

Effect of Adjusted Cuff Pressure of Endotracheal Tube During Thyroidectomy on Postoperative Airway Complications: Prospective, Randomized, and Controlled Trial

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Abstract

Background Postoperative sore throat (POST) is a common complaint after general anesthesia, especially following thyroidectomy.

Materials and methods We examined the effect of adjusting the endotracheal tube cuff pressure during thyroidectomy on the incidence of airway complications. Ninety patients scheduled for elective thyroidectomy were randomized into two groups: control (group A, $n = 45$) and experimental (group B, $n = 45$). All patients underwent total intravenous anesthesia with propofol and remifentanyl. In group A, the cuff pressure was set to 25 cm H₂O initially and then monitored continuously without adjustment during thyroidectomy. In group B, the cuff pressure was maintained at approximately 25 cm H₂O throughout the operation. The incidences and the severity of POST, hoarseness, dysphagia, and cough were recorded at 2 and 24 h postoperatively.

Results Cuff pressures in group A changed significantly over time ($P < 0.05$) and were higher than those of group B during thyroidectomy ($P < 0.05$). The incidences of

POST were lower in group B than in group A at 2 and 24 h postoperatively ($P < 0.05$), and there was a significant difference in the severity of POST at 2 h postoperatively between the two groups. There were no differences in the incidences of hoarseness, dysphagia, and cough between the two study groups ($P > 0.05$). Adjusting the endotracheal cuff pressure during thyroidectomy decreased the incidence and degree of POST.

Conclusions Intraoperative monitoring and adjustment of the cuff pressure can reduce POST in patients undergoing thyroidectomy.

Introduction

Postoperative sore throat (POST) is one of the most common airway complaints of patients undergoing thyroidectomy, with an incidence of 62 to 84 % [1–3]. This may be considered a minor problem, as it resolves spontaneously after a few days [4–6]. However, POST causes unpleasant distress and decreases the quality of recovery and patient satisfaction [7]. Therefore, prophylactic management to reduce its incidence and severity is recommended to improve recovery, particularly in patients with thyroidectomy.

Many of the factors that contribute to POST are associated with tracheal intubation. These include the diameter of the endotracheal tube, cuff design, cuff pressure, and manipulation of the endotracheal tube or trachea during surgery [4, 7–9]. The endotracheal tube cuff is usually inflated immediately after intubation to ensure positive-pressure ventilation with an adequate seal and to prevent pulmonary aspiration [9]. However, increased cuff pressure may compromise tracheal perfusion and result in tracheal mucosal ischemia [10] and POST, even after brief procedures [9].

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The thyroid is adjacent to the trachea, and manipulation of the thyroid during thyroidectomy may cause variation in the cuff pressure and thereby result in POST. Increased incidence of POST after thyroidectomy has been reported in many studies [1–3], but a search of PubMed using the terms “thyroidectomy,” “cuff pressure,” or “sore throat” returned no controlled study with cuff pressure monitoring during thyroidectomy performed from September 1971 to December 2011. We hypothesized that monitoring and adjusting the cuff pressure during thyroidectomy could reduce the incidence and degree of POST after thyroidectomy. This prospective, randomized, and controlled study evaluated the effect of intraoperative adjustment of the endotracheal tube cuff pressure during thyroidectomy on the incidences of airway complication including POST, hoarseness, dysphagia, and cough.

Methods

Patients

The study protocol was approved by the Institutional Review Board of Kangbuk Samsung Hospital (IRB No. KBC12051) and was registered with the Clinical Research Information Service (CRiS, registration number KCT0000439). After obtaining written informed consent during preoperative visits, 90 patients (American Society of Anesthesiologists physical status I–II), 19–70 years of age, who were scheduled for elective thyroidectomy under general anesthesia from April 2012 to July 2012 were included. The larynx was examined preoperatively using a 70 degree rigid laryngoscope to assess vocal fold mobility. Patients with vocal cords that were freely movable were included in this study. Patients with symptoms of upper respiratory infection within 2 weeks of surgery, previous surgery of the oral cavity or pharynx, or a difficult airway (requiring more than two attempts or more than 15s for endotracheal intubation) were excluded from the study.

