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# A Comparative Study on the Endotracheal Tube Cuff Pressure Changes between Supine and Prone in Patients Undergoing Prone Position Surgeries

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**Abstract**

*Background:* The objective of the study was to compare the study on the endotracheal tube cuff pressure changes between *supine and prone* in patients undergoing prone position surgeries. *Materials and Methods:* After obtaining approval from institutional ethics committee, this study was conducted in Department of Anesthesiology at Sri Manakula Vinayagar Medical College and Hospital, Puducherry between *November 2015* and *August 2017*. A total of 60 patients who met the inclusion criteria were enrolled into study and prepared for General Anesthesia in prone position. After induction, the cuff pressure was recorded with head in neutral, flexed and extended position; these parameters were noted with patient in supine position and then in prone position. *Results:* There was no significant difference in mean cuff pressure at neutral posture between *supine* and *prone* position. Mean cuff pressure was increased after flexion and extension from neutral posture in both supine and prone position. At flexed posture mean cuff pressure was higher in supine position and at extended posture mean cuff pressure was higher in prone position. *Conclusion:* With this study we concluded that the supine or prone position has no influence on the cuff pressure when the head is in neutral position. In the supine position flexion of the head should be avoided because it leads to higher cuff pressure than with the head flexed in prone position. Similarly extension of the head should be avoided in the prone position.

**Keywords:** Cuff pressure; Supine position; Prone position.

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## Introduction

Andreas Vesalius (1543) first experimented the idea of tracheal intubation by placing a reed into the trachea of a pig to treat a pneumothorax.[1,2] Benjamin Pugh (1754) performed the first endotracheal intubation to resuscitate a neonate with a leather covered coiled wire.[1] The main evolution of the endotracheal tube (ETT) is intertwined with that of surgery and anesthesia and, more recently, with critical care medicine. General anesthesia is one of the most common type of anesthesia practiced all over the world. Airway management by using a endotracheal tube (ETT) is the most important skill for a clinical anesthesiologist as it is an integral part of general anesthesia. The endotracheal tube cuff pressure is normally kept between *20 and 30 cm* of $H_2O$. Under inflation can cause air leakage

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because the glottis seal is inadequate and which lessens the effect of mechanical ventilation and produces a leakage of inhalation anesthetics, it may lead to micro aspiration and its an risk factor for ventilator associated pneumonia. However, over-inflation of the endotracheal tube cuff can cause a serious injury and affect blood flow to the tracheal mucosa, resulting in tracheal stenosis, tracheoesophageal fistula, or tracheal rupture. It is commonly associated with long procedures, these complications may occur even after a short duration of anesthesia. The tracheal intubated ETT can be displaced by movement of the patient's head and neck. Movement of the head and neck (rotation, flexion, and extension in the supine position) can cause displacement of endotracheal tube and change in endotracheal tube cuff pressure. Flexion may cause carina stimulation or endobronchial intubation by advancing the ETT, whereas extension can cause balloon-induced vocal cord damage or unintentional extubation by withdrawing the tube.[3] Although cuff pressures are checked initially after intubation, seldom it is done intermittently or continuously throughout operation. There are multiple peri-operative factors which may alter the ETT cuff pressure like usage of Nitrous oxide in anesthesia, inadequacy of muscle relaxation, surgical stimulation in cases of head and neck surgeries and change in patient position. This puts the patients for either micro aspiration or to the other extreme tracheal ischemic necrosis leading to tracheal stenosis. The purpose of the study is to compare the endotracheal tube cuff pressure changes between supine and prone positions in patients undergoing prone position surgeries.

## Materials and Methods

After getting clearance from the institutional ethical committee and informed written consent from the study participants, a prospective observational study was conducted on 60 patients between the age group of *20* and *60 years* with ASA I, ASA II physical status undergoing elective surgeries under general anesthesia. Patients with ASA III and ASA IV physical status, Neck pain, previous history of neck surgery, limitation of neck movements, Morbid obesity (body mass index > 35) were excluded from the study.

Pre-anesthetic checkup was done a day prior to the surgery and the patient were kept fasting for *6* to *8 hours*. On the day before surgery the patient's received T Ranitidine *150 mg* in the night and at *7 AM* on the day of surgery along with T. Metoclopramide *10 mg*. The patient's were shifted to waiting room and again re-assesed. An intravenous line was secured using a 18 G venflon. Baseline monitors were attached and recorded (ECG, NIBP, $SpO_2$, $ETCO_2$ & Temperature). Anesthesia was induced by Inj. Glycopyrolate *0.01 mg/kg* I.V., Inj. Midazolam *0.05 mg/kg* I.V. followed by Inj. Fentanyl *2 mcg/kg* I.V., Inj. Propofol *2.mg/kg* I.V., then followed by Inj. Succinylcholine *2 mg/kg* I.V. and patient's were intubated with appropriate size flexometallic endotracheal tube and cuff were inflated by using air. Anesthesia was maintained with Inj. Vecuronium *0.08 mg/kg* I.V. and Sevoflurane following which the cuff pressure was monitored with patient in supine position with head in neutral position, flexion and extension. After the patient position changed from supine to prone once again the cuff pressure was monitored with patient in prone position with head in neutral position, flexion and extension.

