Endotracheal cuff pressure changes with change in position in neurosurgical patients

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ABSTRACT

Background: Placement of a cuffed endotracheal tube for the administration of general anesthesia is routine. The cuff of the endotracheal tube is inflated with air to achieve an adequate seal to prevent micro-aspiration. Over inflation of the cuff can decrease the mucosal perfusion, leading to pressure necrosis and nerve palsies. Inadequate seal can lead to micro aspiration. So the cuff pressure has to be monitored and kept within the prescribed limits of 20-30 cm of water.

Aim of the Study: To observe the effect of different positions on the endotracheal cuff pressure in patients undergoing neurosurgical procedures.

Materials and Methods: This is an observational study conducted on 70 patients undergoing neurosurgical procedures in various positions. After intubation, the cuff pressure was checked with a cuff pressure manometer, Endotest (Teleflex Medical, Rush) and adjusted to be within the allowable pressure limits as is the routine practice. The cuff pressure was checked again at three time points after achieving the final position with the head on pins, at the end of the procedure and before extubation. Various factors such as the age, position, duration of surgery were studied. There were no major complications like aspiration, stridor or hoarseness of voice post extubation in any of the patients.

Results: A significant decline in the cuff pressures were noted from the initial supine position to extubation (P < .001) in the supine group. Also a significant decline in the cuff pressures were found in the prone group from their initial intubated supine position to all the other three corresponding time points namely after final positioning (P < .001), at the end of the procedure (P < .001) and before extubation (P < .001).

Conclusion: Cuff pressure has to be checked after achieving the final positioning of the patient and adjusted to the prescribed limits to prevent micro aspiration.

Key Words: Different positions, ETT cuff pressure, neurosurgical patients

INTRODUCTION

Endotracheal tube cuffs in the mechanically ventilated patients are kept inflated to prevent aspiration. It is recommended that the cuff pressure be maintained between 20-30 cm of H₂O.¹⁻³ If it is below the recommended cuff pressures the glottis seal is inadequate and it may lead to micro aspiration.⁴ Increased cuff pressure leads to tracheal complications, though often associated with long procedures, these complications may occur even after a short duration of anesthesia.⁵ Although cuff pressures
are checked initially after intubation, continuous or intermittent measurement of endotracheal tube cuff pressures in the mechanically ventilated patients during anaesthesia and maintaining it within the recommended range is not routinely done.

Neurosurgical procedures are usually long and involve positioning the head in different positions. To our knowledge, there are no studies highlighting the effect of positioning on the changes in the cuff pressure. This study is intended to highlight the cuff pressure changes in the neurosurgical patients at different positions and to look for complications due to either excessive or decreased cuff pressure.

**MATERIALS AND METHODS**

A prospective observational study was conducted at Christian Medical College, Vellore, India in patients undergoing elective neurosurgical procedures for a period of 2 months after getting the ethical clearance. Seventy ASA 1and 2 patients within the age group of 11-77 posted for elective neurosurgical procedures were included. Patients coming for emergency procedures, ASA >3, pregnant patients, patients with known laryngeal or tracheal pathology, patients intubated with uncuffed tubes and those on tracheostomy were excluded. Informed consent was taken from all the patients recruited for the study.

On arrival of the patient to operating room, intravenous (IV) cannula was secured on the hand and IV fluid was started. The intraoperative parameters monitored include: Noninvasive blood pressure (NIBP), electrocardiogram (ECG), oxygen saturation (SpO₂), end tidal CO₂ (etCO₂) and temperature monitoring. After preoxygenation for 3 minutes, anesthesia was induced with Fentanyl 2 mcg/kg, Propofol 1-2 mg/kg. Vecuronium 0.15 mg/kg was used for neuromuscular blockade. The trachea was intubated with a high volume low pressure cuffed oral endotracheal tube of appropriate size (Male-8 mm ID and Female -7 mm ID Portex). Air was inflated through the pilot balloon and the cuff pressure was checked with Endotest (Teleflex Medical, Rush) and regulated to be between 20-30 cms H₂O. The cuff pressure was checked by the anesthesia provider who was blinded to the study. The volume of air required was noted. This cuff pressure was taken as the base line (A). After intubation, the presence of equal air entry on both the sides were checked with the neck flexion and extension. The ventilatory parameters were set at a respiratory rate of 10-12/minute, tidal volume of 8-10 ml/kg to maintain the end tidal carbon dioxide concentration between 28-32 mmHg. Patients were maintained with 0.8 MAC of Isoflurane with 40% oxygen in air and boluses of intravenous fentanyl was given intraoperatively as needed. Neuromuscular blockade was maintained with a vecuronium infusion until the end of the procedure maintaining two twitches. Oropharyngeal probe was inserted in every patient to maintain normothermia.

The cuff pressure was checked again after achieving the final position with the head on pins (B), at the end of the procedure on the same position (C) and after achieving the supine position, before extubation (D). All the measurements were made by a single manometer. If there was a significant reduction in the cuff pressure after final positioning of the head on pins, which is below 20 cmH2O, then the cuff is inflated again such that the cuff pressure lies between 20-30 cms of H₂O.

**Statistical analysis**

Data parameters collected were entered into the excel sheet and transferred into the SPSS software (Statistical package for Social Sciences version 19) for the statistical analysis. Repeated measures ANOVA was done to find the overall significance between the groups. Paired sample t-test was used to analyze the differences in cuff pressure within the group at different positions. P < .05 is considered statistically significant.

