ORGINAL ARTICLE

Effects of user experience and method in the inflation of endotracheal tube pilot balloon on cuff pressure

AB Ozer, I Demirel, G Gunduz, OL Erhan

Anesthesiology and Reanimation Department, Firat University, Faculty of Medicine, Elazig, Turkey

Abstract

Context: Endotracheal tube cuff pressure (ETCP) is recommended to be maintained between 20-30 cmH_2O limits. While insufficient inflation of ETC may cause aspirations, over-inflation of it may lead to damage in tracheal epithelium.
Aims: We planned to investigate the effects of user experience and cuff pressure inflation method differences following endotracheal tube cuff pressure and complaints about it.
Patients and Methods: Two hundred and fifty patients planned for general anaesthesia were included in this study. ETC was inflated by users with different experience according to leakage or pilot balloon palpation techniques. ETCPs were measured by manometer at three periods (5 and 60 minutes after endotracheal intubation, and before extubation). Complaints about it were recorded in post anaesthetic care unit and 24 hours postoperatively.
Results: Though we found experience of user had significant effect on the ETCP regulations, we observed inflation methods did not have any effect. However we found ETCP was higher than normal range with experienced users. A correlation was observed between cuff pressure and anaesthesia duration with postoperative complaints.
Conclusions: Our study concluded that the methods used do not have any significant advantage over one another. While ETC inflated at normal pressure increases as user's experience increases, experience alone is not enough in adjusting ETCP. A manometer should be used in routine inflation of ETC instead of conventional methods. CP and anaesthesia duration have correlations with some postoperative complaints.

Key words: Endotracheal tube cuff pressure, experience of user, inflation methods

Date of Acceptance: 31-Jul-2012

Introduction

Endotracheal intubation is frequently performed for general anaesthesia and in the intensive care unit. After endotracheal intubation, ETC is inflated via a pilot balloon thereby preventing tracheal aspiration of oropharyngeal secretions as well as leakage of the ventilated volume.[1] Endotracheal tube cuff pressure is recommended to be maintained between 25-30 cmH_2O limits.[1-3] Insufficient inflation of ETC may cause tracheal micro-aspirations and especially ventilator-induced pneumonia in patients that undergo long-term mechanical ventilation.[2,3] On the other hand, pressure reaching 40-45 cmH_2O may lead to damages ranging from a decrease in capillary blood flow in tracheal epithelium to ischemia.[4-7]

In order to prevent insufficient or over-inflation of ETC, one of the following methods have been used in practice: palpation of pilot balloon, elimination of the leakage sound, direct measurement of ETC pressure via a manometer or continuous pressure measurement are used in practice.[4,8-10]

Therefore, we decided to investigate the effects of user experience and different cuff pressure inflation methods

Address for correspondence:
Dr. Ayse Belin Ozer,
Anesthesiology and Reanimation Department, Firat University,
Faculty of Medicine, Elazig, Turkey
E-mail: abelinozer@gmail.com

Access this article online	
Quick Response Code:	**Website**: www.njcponline.com
	DOI: ***
	PMID: *******

on the endotracheal tube cuff pressure and postoperative complaints associated with it.

Patients and Methods

After obtaining approval form the local ethics committee, we included in the study 250 patients aged between 16-60 years with American Society of Anaesthesiologists physical status classification I-III that were planned for elective surgery in supine position. We excluded patients scheduled for head-neck surgery. In addition, cases with an operation period less than 60 minutes, urgent or difficult intubation, with endotracheal tube inner diameter less than 7 mm or more than 8.5 mm, patients having Mallampati score of III-IV, with high aspiration risk (full stomach, pregnancy), diabetes mellitus, congenital, laryngotracheal and rheumatic diseases were excluded in the study.

Written informed consent was obtained from all patients during preoperative evaluation. Patients were pre-medicated with intramuscular administration of 0.07 mg/kg midazolam and 0.01 mg/kg-45 minutes before the operation, and thereafter were monitored by electrocardiography, non-invasive blood pressure and pulse oximeter. Following anaesthetic induction with 5 mg/kg sodium thiopental and 0.1 mg/kg vecuronium, the trachea was intubated with the appropriate size (ID = 7.0-8.5 mm) of low-pressure high-volume cuffed endotracheal tubes made of polyvinylchloride. Maintenance of anaesthetic was carried out with desflurane in 60% O_2-air mixture and 2-4 μg/kg fentanyl. Respiration was adjusted as $ETCO_2$ 30-40 mmHg and maintained mechanically. During emergence from anaesthesia, intravenous neostigmine 0.04 mg/kg, and when necessary, 0.01 mg/kg atropine were used to eliminate the residual effect of muscle relaxant.

