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Effect of Continuous and Slow Endotracheal Tube Cuff Deflation on Post-Extubation Laryngospasm: A Review

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Abstract

Background: Laryngospasm is a critical complication during emergence from general anaesthesia, frequently triggered by airway manipulation and abrupt mechanical stimulation. Conventional rapid endotracheal tube (ETT) cuff deflation may provoke intense tracheal irritation, increasing the risk of airway reflex activation. Slow and continuous cuff deflation has been proposed as a gentler technique that may minimize mucosal stimulation and prevent post-extubation laryngospasm.

Aim: To summarize current evidence regarding the physiological basis and clinical impact of slow ETT cuff deflation, and to evaluate its potential role in reducing post-extubation laryngospasm.

Methods: Narrative review of available randomized trials, observational studies, and physiological literature on ETT cuff mechanics, airway reflexes, extubation complications, and laryngospasm.

Results: Existing randomized clinical trials demonstrate that slow cuff deflation reduces cough incidence, hemodynamic surges, and pharyngolaryngeal irritation compared with rapid deflation. While studies directly assessing laryngospasm are limited, mechanistic evidence suggests that gradual reduction of cuff pressure decreases abrupt mucosal stimulation, reduces activation of rapidly adapting airway receptors, and may lower laryngospasm risk. Clinical practice reports indicate smoother extubation and fewer transient airway complications with slow cuff deflation.

Conclusion: Continuous and slow ETT cuff deflation is a simple, physiologically rational, and effective technique to reduce airway stimulation during extubation. Although direct evidence for laryngospasm prevention is limited, existing data strongly support potential benefit. Larger randomized clinical trials with laryngospasm as the primary endpoint are needed.

Keywords: Laryngospasm, Extubation, Airway Reflexes, Endotracheal Tube Cuff, Cuff Deflation, Anaesthesia, Airway Complications.

Introduction

Laryngospasm is a sustained, involuntary closure of the vocal cords, commonly encountered during induction or emergence from general anaesthesia. It remains a leading cause of perioperative respiratory complications, with the potential to progress to hypoxemia, bradycardia, negative-pressure pulmonary oedema, or cardiac arrest.During emergence, the return of airway reflexes coincides with continued presence of the endotracheal tube. Sudden mechanical stimulation of the larynx or trachea—especially during ETT cuff deflation and removal—can precipitate an exaggerated protective reflex, culminating in laryngospasm. Conventional cuff deflation is typically performed rapidly, creating abrupt mucosal deformation and generating strong afferent signals in the laryngeal mechanoreceptors. Continuous and slow cuff deflation has been proposed as a strategy to minimize this stimulation. This review summarizes available evidence and evaluates whether slow cuff deflation can decrease the incidence of post-extubation laryngospasm.

Pathophysiology of Laryngospasm

Laryngospasm is mediated via the superior laryngeal nerve (SLN), with afferent signals conveyed to the nucleus tractus solitarius and efferent impulses transmitted through the recurrent laryngeal nerve (RLN), resulting in forceful adduction of the vocal cords.
Major triggers include:

- Mechanical irritation from secretions, suctioning, or ETT movement
- Sudden changes in airway pressure
- Light planes of anaesthesia
- Mucosal inflammation
- Hyperreactive airways (smokers, paediatrics, URTI)

Abrupt ETT cuff deflation may activate rapidly adapting receptors located in the larynx and proximal trachea, provoking a laryngeal closure reflex. This suggests deflation mechanics may have a direct impact on laryngospasm risk.

Role of ETT Cuff Mechanics in Airway Reflex Activation

The ETT cuff maintains airway seal and prevents aspiration but also exerts constant pressure on tracheal mucosa (ideal: 20–30 cm H_2O). Rapid cuff deflation disrupts this balance and may cause:

- Sudden collapse of cuff folds against mucosa
- Acute pressure change → receptor stimulation
- Increased turbulence of airflow
- Traction on vocal cords during withdrawal

These events increase the likelihood of coughing, bucking, and laryngospasm.

