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Minimizing adverse effects of subjective measurement of endotracheal tube cuff pressure: Can the use of the loss of resistance technique help?

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Abstract

Background: Appropriate endotracheal tube cuff (ETTc) pressure estimation is essential to prevent airway complications. The pilot balloon palpation technique is the commonly used method of cuff inflation. It is however subjective thus prone to over or under estimation thus unreliable.
Objective: To determine if the use of the passive release technique of cuff inflation would reduce commonly encountered airway complications following ETT intubation.
Methodology: Patients scheduled for elective procedures under general anaesthesia with ETT were recruited into the study, 108 ASA I and II patients aged between 18-65 years were randomized into 2 groups with one group having their cuff inflated using the pilot balloon palpation (PBP) technique and the other by the use of a loss of resistance syringe (LOR). Airway complications were then assessed and compared between the 2 groups.
Results: The incidences of sore throat, cough and hoarseness were significantly lower in the LOR group compared to the PBP group (35.2vs79.6%, 14.8 vs64.8% and 7.4 vs 79.6% respectively; p = 0.0001 in each case).
Conclusion: Passive release technique using LOR was found to be less associated with post-endotracheal intubation airway complications than PBP technique

Keywords: Airway complications, pilot balloon palpation, passive release technique, loss of resistance syringe.

Introduction

Overinflation of the endotracheal tube cuff (ETTc) to a level above the capillary perfusion pressure of the tracheal mucosa may result in certain complications to patients.[1] The commoner and less serious ones include sore throat, dysphagia, hoarseness of voice and cough. Although these complications are typically not incapacitating, they may lead to postoperative discomfort and patient dissatisfaction.[1] Moreover, cough at the peri-extubation period may lead to haemodynamic instability, arrhythmias and increase in intracranial and intraocular pressures.[2] Other more disabling complications of ETT cuff-inflation such as tracheal wall damage, tracheoesophageal fistula, subglottic stenosis and laryngeal nerve injury, although rare, may also occur.[2,3] These complications arise because once the ETTc pressure exceeds the mucosal perfusion pressure of 27-40cmH_2O, ischaemic and necrotic changes may occur.[4]

On the other hand, an under inflation of the ETTc may result in air leak during positive pressure ventilation (PPV) and aspiration of gastric contents or pharyngeal secretions. Endotracheal cuff pressure less than 20cm H_2O has been reported to be a strong factor that predisposes to aspiration.[5,6] This results in postoperative lower respiratory tract infection, which is a major morbidity that may prolong hospital stay and increase cost of care.[3]

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The recommended ETTc pressure is 20 – 30cm H_2O,[1] and the commonly employed method of cuff pressure estimation is the Pilot Balloon Palpation (PBP) technique. With the PBP, anaesthetists or an assistant incrementally inflates and palpate the pilot balloon until they feel satisfied with the fullness of the pilot balloon, but this method is subjective, observer dependent and mostly ineffective in determining optimal ETTc pressure even in the hands of experienced anaesthetists,[7] thus making patients prone to postoperative complications.

The passive release technique of ETTc inflation which uses a loss of resistance (LOR) syringe is a newer method of cuff inflation pressure estimation, and a study has shown that the LOR syringe when used for ETTc estimation, attainment of an optimal cuff pressure is seen in more than 60% of patients.[6] It entails inflation of the ETTc to its maximum capacity at once using an LOR syringe, and then allowing the plunger to recoil passively. The point at which the plunger stops corresponds to the required ETTc pressure. This study seeks to determine if the use of the newer method of passive release technique for ETTc inflation would minimize the occurrence of commonly encountered side effects during endotracheal intubation.

Materials and methods

This randomized prospective study was carried out in 108 ASA I and II patients of either gender aged between 18 and 65years. Patients scheduled for elective surgical procedures under general anaesthesia with orotracheal intubation, in urology, orthopaedics, plastic, gynaecology and general surgery were recruited over a 6 month period into the study. Institutional ethical committee approval was sought and approval obtained, a written informed consent was taken. Patients excluded from this study included; head and neck surgeries, obstetric patients, any patient considered a full stomach, patient with preexisting airway symptoms, patient expected to remain intubated beyond the operative room, surgical procedures in prone position, and patients with anticipated difficult airway. The patients were randomly allocated into either group PBP or LOR comprising of 54 patients each after picking one folded sheet of paper from a box containing uniformly folded pieces of paper labeled either PBP or LOR. The paper was handed over to the research assistant (a designated resident doctor) who was not blinded to the study group the patient belonged to, and was not involved in data collection. The investigator was not notified of the group allocation of the patients.

