



Original Contribution

# Evaluation of pH on removed tracheal tubes after general anesthesia: a prospective observational study ☆, ☆☆☆, ★



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## Abstract

**Study objective:** Aspiration pneumonia is a complication of tracheal intubation and mechanical ventilation. We hypothesized that tracheal tubes removed after anesthesia that have an acidic pH may reflect latent regurgitation of gastric fluid.

**Design:** A prospective observational study.

**Setting:** Operating room.

**Patients:** Tracheal tubes removed from 200 patients (age range, 20–85 years) who had undergone general anesthesia with tracheal intubation and gastric tube placement were examined.

**Measurements:** To detect regurgitated gastric fluid on the tubes, we measured pH at 5 different points along the tubes and in the water in which the removed tracheal tubes were immersed.

**Main results:** Of the 200 removed tracheal tubes, 5 had an acidic pH. The tubes were used in patients who were in the prone (1 patients) or head-down (4 patients) position while under anesthesia. The incidence of acidic pH was significantly higher in patients who were in the prone (1/32) or head-down (4/56) position, compared with those in the supine (0/92) or lateral (0/20) position ( $P < .05$ ).

**Conclusion:** Acidic pH was found on about 2.5% of removed tracheal tubes. These tubes were used in patients who were in the prone or head-down position during general anesthesia, although they did not exhibit significant aspiration symptom. Anesthesiologists should be aware of the inherent risk of gastric fluid regurgitation when their patients undergo general anesthesia in these positions.

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## 1. Introduction

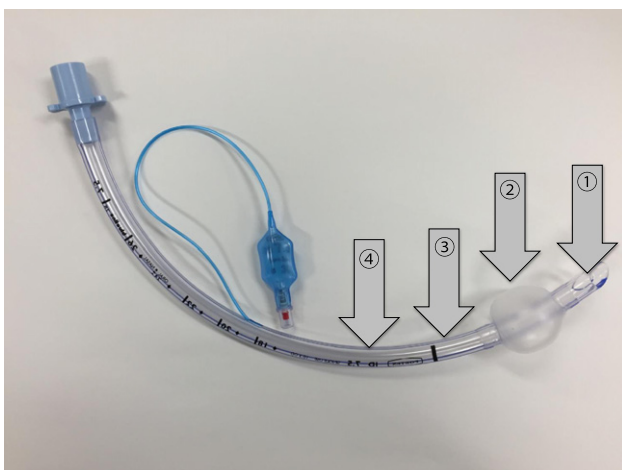
Aspiration pneumonia is a complication of tracheal intubation and prolonged mechanical ventilation [1]. Aspiration of gastric fluid, oropharyngeal pathogens, and leakage of contaminated fluid around the tracheal tube cuff into the lower respiratory tract are potential primary causes of ventilator-associated pneumonia in both adult and pediatric patients [2,3]. (See Fig.)

Numerous efforts have been made to reduce the incidence and severity of perioperative pulmonary aspiration, such as preoperative fasting, preoperative assessment of risk factors in perioperative pulmonary aspiration, emptying of the stomach, rapid-sequence induction of anesthesia with cricoid pressure, and the use of cuffed tracheal tubes [4,5]. These efforts have successfully reduced the incidence of pulmonary aspiration. Nevertheless, recent large-scale studies have found that perioperative pulmonary aspiration is the main cause of anesthesia-related death or irreversible brain damage [6].

Aspiration pneumonia is a nonnegligible cause of mortality associated with general anesthesia, and it is possible that this may be attributed, in part, to regurgitation of gastric fluid during general anesthesia [7-9]. For instance, latent gastric fluid regurgitation around the tracheal tubes could possibly lead to aspiration pneumonia. Thus, we hypothesized that tracheal tubes removed from patients may have an acidic pH, which may be indicative of undiagnosed regurgitation of gastric fluid. To test this hypothesis, we performed a prospective observational study to evaluate the pH on removed tracheal tubes after general anesthesia.

## 2. Methods

This study was approved by the research ethics committee of Osaka Medical College and was registered with the UMIN Clinical Trials Registry (UMIN000018210). From July 2015



**Figure** Evaluation of pH on the removed tracheal tube and pH evaluation points.

to February 2016, tracheal tubes removed from 200 patients (age range, 20-85 years) who had undergone general anesthesia were examined. In our routine clinical practice, 6 and 2 hours of fasting are required for food and water, respectively, before induction of general anesthesia. Exclusion criteria were a full stomach, gastroesophageal reflux, and anticipated difficult airways.

Percutaneous oxygen saturation, invasive blood pressure, heart rate, electrocardiography, and end-tidal carbon dioxide tension were monitored for each patient. Without any premedication, anesthesia was typically induced with a bolus, or continuous target-controlled infusion of propofol 1-2 mg/kg and remifentanyl 0.3-0.5  $\mu\text{g kg}^{-1} \text{min}^{-1}$ . Rocuronium 0.8-1.0 mg/kg was administered as a muscle relaxant [10]. We routinely use Portex Soft Seal (Smith Medical Co Ltd, Kent, United Kingdom) with patients in the supine or lateral position, and the Mallinckrodt spiral tracheal tube (Covidien, Dublin, Ireland) with patients in the prone position. Both tracheal tubes have a high-volume, low-pressure cuff, and cuff pressure is kept at 25 cm H<sub>2</sub>O after tracheal intubation. The size of the tracheal tube was determined by the staff anesthesiologist based on the formula: height/20 mm. In the prone position, the cuff was placed about 2 cm below the cords, as measured using the indicator on the tracheal tube, and fixed to the right side of the mouth. After intubation, we routinely insert a 16F or 18F gastric drainage tube to remove gastric fluid to the extent possible.

Anesthesia was maintained by continuous administration of desflurane or sevoflurane, remifentanyl, and rocuronium. The decision to use epidural block, peripheral nerve blockade, continuous fentanyl administration, or intravenous acetaminophen for postoperative analgesia was based on the discretion of the anesthesiologist.

After the operation, the continuous infusion of sedatives and analgesics was stopped, and the gastric drainage tube was removed after sufficient aspiration. Muscle relaxation was reversed with a sufficient dose of sugammadex, as recommended by the manufacturer. Extubation was performed when the patient recovered consciousness and sufficient spontaneous breathing. When removing the tracheal tube, pH was measured using pH test strips (pH 1-14 test tape; ASONE, Tokyo, Japan). To detect regurgitated gastric fluid on the tracheal tube, we measured pH at 5 different points along the tubes (Figure), as well as in the water in which the removed tracheal tubes were immersed [11].

Statistical analyses were performed with JMP 11 (SAS Institute Inc, Cary, NC). The  $\chi^2$  test was used to assess the incidence of acidic pH at various points along the tubes. Data are presented as mean  $\pm$  SD, or number of cases.  $P < .05$  was considered statistically significant.

## 3. Results

The mean age, height, and body weight of the 200 patients were  $62.6 \pm 15.2$  years,  $160.0 \pm 9.7$  cm, and  $59.9 \pm 10.8$  kg,

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