Anesthesia

The patients received no pre-anesthetic medication. On arrival in the operating room, standard monitoring was started, including electrocardiography, noninvasive blood pressure measurement, and pulse oximetry. Anesthesia was induced and maintained with propofol 3–4 mg ml⁻¹ and remifentanyl 3–4 ng ml⁻¹ administered via target controlled infusions (TCI) using an Orchestra infusion pump system (Fresenius Vial, Brezins, France). Rocuronium was administered to facilitate endotracheal intubation (0.6 mg kg⁻¹) and to maintain 1–2 twitches upon train-of-four stimulation of the ulnar nerve (0.15 mg kg⁻¹) with a peripheral nerve

stimulator (TOF Watch SXw, Organon Ltd, Dublin, Ireland) in all patients. Endotracheal intubation was performed by experienced (at least 2 years) anesthesiologists using appropriately sized (internal diameter: 7.5 mm for males and 7.0 mm for females) reinforced endotracheal tubes (Mallinckrodt Covidien, Athlone, Ireland) with high-volume, low-pressure cuffs. Immediately after intubation, the endotracheal tube cuff was inflated with room air. Patients were ventilated with oxygen and medical air (FiO₂ 0.5) to maintain an end-tidal CO₂ of 35–40 mmHg. To avoid a significant increase in the cuff pressure, nitrous oxide was not used during anesthesia [9]. After surgery, neostigmine 0.04 mg kg⁻¹ and glycopyrrolate 0.01 mg kg⁻¹ were administered to reverse the neuromuscular blockade. Extubation was performed after gentle suctioning of the oral cavity and deflation of the cuff, when the patients had recovered fully and awakened. The patients were transferred to the post-anesthesia care unit.

Randomization and intervention

Before the induction of anesthesia, an independent anesthesiologist who was in charge of patient allocation performed randomization with a computer-generated random number table (Random Allocation Software Version 1.0) with block size 4 to randomly assign patients to the control (group A, $n = 45$) or experimental (group B, $n = 45$) group. The patients and outcome assessors were blinded to the group B assignments. However, the anesthesiologist responsible for caring for the patient during anesthesia was not blinded to the group assignments. Intervention according to the group assignment was as follows:

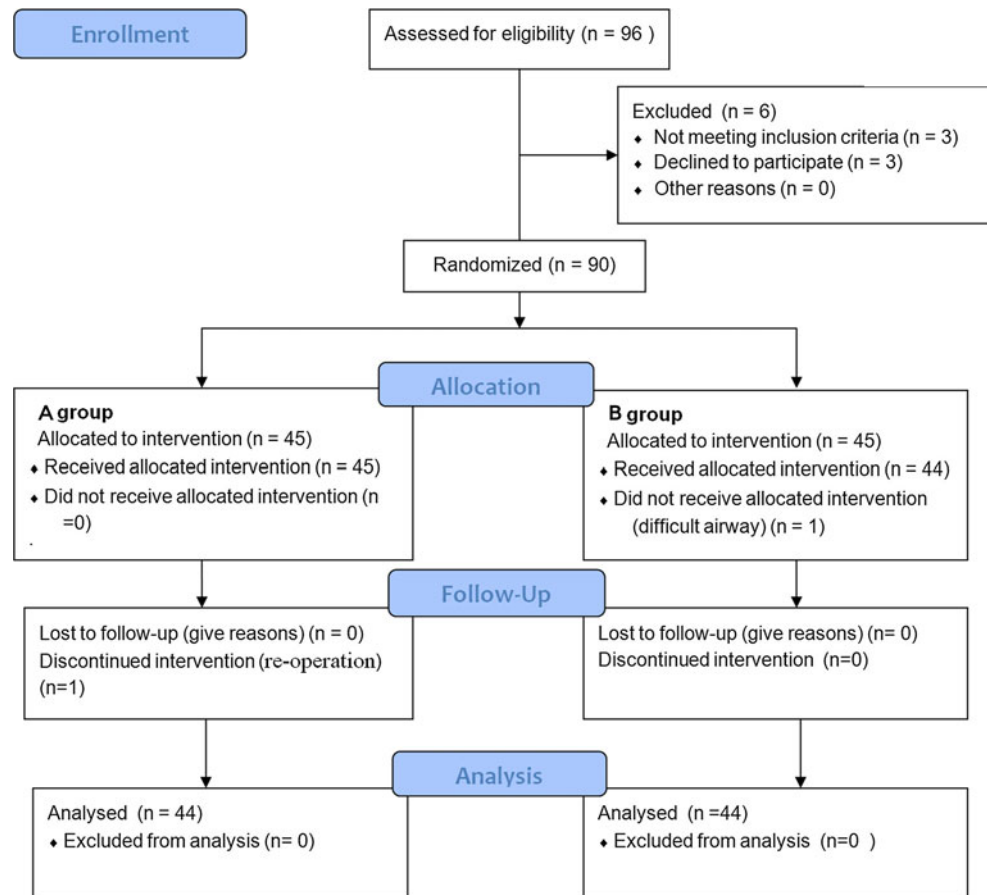
Group A: The endotracheal tube cuff was initially set to approximately 25 cm H₂O. After the initial inflation, the cuff pressure was monitored continuously with a calibrated cuff manometer (Portex, Smiths Medical, Germany), but was not adjusted during the thyroidectomy other than to maintain the cuff pressure within the range of 20–50 cm H₂O, in order to avoid pulmonary aspiration [11] or tracheal mucosal injury [12].