Eligible patients were reviewed a day before surgery. History, physical examination, including mouth opening and Mallampati score, and review of investigation results (such as complete blood count, electrolytes, urea and creatinine) were carried out. Patient's age, sex, weight, height, BMI, neck circumference were recorded, and preoperative fasting ensured.

On arrival in the operating room, routine baseline vital signs which include non-invasive systolic and diastolic blood pressures (SBP and DBP), mean arterial blood pressure (MAP), pulse rate (PR), respiratory rate (RR), peripheral arterial oxygen saturation of hemoglobin (SpO_2) and electrocardiograph were obtained. An intravenous access was secured with size 16G or 18G (wide bore) cannula and 0.9% saline infusion commenced. The patient was preoxygenated with 100% oxygen; induction of anaesthesia was achieved with 2mg/kg intravenous propofol or 5mg/kg intravenous sodium thiopentone attaining loss of consciousness as evidenced by loss of verbal contact or eyelash reflex respectively. After test ventilation, 0.5mg/kg iv atracurium or 0.1mg/kg iv pancuronium was administered, and ventilation was assisted for 3 to 5min to allow for onset of action, direct laryngoscopy using Macintosh laryngoscope with size 3 or 4 blade was carried out followed by intubation with appropriate sized (sizes 7.5 - 8.0mm and 7.0 - 7.5mm internal diameter for male and female patients respectively) endotracheal tube. In the PBP group, the attending anaesthetist used a 10ml syringe (BD Discardit II), fully filled with air, to inflate the cuff via the pilot balloon to a level he or she considered adequate by palpation of the pilot balloon. The syringe was detached and hidden away by a research assistant as the researcher was unaware of the technique of ETTc inflation used. In LOR group, the attending anaesthetist used an air filled 10ml plastic, luer slip, loss of resistance syringe (Halyard Health, Belgium), to inflate the balloon to the maximum it could accommodate, and then released the plunger for passive recoil until it ceased, which was regarded as the end point. The

loss of resistance syringe was then disconnected and hidden away by a research assistant. The researcher, who stayed in the reception area, away from the induction room, was invited by the research assistant after ETTc inflation had been completed Both groups had their ETT connected to the breathing circuit, and ventilation was started. Anaesthesia was maintained with 1-2 MAC of isoflurane in 33% oxygen-air mixture. Analgesia was achieved with 2mcg/kg of intravenous fentanyl. Top up boluses of 1 mcg/kg were given every hour. Muscle relaxant was reversed with neostigmine 2.5mg and atropine 1.2mg. At the end of the surgery, pharyngeal secretions were suctioned and residual neuromuscular block was reversed with 2.5mg IV neostigmine in 1.2mg IV atropine. The patient was extubated awake in the operating room.

Patients were assessed 24hrs after the surgery for the presence of sore throat, cough and hoarseness of the voice by the investigator who remained blinded for patients' group allocation. Sore throat was assessed using Verbal Rating Score (VRS) on a four point scale with a score of zero signifying no pain, 1 for mild pain, 2 for moderate and 3 for severe pain. Cough was similarly assessed on a four point scale with mild cough described as less than what is seen in common cold, moderate cough was similar to common cold and severe was worse than common cold. Hoarseness of voice was graded as zero if it wasn't present at any point in time since the operation, 1 if patient complains of hoarseness but no sign is seen at time of interview, 2 if hoarseness is noticed only by the patient at time of interview, and 3 if easily noticed. Patients with mild sore throat were reassured while those with moderate to severe sore throat were treated with lozenges.

Data obtained was analyzed using Statistical Package for Social Sciences (SPSS) version 21.0. Quantitative variables such as age, weight, height, neck circumference were summarized using mean (± standard deviation) and compared using independent t-test. Qualitative variables such as incidence of cough, sore throat and hoarseness were summarized using percentages and compared using Chi-squared test or Fisher's exact test where applicable. Level of statistical significance was set at a p-value of <0.05.

Results

A total of 108 patients were recruited into this study over a period of 6 months. The mean age of the patients in the PBP and LOR groups were 39.34 ± 13.9 and 38.24 ± 13.8 years respectively (p = 0.702). Other demographic profiles and clinical characteristics of the patients such as age, sex, ASA classification, Mallampati, mean neck circumference and body mass index (BMI) in the two study groups were also comparable as shown in **table 1**.

