ORIGINAL ARTICLE

Effect of intracuff alkalinized 2% lidocaine on endotracheal tube cuff pressure and postoperative throat symptoms in anaesthesia maintained by nitrous oxide

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ABSTRACT

Aim To compare the effects of endotracheal tube cuff inflation media, air, saline and alkalinized 2% lidocaine on increase of cuff pressure (CP) during nitrous oxide maintained anaesthesia and on incidence of postoperative throat symptoms (PTS), and to evaluate the incidence of postoperative throat mucosal injuries (PTMI) depending on cuff inflation medium.

Methods Ninety patients who had undergone elective surgery were randomly allocated into 3 equal groups per cuff inflation media: air (group A), saline (group S) and alkalinized 2% lidocaine (group L). The CP was monitored immediately after cuff inflation and further 5, 15, 30, 60 and 90 minutes after intubation. The incidence and intensity of PTS, sore throat, hoarseness, dysphagia and cough were evaluated 2, 6 and 24 hours after extubation. The incidence and intensity of PTMI were evaluated 24 hours after exubation using indirect laryngoscopy examination.

Results The highest increase of mean CP was recorded in the group A (18.7±4.9), it was significantly lower (6.4±1.1) in the group S, while it remained stable in the group L (0.7±0.7). All PTS occurred less frequently in the group L: sore throat ($p<0.001$), hoarseness and dysphagia ($p<0.05$), but the incidence of cough was not significantly different between the groups. The lowest incidence of PTMI was in the group L ($p<0.001$).

Conclusion The increase of CP contributed to incidence of PTS. The intracuff alkalinized 2% lidocaine was superior to saline and air in the prevention of an increase of CP and reduction of the PTS incidence. There was a strong correlation between the incidence of PTS and PTMI.

Key words: cough, dysphagia, hoarseness, sore throat

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INTRODUCTION

Endotracheal tube provides secure airway, optimal mechanical ventilation and protects from the risk of gastric content aspiration during general anaesthesia. Tracheal intubation is connected with local mechanical irritation, trauma and inflammatory response of the pharyngolaryngeal and tracheal mucosa (1). Preoperative dehydration, trauma from suction before extubation and endotracheal tube cuff pressure (CP) during anaesthesia are additional factors which impair postoperative throat mucosal injuries (PTMI). Anaesthesiologists usually inflate the cuff with air. The cuff makes sure that endotracheal tube stays in place and recommended CP is between 20 - 25 cm H_2O (2). Higher CP results in the reduction of the tracheal mucosa perfusion and ischemia. CP above 30 cmH_2O overlaps capillary blood flow through mucosal vessels and induces various mucosal lesions like: erythema, edema, haematoma, erosions, ulceration, granuloma, etc. (3). These lesions provoke an organic basis for patients' postoperative throat symptoms (PTS): sore throat, hoarseness, dysphagia and cough. The PTS is attributed to multiple perioperative conditions (4). The risk factors leading to PTS could be related with patients (elderly age, female gender, history of smoking, diabetes mellitus, hypertension, hypotension, malnutrition, which could aggravate mucosal perfusion and predispose it to mechanical damage of instrumentation in throat and effects of CP (5), with anaesthesia technique (size of endotracheal tube, type of tube, cuff design, value of CP, use of N_2O in the gas mixture, intubation technique, anaesthesiologist's experience, application of muscle relaxation, movement of the tracheal tube during surgery and excessive pharyngeal suctioning at extubation) (6) and with surgery (type of surgery, surgical technique, insertion of nasogastric tube, patient's position on the operating table and duration of operation (7). During anaesthesia maintained by nitrous oxide (N_2O), the CP rises because of N_2O diffuses into cuff more rapidly that it leaves. After 30 minutes of N_2O anaesthesia, the CP reaches critical pressure of 30 cmH_2O (8). The overinflation of cuff predisposes the patients to PTS by increasing contact area between cuff and mucosa. The measurement of endotracheal tube CP has not been a part of daily anaesthetic clinical practice. Medical staff pay most attention to outcome of the surgical procedures. The PTSs are not routinely investigated and patients suffer from untreated difficulties. Although the PTSs were considered as minor postoperative complications, they could significantly affect the quality of the recovery period and delay oral intake (9). The examination of larynx after airway instrumentation is not routine practice and PTMIs are often neglected.

As a cuff inflation medium in various concentrations alkalinized lidocaine significantly prevents hyperinflation of cuff and eliminates one of the underlying mechanisms of the postoperative throat adverse events (10). Some efforts for preventing PTS have been made, but conclusive measures have not been elucidated yet. No special medication or procedure has been completely useful for pain control (11).

The aim of this study was to compare the increase of CP during N_2O anaesthesia, the incidence and intensity of PTS between three cuff inflation media, air, saline and alkalinized 2% lidocaine, and to evaluate correlation between an increase of CP and subjective PTS. Additionally, a comparison of the incidence and intensity of PTMI, which was evaluated by indirect laryngoscopic examination depending on three cuff inflation media, and an evaluation of a correlation between subjective throat symptoms and objective clinical finding were done.

