

The Professional Experience of Anaesthesiologists in Proper Inflation of Laryngeal Mask and Endotracheal Tube Cuff

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Objective: Cuffs inflated to inappropriately high pressures cause ischemia, reducing tracheal mucosal blood flow, while cuffs inflated at lower pressure than necessary give rise to inadequate ventilation, aspiration of gastric contents, or extubation due to air leakage. In this study, we aimed to investigate the effect of the experience of anaesthesia staff on endotracheal tube and laryngeal mask airway cuff inflation.

Methods: The study included 348 elective patients scheduled to undergo surgery under general anaesthesia, with 34 anaesthesia technicians, 16 anaesthesia residents, and 12 anaesthesiologists with different years of professional experience. The participants were told to inflate the cuff balloon with air to the level of the pressure that was appropriate for them. No information was provided to the participants about the values of the cuff pressure pending the completion of all measurements. After placement of the laryngeal mask airway and endotracheal tube, the success of the procedure was checked by monitoring square-wave capnograph tracing and thoracoabdominal motion. Each participant performed the procedures on three patients, and the mean cuff pressures were measured.

Results: There was no significant correlation between duration of experience of technicians, residents, and experts in using laryngeal mask airway pressure ($r=-0.192/p=0.278$, $r=0.225/p=0.402$, $r=-0.476/p=0.118$, respectively) and endotracheal tube ($r=-0.306/p=0.079$, $r=-0.060/p=0.826$, $r=-0.478/p=0.116$, respectively).

Conclusion: It has been concluded that professional experience does not contribute to achieving normal cuff pressure without monitoring. Introduction of the cuff manometer into routine anaesthesia practice will be useful, irrespective of anaesthesiologists' experience.

Key Words: Laryngeal mask airway, endotracheal tube, pressure, monitoring

Introduction

Providing and maintaining an appropriate cuff pressure for mechanically ventilated patients is essential. Cuffs inflated to an inappropriately high pressure cause ischemia by reducing tracheal mucosal blood flow, while cuffs inflated at pressures lower than necessary give rise to inadequate ventilation or aspiration of gastric contents (1). In critically ill patients, contaminated secretions can leak through the tracheal cuff and result in ventilator-associated pneumonia (2, 3). High cuff pressure increases the risk for tracheomalacia and tracheal dilation in patients intubated for a long time (4). Cuff manometers are manual or automatic devices that measure the pressure in the endotracheal tube (ETT) or laryngeal mask airway (LMA) cuffs, and some can work to keep pressure at a certain level for a long time. These devices are frequently used in intensive care units as well as in operating rooms. Thus, the effects of hyperinflation due to iatrogenic reasons or nitrous oxide diffusion may be prevented. However, the benefit of this device has been proven in daily practice; it is not utilized routinely. Although it is cheap and easy to use, experiences of anaesthesiologists often replace the use of cuff manometers. This approach, which increases complication risk, continues to be a major problem, especially in patients for whom a long-term airway is to be established. This study is different from others in that specialists, technicians, and assistants took part in the study together, and they were classified by professional experience. To our knowledge, there is no clinical trial comparing these three professional groups. In this randomized, prospective study, we aimed to investigate the effect of the experience gained by anaesthesia staff on ETT and LMA cuff pressures.

Methods

Following the approval of the local ethical committee of Marmara University Medical School (No: B.30.2.MAR.0.01.02/AEK/123, date: September 15, 2011), all patients gave their written informed consents. The study included 348 elec-

tive patients with American Society of Anesthesiology (ASA) physical status I-III, scheduled to undergo operation under general anaesthesia. The patients were adults aged between 18-75 years. Patients were included in the study from the surgical departments, including general surgery; plastic and reconstructive surgery; orthopedics; urology; ear, nose, and throat; and ophthalmology. The exclusion criteria were as follows: patients with tracheal stenosis to undergo airway surgery, double-lumen intubation, nasal intubation, tracheotomy, history of difficult intubation and gastroesophageal reflux, anatomical laryngotracheal anomalies, emergency surgeries, and morbidly obese patients.