The duration of laryngoscopy, size of ETT used and duration of intubationare shown in table 2. The mean duration of laryngoscopy was longer in group LOR than in PBP group (15.06 ± 3.56 vs14.13 ± 3.87 seconds), but the difference was not statistically significant (p = 0.20). Similarly, the duration of intubation was longer in the LOR group(107.56 ± 23.46 vs 106.3 ± 26.16 minutes) but the difference was also not statistically significant(p = 0.79). The median ETT size used was 7.5mm (7.0 to 7.5) in the PBP, which was higher compared to the LOR group (7.25mm; 7.0 to 7.5) but the difference was not significant (p = 0.230). (**Table 2**)

The incidences ofsore throat, cough and hoarse voice were significantly higher in patients in the

Table 1: Comparison of patients' demographic data and clinical characteristics

	Group PBP (n = 54)	Group LOR (n = 54)	*p* – value
Age (years)	39.34 ± 13.90	38.24 ± 13.80	0.702
Neck circumference(cm)	34.16 ± 1.58	34.34 ± 2.48	0.644
BMI (kg/m^2)	24.21 ± 4.9	25.65 ± 5.13	0.142
Gender (Male:Female)	25:29	21:33	0.436
ASA (I:II)	30:24	28:26	0.847
Mallampati	40:14	36:18	0.399

Table 2: Comparison of duration of laryngoscopy, duration of intubation and median ETT size between the study groups

	Group PBP (n = 54)	Group LOR (n = 54)	p-value
	Mean ± SD	**Mean ± SD**	
Duration of Laryngoscopy (sec)	15.06 ± 3.56	14.13 ± 3.87	0.200
Duration of Intubation (min)	107.56 ± 23.46	106.3 ± 26.16	0.790
	Median (Range)	**Median (Range)**	
Median ETT size (mm)	7.50 (7.0-7.5)	7.25 (7.0-7.5)	0.230

TABLE 3: Comparison of incidence of postanaesthetic airway complications by group

	Group PBP	Group LOR	X^2- value	p-value
Incidence of symptoms(n = 54)				
Sore throat	43 (79.6%)	19 (35.2%)	21.81	0.0001
Cough	35 (64.8%)	8 (14.8%)	28.17	0.0001
Hoarseness	43 (79.6%)	4 (7.4%)	57.30	0.0001

TABLE 4: Comparison of severity of postanaesthetic airway complications by group

	Group PBP	Group LOR	X^2- value	p-value
Grading of sore throat	**(n = 43)**	**(n = 19)**		
Mild	16 (37.2%)	0 (0.0%)		
Moderate	24 (55.8%)	19(100.0%)	12.11	0.001
Severe	3 (7.0%)	0 (0.0%)		
Grading of cough	**(n = 35)**	**(n = 8)**		
Mild	29 (82.9%)	8 (100.0%)		
Moderate	6 (17.1%)	0(0.0%	1.59	0.334
Severe	0 (0.0%)	0 (0.0%)		
Grading of hoarseness	**(n = 43)**	**(n = 4)**		
Mild	31 (72.1%)	4 (100.0%)		
Moderate	12 (27.9%)	0 (0.0%)	1.50	0.340
Severe	0 (0.0%)	0 (0.0%)		

PBP group compared to those in the LOR group (79.6 vs 35.2%for sore throat; 64.8 vs 14.8% for cough and 79.6 vs 7.4% for hoarseness; p = 0.0001% in each case) as shown in **table 3**. There was a statistically significant difference in the severity of sore throat between the study groups (p=0.001). Only 19 patients in the LOR group had sore throat and all were of the moderate form; whereas in the PBP group, 16 patients had mild, 24 had moderate and 3 had the severe form.

The severity of both cough and hoarseness did not differ significantly among the two study groups (p values 0.334 and 0.340 respectively). Only 8 patients in the LOR group developed cough which were all mild compared to those in the PBP group in which 29 had mild and 6 had moderate cough. Four patients in the LOR group had mild hoarseness whereas in the PBP group, 31 had mild and 12 had moderate form of hoarseness. (**Table 4**)

Use of size 4 laryngoscope blade, Gudel's oropharyngeal airway and suction catheter were common to all the patients in both the study group. None of the patients in both groups had the use of gum elastic bougie, intubating stylet, pharyngeal or oesophageal temperature probe, or blood on the tip of ETT on extubation.