PATIENTS AND METHODS

Patients and study design

This prospective randomized, double-blinded clinical study was conducted in the Department of Anaesthesiology and Intensive Care Unit and the Department of Otorhinolaryngology at the Cantonal Hospital in Zenica, Bosnia and Herzegovina. The study took place during a three-month period, from January to April 2018. The study protocol was approved by the Ethics Committee of the Cantonal Hospital in Zenica.

After obtaining a written informed consent, 90 patients were included in the study. Inclusion criteria were: adult patients aged 18-65 years without predictive signs of difficult intubation, with the American Society of Anesthesiologists (ASA) physical status classes I – III (12), all underwent endotracheal intubation for various elective surgi-

cal procedures, duration not longer than 2 hours, in the supine position. Exclusion criteria were: emergency surgery and surgery in the mouth, throat or neck area, history of smoking, history of preoperative cold, sore throat, cough or hoarseness in the last month, potentially difficult intubation, Mallampati score III and IV (13), more than one attempt needed to achieve tracheal intubation, patients with increased risk of aspiration or gastroesophageal regurgitation, intraoperative nasogastric tube placement, patients with cardiopulmonary, neuromuscular, renal or hepatic disease, body mass index above 40 kg/cm^2, history of allergy to any study drugs, pregnancy, prone position during operation, administration of succinylcholine in anaesthesia or rapid sequence induction.

The day before the surgery patients were randomized into three equal groups with 30 patients by a nurse who was not involved in the study (Figure 1). A closed envelope contained a code indicating the treatment was used according to computer software randomization. Patients were divided in three groups considering cuff inflation medium: group A (the cuff inflated with air), group S (the cuff inflated with 0.9% saline) and group L (the cuff inflated with alkalinized 2% lidocaine). Group A was considered as a control group hence group S and group L were experimental groups.

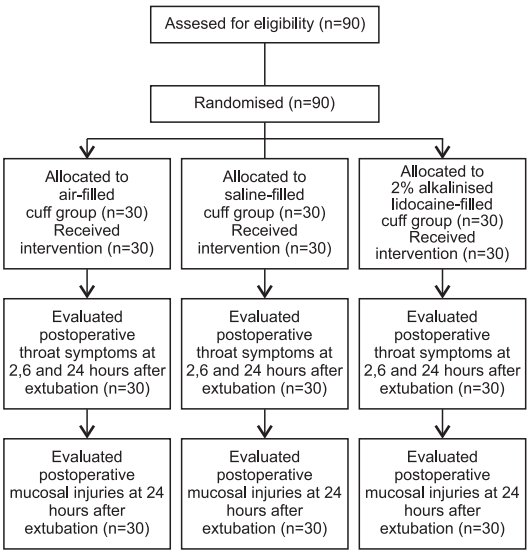

Figure 1. CONSORT flow diagram of patients distribution in the study

Methods

Anaesthesia and assessment of CP. In the operating room, an intravenous cannula of 18 G was inserted to all patients. Standard non-invasive clinical monitoring was performed: pulse oximetry, arterial blood pressure, the electrocardiogram, capnography and neuromuscular block monitoring. Three minutes before induction, all patients were pre-medicated with midazolam 0,05 mg/kg intravenously and preoxygenated with 100% oxygen by facial mask. Anaesthesia was induced with propofol 2 mg/kg, fentanyl 1 μg/kg and atracurium 0,6 mg/kg . After the loss of all four twitches from „train of four“ (TOF) stimulation of the ulnar nerve, endotracheal intubation was made with Machintosh laryngoscope blade size 3 (Machintosh blade, Telefex/Rüsch, Germany). Trachea was intubated with high-volume low-pressure cuffs endotracheal tube and appropriate inner diameter was chosen individually, for males 8.0-8.5 mm and for females 7.0-7.5mm. No lubricant was used on the tube before intubation. One experienced anaesthesiologist, blinded of experimental protocol, performed endotracheal intubation and anaesthesia in all patients during the study. Another anaesthesiologist, who was not blinded to study protocol, though excluded from the data collection, carefully inflated cuffs in all patients. The cuffs were inflated using the minimal occlusive volume technique with the same coloured syringes in the volume of 20 mL. Previously, the cuffs were completely deflated and after intubation the cuffs were gradually inflated with various medium until the air leak stopped during positive pressure ventilation with tidal volume of 6 mL/kg and peak respiratory pressure to 25 cmH_2O. In the group A (control group), the cuff was inflated with air. In the group S, the cuff was inflated with 0.9% saline. In the group L, the cuff was inflated with alkalinized 2% lidocaine (20 mL syringe filled with mixture 2% lidocaine and 8,4% sodium bicarbinate in 19:1 ratio). The volume of the inflation medium was noted. The intracuff pressure was monitored using portable non-invasive manometer graduated in cmH_2O and continuously connected to the pilot balloon of the endotracheal tube (Endotest for low pressure cuffs, Rüsch, Germany). Basal value of CP (t_0) was documented immediately after cuff inflation. Further, CP was noted 5 (t_5), 15 (t_{15}), 30 (t_{30}),