Tracheal tubes (Tyco Healthcare®, Wollerau Switzerland) and LMA (LMA Classic) cuffs were tested for leakage. This test was performed by observing whether there was a leakage after the maximum amount of air was introduced to all of the cuffs by means of a 20 mL syringe. Then, air was completely withdrawn from the cuffs. Airway was established after ensuring appropriate anaesthesia depth for intubation, by relaxation of the jaw and loss of eyelash reflex. We used suitable sizes of sterile ETTs for male and female patients. The sizes of LMAs were used according the manufacturer's manual for handling the LMA. Patients requiring other sizes of the ETT or LMA were excluded from the study.

Laryngeal masks were placed using the individual's preferred technique and guided by the manufacturer's instructions. The ETT was placed using the conventional intubation technique with a Macintosh laryngoscope. The cuff was inflated with air, and the participants were told to inflate the balloon to the level of the pressure that was appropriate for them. The cuff was inflated until the sound of air leak disappeared while the patient was being ventilated from ETT. The cuff was inflated until there was no leak for the LMA and adequate ventilation was achieved. When a sufficient pressure level was attained, the pressure was measured and recorded by means of an aneroid cuff manometer (CPV cuff pressure gauge, Germany), and it was adjusted to the correct pressure. ETT and LMA cuff pressure measurements were recorded by the same experienced anaesthetist. Direct pressure measurement was achieved by a cuff manometer calibrated in cmH_2O , which was attached to the ETT or LMA cuff pilot tube. The study included 34 anaesthesia technicians, 16 anaesthesia residents, and 12 anaesthesiologists. Ten anaesthesia technicians had experience between 0-2 years; 9 had 2-5 years of experience; 7 had 5-10 years of experience, and 8 had experience beyond 10 years. Four anaesthesia residents had between 0 and 1 year of experience, 5 had 1-3 years of experience, and 7 had 3 to 5 years of professional experience. Eight anaesthesia specialists had 5 and 10 years of experience, and 4 had above 10 years. No information was provided to the participants about the values of the pressure until the completion of all measurements. After placement of the LMA and ETT, the success of the procedure was checked by monitoring square-wave capnograph tracing and thoracoabdominal motion. Each

participant performed the procedures on three patients, and the average of cuff pressures measured in three patients was calculated. Pressure was considered to be normal for LMA at 60-70 cmH_2O and for ETT at 20-30 cmH_2O .

Statistical Analysis

Statistical Package for the Social Sciences (SPSS, İstanbul, Turkey) 19.0 software was used for statistical analysis. Frequency and minimum and maximum values were used as descriptive data. The distribution of variables was tested with the Kolmogorov-Smirnov test. ANOVA test was used for parametric analysis of the data; Pearson correlation analysis was used for correlation analysis. The mean and standard deviation values were used for descriptive statistics of the data. A p value below 0.05 was considered to be significant.

Results

Endotracheal tube was used in 220 of 348 patients (132 females, 88 males), and LM was applied in 128 patients (62 females, 66 males). The demographic data were similar between groups (Table 1). The pressure values did not differ significantly between the technicians, assistants, and specialists after the application of the LMA (Table 2). There was no significant difference in terms of cuff pressure between technicians, assistants, and specialists using an ETT (Table 3). All results were above the normal value. There was no significant correlation between the cuff pressures of laryngeal masks and endotracheal tubes and the duration of experience of specialists, technicians, and assistants (Table 4, 5). There was no significant correlation between the duration of experience of technicians, residents, and experts in using laryngeal mask airway pressure ($r=-0.192/p=0.278$, $r=0.225/p=0.402$, $r=-0.476/p=0.118$, respectively) and an endotracheal tube ($r=-0.306/p=0.079$, $r=-0.060/p=0.826$, $r=-0.478/0.116$, respectively) (Figure 1, 2).

Discussion

Inflating cuffs by either high or low volume leads to some serious complications with life-threatening potential. High cuff pressures in patients ventilated with LMA give rise to damage to the lingual, hypoglossal, and recurrent laryngeal nerves (5-7). Hyperinflation of an LMA cuff poses increased airway morbidity due to the pressure in the laryngeal as well as pharyngeal structures (8). Similarly, while an ETT cuff pressure higher than 48 cmH_2O impedes capillary blood flow, a pressure lower than 18 mmHg increases the risk for aspiration of gastric contents (9). An airway obstruction due to ETT cuff overinflation was reported in a case with tracheal stoma herniation (10).

