

**Original Research Article****Estimation of Endotracheal Tube Cuff Pressure among Anaesthesia Providers Does Experience Matter?**Raha AR<sup>1</sup>(✉), Haslinda S<sup>2</sup>, Nadia MN<sup>1</sup>, Nurlia Y<sup>1</sup><sup>1</sup>Department of Anaesthesiology and Intensive Care, Universiti Kebangsaan Malaysia Medical Center, Jalan Yaacob Latiff, 56000 Cheras, Kuala Lumpur.<sup>2</sup>Ipoh General Hospital, Jalan Hospital, 30990 Ipoh, Perak.**Abstract**

The endotracheal tube (ETT) cuff pressure is usually estimated and assumed to be within the appropriate range. However, the estimation of cuff pressure may be influenced by the various estimation techniques used by anaesthesia providers and their different experience level. The main aim of this study was to observe the correlation between the experience of the anaesthesia providers and their ability to estimate endotracheal cuff pressure in a correct manner. One hundred anaesthesia providers were classified into three different groups based on their months of anaesthetic experience: Group I (< 36 months), Group II (36 to 59 months) and Group III ( $\geq$  60 months). Following intubation, the ETT cuff was inflated by the anaesthetic nurse and ETT placement verified by the anaesthesia provider. Using the pilot balloon palpation technique (PBPT), the cuff pressure was estimated to be within the appropriate pressure range, over or under-inflated. The necessary adjustments were made if needed after measurement with a VBM™ Manometer Pressure Gauge. More number of months of anaesthesia experience was not associated with a greater ability to correctly estimate the ETT cuff pressure. However, this correlation was poor ( $r = -0.177$ ). The pilot balloon palpation technique was found to be only moderately sensitive (76.5%) but poorly specific (42.9%) for correct estimation of the ETT cuff pressure, whereby PPV and NPV were 58.2% and 63.6%, respectively. The technique was 50% (95% CI 24.04 - 75.95) sensitive while correctly estimating the under-inflated cuff and 60% (95% CI 13.25-37.81) sensitive to correctly estimating the over-inflated cuff. The results depict that the experience of anaesthesia providers did not correlate with the ability to correctly estimate the ETT cuff pressure.

**Keywords:** Endotracheal, cuff pressures, anaesthesia, intubation, techniques.**Correspondence:**

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Date of submission: 14<sup>th</sup> July 2011Date of acceptance: 26<sup>th</sup> Sept 2011Date of publication: 3<sup>rd</sup> Oct 2011**Introduction**

The endotracheal tube (ETT) cuff is usually inflated with air during general anaesthesia to produce a seal within the trachea to avoid gas leakage and contamination of the lungs. The distension volume of the pilot balloon is assumed as an estimation of the cuff pressure. The 'minimum leak technique' (MLT) and 'pilot balloon palpation technique' (PBPT) are commonly used by anaesthetists. The ETT cuff

pressure is not routinely measured peri-operatively and there are no guidelines on its routine measurement.

Earlier studies recommended that the ETT cuff pressure be within the range of 20-30 cm H<sub>2</sub>O in order to maintain a safe adequate seal of the intubated trachea (1-3). Lomholt (1992) recommended 25 cm H<sub>2</sub>O as a safe minimum pressure to prevent aspiration and leak (2). Seegobin (1984) reported evidence of impaired mucosal capillary blood flow when the ETT

cuff pressure was more than 30 cm H<sub>2</sub>O (3). A previous clinical study showed that post-intubation sore throat, a common side effect in patients intubated for general anaesthesia, partly resulted from ischaemia of the oropharyngeal and tracheal mucosa (4). There are reports of significant changes in habitual pitch, throat clearing and vocal fatigue among intubated patients, but their symptoms subsided within 24 hours, postoperatively (5).