60 (t_{60}) and 90 (t_{90}) minutes after intubation. Balanced anaesthesia was maintained as long as necessary for each case using sevoflurane minimum alveolar concentration of 0.5-1 ‰, N_2O 50% in oxygen**,** at a total flow of 2 L/min. End tidal carbon dioxide was maintained at 30-35 mmHg. At the beginning of the skin closure, every patient received tramadol chloride 100 mg intravenously, to provide postoperatve analgesia. At the end of the surgery, when TOF >0.7 neuromuscular block was reversed with neostigmine 0.05 mg/kg and atropine 0.02 mg/kg. The patients were extubated fully awake after minimal and gentle mouth suctioning and transferred to the post-anaesthesia care unit. Oral airway devices were not used intraoperatively.

Assessment of the incidence and intensity of PTS. The incidence and intensity of PTS were evaluated 2, 6 and 24 hours after extubation according to a 4-point verbal rating scale. Patients were questioned by an observer who was blinded to the study protocol. Sore throat was defined as constant pain or discomfort in the throat independent of swallowing. Intensity of the sore throat was assessed as follows: 0 – no sore throat, 1 – minimal sore throat (less severe than with cold), 2 – moderate sore throat (similar to that noted with cold), 3 – severe sore throat (more severe than with cold). Hoarseness or dysphonia was defined as difficulty in speaking or pain on speaking. Intensity of the hoarseness was scored as: 0 – no hoarseness, 1 – mild hoarseness (noticed by the patient only), 2 – severe hoarseness (noticed by the observer at the time of the interview), 3 – aphonia (inability to speak). Dysphagia was defined as difficulty or pain provoked by swallowing. Intensity of the dysphagia was scored as: 0 – no complaints, 1 – mild dysphagia , 2 – severe dysphagia, 3 – cannot swallow because of pain. Cough was defined as a sudden reflex that forces air out of the throat. Grades of coughing episodes were: 0 – no cough, 1 – one cough, 2 – more than one episode of unsustained coughing, 3 – sustained and repetitive coughing with head lift.

Assessment of the incidence and intensity of PTMI. The incidence and intensity of PTMI were evaluated 24 hours after exubation using indirect laryngoscopy. Pharynx, epiglottis, arytenoid and vocal cords were observed. Intensity of PTMI was graded as: erythema (redness of the mucosa), edema (inflammatory swelling of the mucosa), haematoma (bleeding into mucosa), arytenoid subluxation/luxation (displaced arytenoid with limited movement) and granuloma (granulation tissue into mucosa). Indirect laryngoscopy was performed by an experienced otorhinolaryngologist who was not involved in the study protocol.

The following data were also recorded: age, sex, body weight, ASA physical status class, Mallampati score, type of surgery, volume of intracuff medium, size of endotracheal tube and time from intubation to extubation.

Statistical analysis

Sample size was estimated using sample size calculator software with 95% confidence interval and power of 80%. Statistical significance was considered as $p< 0.05$. Categorical variables were analysed by Pearson's $\chi 2$ test and presented as frequency and relative number of cases (percentage). The parametric variables were expressed as means and standard deviation and analysed by Student's t test, one way analysis of variance (ANOVA) and Pearson's correlation as appropriate.

RESULTS

During the study no patents were excluded from the analysis. All patients were intubated at first attempt. There was no statistically significant difference between demographic parameters in three groups: age, body weight, gender, ASA physical status grade, Mallampati score, type of surgery, size of the endotracheal tube, volume of the intracuff medium and duration of intubation period (Table 1).

Although the basal values of CP were very close between the groups, in the group A basal CP was statistically significantly higher compared to other two groups ($p<0.05$). Through 90-minute observation period, the highest increase of mean CP was recorded in the group A (18.7±4.9). The CP raised to statistically significant level between each studied time points ($p<0.05$) in the group A and critical pressure of 30 cmH_2O was reached 15 minutes after intubation. In the group S, increase of mean CP was statistically significantly lower (6.4±1.1; $p <0,01$) than in the group A. The mean CP was maintained below the critical pressure of

Table 1. Demographic characteristics of patients

Parameter	Group A*	Group S†	Group L‡	p
Male/Female No (%)	15/15 (50/50)	16/14 (53.3/46.7)	13/17 (43.3/56.7)	0.733
Age (years (mean (± standard deviation)	50.8 (±9.7)	47.4 (±11.9)	50.1 (±12.2)	0.471
Body weight (kg) mean (± standard deviation)	80.4 (±10.7)	85.6 (±11.8)	81.7 (±11.3)	0.177
Type of surgery No (%)				0.832
Inguinal hernia	8 (26.7)	10 (33.3)	10 (33.3)	
Cholecystectomy	8 (26.7)	11 (36.7)	11 (36.7)	
Mastectomy	6 (20.0)	4 (13.3)	5 (16.7)	
Transurethral resection of the prostate	8 (26.7)	5 (16.7)	4 (13.3)	
Mallampati score class I/II (No / %)	21/9 (70/30)	24/6 (80/20)	20/10 (66.7/33.3)	0.487
ASA status class I/II/III (No /%)	14/13/3 (46.7/43.3 /10)	14/13/3 (46.7/43.3 /10)	12/14/4 (40/46.7 /13.3)	0.978
Tube size mean (± standard deviation)	7.9 (±0.5)	7.8 (±0.5)	7.8 (±0.6)	0.600
Volume cuff media (mL) mean (± standard deviation)	4.9 (±0.6)	4.7 (±0.5)	4.9 (±0.4)	0.526
Duration of intubation (min) mean (± standard deviation)	87.9 (±9.9)	89.2 (±11.3)	87.5 (±14.5)	0.856