After intubation, endotracheal tube cuff was inflated by two different methods, namely till when the leakage sound was discontinuated or pilot balloon palpation by users. These users had different experience levels i.e., anaesthesia technicians, anaesthesiologist research assistant doctors and specialist anaesthesiologists. Anaesthesia technicians were divided into two groups based on their work experience, which is less than and more than 2 years. Anaesthesiologist assistants were also divided into two, which is having work experience less and more than 3 years. Patients were randomly divided into 5 groups by envelope method based on the experience of users.

Group T1 (n = 50): Anaesthesia technician with less experience (5 users).

Group T2 (n = 50): Anaesthesia technician with more experience (5 users).

Group A1 (n = 50): Research assistant doctor with less experience (5 users).

Group A2 (n = 50): Research assistant doctor with more experience (5 users).

Group S (n = 50): Specialist doctor (5 users).

Each user from these groups conducted the application on 10 patients, and endotracheal tube cuffs were inflated according to leakage sound in half of the patients (n = 5) and pilot balloon palpation in the other half (n = 5).

Cuff pressures were measured and recorded with aneroid manometer at the end of expiration at the 5th and 60th minutes of endotracheal intubation, and immediately before emergence from anaesthesia. This was performed by an anaesthesiologist other than the users and who did not know to which group the patients belonged to. In cases in which the cuff pressure was above 30 cmH_2O or below 20 cmH_2O, the pressure was regulated back to normal limits. The duration of anaesthesia was also recorded. In addition, laryngoscopy and intubation conditions, difficult intubation, and number of attempts of laryngoscopy and intubation were also noted. Laryngoscopy and intubation conditions were assessed according to opening of the chin (impossible, difficult, medium, and ease), condition of vocal cords (fully closed, half closed, moving and fully open, not moving) and to reaction to intubation (severe movement, mild movement, mild diaphragmatic movement, no movement).[11] Presence of sore throat, hoarseness of voice, coughing, and dysphagia were recorded at the PACU and at 24 hours postoperatively "present or absent".

Statistical Package for Social Sciences (SPSS) 12.0 software was used for statistical evaluation. The obtained data were taken as mean ± standard deviation. In inter-group comparison, One-Way ANOVA, Tukey HSD, Kruskal Wallis, and Mann Whitney U test were utilized. Paired-Samples T test were used for inner group comparisons and Pearson correlation analysis was used in correlation. $P < 0.05$ was established as significant.

Results

A significant difference was not observed between the groups in terms of demographic data [Table 1]. When endotracheal tube cuff pressure was compared between the periods, the value measured at the 5th minute in all groups were found as significantly higher compared to the values measured at the 60th minute and before the end of the anaesthesia ($P < 0.001$) [Table 2]. When compared between groups, ETCP measured at the 5th minute was observed as significantly higher in Group T1 compared to other four groups ($P \leq 0.001$). When ETCP measured in Group T2

at the fifth minute was compared with other groups, it was observed as significantly higher than Group A2 and Group S ($P < 0.001$). In Group A1, ETCP measured at the 5th minute was established as significantly higher than Group S ($P < 0.001$). A significant difference was not observed in the comparison of ETCP measured at other periods between the groups. Cuff pressure distribution is given in Table 3. About 70% of mean ETCP at the 5th minute was above 30 cmH_2O and the pressure was between the 20-30 cmH_2O intervals in only 24% of the cases.

When laryngoscopy and intubation conditions were compared between groups, the response given to intubation in Group A1 was observed to be significantly higher than other groups ($P < 0.001$) [Table 4]. A significant difference was not observed between the groups in terms of difficult intubation, difficult laryngoscopy, and the number of intubation attempts.

The investigation for the presence of sore throat, hoarseness in voice, coughing, and dysphagia, showed Group A1 as having a significant increase compared to Group T1 in which was recorded only dysphagia in the PACU ($P < 0.05$). At the 24 hours postoperatively, a significant difference was not observed between the groups, in relation to presence of sore throat, hoarseness in voice, coughing and dysphagia [Figure 1].

