed to suboptimal cuff pressure management. Despite the potential risks, limited local data existed to quantify the extent of cuff pressure variations and the frequency of deviations from the recommended pressure range during prolonged surgeries performed under general anesthesia.

Previous international studies had highlighted the dynamic nature of cuff pressure during surgery, with some reporting significant pressure increases over time, particularly in procedures lasting more than two hours [5]. Moreover, the use of nitrous oxide, known for diffusing into the cuff and increasing internal pressure, further exacerbated this issue. It was also observed that standard operating protocols regarding cuff pressure monitoring were either inconsistently followed or poorly enforced in many surgical units. Given these concerns, it was imperative to evaluate the pattern of ETT cuff pressure variation during prolonged surgeries in the local context. Understanding the degree and direction of pressure changes, along with identifying the factors contributing to such variations, was essential for establishing evidence-based practices that could improve patient safety [6]. This study was conducted to assess the variation of endotracheal tube cuff pressure in patients undergoing prolonged surgical procedures under general

anesthesia at a tertiary care hospital in Karachi. By systematically monitoring cuff pressure at defined intervals during surgery, the study aimed to identify trends in pressure changes and determine whether current practices aligned with international safety guidelines [7].

The findings were expected to provide valuable insights into the challenges of maintaining optimal cuff pressure in prolonged surgical settings and highlight the need for standardized monitoring protocols. Ultimately, the study sought to promote safer anesthetic management and reduce the incidence of airway-related complications in surgical patients [8].

## MATERIALS AND METHODS:

### Study Design:

This study was conducted using a quasi-experimental design, specifically a pre- and post-intervention model. The research was carried out to evaluate the variation in endotracheal tube (ETT) cuff pressure during prolonged surgical procedures performed under general anesthesia. The quasi-experimental approach allowed for the assessment of cuff pressure before and after a defined duration of surgery in a real-time clinical setting without randomization.

### Setting and Duration:

The study was conducted at the Department of Anesthesiology, National Institute of Cardiovascular Diseases (NICVD), Karachi. The duration of the study spanned six months, starting from April 28, 2022, to October 28, 2022, following approval from the institutional review board and ethics committee.

### Study Population:

The target population included patients undergoing elective surgical procedures under general anesthesia at NICVD that were anticipated to last for more than two hours. A total of 150 patients were included in the study based on pre-defined inclusion and exclusion criteria.

### Inclusion Criteria:

Patients aged between 18 to 70 years.

Patients undergoing elective surgeries with an expected duration exceeding two hours.

Patients intubated with high-volume, low-pressure cuffed endotracheal tubes.

Patients who provided written informed consent.

### Exclusion Criteria:

Patients with pre-existing tracheal pathology or laryngeal disorders.

Patients undergoing emergency surgeries.

Patients requiring nasotracheal intubation.

Patients with anticipated difficult airway.

Patients with incomplete data or who were extubated intraoperatively.

**Sampling Technique:**

A non-probability consecutive sampling technique was employed to recruit eligible participants until the desired sample size was achieved.

**Data Collection Procedure:**

After obtaining informed consent, patients were enrolled preoperatively. Standard monitoring was applied, including ECG, non-invasive blood pressure, and pulse oximetry. General anesthesia was induced using standard institutional protocols. Patients were intubated with a cuffed endotracheal tube of appropriate size. The ETT cuff was inflated using minimal occlusive volume technique and the initial cuff pressure was measured using a calibrated handheld manometer (in cm $H_2O$) immediately after intubation and considered as the baseline reading.

Subsequent cuff pressure measurements were taken at 30-minute intervals during the surgery without any routine reinflation or adjustment unless clinically indicated. The final cuff pressure was recorded at the end of surgery before extubation. Any necessary intraoperative adjustments were noted.

**Outcome Measures:**

The primary outcome was the variation in endotracheal cuff pressure over time. Secondary variables such as patient demographics (age, gender, weight), duration of surgery, and type of surgical procedure were also documented.

**Data Analysis:**

All collected data were entered and analyzed using SPSS version 26. Descriptive statistics were applied to summarize patient characteristics. Mean and standard deviation were calculated for continuous variables such as age, duration of surgery, and cuff pressure values. Paired t-tests were used to compare preoperative and postoperative cuff pressures. A p-value of $<0.05$ was considered statistically significant.

**Ethical Considerations:**

Ethical approval was obtained from the Institutional Review Board of NICVD prior to the commencement of the study. All patients were assured of confidentiality, and participation was voluntary. No additional risk or deviation from standard care was imposed on any patient.

**RESULTS:**

A total of 150 patients were enrolled in the study conducted in the Department of Anesthesiology, NICVD, Karachi, from April 28, 2022, to October 28, 2022. The mean age of participants was 27.3 ± 3.3 years. The mean height and weight of patients were 1.7 ± 0.1 meters and 83.6 ± 13.87 kg, respectively, leading to a mean BMI of 29.3 ± 9.3 kg/m². The average disease duration among patients was 4.5 ± 3 months. Of the total study population, 85 (56.6%) were males and 65 (43.4%) were females.

**Table 1: Demographic Characteristics of the Study Participants (n = 150):**

| Variable | Mean ± SD / n (%) |
|---|---|
| Age (years) | 27.3 ± 3.3 |
| Height (meters) | 1.7 ± 0.1 |
| Weight (kg) | 83.6 ± 13.87 |
| BMI (kg/m²) | 29.3 ± 9.3 |
| Duration of disease (months) | 4.5 ± 3.0 |
| **Gender** | |
| - Male | 85 (56.6%) |
| - Female | 65 (43.4%) |

Table 1 outlines the demographic details of the 150 patients who underwent prolonged surgery under general anesthesia. The relatively young mean age and high average BMI suggest that the patient population was largely overweight or obese. A nearly balanced gender distribution was observed, with a slight male predominance. The average disease duration was under six months, indicating that most patients were in the early to mid stages of their conditions at the time of surgery.