*group A, the cuff inflated with air; †group S, the cuff inflated with 0.9% saline; ‡group L, the cuff inflated with alkalinized 2% lidocaine; ASA, American Society of Anesthesiologists

30 cmH_2O during the procedure. In the group L, the mean CP remained stable (0.7±0.7). Post hock analysis using Student's t test indicated significant difference at all studied time periods between groups (Table 2).

Table 2. Cuff pressure (cmH2O) according to the groups and study time

Parameter*	Group A† Mean (±SD) 95%CI	Group S‡ Mean (±SD) 95%CI	Group L¶ Mean (±SD) 95%CI	p
CPt0	21.43(±2.19) 20.61- 22.25	19.53 (±2.90) 18.45- 20.62	18.20 (±1.58) 17.61-18.79	0.001
CPt5	26.90(±3.02)↑ 25.77-28.03	21.80(±3.03)↑ 20.67-22.93	18.80 (±1.27) 18.33-19.27	0.001
CPt15	30.77(±3.31)↑ 29.53- 32.01	23.87(±2.87)↑ 22.79- 24.94	18.93 (±1.28) 18.45-19.41	0.001
CPt30	34.10(±4.02)↑ 32.60- 35.60	25.33(±3.12)↑ 24.17-26.50	8.93 (±1.28) 18.45-19.41	0.001
CPt60	37.47(±4.54)↑ 35.77-39.16	25.93(±2.99)↑ 24.82-27.05	18.93 (±1.28) 18.45-19.41	0.001
CPt60	39.88(±5.95)↑ 36.70-43.05	26.21(2±.89)↑ 24.81-27.61	19.20 (±1.37) 18.44-19.96	0.001

*Data was expressed as mean and standard deviation (±SD); CI, confidence interval; CP, cuff pressure (cmH20); t0, immediately after cuff inflation; t5, cuff pressure 5 minutes after intubation; t15,cuff pressure 15 minutes after intubation; t30, cuff pressure 30 minutes after intubation; t60, cuff pressure 60 minutes after intubation; t90, cuff pressure 90 minutes after intubation; †group A, the cuff inflated with air; ‡group S, the cuff inflated with 0.9% saline; ¶group L, the cuff inflated with alkalinized 2% lidocaine; ↑, p<0.05 for the difference between two points of study time within the same group;

The highest incidence of sore throat was noted in the group A, considerably less in the group S (p<0.05) and it was the lowest in the group L (p<0.001) 2, 6 and 24 hours after extubation. The incidence of sore throat dropped by half in the group S (23.3%) and in the group L (13.3%), 6 hours after extubation, while it remained unchanged (60%) in the group A. Twenty-four hours after extubation, sore throat persisted only in the group A.

The peak of hoarseness incidence was recorded 2 hours after extubation: 18 (60%) patients in the group A, 14 (46.3%) in the group S and 7 (23.3%) in the group L. The distribution of hoarseness 6 hours after extubation was only slightly lower in all groups but the difference was still statistically significant (p<0.043). The incidence of hoarseness was not significantly different between the groups, 24 hours after extubation, despite of higher occurrence (30%) in the group A than (6.7%) in the group L.

The incidence of dysphagia was significantly higher in the group A compared to the group S and L, 2 hours (p<0.05) and 6 hours (p<0.001) after extubation, while there was no notable difference between the groups 24 hours after extubation.

There was a trend of decreasing the incidence of postoperative cough in the L group comparing with the group A and the group S, but it was not statistically significant (Table 3).

Table 3. Incidence of postoperative throat symptoms according to the groups

Symptom	Time after extubation	No (%) of patients Group A*	Group S†	Group L‡	P
Sore throat					
	2h	18 (60)	14 (46.7)	7 (23.3)	0.015
	6h	18 (60)	7 (23.3)	4 (13.3)	0.001
	24h	4 (13.3)	0	0	0.015
Hoarseness					
	2h	18 (60.0)	14 (46.7)	7 (23.3)	0.015
	6h	15 (50.0)	9 (30.0)	6 (20.0)	0.043
	24h	9 (30.0)	9 (30.0)	2 (6.7)	0.060
Dysphagia					
	2h	16 (53.3)	11 (36.7)	7 (23.3)	0.050
	6h	15 (50.0)	4 (13.3)	2 (6.7)	0.001
	24h	3 (10.0)	4 (13.3)	1 (3.3)	0.383
Cough					
	2h	7 (26.6)	5 (16.7)	4 (13.3)	0.587
	6h	6 (20.0)	3 (10.0)	3 (10.0)	0.421
	24h	2 (6.7)	2 (6.7)	1 (3.3)	0.809