In a recent study in canines, the correlation between endotracheal cuff volume and endotracheal cuff pressure was a near-perfect linear relationship. However, the margin of error in over-inflation was small (6). A study on intubated patients under general anaesthesia also showed similar results where a linear relationship was observed between the cuff pressure and the pilot balloon volume (7).

In the year 2000, the U.S Department of Labor estimated that more than 200 000 medical personnel in America, inclusive of anaesthetists and nurse anaesthetists, were potentially exposed to waste anaesthetic gases and at risk of occupational illnesses (8). This exposure could be due to improperly inflated ETT cuffs. In a local study performed in 2007 (9), it was found that the nitrous oxide level in the operating theatre environment after eight hours of surgery was well above that recommended by the National Institute of Occupational Safety and Health, Malaysia (NIOSH).

The main aim of this study was to see the correlation between the experience of the anaesthesia provider and their ability to correctly estimate ETT cuff pressure.

## Materials and Methods

One hundred anaesthesia providers (n=100) which included anaesthesiology registrars and anaesthesiologists were recruited for the study after obtaining prior approval from the institutional research and ethics committee. This study was carried out in the general operating theatres of Universiti Kebangsaan Malaysia Medical Centre and Hospital Kuala Lumpur. The anaesthesia providers were classified into three groups based on their months of anaesthetic experiences. Group I, II and III comprised of individuals with experience of less than 36 months, between 36 to 59 months, and 60 months and above, respectively.

During the pre-medication visit, the patient was briefed regarding the study protocol and written informed consent obtained. All the anaesthesia providers were briefed on the methodology once they consented to be part of the study. Standard monitoring

devices were used for all patients. Induction of general anaesthesia and intubation was done by the anaesthesia providers. Induction proceeded with intravenous fentanyl and propofol or sodium thiopentone, followed by either atracurium or rocuronium. After intubation using a high volume, low pressure cuff ETT (Eure+Care®) of size 7.5 or 8.0 for females and males respectively, anaesthesia was maintained with oxygen, air and sevoflurane. The ETT cuff was inflated by the anaesthetic nurse. Immediately following that, the anaesthesia provider verified the tube placement and assessed the adequacy of intra-cuff pressure using the PBPT, where the pilot balloon was palpated, grossly estimating the intra-cuff pressure. The anaesthesia provider commented whether the ETT cuff was within the appropriate range of pressure, over or under-inflated and measurement of the cuff pressure was then made using a VBM™ Manometer Pressure Gauge with calibration ranging between 0 to 120 cm H<sub>2</sub>O. The pressure measurement was categorized as appropriate when the pressure ranged between 20 to 30 cm H<sub>2</sub>O or inappropriate when the pressure was less than 20 cm H<sub>2</sub>O or more than 30 cm H<sub>2</sub>O. Adjustment was done if necessary to ensure that the ETT cuff pressure was within the appropriate pressure range.

## Statistical Analysis

Calculation of sample size was based on a similar study performed in a group of paramedic, where a sample size of 53 was expected to be adequate to yield a 1% significance level ( $\alpha$ ) and 80% power (1- $\beta$ )(10). However, we sampled 100 participants so as to include as many practicing anaesthetic doctors in the two centres where the study was done. The results were analyzed using Spearman's correlation in the SPSS version 12.0. Sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were calculated with the VassarStat© Software Calculation. A p value of < 0.05 was considered statistically significant. The results were rated to be of high, moderate, fair or poor sensitivity and specificity if it had values of >90%, 70% - 89%, 50% - 69% or 50%, respectively.

## Results

There were no significant differences in the distribution of gender among the anaesthesia providers (Table 1). As the data was not normally distributed, Spearman's correlation was used to see the correlation between the anaesthesia providers' experience and the ability to correctly estimate the ETT cuff pressure. This study found that the anaesthesia providers'

experience was inversely correlated to correct cuff pressure estimation with an r value of -0.177. More number of months of anaesthesia experience was not associated with a greater ability to correctly estimate the ETT cuff pressure, however this correlation was poor (Table 2).