High cuff pressure was more frequently reported than insufficient pressure (11). The incidence of pharyngolaryngeal complications decreased in patients in whom less than 44 mmHg cuff pressure was sustained with a cuff manometer (12). In our study, LMA cuff pressure varied between 60 to 120 mm

Table 1. Subject demographics (mean±SD)

Endotracheal Tube	Technician	Assistant	Specialist
Female/Male, (n)	74/52	34/21	24/15
Age (years)	46.86±17.02	42.50±17.08	49.74±15.78
Weight (kg)	72.21±9.55	71.41±10.89	69.23±10.15
Laryngeal Mask	Technician	Assistant	Specialist
Female/Male, (n)	36/38	8/15	18/13
Age (year)	45.41±17.36	40.56±16.03	45.87±16.04
Weight (kg)	70.90±9.53	74.13±10.28	74.20±8.36

SD: standard deviation

Table 2. Laryngeal mask cuff pressures (mmHg) (mean±SD)

Pressure	Min	Max	Mean
Technician	60.0	120.0	89.96±17.39
Assistant	65.0	106.6	90.37±13.08
Specialist	66.6	120.0	94.12±16.13

ANOVA, p=0.739; SD: standard deviation; min: minimum; max: maximum

Table 3. Endotracheal tube cuff pressures (mmHg) (mean±SD)

Pressure	Min	Max	Mean
Technician	24.0	61.3	41.40±11.97
Assistant	23.6	68.0	39.23±11.20
Specialist	21.6	74.3	39.64±18.18

ANOVA, p=0.807; SD: standard deviation; min: minimum; max: maximum

Table 4. The correlation between laryngeal mask airway cuff inflation and professional experience

	Technician	Assistant	Specialist
r	-0.192	0.225	-0.476
p	0.278	0.402	0.118

Pearson correlation

Table 5. The correlation between endotracheal tube cuff inflation and professional experience

	Technician	Assistant	Specialist
r	-0.306	-0.060	-0.478
p	0.079	0.826	0.116

Pearson correlation

Hg, while the ETT values range from 6.21 to 74.3 mmHg. While anaesthesia specialists attained the average maximum LMA cuff pressure (94.12±16.13 mmHg), anaesthesia technicians gained the highest ETT cuff pressure (41.40±11.97 mmHg). All participants inflated both the LMA and ETT cuffs beyond the normal range, but no significant difference

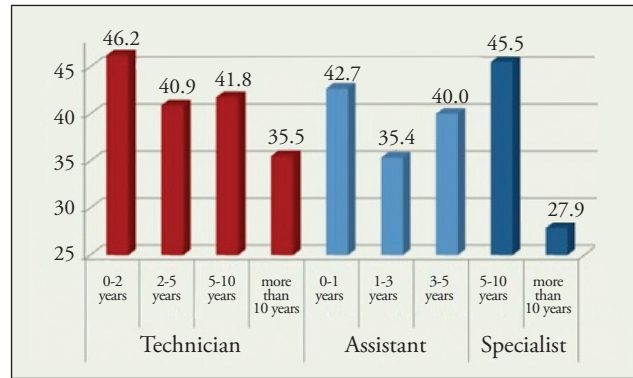


Figure 1. The relationship between professional experience and endotracheal tube cuff pressures

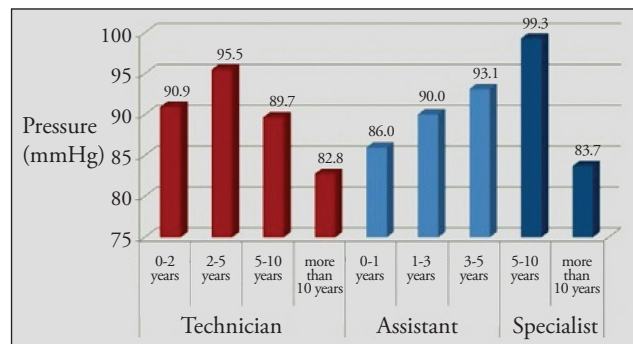


Figure 2. The relationship between professional experience and laryngeal mask airway cuff pressures