*group A, the cuff inflated with air; †group S, the cuff inflated with 0.9% saline; ‡group L, the cuff inflated with alkalinized 2% lidocaine; ↑, p<0.05 for the difference between two points of study time within the same group;

Most commonly the intensity of PTS was rated with grade 1 as minimal or mild intensity. In the group A, one patient (3.3%) rated sore throat with grade 2 (moderate sore throat) 2 hours after extubation, and two patients (6.7%) 6 hours after extubation. In the group S, two patients (6.7%) declared sore throat with grade 2, 2 hours after extubation. Hoarseness was noted with grade 2 (severe hoarseness) by one patient (3.3%) in the group A and two patients (6.7%) in the group S, 2 hours after extubation. Intensity of dysphagia was declared with grade 1 at all recording times in all groups. Cough was noted with grade 2 (more than one episode of coughing) by one patient (3.3%) in the group S and one patient (3.3%) in the group L two hours after extubation. None of the patients described PTS with grade 3.

The increase of mean CP during anaesthesia and incidence of PTS were directly related. Significant correlation (rho=0.450; p=0.0001) was found between the increase of mean CP (18.7±4.9) and overall incidence of PTS (4.3±2.1) in the group A. In the group S, a notably lower change of mean CP (6.4±1.1) was associated with lower overall incidence of PTS (2.6±1.8) and the relation was statistically significant (rho=0.494; p=0.0001). In the group L, significant correlation was not found considering that the increase of mean CP was negligible (0.7±0.7) and connected with the lowest incidence of overall PTS (1.5±1.4).

Table 4. Incidence and intensity of postoperative throat injuries according to the groups

Localisation of injuries	Intensity of injuries	No (%) of patients			p
		Group A*	Group S†	Group L‡	
Pharynx					0.001
	No lesion	11 (36.7)	21 (70)	26 (86.7)	
	Erythema	15 (50)	9 (30)	4 (13.3)	
	Edema	4 (13.3)	0 (0)	0 (0)	
Epiglottis					0.364
	No lesion	29 (96.7)	30 (100)	30 (100)	
	Erythema	1 (3.3)	0 (0)	0 (0)	
	Edema	0 (0)	0 (0)	0 (0)	
Arytenoid					0.499
	No lesion	22 (73.3)	23 (76.7)	26 (86.7)	
	Erythema	7 (23.3)	7 (23.3)	4 (13.3)	
	Edema	1 (3.3)	0 (0)	0 (0)	
Vocal cord right					0.036
	No lesion	22 (73.3)	26 (86.7)	29 (96.7)	
	Erythema	8 (26.7)	4 (13.3)	1 (3.3)	
	Edema	0 (0)	0 (0)	0 (0)	
Vocal cord left					0.006
	No lesion	13 (43.3)	19 (63.3)	25 (83.3)	
	Erythema	17 (56.7)	11 (36.7)	5 (16.7)	
	Edema	0 (0)	0 (0)	0 (0)	
Overall incidence of injuries within the group		27 (90)	21 (70)	11 (36.7)	0.001

*group A, the cuff inflated with air; †group S, the cuff inflated with 0.9% saline; ‡group L, the cuff inflated with alkalinized 2% lidocaine;

Overall incidence of PTMI was higher in the group A (90%) than in the group S (70%) or in the group L (36.7%). With regard to localisation, PTMI was mostly placed in vocal cord left: 17 (56.7%) patients in the group A, 11 (36.7%) in the group S and five (16.7%) in the group L. With regard to intensity of PTMI, most commonly occurring lesion was erythema.. Edema was only noted in the group A. Other lesions, e. g. haematoma, arytenoid subluxation/luxation and granuloma were not noted (Table 4).

A correlation between overall incidence of subjective PTS recorded at all studied time points and incidence of PTMI was excellent. In the group A rho=0.651 (p=0.0001), in the group S rho=0.651 (p=0.0001) and in the group L rho=0.443 (p=0.44). The coefficient correlation for the entire sample was rho=0.733 (p=0.0001).

DISCUSSION

The presented study investigated the effect of alkalinized 2% lidocaine used as a cuff inflation medium on endotracheal tube CP during N_2O maintained anaesthesia and on PTS.

The results of this study suggest that alkalinized 2% lidocaine is better cuff inflation medium comparing to saline or air to prevent increase of CP and postoperative sore throat, hoarseness and dysphagia. Alkalinized lidocaine also reduced the incidence of postoperative cough, but with no statistical significance. There was a positive correlation between increase of CP during N_2O anaesthesia and incidence and intensity of the subjective PTS. Alkalinized lidocaine had more superior activity than saline or air in reducing incidence and intensity of PTMI evaluated by indirect laryngoscopy. There was a positive correlation between subjective throat symptoms and objective clinical findings.