As distinct from other groups, since both significant intubation reaction and dysphagia in PACU were established in Group A1, a correlation analysis was conducted between them. However, a significant correlation was not found. Correlation analysis was conducted between cuff pressure with PACU and postoperative 24th hour complaints. A significant correlation was observed between the cuff pressure at the 5th minute and sore throat in the PACU ($P = 0.001$), hoarseness in voice ($P < 0.05$), coughing ($P < 0.05$) and coughing at the postoperative 24th hour ($P < 0.05$). A significant correlation was also found between the cuff pressure measured at the 60th minute and coughing in

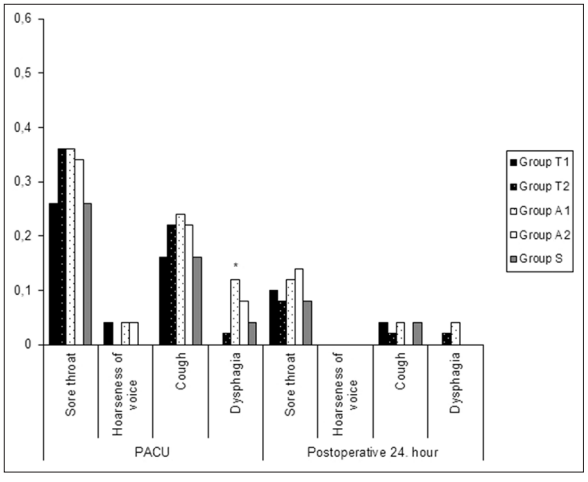

Figure 1: Complaints related to endotracheal intubation. *: $P < 0.05$, when Group A1 was compared with the Group T1

Table 1: Demographic data of patients

Group	Age	ASA	Operation duration
Group T1	37,26±13,11	1,60±0,53	100,42±42,18
Group T2	33,44±11,95	1,62±0,56	115,20±44,42
Group A1	36,82±13,74	1,58±0,53	109,70±48,04
Group A2	35,80±12,34	1,44±0,54	107,80±44,12
Group S	37,64±14,71	1,58±0,49	110,10±88,43
Total	36,19±13,19	1,56±0,53	108,64±56,01

Table 2: Endotracheal cuff pressure values of patients

Group	5th minute	60th minute	Before emergence
Group T1 (n=50)	72,30±22,04*†	28,10±3,01	27,80±2,50
Leakage (n=25)	68,60±17,47	28,60±3,39	28,20±2,44
Ball. Palp. (n=25)	76,00±25,65	27,60±2,54	27,40±2,54
Group T2 (n=50)	54,20±16,85*†	28,00±4,16	28,46±6,16
Leakage (n=25)	54,60±16,51	28,20±3,18	27,72±2,49
Ball. Palp. (n=25)	53,80±17,51	27,80±5,01	29,20±8,37
Group A1 (n=50)	47,60±21,55*§	27,26±3,20	27,85±6,84
Leakage (n=25)	49,80±20,48	27,12±3,20	27,20±3,84
Ball. Palp. (n=25)	45,40±22,77	27,40±3,26	28,54±9,02
Group A2 (n=50)	39,40±19,02*	27,92±3,32	29,00±9,52
Leakage (n=25)	42,20±19,95	27,72±3,22	27,60±3,26
Ball. Palp. (n=25)	36,60±18,01	28,12±3,47	30,40±13,06
Group S (n=50)	32,40±13,33*	28,50±5,17	27,90±2,49
Leakage (n=5)	33,60±15,31	29,80±6,68	28,60±2,29
Ball. Palp. (n=25)	31,20±11,20	27,20±2,53	27,20±2,53
Total	49,18±23,19	27,95±3,85	28,20±6,09

*: $P \leq 0.001$ when the fifth minute in all groups was compared with the other periods, †: $P \leq 0.001$ when Group T1 was compared with the other groups ‡: $P < 0.001$ when Group T2 was compared with Group T1, Group A2, and Group S §: $P < 0.001$ when Group A1 was compared with Group T1 and Group S

Table 3: Cuff pressure errors of patients

Group	<20 cmH2O	20-30 cmH2O	>30 cmH2O
Group T1	0 (% 0)	1 (% 2)	49 (% 98)
Group T2	1 (% 2)	4 (% 8)	45 (% 90)
Group A1	0 (% 0)	16 (% 32)	34 (% 68)
Group A2	6 (%12)	18 (% 36)	26 (% 52)
Group S	6 (%12)	22 (%44)	22 (%44)
Total	13 (% 5)	61 (% 24)	176 (% 70)

