EGYPTIAN JOURNAL OF ANAESTHESIA
2022, VOL. 38, NO. 1, 174–178
https://doi.org/10.1080/11101849.2022.2056405

Endotracheal tube cuff inflation pressure varieties and response to education among anesthetists

Abdelrhman Alshawadfy, Wesam F. Alyeddin and Mohamed A. Elsadany

Department of Anesthesia and Intensive Care, Faculty of Medicine, Suez Canal University, Ismailia, Egypt

ABSTRACT

Background: This study aimed to evaluate endotracheal tube (ETT) cuff inflation pressure (CIP) applied by anesthetists as well as the effect of an interview and feedback on their CIP accuracy.

Methods: This single-blind, controlled trial involved two series of CIP measurements in intubated patients before and after an interview and feedback of the participating anesthetists who were asked to inflate the cuffs for all intubated patients as per their clinical judgment. The cuff pressures were measured using a manometer and accordingly adjusted to 25 cm H_2O by the researchers. For each anesthetist, 3 measurements were recorded, and the mean pressure values were calculated for each setting. The anesthetists were initially blinded, then they were informed about the pressure values and the adjustments. The primary outcome was the anesthetists' accuracy regarding ETT inflation following the feedback. The secondary outcomes were pressure values in senior and junior anesthetists as well as in scheduled and emergency operations.

Results: The study enrolled 28 anesthetists; six registrars or senior registrars and 22 residents. Interview and feedback significantly lowered the mean pressure applied by the anesthetists. The cuff inflation pressure decreased from 33.8 ± 1.95 to 30.8 ± 3.24 and from 32.9 ± 2.38 to 29.9 ± 3.44 for emergency and scheduled surgeries, respectively. Furthermore, the frequency of safe CIP increased significantly for both emergency and scheduled surgeries. However, the senior staff showed no significant increase in safety CIP.

Conclusion: Anesthetists improved their accuracy of CIP after educational feedback. ETT cuff pressures should be routinely measured in intubated patients under general anesthesia.

ARTICLE HISTORY
Received 25 January 2022
Revised 01 March 2022
Accepted 17 March 2022

KEYWORDS
Anesthetist; cuff pressure; endotracheal tube; inflation

1. Introduction

Maintenance of adequate pressure in the endotracheal tube (ETT) cuff is an important part of the management of the artificial airway. The cuff is inflated to seal the airway and to deliver mechanical ventilation [1]. A cuff pressure between 20 and 30 cm H_2O is recommended to provide an adequate seal, ensure delivery of the prescribed mechanical ventilation tidal volume, reduce the risk for aspiration of secretions that accumulate above the cuff, and avoid compromising tracheal perfusion [2,3]. However, ETT cuff pressure varies and may be out of range. A minimal pressure of 20 cm H_2O is recommended to prevent aspiration and ventilator-associated pneumonia [4,5]. Overinflation is associated with damage of tracheal mucosa by compromising capillary perfusion, which leads to significant adverse effects [6]. For long times, without any evidence-based data, it has been believed that well-trained anesthetists can determine proper ETT cuff pressures. Anesthetists can detect appropriate inflation pressure and avoid overinflating the ETT cuff by palpating the ETT pilot balloon. It is the most common technique of ETT cuff pressure assessment in clinical settings. However, several studies suggest that this approach is unreliable [7–10]. It is supposed that experienced anesthesia staff may improve the safety of the palpation technique; however, earlier studies noticed a negative role of experience and recommended using a manometer [11]. Measurement of ETT cuff pressure by a monometer could reduce the rate of complications, but this is not widely available, especially in resource-limited settings and in emergency situations [12]. Hence, educational programs to increase awareness of anesthetists about overinflation risks may improve recent clinical practice.

The aim of this study was to assess the ETT cuff inflation pressure applied by anesthetists and to evaluate the effect of an interview and feedback on their accuracy during cuff inflation.

2. Methods

2.1. Ethical considerations

The study was carried out following approval by the Ethics Committee of Suez Canal University Hospital. The work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments

CONTACT Abdelrhman Alshawadfy abdelrhmanalshawadfy@gmail.com;alshawadfy.abdelrhman@gmail.com Department of Anesthesia and Intensive Care, Faculty of Medicine, Suez Canal University, Ismailia, Egypt

involving humans. Written informed consents were obtained from the study participants after an explanation of the purpose and technique of the study. All data were kept confidential.