Group B: The endotracheal tube cuff was initially inflated and then adjusted to achieve a cuff pressure of approximately 25 cm H₂O. The cuff pressure was monitored continuously and maintained at 25 cm H₂O [13] with a manometer throughout thyroidectomy.

Assessment of outcomes

The primary endpoint of this study was the incidence and degree of POST. Secondary objectives were the incidences of hoarseness, dysphasia, and cough; POST was defined as pain at larynx or pharynx; dysphagia was defined as difficulty in swallowing; hoarseness was defined as a harsh or

Fig. 1 Flow diagram of the patients. Ninety patients were randomized and two patients were excluded from final analysis due to difficult intubation (one patient from group B) and reoperation (one patient from group A). A group: control group, B group: experimental group (adjusting cuff pressure group)



strained voice; cough, as a sudden reflex that forces air out of the throat.

The incidences of POST, hoarseness, dysphasia, and cough were evaluated at 2 and 24 h postoperatively by an independent observer who was unaware of the group assignments. In addition, the degree of POST was evaluated with a questionnaire [14]. Mild POST was defined as less severe than that noted with a cold; moderate POST was defined as similar to that noted with a cold; severe POST was more severe than that noted with a cold [14].

Statistics

In a previous study, the incidence of POST at 24 h after thyroidectomy was 65 % in the control group [1]. A decrease in the incidence of POST from 65 to 35 % was considered to be clinically relevant, and a group size requirement of 41 patients was calculated with a power of 80 % and $\alpha = 0.05$. We enrolled 45 patients for each group, taking into consideration a 10 % dropout rate.

The data were analyzed with SPSS 15.0 for Windows (SPSS, Chicago, IL). Repeated measures analysis of variance (ANOVA) was used to compare the cuff pressure

between the two groups over time, and the *t*-test was used to compare the cuff pressure at each time point. Incidence variables (incidences of POST, hoarseness, dysphasia, and cough; degree of POST) were compared with the χ^2 test. Data are expressed as means (SD) or numbers of patients (%). A two-sided $P < 0.05$ was considered to indicate statistical significance.

Results

Ninety patients who underwent thyroid surgery from April 2012 to July 2012 were enrolled in this study, and 88 patients were included in the final analysis. Two patients were excluded from the analysis because of difficult intubation (one patient in B group) or reoperation due to postoperative bleeding (one patient in A group) (Fig. 1). The patient and surgery characteristics are summarized in Table 1.

Repeated-measures ANOVA revealed a significant difference in the cuff pressure over time between the two groups ($P < 0.01$); the cuff pressure was higher in group A than in group B, although there was no difference in the baseline cuff pressure between the two groups. In addition,

Table 1 Patient and procedure characteristics

Characteristic	Treatment groups ^a	
	A group (n = 44)	B group (n = 44)
Age, years	46.3 (11.3)	47.0 (14.5)
Male/female (%)	12 (27) / 32 (73)	14 (32) / 30 (68)
Weight, kg	62.8 (12.9)	62.5 (9.6)
Height, cm	163.4 (7.9)	162.2 (7.5)
BMI	23.3(3.6)	23.6 (2.9)
ASA class (I/II)	33 (75) / 11 (25)	29 (66) / 15 (34)
Indication of thyroidectomy (%)		
Thyroid cancer	41 (93)	36 (82)
Hyperthyroidism	0 (0)	1 (2)
Thyroid nodule	3 (7)	7 (16)
Duration of operation, min	100.2 (47.8)	98.1 (61.2)
Duration of intubation, min	120.5 (52.4)	118.0 (62.7)
Duration of anesthesia, min	134.6 (53.2)	131.5 (62.8)
Inner diameter of endotracheal tube, mm		
7.0 / 7.5	38/ 5	38/ 6
Anesthesiologist experience		
1–3 years	31 (72)	31 (70)
More than 3 years	12 (28)	13 (30)
Type of operation		
Hemithyroidectomy	3 (7)	5 (11)
Total thyroidectomy	1 (2)	3 (7)
Hemithyroidectomy with neck dissection	4 (9)	8 (18)
Total thyroidectomy with neck dissection	36 (82)	28 (64)