The PBPT was found to be only moderately sensitive, (76.5%) but poorly specific (42.9%) in estimating appropriate ETT cuff pressure whereby PPV and NPV were 58.2% and 63.6%, respectively. The technique was 50% (95% CI 24.04-75.95) sensitive in correctly estimating the under-inflated cuff and 60% (95%CI 13.25-37.81) sensitive in correctly estimating the hyper-inflated cuff.

**Discussion**

This study found no significant correlation between the experience of the anaesthesia providers and their ability to correctly estimate the ETT cuff pressure. Similarly, an earlier study also found no difference in the ability to correctly estimate the ETT cuff pressure among the first and second year anaesthesia student nurses (the non-experienced group), and the Certified Registered Nurse Anaesthetists and anaesthesiologists (the experienced groups) (11).

This study also found that the PBPT had moderate sensitivity but poor specificity in estimating the ETT cuff pressure correctly. Other studies that had focused on specific groups like paramedics or emergency medicine (EM) physicians, reported that estimation techniques had very low sensitivity (13-22%) in correctly estimating the ETT cuff pressure(10,12). In the study performed in the paramedics the average frequency of endotracheal intubation was only 3.6 times per year (10). However, in the study involving

the EM physicians, their rate of performance of endotracheal intubation ranged between 4-25 times per year (12). The average frequency of intubation of the anesthesia providers included in our study was not recorded, but generally they performed endotracheal intubations on a daily basis.

A study by David et al (2008) found that the PBPT had a high sensitivity of 96% and specificity of 26% in assessing the ETT cuff pressure(13). However, the very high sensitivity in that study was most probably due to the fact that a 15 minute ‘training session’ was given to the emergency residents prior to the test. Similarly, a later study reported that through training courses, airway care providers may be able to estimate the ETT cuff pressure better (14).

The amount of air required to inflate an ETT cuff to an approximate pressure of 20 cm H<sub>2</sub>O was found to be similar with tube sizes ranging between 7.0 to 8.5 (8,9). However, there are always confounding factors that may expand the air in the cuff or cause leakage that may lead to variations in the cuff pressure during the time when a patient is under general anaesthesia. Routine ETT cuff pressure measurement has not been a standard practice in the operating theatre, unlike most intensive care units (15,16). In view of the fact that we cannot depend on estimation techniques to ensure appropriate intra-cuff pressures, we strongly recommend that the ETT cuff pressure be monitored

**Table 1:** Gender of the anaesthesia providers. Values expressed as number (n)

	<b>Group 1 (n = 30)</b>	<b>Group 2 (n = 23)</b>	<b>Group3 (n = 47)</b>
Gender			
Male : Female	6:24	4:19	14:13

**Table 2:** Comparison of the endotracheal cuff pressure measured to the estimation of appropriate endotracheal cuff pressure. Value expressed as numbers.

	<b>Endotracheal cuff pressure measured:</b>	
	<b>within appropriate pressure range, n (20-30 cm H<sub>2</sub>O)</b>	<b>not within appropriate pressure range, n (&lt; 20 or &gt; 30 cm H<sub>2</sub>O)</b>
Estimation of appropriate endotracheal cuff pressure:		
correct estimation	39	28
wrong estimation	12	21

using a standard measurement device intra-operatively to avoid the possibility of inappropriate intra-cuff pressure due to accumulation, or loss of intra-cuff volume during anaesthesia.

In this study, the experience of the anaesthesia providers was gauged based on duration of anaesthetic experience. We assumed that their duration of anaesthetic experience positively correlated with the number of intubations. It might have been more accurate to take into account their average number of intubations as a gauge of their experience, as was done in earlier studies (10,12).

### Conclusion

The results depict that the experience of anaesthesia providers did not correlate to the ability to correctly estimate the ETT cuff pressure. The pilot balloon palpation technique showed moderate sensitivity and poor specificity in estimating the ETT cuff pressure.

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