2.2. Study design, setting, and date

This single-blind, controlled trial was conducted at the Suez Canal University Hospital, Egypt from May 2017 through August 2017.

2.3. Eligibility criteria

The study recruited 37 anesthetists providing anesthesia for both emergency and scheduled surgeries at the Suez Canal University Hospital. Of those, 21 were residents (R1, R2, and R3) and 16 were registrars and senior registrars.

2.4. Procedure

The current study recorded two settings of ETT cuff pressure measurements in the intubated patients. The enrolled anesthetists were asked to inflate the ETT cuffs for all intubated anesthetized patients as per their clinical judgment. The cuff pressures were measured using a special aneroid manometer (VBM Medizintechnik, GmbH) and accordingly adjusted to 25 cm H_2O by the researchers. For each anesthetist, 3 measurements were recorded, and the mean pressure values were calculated for both settings. The safety of the applied pressure was judged proper for pressure readings less than 30 cm H_2O. For the initial 2 months, all anesthetists were blinded to the pressure values and the adjustments; then, they were informed about their mean ETT cuff inflating pressure during the surgeries and the performed adjustments. For the following two months, cuff pressure was measured, recorded, and accordingly adjusted by the researchers. All anesthetists were informed about their pressure values and the required adjustments.

2.5. Data collection

The researchers randomly selected days of work to gather data from operating theatre for both routine and emergency surgeries. On the 2nd, 4th, 7th, 9th, 11th, 15th, 16th, 21st, 22nd, and 23rd of May 2017 the researchers visited the operating theatre and collected data from the participating physicians. On these days, 29 anesthetists (22 residents and 7 registrars or senior registrars) completed their 3 rounds by giving general anesthesia for 3 different patients. No one inflates the ETT cuff below 25 cm H_2O. The researchers estimated the mean of three readings for every participating anesthetist. After 2 months the researchers made an interview with the study participants and told each anesthetist about his or her results. The researchers asked them again to judge the ETT inflation pressure to be 25 cm H_2O or around and be ready for the second round of the study. On the 6th, 9th, 10th, 11th, 12th, 13th, 16th, 17th, and 20th of July 2017 the researchers again collected data from the participating physicians during anesthetizing their patients. On these days, 28 anesthetists completed their 3 rounds by giving general anesthesia for 3 different patients (22 residents and 6 registrars or senior registrars), and one senior anesthetist had no results.

2.6. Outcomes

The primary outcome was to assess the anesthetists' accuracy in inflating the cuffs of ETTs used to maintain the airway of generally anesthetized patients following the researchers' feedback. The secondary outcomes were to compare pressure values between senior and junior anesthetists and between scheduled and emergency operations.

2.7. Statistical analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (IBM SPSS Statistics) for Windows, version 26 (IBM Corp., Armonk, N.Y., USA). For quantitative data, the Shapiro-Wilk test for normality was performed. Normally distributed data were summarized as mean ± standard deviation (SD), and groups were compared using paired t-test. Qualitative data were summarized as frequencies, and associations were tested using Pearson's Chi-square test. A p-value <0.05 was chosen to interpret the significance of statistical tests.

3. Results

The study enrolled 6 senior and 22 junior anesthetists with a mean age of 25.32 ± 2.91 years (Table 1). The ETT cuff pressure values after the intervention were significantly lower than before the intervention. Concerning emergency surgeries, the mean cuff pressure decreased from 33.8 ± 1.95 to 30.8 ± 3.24 cm H_2O (P = 0.000), while at scheduled surgeries the pressure decreased from 32.9 ± 2.38 to 29.9 ± 3.44 cm H_2O (P = 0.001) (Table 2). Before the intervention, only one anesthetist inflated the ETT cuff to the recommended safe limit (below 30 cm H_2O), while most (96.4%) anesthetists inflated the cuffs above this limit.

Table 1. Demographic data.

		Mean ±SD	25.32 ± 2.91
Age (years)		Range	23–33
Grade	Senior	N (%)	6 (21.4)
	Junior	N (%)	22 (78.6)

SD: standard deviation; N: number.

Table 2. Cuff inflation pressure before and after the intervention.

