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Endotracheal Tube Cuff Pressures During Anaesthesia: Safety of Estimation Techniques

KEYWORDS: Endotracheal tube cuff pressure; estimation techniques; cuff pressure manometer

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ABSTRACT ***Background:*** Optimal endotracheal tube (ETT) cuff pressure guarantees adequate ventilation without air leak and precludes aspiration while maintaining tracheal perfusion. The aim of the present study was to evaluate the efficacy of the routinely used cuff inflation estimation techniques to achieve optimal cuff pressures.

Methods: One hundred ASA I-II adults undergoing elective surgery under general anaesthesia were included for determination of ETT cuff pressures with a pressure manometer after the attending anaesthesiologist inflated the ETT cuff using their routine estimation technique.

Results: The various estimation techniques used for measuring cuff pressures were the palpation technique (90%), minimum leak technique (8%) and predetermined volume technique (2%). The mean cuff pressure obtained by estimation techniques was 36.68 ± 11.46 cm H2O with range from 16 to 70 cm H2O. Only 38% of the estimated cuff pressures were within the normal range of 20-30 cm H2O.

Conclusion: We conclude that estimation techniques for endotracheal tube cuff inflation cannot be relied upon and suggest the use of manometer as standard intraoperative monitoring tool in the interest of patient safety.

Introduction:

Management by cuffed endotracheal tubes is a common practice during routine anaesthesia to best secure an airway. Inflation, determination and maintenance of optimal endotracheal tube cuff pressure is a fundamental aspect of endotracheal intubation. Optimal endotracheal tube cuff pressure guarantees positive pressure ventilation without air leak and also prevents aspiration by providing adequate airway seal. The consensus in literature regarding optimal cuff pressure ranges from 20 - 30 cm H_2O.[1-4] Overinflated cuffs can hamper the capillary blood flow, potentially causing complications such as mucosal ischemia, postoperative sore throat and hoarseness[5], laryngeal nerve palsy[6], tracheal rupture[7], stenosis[8] and trachea-esophageal fistula[9]. Underinflated cuffs increase the possibility of aspiration.[10] The cuff pressure is dynamic and the factors which influence cuff pressures are volume of gas or liquid used to inflate the cuff, tracheal diameter[11], nitrous oxide[12], timing and type of the operative procedure and position of the head[13]. There is paucity in literature regarding the precise method of cuff inflation and anaesthesiologists use various estimation techniques for cuff inflation. These estimation techniques include hands on palpation of the pilot balloon, listening or auscultating for air leak on ventilating the patient, or inflation of cuff with predetermined amount of air.[3,11,14] Monitoring the cuff pressure with manometer is a reliable standard method to confirm pressure to tracheal wall.[15] But it is not routinely used in clinical practice.[16]

The aim of the present study was to evaluate the efficacy of the routinely used cuff inflation estimation techniques to achieve optimal cuff pressures.

Methods:

After Institutional Review Board approval and patient's written informed consent, one hundred patients of either sex, between the age of 18-70 years, having physical status of American Society Of Anaesthesiologists grade I & II, scheduled for elective surgery under general anaesthesia requiring endotracheal intubation, in supine position were enrolled for the study. Exclusion criteria were pregnant patients, trauma cases, head and neck and thoracic surgeries and patients requiring placement of nasogastric tube or with predicted difficult intubation.

In this study, the anaesthetic plan was at the discretion of the attending anaesthesiologist except that the nitrous oxide was started only after measurement of endotracheal tube (ETT) cuff pressures by the manometer. We used Portex cuff pressure manometer designed specifically for high volume low pressure cuffs with an upper scale limit of 120 cm H_2O.

The cuff pressure was measured by attaching the manometer to the pilot balloon of endotracheal tube.

After institution of standard monitoring and induction of anaesthesia, endotracheal intubation was performed with No. 7, 7.5 or 8 mm ID high volume low pressure PVC tube, as judged appropriate for the patient. After verification of correct tube placement, the anaesthesiologists inflated the ETT cuff and determined the adequacy of intracuff pressure using the estimation technique, at their discretion. A single intracuff pressure measurement was then obtained in centimeters of water by attaching the manometer to ETT pilot balloon. In case, the cuff pressure was outside the recommended level of 20 -30 cm H_2O[1-4], the pressure was adjusted. The types of estimation techniques used by the anaesthesiologists were also recorded.

Volume : 5 | Issue : 11 | November 2015 | ISSN - 2249-555X

Continuous parameters (age, weight, height, BMI) in the study were presented as mean and SD (standard deviation) and categorical variables were expressed in percentages.