Values are given as mean (SD) or number of patients (%)

^a A group: control group, B group: adjusted endotracheal tube cuff pressure group

BMI body mass index, *ASA* American Society of Anesthesiologists

the intragroup analysis showed that there was a significant change in the cuff pressure in group A during anesthesia ($P < 0.05$) (Fig. 2). The mean cuff pressure during surgery was 30.6 (2.2) cm H₂O in group A and 24.8 (1.4) cm H₂O in group B ($P < 0.001$).

There was a significant difference in the incidence and degree of POST between groups B and A. The incidence of POST was lower in group B than in group A at 2 h (61 % vs. 86 %; $P = 0.008$) and 24 h (43 % vs. 66 %; $P = 0.032$; Table 2) postoperatively. In addition, the POST in group B was less severe than that in group A at 2 h postoperatively ($P = 0.043$; Table 3). By contrast, the incidences of hoarseness, dysphagia, and cough were comparable between the study groups at both 2 and 24 h postoperatively (Table 2).

Discussion

We evaluated the effect of adjusting cuff pressure of the endotracheal tube during anesthesia on the incidences of airway complication after thyroidectomy. Continuous monitoring of the cuff pressure in critically ill patients showed that the cuff pressure decreased slightly over time without intervention [13, 15]. Interestingly, the cuff pressure in the control group was slightly increased during thyroidectomy after the initial adjustment of 25 cm H₂O. This phenomenon may be explained by the fact that the thyroid is adjacent to the trachea. In a previous study, the incidence of POST and blood-streaked sputum was high in patients with excessive intraoperative cuff pressures [16]. The high incidence of POST after thyroidectomy may be attributable to the mechanical compression of the trachea and consequent increase in cuff pressure during manipulation of the thyroid. Therefore, monitoring and controlling the cuff pressure during thyroidectomy is recommended to prevent overinflation of the endotracheal tube cuff [9].

The incidences of hoarseness, dysphagia, and cough were similar between the two groups. This is in line with previous results [9] and suggests that these symptoms are not associated with the cuff pressure. Hoarseness results from edema of the vocal cords or mechanical injury to the glottic area [16]. Therefore, the application of cricoid pressure during laryngoscopy and the avoidance of forcible intubation have been shown to reduce the incidence of hoarseness [4]. In a study of patients undergoing anterior cervical spine surgery, dysphagia was not related to the cuff pressure, but rather to the duration of neck retraction, whereas increased cuff pressure during neck retraction influenced the incidence of POST [17].

In addition to the use of endotracheal tubes for general anesthesia, several risk factors are associated with the incidence of POST. Higgins et al. investigated the risk factors for POST after ambulatory surgery and reported that airway management, female sex, younger age, gynecologic surgery, and succinylcholine were related to the occurrence of POST [7]. Of these, airway management had the greatest influence on the incidence of POST [7]. Manipulation of the thyroid during surgery stimulated the adjacent trachea and increased the cuff pressures in the control group. Most of the patients undergoing thyroidectomy in our study were female (73 % of the controls and 68 % of the adjusted group) due to the epidemiology of thyroid disease [18]. As there was no difference in the risk factors for POST, including age and gender, between our two study groups, the difference in the incidence of POST may be explained by the difference in the cuff pressure.