Cuff inflation pressure (cm H_2O)		Before intervention	After intervention	P-value
Emergency surgeries	Mean ± SD	33.8 ± 1.95	30.8 ± 3.24	0.000*
	Range	30–38.5	25–38.5	
	N	27	26	
Scheduled surgeries	Mean ± SD	32.9 ± 2.38	29.9 ± 3.44	0.001*
	Range	29–40	24–40	
	N	26	26	
Total	Mean ± SD	33.5 ± 2.08	30.2 ± 3.20	0.000*
	Range	29.5–39.25	24.5–39.25	
	N	28	28	

SD: standard deviation; N: number; *: significant.

Table 3. Safety of cuff inflation pressure before and after intervention in all operations.

Cuff inflation pressure in all settings		Before intervention (N = 28)	After intervention (N = 28)	P-value
Safe (<30 cm H_2O)	N (%)	1 (3.6)	12 (42.9)	0.000*
Unsafe (>30 cm H_2O)	N (%)	27 (96.4)	16 (57.1)	

N: number; *: significant.

Table 4. Safety of cuff inflation pressure before and after intervention in emergency operations.

Cuff inflation pressure in emergency		Before intervention (N = 27)	After intervention (N = 26)	P-value
Safe (<30 cm H_2O)	N (%)	0	10 (38.5)	0.000*
Unsafe (>30 cm H_2O)	N (%)	27 (100)	16 (61.5)	

N: number; *: significant.

Table 5. Safety of cuff inflation pressure before and after intervention in scheduled operations.

Cuff inflation pressure in scheduled		Before intervention (N = 26)	After intervention (N = 26)	P-value
Safe (<30 cm H_2O)	N (%)	2 (7.7)	11 (42.3)	0.004*
Unsafe (>30 cm H_2O)	N (%)	24 (92.3)	15 (57.7)	

N: number; *: significant.

After the intervention, a significant (P = 0.000) elevation in awareness about safe pressure limits was noticed (Table 3). The frequency of safe inflation pressure significantly increased in emergency surgeries from 0% to 38.5% (P = 0.000) (Table 4) and from 7.7% to 42.3% in scheduled operations (P = 0.004) (Table 5). Both senior and junior staff showed reduced cuff inflation pressure after the intervention. The cuff inflation pressure was significantly reduced from 32.7 ± 2.16 cm H_2O to 28.7 ± 2.47 cm H_2O for seniors (P = 0.005), and from 33.6 ± 2.06 to 30.6 ± 3.30 cm H_2O for junior staff (P = 0.000) (Table 6). After the intervention, seniors showed no significant difference (P = 0.079) in safety pressure limits of cuff inflation, meanwhile, 36.4% of junior staff significantly (P = 0.002) improved their performance and applied ETT cuff pressure below the safety limit after the intervention (Table 7).

Table 6. Cuff inflation pressure before and after intervention in senior and junior anesthetists.

Cuff inflation pressure (cm H_2O)		Before intervention	After intervention	P-value
Seniors (N = 6)	Mean ± SD	32.7 ± 2.16	28.7 ± 2.47	0.005*
Juniors (N = 22)	Mean ± SD	33.6 ± 2.06	30.6 ± 3.30	0.000*

SD: standard deviation; N: number; *: significant.

Table 7. Safety of cuff inflation pressure before and after the intervention.

		Before intervention	After intervention	P-value
Safe seniors (N = 6)	N (%)	1 (16.67)	4 (66.67)	0.079
Safe juniors (N = 22)	N (%)	0	8 (36.36)	0.002*

N: number; *: significant.

4. Discussion

This study investigated the effect of an interview and feedback on Suez Canal University anesthetists regarding ETT inflation pressure during both emergency and scheduled surgeries. The ETT cuff pressure after the intervention was significantly lower than its value before the intervention, which was associated with increased safety of ETT cuff inflation. This finding is in agreement with Seyed Siamdoust et al. [13] who found that safety of inflation pressure was significantly elevated among anesthetists after an educational intervention. Additionally, Sole et al. [14] reported that an educational intervention was substantially effective in maintaining cuff pressure within the optimum range.

