RELEVANCE OF ENDOTRACHEAL TUBE CUFF PRESSURE (ETTc) MONITORING DURING CERVICAL SPINE SURGERIES- MANUAL V/S AUTOMATIC METHOD

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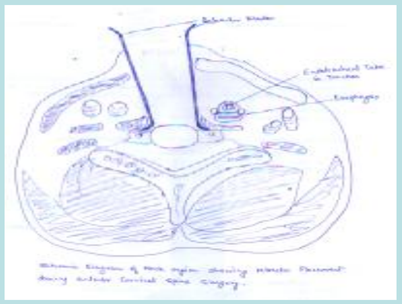
ABSTRACT

Inflation and assessment of the endotracheal tube cuff (ETTc) pressure is often underappreciated as a critical aspect of endotracheal intubation. Using appropriate ETTc pressure, endotracheal intubation lets the clinician seal the airway to prevent aspiration and provide positive-pressure ventilation without air leaking. If the ETTc pressure exceeds the tracheal mucosal capillary perfusion pressure, the ETTc quickly begins to injure the mucosa and surrounding tissues. During anterior surgical approach for cervical spine diseases, use of retraction and distraction devices increases the pressure on the tracheal mucosa by the endotracheal tube cuff.

The length of time needed for an elevated cuff pressure to cause these complications is unclear, but mucosal damage has been demonstrated after only 15 minutes in an animal model. Based on recent recommendations, the cuff pressure should be maintained around 25 cmH_2O in critically ill intubated and mechanically ventilated patients. Automated cuff pressure controllers have been introduced to overcome these risks and to keep the cuff constantly inflated.

The aim of the present study was to investigate the effect of continuous automated cuff pressure regulation on tracheal sealing during cervical spine surgery. Correlations between manual methods of assessing the pressure by an experienced anaesthesiologist and assessment with maintenance of the pressure within the normal range (20-30 cm of H2O, fixed at 25 cm of H2O) by the automated pressure controller device were studied.

We concluded that the EETc pressures were significantly in the higher range when ETTc was inflated manually, even with the sufficient experienced anesthetist and due to placement of retractors during anterior approach, ETTc further increases. The ETTC pressure further rises with the use of Nitrous Oxide. The known complications of high ETTc pressure can be avoided if the cuff pressure controller device is used and manual methods cannot be relied upon for keeping the pressure within the recommended levels.



OBJECTIVE

The objective of the present study was to investigate the effect of continuous automated cuff pressure regulation on tracheal sealing during cervical spine surgery.

METHODS

.The study was a prospective observational study by trained anesthesiologists. The anesthesiologists who were responsible for the inflation of the cuff were blinded and unaware of the study.

- After obtaining the institutional ethical committee clearance and written consent, 100 patients were randomly selected of either sex and age between 20-50 yrs of ASA grade I and II and MPG I & II. All the patients were posted for cervical spine surgery under general anaesthesia. All emergency intubations, patient with tracheostomy tube, laryngeal disease, requiring placement of a nasogastric tube, pregnant patients, full stomach, trauma cases and patients with predicted difficult intubation were excluded from the study.
- After induction of anaesthesia with Propofol and relaxing with a non depolarizing muscle relaxant, oral endotracheal intubation was done with the appropriate size ETT. All the patients were intubated with oral cuffed PVC single usage endotracheal tube with high volume low pressure cuff and a luer lock at the pilot balloon (Romsons, India) with internal diameter 7.0 – 8.5 mm or oral flexometallic endotracheal tube with high volume low pressure cuff (Portex Reinforced Tracheal Tube ,Smiths Medical International Ltd. CT21JL. UK) single usage tube with internal diameter 7.0 – 8.5 mm. Patients were maintained on oxygen + N2O (1:2), inhalational anaesthetic (Isoflurane), fentanyl and nondepolarizing muscle relaxant (Inj. Vecuronium Bromide). Mechanical ventilation was controlled and adapted to maintain end tidal carbon dioxide at 30-35 mmHg. At the end of surgery, neuromuscular block is reversed with neostigmine 0.05 mg/Kg and atropine 0.025 mg/Kg. After assessing full reversal by NM monitor (ulnar nerve T4/T1 ration= 1), patient were extubated.
- These patients were divided into two groups; those were further divided in two sub groups-
- **Group A-** Patients were posted for cervical spine surgeries through anterior approach-
- **Sub Group AM of 50 patients-** In this group, the ETTc was inflated manually by a trained anesthesiologist and checked for its pressure hourly by cuff pressure monitor.
- **Sub Group AC of 50 patients-** In this group, ETTc was inflated by Automatic cuff pressure controller and pressure was maintained at 25 cm H2O throughout the surgeries.
- **Group P-** Patients were posted for cervical spine surgeries other than anterior approach-
- **Sub Group PM of 50 patients-** In this group, the ETTc was inflated manually by a trained anesthesiologist and checked for its pressure hourly by cuff pressure monitor.
- **Sub Group PC of 50 patients-** In this group, ETTc was inflated by Automatic cuff pressure controller and pressure was maintained at 25 cm H2O throughout the surgeries.
- In subgroup AM & PM, for cuff inflation standard syringe technique consisted of ETT cuff inflation using a syringe to inject air into the cuff and assessment of cuff pressure by palpation of the external pilot balloon and by listening to the disappearance of the audible air leak by the anaesthesiologist with atleast 5 years experience as anesthetist and after that pressure of ETTc was recorded and monitored hourly, while in subgroup AC & PC, cuff was inflated by attaching with Automatic cuff pressure controller and pressure was maintained at 25 cm H2O throughout the surgeries. The safe cuff pressure in our study protocol was taken as any pressure less than 25 cm of H2O. This pressure was measured by highly sensitive and accurate VMB cuff controller (type –cuff controller digital 0-99 cm H2O, VMB Medizintechnik GMBH., Germany).