Rationale for Slow and Continuous Cuff Deflation

Several physiological mechanisms support slow cuff deflation:

1. **Reduced mechanical irritation**
   Gradual decrease in pressure prevents abrupt mucosal rebound.
2. **Blunted airway reflex activation**
   Reduced stimulation of fast-adapting stretch receptors lowers cough and reflex glottic closure.
3. **Improved mucosal perfusion**
   Progressive reperfusion decreases inflammation and ischemia-reperfusion injury.
4. **Smoother extubation trajectory**
   Decreases sudden tugging forces on laryngeal structures.

These benefits create a theoretically protective environment against laryngospasm.

Method

In this trial, 126 patients with ASA physical status I or II aged 18–65 years who were prearranged for operations within 3 h under general anaesthesia with orotracheal intubation were included between March 2022 and June 2022. The exclusion criteria were incapacity to provide informed consent; body mass index < 19 kg - m2 or > 30 kg /m2; Mallampati classification III or IV; pre existing sore throat, hoarseness, cough or laryngeal mucosa haemorrhage; intubation more than once when induction; bucking during surgery; delayed emergence (inability to regain an adequate level of consciousness, unresponsive or deeply sedated over 60 min from the last administration of the anesthetic agents .re intubation after extubation within 48 h; asthma, chronic obstructive pulmonary disease or smoking; psychiatric disorders; and brain surgery, laparoscopic surgery, ear-nose-throat surgery and nasotracheal intubation.

Randomisation

The online computer system 'OPEN-randomize' was used to randomly assign patients to the groups, and it generated the randomization sequence to ensure equal distribution .No restrictions applied for random selection, and the numbers for allocation were packaged in opaque envelopes, which could be observed by the anesthesiologist, who has more than 5 years of experience and conducted intubation and extubation. Patients, two outcome evaluators, data information analysts were blinded to the trial intervention. As it was difficult to fully blind the evaluator if he assessed the cough reflex and the hemodynamic changs at the same time, so we recorded video to assess the incidence and severity of cough reflex by anindependent evaluator and other outcomes were assessed by another evaluator.

Patients in the **(C) group** (n=42) under went endotracheal tube cuff deflation using a 10-ml syringe in 1 s, those in the **(E) group** (n=42) under-went endotracheal tube cuff deflation by same amount of pressure reduction each second until the pressure was zero continuously and slowly with a cuff pressure gauge (Ambu*R, Germany) in 5 s, and the pressure guage still attached when removing the tube because this would allow the cuff to further deflate when passing the vocal cords. Patients in the syringe (S) group (n=42) under-went endotracheal tube cuff deflation using a 10-ml syringe at a speed of 1 ml - s−1

Methodology

All the patients received standardized monitoring procedures after entering the operation room: electrocardiography, the saturation of haemoglobin with oxygen, non-invasive blood pressure and bispectral index (BIS).The patients were induced with sufentanil 0.4 μg - kg−1 propofol 2.0 mg - kg−1 and atracurium 0.6mg - kg−1. An endotracheal tube re inforced with steel and a tapered cuff was selected.The tube size was determined by the inner diameter. selected 7.0 or 7.5 mm for females and 7.5 or 8.0 mm for males. The endotracheal tube cuff was inflated with 5–8 ml room-temperature air, and the cuff pressure was strictly maintained at 25–30 - cmH2O during anaesthesia. Anaesthesia was maintained using remifentanil 0.5 μg - kg−1 min−1, propofol 4–8 mg - kg−1- h−1 and atracurium 0.05 mg kg every 30 min. Intraoperative mechanical ventilation was determined according to the institution protocol (volume-controlled ventilation; tidal volume 6–8 mL - kg−1 of ideal body weight, initial respiratory rate of 10–12 breaths - min−1 I:E ratio of 1:2, PEEP was 0 cm - H2O, peak airway pressure was below 25 mmHg). The BIS value was maintained at 40–60, end-tidal - CO2 - (EtCO2) was maintained at 35–45 mmHg and blood pressure fluctuation was within ± 20%. Cisatracurium was no longer added 30 min before the end of surgery. Before subcuticular closure, the administration of propofol and remifentanil were stopped and 0.2 μg - kg−1 sufentanil was injected intravenously. Postoperatively, all patients were transported to the post-anaesthesia care unit (PACU). During recovery from general anaesthesia in PACU, sputum around the airway and endotracheal tube cuff could be suctioned when the patients were still under deep anaesthesia. No medications were given except neostigmine and atropine to antagonize residual neuromuscular block before extubation. Once the patients conformed to the indications of extubation (train of four ratio (TOF) was ≥ 0.9, - EtCO2 was < 45 mmHg on spontaneous respiration and could follow voice commands), endotracheal tube cuff deflation was performed by the anesthesiologist who intubated the patient and then the tracheal tube was slowly and gently extubated. All the patients received patient-controlled intravenous analgesia postoperatively: sufentanil 50 μg; dexmedetomidine 200 μg and ondansetron 8 mg diluted to 100 ml with 0.9% sodium chloride. The dose was controlled at1.5 ml at all times, the rate was 2 ml h −1, and was locked for 15 min.