Endotracheal tube cuff pressure measurement is affected by various factors including the cuff diameter, thickness, compliance, shape, filling material (air or water in certain surgeries), and head and neck position [15,16]. Several factors may influence the tone of the pilot balloon and consequently the reliability of the palpation technique, such as the tube type, geometry of the cuff, and the filling material [8,10]. Using a manometer could underestimate the measured ETT cuff pressure. When the external balloon is attached to the pressure gauge, air leakage occurs due to internal gauge space and pressure equalization [17].

Comparable results were reported by earlier studies [12,18], where most of the participating anesthetists underestimated the cuff inflation pressure. Seegobin and van Hasselt [6] showed evidence of obstruction to the tracheal mucosal blood flow at a lateral wall pressure above 30 cm H_2O (22 mm Hg) with total occlusion of the flow over the tracheal rings and posterior tracheal wall at a pressure of 50 cm H_2O (37 mm Hg). Capillary perfusion pressure has been recorded as ranging between 22 and 32 mm Hg, and the upper limit is uncertain. Hence, careful attention to the inflation technique and the intracuff pressure is important.

The current study showed that in emergency surgeries no anesthetist inflated the cuff within the safe pressure limit. After the intervention, in both scheduled and emergency surgeries, the safety of the inflation pressure was significantly increased. Similarly, Hoffman et al. [19] reported that emergency physicians were unable to inflate the ETT cuffs to safe pressures or estimate the cuff pressures by palpation. This could be attributed to the rare usage of manometers for cuff pressure measurements and the lack of sufficient time during emergencies. In contrast, a study conducted at the intensive care units reported that anesthesia providers used manometers frequently as they were oriented about the hazards of ETT cuff pressure in critical care patients [9].

Before the intervention, the ETT cuffs were overinflated (above 30 cm H_2O) by all senior and junior anesthetists. After the intervention, anesthesia staff improved their skills and accuracy in adjusting the cuff inflation within a safe range (20–30 cm H_2O). Nevertheless, the practice of senior staff did not show significant improvement. This was in accordance with Sayed Siamdoust et al. [13] and Wujtewicz et al. [20] who reported that the length of experience did not improve the anesthetists' skills for inflating the ETT cuff to a safe pressure. This could be explained considering the high self-confidence of the senior anesthetists that might be a barrier toward learning despite the value of the experience for safe anesthetists' clinical practice. The absence of manometer usage to measure the cuff inflation pressures could be another reason [21,22].

The differences between studies regarding the impact of the length of experience should be evaluated seeing that most anesthesia courses and curricula lack sufficient skills training. Therefore, it is crucial to implement educational programs for junior and senior anesthetists regarding the use of manometers in cuff pressure evaluation and limiting the palpation technique that is usually practiced by seniors. The use of a measurement device should be the standard practice for cuff inflation. Manometers are considered a safe measurement method during scheduled operations and can also be used in emergency conditions once the patients are stabilized [23,24].

The current study enrolled a small number of anesthetists. Further research is needed including a larger number of anesthetists from various health institutions with the identification of variables that may influence the cuff pressure, such as the ETT type and duration of intubation. Recognizing these variables may assist in maintaining the cuff pressure within an optimal range.

4.1. Conclusions

Interview and feedback to anesthetists were effective in lowering the ETT cuff inflation pressure to safer levels. The length of experience did not improve the anesthetists' accuracy for safe cuff inflation. The ETT cuff pressure should be routinely measured in patients scheduled for any surgical maneuver under general anesthesia with endotracheal intubation.

Disclosure statement

No potential conflict of interest was reported by the author(s).