One limitation of our study was that the incidence of coughing during endotracheal intubation or extubation was

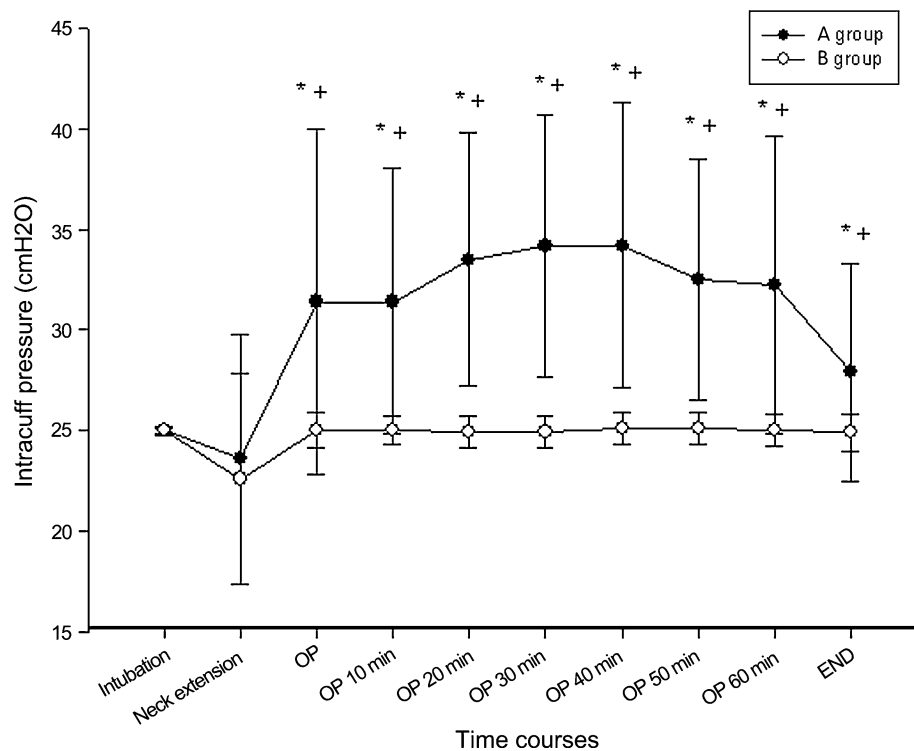


Fig. 2 Changes in the cuff pressure during thyroidectomy. There was a significant difference in the cuff pressure over time between the two groups ($P < 0.01$); the cuff pressure was higher in group A than in group B, although there was no difference in the baseline cuff pressure between the two groups. In addition, the intragroup analysis showed that there was a significant change in the cuff pressure in

group A during anesthesia ($P < 0.05$). Results are expressed as means (SD). A group, control group, B group: experimental group (adjusting cuff pressure group). * $P < 0.05$ compared with group A. † $P < 0.05$ compared with baseline

Table 2 Incidences of postoperative sore throat (POST), hoarseness, dysphagia, and cough

	Treatment groups		<i>P</i> value
	A group (<i>n</i> = 44)	B group (<i>n</i> = 44)	
Postoperative 2 h			
POST	38 (86)	27 (61)	0.008
Hoarseness	25 (57)	26 (59)	0.829
Dysphagia	39 (89)	36 (82)	0.367
Cough	8 (18)	5 (11)	0.367
Postoperative 24 h			
POST	29 (66)	19 (43)	0.032
Hoarseness	24 (55)	24 (55)	1.000
Dysphagia	31 (71)	34 (77)	0.467
Cough	7 (16)	7 (16)	1.000

Values are presented as number of patients (%)

A group: control group, B group: adjusted endotracheal tube cuff pressure group

not recorded, although no difference was observed based on the impressions of the anesthesiologist. The degree of coughing or bucking during intubation or extubation is related to the incidence of POST [19]. Second, no

Table 3 Severity of POST

Grade of discomfort	Treatment groups		<i>P</i> value
	A group (<i>n</i> = 43)	B group (<i>n</i> = 44)	
Postoperative 2 h			0.043
None	6 (14)	17 (39)	
Mild	5 (11)	6 (14)	
Moderate	17 (39)	12 (27)	
Severe	16 (36)	9 (20)	
Postoperative 24 h			0.180
None	15 (34)	25 (57)	
Mild	16 (36)	11 (25)	
Moderate	5 (12)	4 (9)	
Severe	8 (18)	4 (9)	

fiberoptic bronchoscopy was performed to compare tracheal mucosal injury between the two study groups.

In conclusion, there is a significant change in the cuff pressure due to manipulation of the thyroid during thyroidectomy. Adjusting the cuff pressure during surgery decreased the incidence and degree of POST. Intraoperative

monitoring and adjustment of cuff pressure is needed to reduce POST, especially in thyroidectomy patients.

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