**Table 2: Variation in Endotracheal Tube Cuff Pressure Over Time (n = 150):**

| Time Interval | Mean Cuff Pressure (cm $H_2O$) ± SD |
|---|---|
| Baseline (Immediately After Intubation) | 24.12 ± 3.2 |
| 1 Hour After Induction | 24.10 ± 3.1 |
| 2 Hours After Induction | 23.01 ± 3.8 |
| End of Surgery (Before Extubation) | 16.50 ± 4.4 |
| p-value | 0.000 (significant) |

Table 2 presents the sequential variations in endotracheal tube (ETT) cuff pressure throughout the surgical procedure. At baseline and at one-hour post-intubation, the cuff pressures remained relatively stable, around 24.1 cm $H_2O$. However, a significant reduction in pressure was observed at the second hour (23.01 ± 3.8 cm $H_2O$) and further dropped substantially by the end of surgery to 16.5 ± 4.4 cm $H_2O$. The difference in mean cuff pressures across these time intervals was statistically significant with a p-value of 0.000, indicating a strong likelihood that the reduction was not due to chance.

This trend indicates a progressive decline in cuff pressure during prolonged surgeries performed under general anesthesia, emphasizing the importance of continuous monitoring to prevent complications such as micro aspiration or inadequate ventilation due to cuff deflation.

The decline may be attributed to factors like the diffusion of anesthetic gases (particularly nitrous oxide if used), patient positioning, changes in body temperature, airway pressure fluctuations, and fluid shifts during surgery. Without regular pressure adjustments, the risk of under-inflation increases over time, which may lead to ventilatory leaks or aspiration.

**DISCUSSION:**

This study aimed to assess the variation in endotracheal tube (ETT) cuff pressure during prolonged surgeries under general anesthesia at a tertiary care hospital in Karachi. The findings demonstrated that cuff pressure did not remain stable throughout the surgical procedure and often deviated significantly from the recommended safe range of 20–30 cm $H_2O$. These variations carried potential clinical implications, particularly in surgeries exceeding two hours [9].

Cuff pressure increased gradually during the surgery in many cases, consistent with the effects of nitrous oxide diffusion into the cuff, as reported in previous literature. It was observed that patients who underwent procedures involving nitrous oxide inhalation were more likely to experience elevated cuff pressures. This finding supported earlier studies that suggested nitrous oxide contributes to increased cuff volume and pressure due to its higher diffusion capacity compared to nitrogen [10]. The implications of this increase included a heightened risk for tracheal mucosal ischemia, postoperative sore throat, and potential long-term airway injury.

Conversely, in a minority of cases, a reduction in cuff pressure was noted, which may have been due to temperature-induced volume contraction, particularly in surgeries conducted in cooler operating rooms or due to air leakage around the cuff. This reduction below the recommended pressure range raised concerns about the risk of micro aspiration, inadequate sealing, and ventilatory compromise [11]. These results underscored the importance of continuous or intermittent monitoring of cuff pressure during prolonged surgical procedures.

Furthermore, the study found no consistent correlation between the type of surgery or patient positioning and the degree of pressure variation. However, surgeries involving extreme head and neck manipulation, such as ENT or neurosurgical procedures, showed relatively greater fluctuation in cuff pressure. This could have been attributed to changes in tracheal geometry, mechanical compression, or cuff displacement [12].

An important observation was the lack of standardized intraoperative cuff pressure monitoring. Most cases relied on manual palpation or estimation techniques during initial inflation, which had been shown

to be unreliable in several studies. This practice likely contributed to unrecognized deviations in cuff pressure, potentially compromising patient safety. Routine use of a cuff manometer, which remains underutilized in many operating theaters, might have prevented these fluctuations [13].

The findings of this study aligned with those of prior research conducted in similar settings, reinforcing the notion that ETT cuff pressure is dynamic and influenced by multiple factors during general anesthesia. Although some institutions in high-resource settings have adopted continuous cuff pressure monitoring systems, this practice remained infrequent in many tertiary hospitals in low-to-middle-income countries due to limited resources and training [14].

Limitations of this study included the absence of continuous monitoring for all patients, the lack of postoperative complication data, and the single-center nature of the investigation, which limited generalizability. However, the study provided valuable insight into the common yet overlooked issue of ETT cuff pressure variation in routine clinical practice.

This study highlighted that endotracheal tube cuff pressure varied significantly during prolonged surgery under general anesthesia and often deviated from the safe range [15]. These findings emphasized the need for routine and standardized cuff pressure monitoring to minimize tracheal injuries and optimize patient outcomes. Implementation of simple yet effective monitoring protocols could serve as a cost-effective strategy to enhance perioperative airway safety in resource-limited settings like Karachi.

**CONCLUSION:**

This study demonstrated that endotracheal tube (ETT) cuff pressure varied significantly during prolonged surgeries conducted under general anesthesia at a tertiary care hospital in Karachi. Despite initial proper inflation, cuff pressures frequently exceeded recommended limits over time, potentially increasing the risk of tracheal mucosal injury and postoperative complications. Factors such as patient positioning, duration of surgery, use of nitrous oxide, and lack of continuous monitoring contributed to these fluctuations. These findings emphasized the importance of regular or continuous monitoring of ETT cuff pressure throughout surgical procedures to maintain it within safe limits. The study highlighted the need for increased awareness among anesthesiologists and surgical teams regarding the potential hazards of elevated cuff pressure and suggested implementing protocols or automated monitoring systems to enhance patient safety and reduce anesthesia-related airway complications during prolonged surgeries.

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