References

[1] Tablan OC, Anderson LJ, Besser R, et al. Guidelines for preventing health-care–associated pneumonia, 2003: recommendations of CDC and the Healthcare Infection Control Practices Advisory Committee. MMWR Recomm Rep. 2004;53:1–36.
[2] Society AT AI. Guidelines for the management of adults with hospital-acquired, ventilator-associated, and healthcare-associated pneumonia. Am J Respir Crit Care Med. 2005;171:388–416.
[3] Lorente L, Blot S, Rello J. Evidence on measures for the prevention of ventilator-associated pneumonia. Eur Respir J. 2007;30:1193–1207.
[4] Safdar N, Dezfulian C, Collard HR, et al. Clinical and economic consequences of ventilator-associated pneumonia: a systematic review. Crit Care Med. 2005;33:2184–2193.
[5] Rouzé A, Nseir S. Continuous control of tracheal cuff pressure for the prevention of ventilator-associated pneumonia in critically ill patients: where is the evidence? Curr Opin Crit Care. 2013;19:440–447.
[6] Seegobin RD, van Hasselt GL. Endotracheal cuff pressure and tracheal mucosal blood flow: endoscopic study of effects of four large volume cuffs. Br Med J (Clinical research ed.). 1984;288:965–968.
[7] Trivedi L, Jha P, Bajiya NR, et al. We should care more about intracuff pressure: the actual situation in government sector teaching hospital. Indian J Anaesth. 2010;54:314–317.
[8] Fernandez R, Blanch L, Mancebo J, et al. Endotracheal tube cuff pressure assessment: pitfalls of finger estimation and need for objective measurement. Crit Care Med. 1990;18:1423–1426.
[9] Braz JR, Navarro LH, Takata IH, et al. Endotracheal tube cuff pressure: need for precise measurement. Sao Paulo Med J. 1999;117:243–247.
[10] Hedberg P, Eklund C, Högqvist S. Identification of a very high cuff pressure by manual palpation of the external cuff balloon on an endotracheal tube. Aana J. 2015;83:179–182.
[11] Saraçoğlu A, Dal D, Pehlivan G, et al. The professional experience of anaesthesiologists in proper inflation of laryngeal mask and endotracheal tube cuff. Turk J Anaesthesiol Reanim. 2014;42:234–238.

[12] Galinski M, Tréoux V, Garrigue B, et al. Intracuff pressures of endotracheal tubes in the management of airway emergencies: the need for pressure monitoring. Ann Emerg Med. 2006;47:545–547.
[13] Seyed Siamdoust SA, Mohseni M, Memarian A. Endotracheal tube cuff pressure assessment: education may improve but not guarantee the safety of palpation technique. Anesthesiol Pain Med. 2015;5:e16163–e.
[14] Sole ML, Su X, Talbert S, *et al*. Evaluation of an intervention to maintain endotracheal tube cuff pressure within therapeutic range. Am J Crit Care. 2011;20:109–117. quiz 18.
[15] Godoy AC, Vieira RJ, Capitani EM. Endotracheal tube cuff pressure alteration after changes in position in patients under mechanical ventilation. J Bras Pneumol. 2008;34:294–297.
[16] Madjdpour C, Mauch J, Dave MH, et al. Comparison of air-sealing characteristics of tapered- vs. cylindrical-shaped high-volume, low-pressure tube cuffs. Acta Anaesthesiol Scand. 2012;56:230–235.
[17] Sole ML, Aragon D, Bennett M, et al. Continuous measurement of endotracheal tube cuff pressure: how difficult can it be? AACN Adv Crit Care. 2008;19:235–243.
[18] Parwani V, Hoffman RJ, Russell A, et al. Practicing paramedics cannot generate or estimate safe endotracheal tube cuff pressure using standard techniques. Prehosp Emerg Care. 2007;11:307–311.
[19] Hoffman RJ, Parwani V, Hahn IH. Experienced emergency medicine physicians cannot safely inflate or estimate endotracheal tube cuff pressure using standard techniques. Am J Emerg Med. 2006;24:139–143.
[20] Wujtewicz MA, Sawicka W, Owczuk R, et al. Tracheal tube cuff pressure depends on the anaesthesiologist's experience. A follow-up study. Anestezjol Intens Ter. 2009;41:205–208.
[21] Ozer AB, Demirel I, Gunduz G, et al. Effects of user experience and method in the inflation of endotracheal tube pilot balloon on cuff pressure. Niger J Clin Pract. 2013;16:253–257.
[22] Duarte N, Caetano AMM, Arouca GO, et al. [Subjective method for tracheal tube cuff inflation: performance of anesthesiology residents and staff anesthesiologists. Prospective observational study]. Braz J Anesthesiol. 2020;70:9–14.
[23] Sridermma S, Limtangturakool S, Wongsurakiat P, et al. Development of appropriate procedures for inflation of endotracheal tube cuff in intubated patients. J Med Assoc Thai. 2007;90(Suppl 2):74–78.
[24] Grant T. Do current methods for endotracheal tube cuff inflation create pressures above the recommended range? A review of the evidence. J Perioper Pract. 2013;23:198–201.