Table 4: Intubation conditions of patients

Group	Chin opening	Vocal cord	Reaction to intubation
Group T1	4,00±0,00	3,98±0,14	3,78±0,54
Group T2	4,00±0,00	3,94±0,23	3,72±0,60
Group A1	4,00±0,00	3,94±0,23	3,24±0,82*
Group A2	3,98±0,14	3,90±0,41	3,88±0,32
Group S	4,00±0,00	4,00±0,00	3,94±0,31
Total	3,99±0,06	3,95±0,24	3,71±0,60

*: $P < 0.05$, when Group A1 was compared with the other groups

PACU ($P < 0.05$) and sore throat in postoperative 24th hour ($P < 0.01$) and between cuff pressure before emergence and coughing in PACU ($P < 0.05$). In addition, a correlation was established between operation duration and coughing in PACU ($P = 0.001$), sore throat at the postoperative 24th hour ($P = 0.001$) and coughing ($P < 0.05$).

There were no significant effects found on ETCP of the inflation of ETC with leak sound or pilot balloon palpation [Table 3].

Discussion

In order to prevent some undesired effects of endotracheal intubation such as sore throat, aspiration and stenosis, ETC must be inflated and maintained at a certain pressure interval. In our study, the two methods most commonly used in practice for the inflation of ETC were investigated with users having different levels of experience. While significant difference was not observed between the two methods applied by users having the same level of experience, significant decreases were established in cuff pressure values parallel to experience. Although increases occurred in acceptable pressure values in ETCP along with experience, even in specialist physician group erroneous inflation rate was observed as high. In addition, a correlation was found between postoperative complaints with cuff pressure and the duration of anaesthesia.

ETCP average of all groups at the 5th minute was found as 49 cmH_2O in our study, and the pressure was within normal values in only 24% of the patients. The remaining 70% of the patients had a pressure of above 30 cmH_2O. A similar study conducted by Sengupta *et al*. in three different hospitals in which they applied pilot balloon palpation predominantly for ETC inflation, established ETCP as 20-30 cmH_2O only in 27% of the patients.[12] They established ETCP as below 20 cmH_2O in the remaining 23%, above 30 cmH_2O in 50%, and above 40 cmH_2O in 27%. Braz *et al*. measured ETCPs of patients in postoperative care unit (PACU) and intensive care unit (ICU).[13] While cuff pressure had measured as above 40 cmH_2O in 90.6% of the patients who underwent anaesthesia with nitrous oxide and 45.4% of patients who underwent anaesthesia without nitrous oxide in PACU, this rate for patients in ICU was reported as 54.8%.

In the literature, they have been compared routinely used methods (such as pilot balloon palpation and leakage sound) with manometric method in terms of their effects on the ETCP.[14,15] A study that compares pilot balloon leakage with leakage sound does not exist in literature. In our study, users applied both methods but a significant difference was not observed between the two methods.

Faris *et al*., in their study, compared assistant anaesthesiologists with consultant anaesthesiologists, and staff nurses with head nurse in order to establish the role of experience in ETCP inflation.[8] The study reported that a difference was not observed between assistant anaesthesiologist and consultant anaesthesiologists but there was a difference between nurses. We found appropriate inflation rate increased with increasing experience of anaesthesia technicians. While a significant difference was not found between experience assistant anaesthesiologists and specialist anaesthesiologists, we established a significant difference between assistant anaesthesiologists with less experience and specialist anaesthesiologists.

In studies by Wujtewicz *et al*. conducted with users having different levels of experience in 2002 and in recent years, it was reported that errors do not diminish with the passing years in ETCP inflation and there is a tendency to over-inflation of ETC even among highly experienced users.[16] Although, in our study, we established a difference between experience and ETCP, we found that even the applications of anaesthesiology specialists were erroneous at a rate of 56%, 44% of which were over-inflation and 12% were under-inflation.

In evaluations in the PACU and postoperative 24th hour, it has been demonstrated that sore throat,[14,15] coughing,[14] hoarseness in voice[14,17] and hemoptysis[17] complaints were more common in pilot balloon palpation compared to manometric method. In our study, dysphagia was observed at the PACU in Group A1. Since, in patients belonging to this group, reaction given to intubation was more compared to other groups, a correlation test was carried out, but a significant result was not obtained. A significant correlation was established between postoperative complaints with cuff pressures and the duration of anaesthesia.