## *Results*

Sixty patients including 33 men and 27 women were assessed for endotracheal cuff pressure between supine and prone position. Demographic data are shown in (**Table 1**).

**Table 1:** Demographic data of the studied patients

| **Gender (Male/Female)** | **33/27** |
|---|---|
| Patients age in years (Mean ± SD) | 42.1 ± 9.8 |
| BMI (Mean ± SD) | 22.3 ± 2.6 |

Mean cuff pressure was increased after flexion and extension from neutral posture in both supine and prone position. At flexed posture mean cuff pressure were higher in supine position and at extended posture mean cuff pressure were higher in prone position. There were no differences between supine and prone in neutral, flexed and extended posture shows in (**Table 2**).

**Table 2:** Cuff pressure in Supine and Prone positions

| **Cuff pressure** | **Supine** | **Prone** |
|---|---|---|
| | **Mean ± SD** | **Mean ± SD** |
| Neutral Posture | 25.2 ± 2.3 | 24.8 ± 1.9 |
| Flexed Posture | 38.6 ± 3.2 | 37.5 ± 3.1 |
| Extended Posture | 41.1 ± 4.4 | 42.6 ± 4.0 |

There were no significant difference in mean cuff pressure between males and females in both supine and prone position shows in (**Table 3**).

**Table 3:** Difference in cuff pressure in Supine and Prone position between males and females

| | Supine (Mean ± SD) | | Prone (Mean ± SD) | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| Neutral Posture | 24.8 ± 2.3 | 25.6 ± 2.3 | 25.1 ± 1.7 | 24.4 ± 2.0 |
| Flexed Posture | 39.0 ± 3.3 | 38.1 ± 2.9 | 37.1 ± 3.4 | 38.1± 2.8 |
| Extended Posture | 41.8 ± 3.8 | 40.2 ± 5.0 | 43.3 ± 3.2 | 41.6 ± 4.7 |
| Supine Neutral to Flexion | 36.0 ± 6.2 | 32.7 ± 7.5 | 31.9 ± 7.2 | 35.5 ± 7.3 |
| Supine Neutral to Extension | 40.0 ± 7.6 | 34.7 ± 17.3 | 41.8 ± 5.4 | 40.7 ± 6.7 |

Mean cuff pressure were lowest in neutral position and highest in extended posture in all the BMI groups. Mean cuff pressures in supine positions were highest in normal BMI subjects and lowest in underweight subjects shows in (**Table 4**).

**Table 4:** Mean cuff pressure comparison with respect to BMI in neutral, flexed and extended posture in supine and prone positions.

| | | BMI | | |
|---|---|---|---|---|
| | | < 18.5 (Underweight) | 18.5 to 24.9 (Normal) | > 25 (Overweight) |
| | | Mean ± SD | Mean ± SD | Mean ± SD |
| Supine | Neutral Posture | 26.0 ± 2.8 | 25.1 ±1.9 | 25.1 ± 4.5 |
| | Flexed Posture | 36.0 ± 5.7 | 38.9 ± 2.4 | 37.1 ± 6.3 |
| | Extended Posture | 37.0 ± 9.9 | 41.4 ± 3.7 | 39.7 ± 7.4 |
| Prone | Neutral Posture | 26.0 ± 2.8 | 24.9 ± 1.6 | 23.7 ± 3.1 |
| | Flexed Posture | 39.0 ± 4.2 | 38.0 ± 2.9 | 33.7 ± 2.4 |
| | Extended Posture | 43.0 ± 4.2 | 42.9 ± 3.5 | 39.7 ± 6.5 |

## Discussion

Trendelenburg (1869) is credited with designing the first inflatable cuff, which was a thin rubber bag fitted over the end of a tracheostomy tube, creating a tight seal to prevent aspiration during anesthesia.[4] Although the detachable inflatable cuff had been introduced by Trendelenburg, it had fallen out of favor due to technical issues, and clinicians preferred to use pharyngeal packing with sponges to seal the upper airway.