Discussion

The results obtained from this study showed that the incidence and severity of postanaesthetic airway complications were higher in the PBP group compared to the LOR group. Significantly higher incidences were seen with PBP group (79.9, 64.8 and 79.9% for sore throat, cough and hoarseness respectively) compared to those in LOR group (35.2, 14.8 and 7.4% for sore throat, cough and hoarseness respectively; p = 0.0001). (Table 3)The subjectivity associated with the PBP method of ETTc pressure estimation could have resulted in high pressure causing ischaemic changes in the tracheal mucosa in contact with the cuff, leading to the higher numbers of postanaesthetic airway complications. Another reason for the higher incidence could be due to the higher ETT size that was found in the PBP group, but there were more males in this group which could explain the higher ETT size recorded. Higher ETT size had been reported by Shrestha et al[8] to increase incidence of postoperative sore throat, the increase was however not statistically significant.

The two groups in the present study were comparable in terms of other confounding factors for postoperative airway complications as shown in the results. All patients had size 4 laryngoscope blade, Gudel's oropharyngeal airway and suction catheter used, and none of them had the use of gum elastic bougie, intubating stylet, pharyngeal or oesophageal temperature probe, or had blood on the tip of their ETT on extubation. We can therefore conclude that the significant difference in postoperative airway complications seen between the two groups was as a result of the subjective PBP method of ETTc inflation.

Bulamba et al[6] like in this present study compared the incidence of postanaesthetic airway complications in patients whose ETTc was inflated with either the PBP or LOR techniques, they also found higher incidences in their PBP group with an overall complication of 73% compared to 55% in the LOR group. Liu et al[9] reported significantly higher incidence of sore throat, cough and hoarseness in their PBP group (which was their control group) compared to a study group where the cuff pressures were adjusted using a manometer to a range of 15 to 20mmHg. They found a significantly higher mean ETTc pressure in the PBP group (58.46 ± 31.68cm H_2O). This reaffirms that high ETTc pressure may with higher incidence of postanaesthetic airway complications.

Similar to our observation, sore throat had been consistently reported by different researchers to be the more frequent airway complication than cough and hoarseness.[6,9] Our finding therefore added to the knowledge that sore throat is the most common postanaesthetic airway complaint following endotracheal intubation.[10] Sarki and cowokers[11] reported a 70% incidence of sore throat 24hrs following endotracheal intubation. This finding is lower than that found in this study (79.6%) at 24hr post extubation in the PBP group. However, their ETTc inflation was with the minimal occlusive volume (MOV) technique, which has been reported to have lower mean ETTc pressure, therefore less likely to be associated with airway complications than the PBP technique.[10] Another reason for their lower incidence could be because they lubricated their ETT with K-Y gel before intubation, which may reduce frictional injury, whereas no ETT lubrication was done in the present study.

The incidence of at least one postanaesthetic airway complication in this study was found to be 64.8% amongst the study population. That was lower than was reported by Kolawole et al[12] (75.2%) and Bulamba et al[6] (71.2%). The differences could be because their study involved a higher proportion of female patients than in the present study, females are reported to be at higher risk of postoperative airway complaints.[13] Moreover, some of the patients in Bulamba's study were intubated with size 8.5mm ETT, whereas this study limited the ETT size to 8.0mm as the largest. This larger tube size could be responsible for their increased incidence of postoperative airway symptoms.[13]

The ideal way to ensure an optimal ETTc pressure following endotracheal intubation thus preventing airway complications is the use of a manometer,1 but this is usually expensive and unavailable. The inaccurate estimation of ETTc pressure with an under or over inflation may result in various complications in patients following extubation thus resulting in increased patient burden. To forestall this, other ETTc inflation techniques have been employed in clinical practice; these include MOV, minimal leak technique (MLT), predetermined volume of air (PVA), including the commonly used

PBP though not with successes.[14]
This study has however demonstrated that the passive release method using the LOR syringe for ETTc inflation results in a significantly reduced incidence of airway complications compared to the commonly used PBP method.

Conclusion: We conclude that PBP technique of ETTc inflation is significantly more associated with postanaesthetic sore throat, cough and hoarseness of voice than the Passive Release Technique using LOR syringe

Conflict of interest: We declare no conflict of interest

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