In this study many of the risk factors for PTS were controlled by inclusion criteria, exclusion criteria and adjusted anaesthesia airway management in order to reduce bias and minimize the influence of confounding factors as much as possible. The results of demographic data were standardized between the groups. The aforementioned circumstances allowed us to explain our results in light of overwhelming influence of various intracuff media on CP and PTS.

The CP was not monitored and measured routinely. Anaesthesiologists estimate CP by pilot balloon palpitation, using their own experience, but Jain et al. concluded that it is not an accurate and safe method (14). The increase of CP is responsible for the reduction in mucosal perfusion and occurrence of PTS (15). One of the proposed methods to reduce CP is filling the cuff with alkalinized lidocaine (16). The N_2O diffuses into cuff and causes spreading of lidocaine outside of cuff. That balance provides stable CP during anaesthesia (17). Outside of cuff lidocaine acts as a local anaesthetic to the mucosa and blunt PTS. Alkalinization of lidocaine with sodium bicarbonate increases pH value of the solution to 7.43 accelerates diffusion through cuff and anaesthetic action of lidocaine to the mucosa (18). Many investigators assessed effectiveness of alkalinised lidocaine on CP and the occurrence of PTS (19). Various methodological approaches are the reason of contradictory findings between the studies. To our knowledge, there is no earlier study which evaluated impact of intracuff alkalinized 2% lidocaine on CP, on the incidence and intensity of PTS in connection with PTMI, in N_2O maintained anaesthesia and surgical procedures lasting up to 2 hours. The results of this study have shown the absence of CP increase using 2% alkalinized lidocaine as a cuff inflation medium during N_2O anaesthesia. The saline-inflated cuff kept CP below the critical value of 30 cmH_2O because liquid does not expand volume when N_2O diffuses in it, but CP increased statistically significant.

A revealed incidence of postoperative sore throat is 30 – 70% (20). The activation of pain receptors in throat mucosa due to adherence of endotracheal tube and cuff cause PTS. (21). In this study the peak of sore throat was 2 hours after extubation with the incidence between 23.3% in the lidocaine group and 60% in the air group. In the saline group lack of sore throat was not reached despite of the absence of cuff overinflation because of mechanical effects of endotracheal tube on throat mucosa.

Mechanical trauma during endotracheal intubation and influence of CP during anaesthesia cause edema of vocal cords, which leads to postoperative hoarseness in the overall incidence from 20-53% (22). In the present study, the highest incidence of hoarseness (60%) was in relation with the highest value of mean CP (39.88 cmH_2O). Hamdan et al. found that the mean CP is most influent factor associated with incidence of vocal symptoms (23). Twenty-four hours after extubation, hoarseness persisted in 30% patients in the air group, while alkalinized lidocaine reduced hoarseness to 7.6%. Some investigators reported persistent hoarseness as many as 11% for up to 96 hours postoperatively (24).

The presumed reasons for onset of dysphagia include neuropraxia of the recurrent laryngeal nerve and mucosal injuries like edema or haematoma (25). Alkalinized 2% lidocaine suppressed postoperative dysphagia better than other two media in this study by limiting CP. Arts et al. suggested that adjustment of CP to 20 mmHg (26 cmH_2O) decreased the incidence of dysphagia (26).

Cough is provoked by mechanical or chemical factors that act to sensory receptors along the respiratory mucosa with postoperative incidence ranging from 40-90% (27). Cough is a protective airway reflex, but it can lead to arrhythmias, hypertension, increase intraocular and intracranial pressure, bronchospasm, wound dehiscence and postoperative surgical complications (28). The present study detected beneficial effects of alkalinized 2% lidocaine on postoperative cough, but with no statistical significance. D'Aragon et al. have found that alkalinized lidocaine has no influence on incidence of cough (29). Contrary to that study, Souissi at al. achieved significant reduction of postoperative cough but N_2O-free anaesthesia was conducted and a larger amount of intracuff alkalinized lidocaine was used than in our study (160 mg versus approximately 100 mg), beside the duration of lidocaine diffusion that was up to 2 hours (30). The diffusion time longer than 2 hours would allow effective anaesthetic concentration in the mucosa to produce a reversible block in the transmission of peripheral nerve impulses (31). Respectively, lower incidence of coughing (3.3-26.6%) in the presented study than in the literature could be explained by very strict airway management method during anaesthesia.

With regard to intensity of PTS, patients predominantly expressed mild symptoms, grade one of intensity. The low intensity of symptoms was not the reason to neglect PTS, particularly if the cuff overinflation and throat mucosal injuries were presented.

The observation of PTMI in our study was provided by indirect laryngoscopy examination. Fiberoptic laryngoscopy was available to us, but a more simple, cheaper and less invasive method was used. Efficiency of alkalinized 2% lidocaine in the prevention PTMI was confirmed in the presented study. The left vocal cord is injured more often than the right vocal cord because insertion of endotracheal tube goes from the right angle of the mouth to the left side of glottis (32). In terms of intensity of injuries, the most common founding in our study was erythema in all groups. Edema was recorded only in the air group due to the beneficial effect of saline and alkalinized lidocaine on CP.