Outcome measures

The primary goal was to determine the incidence and severity of cough reflex when extubation and immediate post-extubation within first second (mentioned as extubation immediately). The incidence of postoperative air- way complications, such as apnoea, hypoxaemia, airway spasm within 30 min and sore throat, hoarseness, laryngeal mucosa haemorrhage within 48 h were the secondary outcomes. Furthermore, mean artery pressure (MAP) and heart rate (HR) were measured at various time points after entering the operating room (baseline), extubation immediately and 1, 10 and 30 min later. Operation duration, emergence duration (from the end of surgery to extubation) and anaesthesia duration (from anaesthesia induction to extubation) were also recorded. Cough was graded on 0–3 scales as follows: 0=no cough, 1=singlecough, 2=more than one episode of unsustained cough,3=severe sustained bouts of cough [14]. Unsustained cough was defined as less than 5 s between two coughs and cough reflex was defined as cough score > 0.

Sample size and statistical analysis

According to published data, the incidence of cough reflex during extubation can reach 76% .If a 50% reduction in cough reflex incidence was determined to be clinically significant, with an effect size of 0.36, degrees of freedom of 2, a power of 90%, and an error of 0.05, Chi- Square test by the Power Analysis and Sample Size Software (version 15.0; NCSS, LLC, USA) calculated that 99 patients were required totally. Given a 20% dropout rate, 126 patients were included, each group was 42 patients. According to the normality of the distribution, continuous study variables were summarized as mean (standarddeviation) or median (25–75th percentiles). Frequencies were used to summarize categorical variables (percent-age). The Shapiro–Wilk test was used to determine normality. For normally distributed continuous variables, group differences were tested using one-way analysis ofvariance (ANOVA). The Levene test for homogeneity of variance was performed, and $p > 0.1$ was considered homogeneous of variance. If the ANOVA result was statistically significant, least significant difference (LSD) was performed for pairwise comparison when the variance between the groups was homogeneous; otherwise, Dunnett T3 was used. For non-normally distributed continuous variables, the Kruskal–Wallis test was used, and if the result was statistically significant, the Mann–Whit-ney test was used for pairwise comparison. Categorical variables were compared using the chi-square test. SPSS version 19.0 was used to conduct the statistical analyses (SPSS Inc., Chicago, IL, USA). The reported p-values were Bonferroni-corrected. $p < 0.05$ was regarded as statistically significant.