Guedel (1928) and Waters (1931) reintroduced the inflatable cuff to Magill's rubber tube and are credited with starting a period of ETT design.[5] Their first cuffs were made from the fingers of rubber gloves and from rubber condoms. These cuffs, ranging from *3* to *4 inches* long, were designed to sit half above and half below the glottis.[6] Later, they designed cuffs from rubber dental dams that were shorter, 1.5 inches long, and designed to sit below the vocal cords.[7]

Two modifications of the standard ETT were introduced commercially in the 1970s. One modification was to replace the standard pilot balloon with a larger balloon containing an inner pressure-regulating valve that maintains intra cuff pressure at *30 cm* $H_2O$.[8] Another modification was to replace the air-filled cuff with a self-inflating foam cuff in 1971 by Kamen and Wilkinson, it is known as the Bivona Fome-Cuff Tube.[9,10] Eisenmenger (1893) was the first to describe the use of a cuffed ETT, as well as the concept of a pilot balloon to monitor intra cuff pressure.[11]

Endotracheal tube cuff pressure monitoring is important to prevent serious complications like tracheal micro aspirations, inadequate delivery of inhaled anesthetics, aspiration pneumonia, bronchospasm, laryngospasm, tracheal stenosis, tracheoesophageal fistula, or tracheal rupture.

Normal endotracheal tube cuff pressure should be maintained between *20* and *30 cm* of $H_2O$ to prevent above said complications. It is noted that endotracheal tube cuff pressure varies with varying head posture like neutral, flexion and extension in both supine and prone position. This study was conducted to know the changes in the endotracheal tube cuff pressure in different head postures and results are obtained.

In similar to our study, Christelle Lizy *et al.*, showed that there was a significant rise in endotracheal tube cuff pressure with change of position from supine neutral to supine extension and supine flexion.[12]

In similar to our study Deokkyu *et al.*, observed there were differences between *supine* and *prone* position for neutral, flexed, and extended angles. The initial neutral pressure increased after changing position from supine to prone. Flexed and extended pressure in supine was increased than the adjusted neutral pressure. Flexed and extended pressure in prone were increased than the adjusted neutral pressure.[3] In our study. we observed that endotracheal tube cuff pressure increases when the patient's position changed from supine neutral to supine flexion and supine extension.

In a study, done by Umeshkumar Athiraman *et al.*, showed that significant decline in endotracheal tube cuff pressure were found in the prone group from initial intubated supine position. These results were non-concurrent with our study, we observed that there is rise in endotracheal tube cuff pressure were noted in prone flexion and prone extension.[13]

In similar to our study, Armando Carios Franco de Godoy *et al.*, showed that change in body position can cause significant change in endotracheal tube cuff pressure. These results are comparable with our study where endotracheal tube cuff pressure were increased in both flexion and extension in supine and prone position.[14]

In similar to our study, Hiromi Kako *et al.*, concluded that the significant changes in the intra cuff pressure occur with changes in head and neck position.[15]

In contrast to our study, Toshiyuki Minonishi *et al.*, concluded that after the supine-to-prone position change, patients had ETT tube displacement. Such ETT movement may be accompanied by a decrease in cuff pressure. But in our study, we observed that there was no ETT displacement in supine to prone position. But endotracheal tube cuff pressure increases when the patient's position changed from prone neutral to prone flexion and prone extension.[16]

In similar to our study, Nobuyasu Komasawa *et al.*, concluded that there were cuff pressure increases with positional changes in head and neck flexion and extension. But in our study, we observed that at Flexed posture mean cuff pressure was higher in supine position and at extended posture mean cuff pressure was higher in prone position.[17]

In our study, we compared the changes in endotracheal tube cuff pressure by change in position by classifying the study objects based on their Body Mass Index (BMI). Our observation showed that there were no significant change in endotracheal tube cuff pressure in obese patient compared to normal and underweight patients. The changes were similar in both group, so we conclude that the change in Body Mass Index (BMI) has no impact in endotracheal tube cuff pressure.

Based on our observation we recommend that either in supine or prone position the head should be preferably placed in neutral position to avoid unwanted incidents like tracheal ischemic necrosis, stenosis due to pressure changes in cuff. We also advocate intermittent endotracheal tube cuff pressure monitoring is mandatory intra-operatively for the safety outcome of the patients.

## Conclusion

The supine or prone position have no influence on the endotracheal tube cuff pressure when the head is in neutral position.

In supine position, flexion of the head should be avoided because it leads to higher cuff pressure than with the head flexed in prone position. Similarly extension of the head should be avoided in the prone position because it leads to higher cuff pressure.

Endotracheal tube cuff pressure have to be monitored and optimized during change of patients position from supine to prone position to prevent micro aspiration and mucosal damage of airway.

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***Conflicting Interest:*** Nil

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