Because the symptoms are always subjective, the incidence of PTS in our study was evaluated in relation with the incidence of PTMI. A strong correlation between subjective throat symptoms and objective clinical finding was found.

This study has some limitations. The effects of alkalinised 2% lidocaine on haemodynamic changes during extubation were not observed. Investigators revealed that intacuff alkalinised lidocaine induces significantly less heart rate and blood pressure during extubation, compared with air and saline group in children (33) and adults (34). There was no evaluation of deflating volume of intracuff media at extubation time. The expectation is that deflating volume of liquid media would be less than inflating volume because of the diffusion through the cuff. In the air group, removed volume would be larger than inflating because of the absorption of N_2O into cuff (35). We did not have a possibility to detect the serum concentration of lidocaine. The statements of previous investigators that intrcuff alkalinized lidocaine has no cumulative effect in the patient's serum were considered. (36).

There was no depression of swallowing reflex, laryngospasm, cuff rupture, any sign of toxicity or any adverse effects during the study, confirming this technique safe and applicable in clinical practice. Further research is needed to evaluate optimal dose of alkalinised 2% lidocaine to obtain significant reduction on the incidence of cough in the aforementioned conditions.

In conclusion, N_2O maintained anaesthesia is associated with significant increase of CP. The increase of CP contributes to incidence and intensity of PTS. The intracuff alkalinized 2% lidocaine is a better cuff inflation medium than air and saline in limiting CP, the prevention of PTS and PTMI. The incidence of postoperative cough is reduced but not significantly different. The use of intracuff alkalinized 2% lidocaine is a safe and reliable method which could be recommended in daily anaesthesia practice.

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REFERENCES

1. Scuderi PE. Postoperative sore throat: more answers than questions. Anesth Analg 2010; 111:831-2.
2. Sole ML, Penoyer DA, Su X, Jimenez E, Kalita SJ, Poalillo E, Byers JF, Bennett M, Ludy JE. Assessment of endotracheal cuff pressure by continuous monitoring: a pilot study. Am J Crit Care 2009; 18:133-3.
3. Sultan P, Carvalho B, Rose BO, Cregg R. Endotracheal tube cuff pressure monitoring: a review of the evidence. J Perioper Pract 2011; 21:379–86.
4. Aqil M, Khan MU, Mansoor S, Mansoor S, Khokhar RS, Narejo AS. Incidence and severity of postoperative sore throat: a randomized comparison of glidescope with Macintosh laryngoscope. BMC Anesthesiol 2017; 17:127-34.
5. Jaensson M, Gupta A, Nilsson U. Gender differences in sore throat and hoarseness following endotracheal tube or laryngeal mask airway: a prospective study. BMC Anaesthesiol 2014; 14:56.
6. Mendels EJ, Brunings JW, Hamaekers AE, Stokroos RJ, Kremer B, Baijens LW. Adverse laryngeal effects following short-term general anesthesia: a systematic review. Arch Otolaryngol Head Neck Surg 2012; 138:257-64
7. Garg R, Rath GP, Bithal PK, Prabhakar H, Marda MK. Effects of retractor application on cuff pressure and vocal cord function in patients undergoing anterior cervical discectomy and fusion. Indian J Anaesth 2010; 54:292-5.
8. Combes X, Schauvliege F, Peyrouset O, Motamed C, Kirov K, Dhonneur G, Duvaldestin P. Intracuff pressure and tracheal morbidity. Influence of filling with saline during nitrous oxide anesthesia. Anesthesiology 2001; 95:1120-4.
9. Hu B, Bao R, Wang X, Liu S, Tao T, Xie Q, Yu X, Li J, Bo L, Deng X. The size of endotracheal tube and sore throat after surgery: a systematic review and meta-analysis. PLoS One 2013; 8:e74467.