**RESULTS**

Demographic information is given in the Table 1. The repeated measures ANOVA (RMANOVA) was initially done to find the existence of significance between the four time positions for the corresponding groups. We found a significant difference for the supine (P <.022) and the prone groups (P <.001). A paired sample t-test was conducted between the baseline and the other three time points for each group. We observed a significant difference in the cuff pressures between the baseline and before extubation with a P value of 0.000 in the supine group. We also observed a highly significant difference in the cuff pressures between the baseline and final positioning, end of procedure, and before extubation with P values less than .001 for the patients undergoing procedures in prone position. Tables 2 and 3 shows the t-test results for the supine and prone population. None of the complications such as sore throat, stridor and hoarseness was noted postoperatively in any patient.

**Table 1: Demographics**

| Gender (M:F) | 39/31 |
|-----------------|-------|
| Patients age in years (mean ± SD) | 36.29 ± 15.31 |
| Duration of procedure in hours (range) | 2-11 |
| Positions: |  |
| Supine | 34 |
| Prone | 30 |
| Lateral | 4 |
| Sitting | 2 |

SD: Standard deviation, M: Male, F: Female
Our study shows a significant reduction in the endotracheal cuff pressures from the initial supine position to the further end points in the study in the patients undergoing neurosurgical procedures [Figure 1]. It is more obvious in the patient population who underwent procedures in supine and prone [Figures 2 and 3]. We couldn’t comment on the patient population who underwent procedures in the lateral and sitting position as the numbers were insufficient.

Once the head is supported on pins, it is likely that the neck is no longer held firmly against the back of the table but is free. The tension on the posterior laryngeal structures is reduced hence the drop in the cuff pressure. The reduction in the cuff pressure might have probably occurred the moment the neck was freed, even before our first measured time point which is after final positioning of the patient. We couldn’t appreciate that as we measured the cuff pressure only at four time points since recurrent intermittent measurements of the cuff pressure by itself reduces the cuff pressure.

There are several factors responsible for the changes in the cuff pressures, which are time, positive pressure ventilation, use of nitrous oxide, altitude, measurement of the cuff pressure, muscle relaxation, hypothermia, different neck and body positions, endotracheal tube positions, duration of intubation, pathologic factors such as laryngeal edema, bronchoconstriction and etc.

Sole et al. have showed that the cuff pressure over time results in the reduction of cuff pressure and our study agrees with their findings. Skeletal muscle tone and the consciousness in the patients are responsible in maintaining the upper airway structures and the laryngeal dimensions in position. In the supine position, during the induction of anesthesia, loss of consciousness is associated with loss of the tonicity of the muscles around the neck which results in the posterior displacement of upper airway structures. Gravity in part also plays a role in the posterior displacement of the upper airway structures by the loss of activity of the muscles during induction of anesthesia. This might have resulted
in the reduction of the cuff pressures initially and the continuous level of unconsciousness provided by the adequate level of depth of anesthesia and paralysis over time would have resulted in the reduction of cuff pressures over a period of time.

Studies have shown that the use of muscle relaxant results in the reduction of the cuff pressure. Induction of anesthesia and neuromuscular blockade results in the reduction of oropharyngeal dimension and increase in the laryngeal dimensions because of the loss of the muscular tension around the neck. Anatomic relationship between the endotracheal tube and the larynx constantly fluctuates because of the changing levels of consciousness and muscle relaxation. This causes an undue strain on the laryngeal structures which might result in the variations in the cuff pressure. In our case, since we maintained a MAC of 0.8 and a continuous infusion of muscle relaxant, the patient was kept at an adequate level of anesthesia at all times and a continuous drop in cuff pressures was noticed. Patients inter individual variability such as the anatomy of trachea, cuff positioning over trachea and cuff physical characteristics such as material, diameter, thickness, compliance, geometry are also the factors which influence the cuff pressure.

Different body positions result in wide variations in cuff pressure. There are conflicting results observed by different authors in the measurement of the cuff pressures in different positions. Our study showed a significant reduction of cuff pressure over a period of time in both the supine and prone population. Few authors have explained the importance of endotracheal tube positioning and the variations of cuff pressures.

Lower cuff pressures have been observed in the patients frequently when the endotracheal tubes have gone deeper into the trachea. During extension of the head, the tube usually moves up and moves in during flexion. In Neurosurgical procedures, positioning often involves some element of flexion and extension along with mild rotation of the neck, which may further add on to the decrease in cuff pressures.

Multiple mechanical factors such as a defect in the inflation valve, pilot balloon and the cuff itself can result in the decrease in cuff pressure; in our case we checked all the endotracheal tubes for cuff leak before intubating the patient.

There are a few limitations to our study; continuous measurement of the cuff pressures was not done. We could not comment on the cuff pressure changes in the patients who underwent procedures in lateral and sitting position as the sample size was insufficient. The relationship between the duration of surgery and decrease in cuff pressure was not studied. Long term assessment for the postoperative complications such as sore throat, stridor and hoarseness was not been assessed. Our study population includes only the elective neurosurgical patients. The effect of this decrease in cuff pressure during surgery is probably more significant in the sub group of patients who undergo emergency surgery rather than elective surgery where the chances of aspiration are much higher and the need for cuff pressure to be regulated between 20-30 cms of H2O is mandatory.

**CONCLUSION**

To conclude, cuff pressure has to be checked after achieving the final position with the head on Mayfield Clamp and adjusted to the prescribed limits to prevent micro aspiration. Whenever the patient position is changed, care must be taken to adjust the cuff pressure within the prescribed limits. Frequent intermittent measurement or continuous measurement of endotracheal tube cuff pressures where available is warranted in all the neurosurgical patients. The clinical significance of these cuff pressure variations in neurosurgical population needs to be further studied in a larger study groups in all positions.

**Financial support and sponsorship**

Nil.

**Conflicts of interest**

There are no conflicts of interest.

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