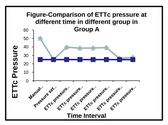
RESULTS

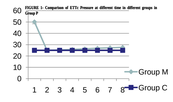
- Studied subjects were randomly allocated in 2 groups using appropriate randomization method which is freely available on site www.randomization.com.
- Analysis performed as:
  - Descriptive Statistics
  - Independent t-Test
  - Test of Sphericity (Mauchy's Test)
  - Repeated measure ANOVA
  - Bonferroni Correction Test

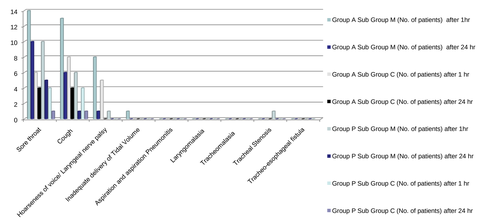
Demographic Profile

	Group A		Group P	
Variables	**Subgroup –AM** (Mean ± SD) n= 50	**Subgroup –AC** (Mean ± SD) n = 50	**Subgroup-PM** (Mean ± SD) n= 50	**Subgroup-PC** (Mean ± SD) n = 50
Age- in Yrs	45.70 ± 10.40	46.92 ± 10.06	45.560±10.940	46.820± 10.440
Sex (M:F)	30:20	31:19	24:26	27:23
Weight- in Kg	54.02 ± 8.15	58.70 ± 9.00	55.812±9.270	57.698± 9.518
Height- in Cm.	161.28 ± 5.65	161.69 ± 6.72	161.076±6.040	161.145± 7.034
Spo2 (in %)	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00	100.00 ± 0.00
Eco2 (mmHg)	33.28 ± 1.80	33.32 ± 1.78	33.110±1.792	33.432±1.765
Tidal volume (in ML)	434.60 ± 66.00	474.80 ± 68.19	448.600±71.771	465.600±72.847
Airway pressure (in Cm of H2O)	18.87 ± 0.58	18.70 ± 0.43	18.866±0.579	18.696±0.432
Leak of air from side of ETTc	Nil	Nil	Nil	Nil

Group A (N=50)			Group P(N=50)		
ETTc Pressure	**SubGroup – AM (Mean ± SD)**	**Group- AC (Mean± SD)**	**ETTc Pressure**	**Group – PM (Mean ± SD)**	**Group- PC (Mean± SD)**
Manual pressure (cm of H_2O), Baseline	50.10 ±11.67	25.00 ± 0.00	Manual pressure (cm of H_2O), Baseline	50.100±11.671	25.00 ± 0.00
Pressure set after measuring by cuff pressure monitor (cm of H_2O)	25.00 ± 0.00	25.00 ± 0.00	Pressure set after measuring by cuff pressure monitor (cm of H_2O)	25.000±00	25.00 ± 0.00
ETTc pressure after placement of retractor in Group A	39.64 ± 2.55	25.00 ± 0.00	ETTc pressure after 1 hr in Group P	25.240±0.517	25.00 ± 0.00
ETTc pressure after 30 minutes of retractor's placement in Group A	38.52 ± 1.18	25.00 ± 0.00	ETTc pressure after 2 hr in Group P	25.780±0.790	25.00 ± 0.00
ETTc pressure after 60 minutes of retractor's placement in Group A	38.68 ± 1.15	25.00 ± 0.00	ETTc pressure after 3 hr in Group P	26.260±0.723	25.00 ± 0.00
ETTc pressure after removal of retractor in Group A	39.16 ± 1.53	25.00 ± 0.00	ETTc pressure after 4 hr in Group P	26.820±0.850	25.00 ± 0.00
ETTc pressure after 30 minutes of retractor's removal in Group A	26.34 ± 0.56	25.00 ± 0.00	ETTc pressure after 5 hr in Group P	27.240±0.916	25.00 ± 0.00
ETTc pressure after completion of surgery	27.64 ± 0.63	25.00 ± 0.00	ETTc pressure after completion of surgery	27.420±0.926	25.00 ± 0.00







- Mean duration of surgery was 5.2 hrs.
- One way repeated measure ANOVA- Sub group AM and PM p value- .000 (highly significant statistically), to find out the group where is the significant difference- post hoc test (Bonfem Test) was applied- all groups were significantly different from each other.
- In both A and P groups, repeated measure ANOVA and multiple comparison analysis was done and in all groups it was found significant (p value-0.00). Bonferroni correction test showed that average ETTc pressure at all six point of time were significantly differently (p – value: 0.00) from the baseline pressure.
- In Subgroup AC and PC- as there was constant ETTc pressure i.e. 25 Cm H2O, statistics cannot be applied there and Subgroup M and Subgroup C cannot be compared as one group is constant.