In this study, we investigated the effects of user's experience and different cuff inflation methods on the ETCP and postoperative complaints associated with it. We observed effects on the ETCP of both leak sound and pilot balloon palpation methods were similar. The more safely ETCP values were obtained with increasing experience of the users. But, all of the obtained values were not completely accurate and safe. Therefore, it was thought this experience does not suffice alone in adjusting ETCP. However, we found that cuff pressure and operation duration have correlations with some postoperative complaints. There were no obtained for exactly correct and safe ETCP values, no matter which user experience and inflation method. We suggest ETCPs are checked via manometer instead of conventional methods.

References

1. Henderson J. Airway management in the adult. In: Miller RD, Eriksson LI, Wiener-Kronish JP, Young WL, editors. Miller's Anesthesia. 7th ed. Philedelphia: Churchill-Livingstone Elsevier; 2010. p. 1573-610.
2. Seegobin RD, Van Hasselt GL. Endotracheal cuff pressure and tracheal mucosal blood flow: Endoscopic study of effects of four large volume cuffs. BMJ 1984;288:965-8.
3. Mehta S. Endotracheal cuff pressure. BMJ 1984;288:1763-4.

4. Nseir S, Duguet A, Copin MC, De Jonckheere J, Zhang M, Similowski T. Continuous control of endotracheal cuff pressure and tracheal wall damage: A randomized controlled animal study. Crit Care 2007;11:R109.
5. Nesek-Adam V, Mrsic V, Oberhofer D, Grizelj-Stojcic E, Kosuta D, Rasic Z. Post-intubation long-segment tracheal stenosis of the posterior wall: A case report and review of the literature. J Anesth 2010;24:621-5.
6. De S, De S. Post intubation tracheal stenosis. Indian J Crit Care Med 2008;12:194-7.
7. Hameed AA, Mohamed H, Al-Mansoori M. Acquired tracheoesophageal fistula due to high intracuff pressure. Ann Thorac Med 2006;3:23-5.
8. Faris C, Koury E, Philpott J, Sharma S, Tolley N, Narula A. Estimation of tracheostomy tube cuff pressure by pilot balloon palpation. J Laryngol Otol 2007;121:869-71.
9. Morris LG, Zoumalan RA, Roccaforte JD, Amin MR. Monitoring Tracheal Tube Cuff Pressures in the Intensive Care Unit: A Comparison of Digital Palpation and Manometry. Ann Otol Rhinol Laryngol 2007;116:639-42.
10. Sole ML, Aragon D, Bennett M, Johnson RL. Continuous measurement of endotracheal tube cuff pressure: How difficult can it be? AACN Adv Crit Care 2008;19:235-43.
11. Krieg N, Mazur L, Booij LH, Crul JF. Intubation conditions and reversibility of a new non-depolarizing neuromuscular blocking agent, Org-NC45. Acta Anaesthesiol Scand 1980;24:423-5.
12. Sengupta P, Sessler DI, Maglinger P, Wells S, Vogt A, Durrani J. Endotracheal tube cuff pressure in three hospitals, and the volume required to produce an appropriate cuff pressure. BMC Anesthesiol 2004;4:8.
13. Braz JR, Navarro LH, Takata IH, Nascimento Junior P. Endotracheal tube cuff pressure: Need for precise measurement. Sao Paulo Med J 1999;117:243-7.
14. Jain MK, Tripathi CB. Endotracheal tube cuff pressure monitoring during neurosurgery - Manual vs. automatic method. J Anaesthesiol Clin Pharmacol 2011;27:358-61.
15. Al-Metwalli RR, Al-Ghamdi AA, Mowafi HA, Sadek S, Abdulshafi M, Mousa WF. Is sealing cuff pressure, easy, reliable and safe technique for endotracheal tube cuff inflation? A comparative study. Saudi J Anaesth 2011;5:185-9.
16. Wujtewicz MA, Sawicka W, Owczuk R, Dylczyk-Sommer A, Wujtewicz M. Tracheal tube cuff pressure depends on the anaesthesiologist's experience. A follow-up study. Anestezjol Intens Ter 2009;41:205-8.
17. Liu J, Zhang X, Gong W, Li S, Wang F, Fu S. Correlations between controlled endotracheal tube cuff pressure and postprocedural complications: A multicenter study. Anesth Analg 2010;111:1133-7.

How to cite this article: ???

Source of Support: Nil, **Conflict of Interest:** None declared.

AUTHOR INSTITUTION MAP FOR THIS ISSUE

Map will be added once issue gets online***********

Please note that not all the institutions may get mapped due to non-availability of requisite information in Google Map. For AIM of other issues, please check Archives/Back Issues page on the journal's website.