10. Estebe JP, Dollo G, Le Corre P, Le Naoures A, Chevanne F, Le Verge R, Ecoffey C. Alkalinization of intracuff lidocaine improves endotracheal tube-induced emergence phenomena. Anesth Analg 2002; 94:227-30.
11. Taghavi GM, Soleimani MI, Razavi M, Salehi M. Reducing sore throat following laryngeal mask airway insertion: comparing lidocaine gel, saline, and washing mouth with the control group. Rev Bras Anesthesiol 2015; 65:450-4.
12. American Society of Anesthesiologist. ASA physical status classification system. 2014. http://www.asahq.org/resources/clinical-information/asa-physical-status-classification -system (20 October 2018).
13. Apfelbaum JL, Hagberg CA, Caplan RA, Blitt CD, Connis RT, Nickinovich DG, Hagberg CA, Caplan RA, Benumof JL, Berry FA, Blitt CD, Bode RH, Cheney FVV, Connis RT, Guidry OF, Nickinovich DG, Ovassapian A. Practice guidelines for management of the difficult airway: an updated report by the American Society of Anesthesiologists Task Force on management of the difficult airway. Anesthesiology 2013; 118:251-70.
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. Chen BZ, Luo LH, Jiang L, Wang RR, Li J, Tan L. The effect of nitrous oxide on intracuff pressure of the size 2 ProSeal laryngeal mask airway. J Clin Anesth 2011; 23:214-7.
16. Shroff PP, Patil V. Efficacy of cuff inflation media to prevent postintubation-related emergence phenomenon: air, saline and alkalinized lignocaine. Eur J Anaesthesiol 2009; 26:458-62.
17. Estebe JP, Gentili M, Le Corre P, Dollo G, Chevanne F, Ecoffey C. Alkalinization of intracuff lidocaine: efficacy and safety. Anesth Analg 2005; 101:1536-41.
18. Wetzel LE, Ancona AL, Cooper AS, Kortman AJ, Loniewski GB, Lebeck LL. The effectivenes of 4% intracuff lidocaine in reducing coughing during emergence from general anesthesia in smokers undergoing procedures lasting less than 1.5 hours. AANA J 2008; 76:105-8.
19. Tanaka Y, Nakayama T, Nishimori M, Tsujimura Y, Kawaguchi M, Sato Y. Lidocaine for preventig postperative sore throat. Cochrane Database Syst Rev 2015; 7:CD004081.
20. Lehmann M, Monte K, Barach P, Kindler CH. Postoperative patient complaints: a prospective interview study of 12,276 patients. J Clin Anesth 2010; 22:13-21.
21. Lam F, Lin YC, Tsai HC, Chen TL, Tam KW, Chen CY. Effect of intracuff lidocaine on postoperative sore throat and the emergence phenomenon: a systematic review and meta-analysis of randomized controlled trials. PLoS One 10:e0136184.
22. Liu J, Zhang X, Gong W, Li S, Wang F, Fu S, Zhang M, Hang Y. Correlations between controlled endotracheal tube cuff pressure and postprocedural complications: a multicenter study. Anesth Analg 2010; 111:1133-7.
23. Hamdan AL, Sibai A, Rameh C, Kanazeh G. Short-term effects of endotracheal intubation on voice. J Voice 2007; 21:762-8.
24. Mendels J, Brunings JW, Hamaekers AE, Stokroos RJ, Kemer B, Baijens LW. Adverse laryngeal effects following short-term general anesthesia: a systematic review. Arch Otolaryngol Head Neck Surg 2012; 138:257-64.
25. Kowalczik I, Ryu WH, Rabin D, Arango M, Duggal N. Reduced endotracheal tube cuff pressure to assess dysphagia after anterior cervical spine surgery. J Spinal Disord Tech 2015; 28:552-8.
26. Arts MP, Rettig TC, De Vries J, Wolfs JF, Veld BA. Maintaining endotracheal tube cuff pressure at 20 mmHg to prevent dysphagia after anterior cervical spine surgery; protocol of double-blind randomised controlled trial. BMC Musculoskelet Disord 2013; 14:280-4.
27. Mazzone SB. An overview of the sensory receptors regulating cough. Cough 2005; 1:2-2.
28. Irwin RS. Complications of cough: ACCP evidence-based clinical practice guidelines. Chest 2006; 129(1 Suppl):54S-58S.
29. D'Aragon F, Beaudet N, Gagnon V, Martin R, Sansoucy Y. The effects of lidocaine spray and intracuff alkalinized lidocaine on the occurrence of cough at extubation: a double-blind randomized controlled trial. Can J Anaesth 2013; 60:370-6.
30. Souissi H, Frechette Y, Murza A, Masse MH, Marsault E, Sarret P, D'Aragon F, Parent AJ, Sansoucy Y. Intracuff 160 mg alkalinized lidocaine reduces cough upon emergence from N_2O-free general anesthesia: a randomized controlled trial. Can J Anaesth 2016; 63:862-70.
31. Widdicombe JG. Neurophysiology of the cough reflex. Eur Respir J 1995; 8:1193-202.
32. Mota LA, De Cavalho GB, Brito VA. Laryngeal complications by orotracheal intubation: literature review. Int Arch Otorinolaryngolog 2012; 16:236-45.
33. Soares SM, Arantes VM, Módolo MP, Dos Santos VJ, Vane LA, Navarro E Lima LH, Braz LG, do Nascimento P Jr, Módolo NS. The effects of tracheal tube cuffs filled with air, saline or alkalinised lidocaine on haemodynamic changes and laryngotracheal morbidity in children: a randomised, controlled trial. Anaesthesia- 2017; 72:496-503.
34. Altintas F, Bozkurt P, Kaya G, Akkan G. Lidocaine 10% in the endotracheal tube cuff: blood concentrations, haemodynamic and clinical effects. Eur J Anaesthesiol 2000; 17:436-42.
35. Gaur P, Ubale P, Khadanga P. Efficacy and safety of using air versus alkalinized 2% lignocaine for inflating endotracheal tube cuff and its pressure effects on incidence of postoperative coughing and sore throat. Anesth Essays Res 2017; 11:1057-63.
36. Navarro LH, Braz JR, Nakamura G, Lima RM, Silva F de P, Módolo NS. Effectiveness and safety of endotracheal tube cuffs filled with air versus filled with alkalinized lidocaine: a randomized clinical trial. Sao Paulo Med J 2007; 125:322-8.