was noted between the groups. Use of a cuff manometer is of vital importance both for patients in operating theaters and for those in the intensive care unit. The rate of cuff hyperinflation in intensive care patients has been reported to be 55% to 62% in international studies (13). The use of a cuff manometer either in intensive care units or the operating room has been replaced by experience of the anaesthesia staff due to heavy work load. Although this trend is common, professional experience and cuff pressure were found to be inversely related to each other. Wujitevicz et al. (14) demonstrated that overinflation of an ETT cuff was higher for experienced anaesthetists. Of the anaesthesiologists with over 10 years of professional experience, only 2 participants (4.8%) achieved normal cuff pressure, 39 (92.8%) inflated with higher pressure, and 1 (2.4%) inflated to under normal pressure. The rate of overinflation was significantly higher than those in the 2002 results (46.5%) (15). The study by Stewart et al. (16) included 40 participants composed of students, anaesthesia technicians, and anaesthesiologists. In this study, no significant difference was found between level of profession of anaesthesiologists and cuff inflation pressure. Therefore, instead of creating an estimated pressure value, direct cuff pressure measurement is recommended. Tracheotomy cuff pressures were evaluated in a study by otolaryngologists. In this study comparing the results of the fingertip and those of the cuff manometer test, no correlation was found between cuff pressure readings and the professional experience of otolaryngol-

ogists, and once again, the need for cuff pressure gauge was highlighted. It was suggested that the technique of pilot balloon palpation was unreliable after intubation (17). Colak et al. (18) divided residents into 4 groups based on professional experience and reported that the rate of appropriate inflation was higher in residents having 2 years of experience, that a high pressure ratio was noted with those having 1 year of experience, and that the rate of low pressure-inflated balloons was higher with those having a 4 years of experience. In another study, inflation of the ETT cuff at higher pressure was noted for 2-year-experienced anaesthetists compared to those having less than 2 years of experience. However, tendency to overinflate was observed in all groups. In our study, LMA and ETT cuff inflation rates of anaesthesia specialists, technicians, and research assistants were compared, and the participants were grouped according to professional experience, but no statistical difference was observed between them. On the other hand, participants were left free to apply their own appropriate estimation method. However, no correlation was found between professional experience and creation of the correct cuff pressure, and attention was drawn to the absolute necessity of a cuff gauge. As the complications induced by inappropriate cuff pressure are noted to be considerably higher, new devices are still being developed. Dullenkopf et al. (19) reported a new cuff pressure release valve system, and they achieved a cuff pressure kept between 10 to 25 cmH₂O automatically without the need for additional adjustments. Tubes with a pressure-reducing valve lower increased pressure due to nitrogen during operation; however, because these tubes are expensive, their usage is limited (20). Use of the paediatric cuffed tube seems to be beneficial in patients. Patients are often intubated in operating rooms and intensive care units as well as in emergency rooms and other departments. However, the cuff manometer is utilized at very low rates in these units. The reason appears to be the need for a specific device. In a study conducted in the emergency unit, ETT cuff pressure was found to be 27 cmH₂O in 79% of patients in the initial examination after intubation (21). The optimal LMA cuff pressure proposed by its user manual is 60 cmH₂O. However, in a study carried out on patients ventilated by no. 1.5 to 3 LMA, less leakage was identified in cuffs inflated at a pressure of 40 cmH₂O compared to those inflated at a pressure of 60 or 20 cmH₂O (22).

These results revealed that pressure values may vary from patient to patient and that monitoring is needed. In our study, we considered 60 to 70 cmH₂O for LMA and 20-30 cmH₂O for ETT cuffs to be normal. As soon as an airway was established, cuff pressures were measured and recorded in this study. So, factors that affect cuff pressure, such as diffusion of nitrous oxide into the cuff, positioning, and hemodynamic changes, could be prevented fairly well.

Conclusion

It has been concluded that professional experience does not contribute to obtaining normal cuff pressure without mea-

suring. Therefore, the use of a cuff manometer may be helpful in patients receiving general anaesthesia in order to reduce the incidence of tracheal and laryngeal trauma induced by tracheal mucosal blood flow continuity. Introduction of cuff manometer monitoring into routine anaesthesia practice will be useful, irrespective of anaesthesiologists' experience.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Marmara University Medical School.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

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