Results:
Demographic data of the study is presented in table 1. The various estimation techniques used by the anaesthesiologists for measuring ETT cuff pressures were the palpation technique (90%), minimum leak technique (8%) and predetermined volume technique (2%) (Table 2) The mean cuff pressure obtained by estimation techniques was 36.68 ± 11.46 cm H_2O with range from 16 to 70 cm H_2O. Only 38% of the estimated cuff pressures were within the normal range of 20-30 cm H_2O. 60% of the estimated cuff pressures were greater than 30 cm H_2O and 2% were below 20 cm H_2O. (Figure 1)

Discussion:
Maintenance of optimal ETT cuff pressure is an important but neglected aspect of endotracheal intubation. There are no accepted guidelines in literature for ideal cuff pressure. The proposed 'safe' cuff pressure for adequate delivery of tidal volume without air leak and prevention of aspiration is 25 cm H_2O as capillary perfusion is not impaired. [17] Seegobin and Hasselt advocated that ETT cuff pressures should not exceed 30 cm H_2O.[18] The accurate pressure at which tracheal mucosal blood flow will be hampered also depends upon factors like blood pressure[19], altitude[20] and head and neck position.[13] Recent research suggests that a range of 20-30 cm H_2O is safe.[2-4] We considered this interval of 20-30 cm H_2O as optimal cuff pressure for our study.

The literature does not shed light on the precise method of cuff inflation and anaesthesiologists use various estimation techniques for ETT cuff inflation. These estimation techniques include hands on palpation of the pilot balloon, listening or auscultating for air leak on ventilating the patient, or inflation of cuff with predetermined amount of air.[3,11,14] Stewart et al in their study on 40 patients compared endotracheal cuff pressures obtained by estimation techniques with direct endotracheal cuff pressure measurements. They reported that 80% of the anaesthesia providers used palpation of the pilot balloon for establishing ETT cuff pressures. This is in concurrence with our study where 90% of the anaesthesiologists used this technique for inflating ETT cuff pressure. However, the palpation technique can lead to either hyper or under inflation because numerous factors like ETT type, ETT to tracheal diameter, geometry of cuff and filling material (air or water) influence the tone of pilot balloon.[21]

Ozer et al[4] in their study on 250 patients, investigated the effects of user experience and cuff pressure inflation method differences following endotracheal tube cuff inflation and reported that 70% of the anaesthesia providers cuffed the tracheal tube to pressures greater than 30 cm H_2O. Sengupta et al[2] found that among 93 patients undergoing general anaesthesia with tracheal tube , 50% of the patients were having a cuff pressure above 30 cm H_2O and 27% had a cuff pressure above 40 cm H_2O. Galinski et al[22] measured cuff pressures in intubated patients transported by ambulance and found that the cuff pressure was higher than 27 cm H_2O among 79% of the patients. Liu et al[23] reported that the cuff pressure was 58 cm H_2O after intubation and after the providers manually palpated the external cuff balloon. The results of above studies are in concurrence with our findings.

The role of the years of experience in the ability to discern optimal cuff pressure has been studied with some studies supporting[4] while others negating the relationship.[24] Several studies have reported that it is difficult to train for the skill needed to identify optimal cuff pressures, and objective methods such as a cuff manometer should by employed.[21,25]

There are some limitations of our study. Firstly the cuff pressures were measured only once during anaesthesia. We did not study the fluctuations in pressure for the whole period of anaesthesia. Secondly, the role of experience of anaesthesiologist in optimal inflation of ETT cuff was not evaluated.

Conclusion:
We conclude that estimation techniques for endotracheal tube cuff inflation cannot be relied upon and suggest the use of manometer as standard intraoperative monitoring tool for enhancing patient safety.

Table 1:
Demographic data of the study group

Variable	Measured Value n = 100
Age, yr	40.71 ± 15.36
Sex, M/F, n (%)	66/34 (66/34)
Weight, kg	62.98 ± 9.74
Height, cm	167.05 ± 8.32
BMI, kg m^{-2}	22.49 ± 2.54
ASA, I/II, n (%)	77/23 (77/23)

Data are expressed as mean ± SD or number of patients (%) BMI: Body mass index

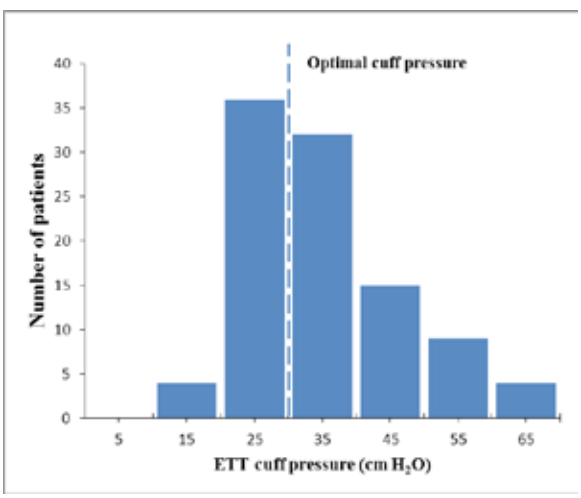
Table 2:
Estimation techniques and measured ETT cuff pressure

Variable		Measured Value n=100
Estimation Techniques, n (%)	Palpation	90 (90%)
	Minimal Leak	8 (8%)
	Predetermined Volume	2 (2%)

Volume : 5 | Issue : 11 | November 2015 | ISSN - 2249-555X

Measured ETT cuff pressure, n (%)	< 20 cm H_2O	2 (2%)
	20-30 cm H_2O (Optimal range)	38 (38%)
	>30-40 cm H_2O	32 (32%)
	> 40 cm H_2O	28 (28%)
Mean ETT cuff pressure (cm H_2O), mean ± SD		36.68 ± 11.46

Figure 1:
Estimated Cuff Pressures in the study group (Broken line indicates optimal cuff pressure)



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