DISCUSSION

- When the pressure in an ETTc exceeds the capillary perfusion pressure of the tracheal mucosa, mucosal blood flow is obstructed lead to severe, even fatal injury. Pressures greater than 40 cm H2O have been reported in 91% of postoperative patients after nitrous oxide anesthesia and in 45% of patients receiving other anesthetics.
- The suggested "safe" pressure at which capillary perfusion is impaired, is 25 cm H2O, to prevent aspiration and leaks past the cuff. On the other hand, in an *in vitro* study, Seegobin and Hasselt reached similar conclusions and recommended cuff inflation pressure not exceed 30 cm H_2O. Thus it is essential to maintain cuff pressures in the range of 20–30 cm of H_2O.
- The precise pressure at which any individual will experience impaired or obstructed tracheal mucosal blood flow will depend upon numerous factors, most important their blood pressure. Other factors are also important in avoiding damage; these include adjusting cuff inflation for altitude, correct positioning of the patient's head and neck during intubation, avoiding infection involving the patient's secretions, preventing severe respiratory failure, and avoiding prolonged intubation. Endotracheal suctioning, coughing, and positioning affected cuff pressure.
- Especially in neurosurgery, where awkward positioning of head and neck after intubation, as per requirement of surgery, is a common practice, the risk of tracheal mucosal damage is even more. This when coupled with overinflation of the ETTc during prolonged surgeries will lead to severe postoperative complications.
- In patients undergoing for GA through a high-volume, low-pressure endotracheal tube, the automatic cuff pressure monitor enabled an effective continuous control of the endotracheal cuff pressure. This effective control of cuff pressure did not, however, result in any difference with regard to tracheal mucosal damage. The severity of tracheal damage, however, is related to the duration of intubation.
- This study demonstrates that even experienced anesthesiologists were unable to inflate an ETT cuff to a safe pressure limit. The manual methods as palpation of pilot balloon and disappearance of audible air leak were found to be inaccurate methods to assess adequate ETTc pressure and most of the time; it was more than the safe pressure limit. The inability of clinicians to determine endotracheal tube cuff pressure by the traditional standard method of palpation of the pilot balloon has been addressed by other investigators.
- Cuff pressure measurement is not included in the minimum standards for the safe provision of anesthesia and not routinely used. However the complications of high cuff pressure include cuff herniation, vocal cord damage or paralysis and tracheal ischemia resulting to airway obstruction. The mean just seal pressure (15.2 mm Hg ±1.6 mm Hg) was significantly different than the mean cuff pressure after the application of retraction and distraction (43.2 mm Hg± 5.0 mm Hg). There was 60 % incidence of sore throat. No patient experienced hoarseness or apparent laryngeal nerve damage. In our study also the main post operative complications are sore throat; cough and hoarseness of voice, but the incidence of these complications are low in comparison of Manual method.
- Cuff pressure as well as the incidence of sore throat were significantly higher in the finger group compared to both the control and the sealing group (p<0.001 and p=0.008).
- Our study confirms a previous report that initial inflation of the endotracheal tube cuff with subjective evaluation of cuff pressure by finger estimation may result in increased pressure on tracheal mucosa.
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- Further with the application of retractors on anterior wall of neck during surgery, the ETTc increases significantly (39.64 ± 2.55) and remained high during the retractors application. This corresponds the influence of endotracheal tube cuff pressure and placement of tissue retractors transmits pressure through the soft tissues of the neck to the trachea.
- Using standardized instruments to measure cuff pressures might help increase safety by decreasing the possibility of injury resulting from endotracheal intubation. It has been suggested that using standardized instrumentation to measure cuff pressure would help to decrease the possibility of injury resulting from endotracheal intubation.

CONCLUSION

This study suggests that even experienced anesthesiologists are unable to inflate an ETT cuff to a safe pressure limit manually as palpation of pilot balloon and disappearance of audible air leak. Further with the application of retractors on anterior wall of neck during surgery, the ETTc increases significantly and remained high during the retractors application. It has been suggested that using standardized instrumentation like automatic cuff pressure controller, to measure cuff pressure would help to decrease the possibility of injury resulting from endotracheal intubation and better maintain ETTc pressure especially during anterior cervical spine operations.

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