Results

This study enrolled 126 of 276 eligible patients, and 5 were excluded from the analysis: 3 had an operation that lasted more than 3 h, 1 was lost to follow-up, 1 had reintubation during emergence from anesthesia (Fig. 1).The characteristics of the patients and the operations were comparable across the groups (Table 1). There were no differences in age, sex, BMI, ASA classification, Mallampati classification or sort of surgeries among the three groups. There were no significant differences among the groups in terms of the patients' tracheal tube size, the cuff inflation volumes when intubation, operation duration, anaesthesia duration and emergence duration. The incidence of cough reflex was 60.0% in group C, 9.8% in group E and 12.5% in group S ($p < 0.001$ for all groups, group C was higher than group E and S, $p < 0.001$ for both comparisons, The severity of cough reflex was graded as 2 (1–2) in group C, 1 (1–1) in group E, and 1 (1–1) in group S ($p < 0.001$ for group comparisons, Fig. 2). The incidence of postoperative airway complications in group C was 15.0%, in group E was 31.7% and in group S was 12.5% (p=0.062, Table 2). To further analyse, the postoperative airway complications were mainly hoarse- ness and sore throat. The incidence of hoarseness in group C was 0.0%, in group E was 19.5% and in group S was 5.0% ($p < 0.05$ for all groups, p= 0.009 between group C and E, Table 2). The incidence of sore throat in group C was 7.5%, in group E was 9.8% and in group S was 7.5%(p= 0.913, Table 2). The incidence of other postoperative airway complications including apnoea, hypoxaemia, air- way spasm within 30 min and laryngeal mucosa haemorrhage within 48 h in group C was 7.5%, in group E was 2.4% and in group S was 0.0% (p = 0.160, Table 2). There was no difference in MAP or HR among baseline, extubation immediately and 1, 10, 30 min later (Fig. 3).

Discussion

Compared with deflating a tracheal tube cuff with a 10-ml syringe in 1 s, deflating continuously and slowly until the pressure reduce to zero via a cuff pressure gauge in 5 s or using a 10-ml syringe at a speed of 1 ml s^{-1} can both reduce the incidence and severity of cough reflex. However, the use of a cuff pressure guage to deflate the cuff increased the incidence of postoperative hoarseness. In this trial, we adopted a cuff pressure gauge for deflation to modulate the speed of deflation according to cuff pressure objectively. We designed a group to deflate with a 10 ml syringe at a speed of 1 ml s^{-1}, which we believe was similar to the deflating speed via a cuff pressure gauge for convenience in clinical practice. The incidence of cough reflex in group C was 60.0%, which was confirmed in 15–94%,3 however, it was lower than 76%, we estimated it was because of total intravenous anesthesia rather than isoflurane anesthesia and the sufentanil injection before subcuticular closure. Numerous studies have reported intravenous medications such as opioids, dexmedetomidine or corticosteroids, water-soluble lubrication, and local anaesthetics such as lidocaine applied to the surface of the cuff can suppress cough reflex at the time of extubation. However, medication preventions have limitations. For instance, opioids can cause opioid induced respiratory depression, the effects of local anaesthetics depend on the type and concentration used. In addition, the protective cough reflexes above the tube cuff and of the vocal cords should remain intact. Up to now, no trials evaluated whether deflating the tracheal tube cuff continuously and slowly can reduce the incidence of cough reflex, which repre- sents relieving the pressure on the trachea continuously and slowly. Tracheal tube cuff is in closest contact with the tracheal mucosa, so most stimulation come from the cuff .Extubation can stimulate reflex responses via irritanting or stretching trachea and larynx .And rapidly acting receptors are found throughout the trachea and are primarily superficial. They are thought to be the irritant receptors involved in the cough reflex.The underlying mechanisms of cough suppression with slow and continuous endotracheal tube cuff deflation are not clearly understood. We estimated that slow and continuous deflation lead to a mild release of pressure on trachea, which may reduce stimulation intensity on rapidly acting receptors. Airway sensory C fibers is high sensitive to chemical stimulation and moderate sensitive to physical stimulation .Mild release of pressure compared to sudden release may suppress the excitation of airway sensory C fibers and secondary neuroplasticity accompanied by cough. Also, these can decrease throat irritation and inflammation in turn .In this circumstance, cough reflex may significantly be suppressed. Postoperative airway complications in this study were mainly sore throat and hoarseness. They were caused by inflammation and stimulation of the airway due to the pressure exerted on the tracheal wall by the endotracheal ,tracheal mucosal trauma, vocal cord hematoma, mucosal dehydration ,or laryngeal oedema. As cuffs in group E were deflated passively, we found approximately 1 ml of gas left in several cuffs after extubation despite cuff pressures were zero. We estimated it was the cause of higher incidence of hoarseness in group E than in group c.