

Comparison of 2 Laryngeal Tracheal Anesthesia Techniques in Reducing Emergence Phenomena

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Endotracheal intubation (ETT) can cause emergence phenomena (EP) including coughing, sore throat, and dysphonia. Two methods used to prevent EP are the administration of local anesthetics directly onto airway structures using a specialized laryngotracheal instillation of topical anesthesia (LITA) tube (Sheridan Catheter Corporation, Argyle, New York) or the placement of a local anesthetic into the ETT cuff. The purpose of this study was to determine which method was better at preventing EP.

In this prospective, randomized, comparative analysis, a sample of 160 ASA class I through III patients were randomly assigned to receive their EP prophylaxes either by placement of alkalized lidocaine directly into the ETT cuff at intubation or by injection into a special-

ized port on the LITA tube approximately 30 minutes before extubation. Variables measured included the incidence and severity of sore throat, coughing, and dysphonia for the first 24 hours following surgery.

The incidence of cough and sore throat was higher in the LITA group, achieving significance in the postanesthesia care unit and after discharge to home. No difference in any of the other variables was noted between groups.

Our study demonstrated greater efficacy in decreasing the incidence and severity of EP by placing an alkalized solution of lidocaine into the ETT cuff on intubation.

Keywords: Alkalized, emergence phenomena, laryngotracheal, lidocaine.

Endotracheal tube-induced emergence phenomena (EP) include postoperative sore throat, cough, and dysphonia following general anesthesia.¹⁻⁷ The occurrence of EP ranges from 15% to 96%.¹⁻⁶ Potential causes of EP are thought to be mechanical irritation from the insertion of the endotracheal tube (ETT) and inflation of the cuff, positive pressure ventilation of the lungs, and chemical irritation caused by inhalational agents.^{8,9} This irritation activates lightly myelinated nociceptive fibers in the trachea, identified as rapidly acting stretch receptors, which are thought to be the principle mechanism eliciting ETT-induced EP.^{8,9} Laryngospasm, tachycardia, hypertension, cardiac ischemia, bleeding, and increased intracranial and intraocular pressures may result from postoperative sore throat and cough. In addition, patients may move and struggle because of EP causing harm by disrupting surgical sites and removing tubes and lines.^{1,2,9,10} Lastly, it is well documented that sore throat is a significant source of discomfort and dissatisfaction for postoperative patients.⁵

The strategies employed to diminish EP include local anesthetics,^{1-4,6} transdermal nonsteroidal anti-inflammatory drugs,¹¹ capsiicum plaster applied to an acupuncture point,³ sterile water or gel lubrication of the endotracheal

cuff,⁴ and extubation during a deep plane of anesthesia.¹⁰ The number and variety of these methods underscore the importance of identifying clinically successful interventions. Anecdotally, administration of local anesthetics appears to be one of the most common methods used by practitioners. Lidocaine may be the drug of choice because it has been administered safely to many patients and has a low adverse effect profile;¹² however, the methods of administration vary widely.^{1,2} Clinical studies have analyzed the effects of lidocaine sprayed topically, administered intravenously, and instilled through specially designed endotracheal tubes with varying levels of cough and sore throat suppression.^{1,2,4,7,12-16} Two promising and innovative methods of lidocaine administration are the filling of the endotracheal cuff with a lidocaine solution^{4,6,9,17-19} and the use of laryngotracheal-instilled topical anesthesia.^{10,14,20}

Repeated success has been demonstrated with the use of ETT cuffs as reservoirs to diffuse local anesthetics across the hydrophobic membrane.^{1,2,4,7,18} Early studies using large doses of lidocaine hydrochloride (200-500 mg) showed benefit in reducing EP, but diffusion across the membrane was slow and could be hazardous to the patient if the cuffs ruptured.^{21,22} To increase diffusion across the cuffs, practitioners began alkalizing the lido-

caine solution with sodium bicarbonate and reported that the rate of diffusion across the membrane increased more than 100%, resulting in a faster and steadier state of anesthesia on the airway structures.^{18,19,23} Because of this faster rate of diffusion lidocaine dose decreased dramatically, with as little as 40 mg achieving anesthesia when used with 3 mL to 7 mL of 8.4% sodium bicarbonate solution.^{4,7} In 2 separate investigations in which the ETT cuff was inflated with air or 40 mg of alkalized lidocaine, Estebe et al^{4,7} noted that the intracuffed lidocaine group experienced a 96% decrease in the incidence of sore throat during the first 24 hours and a 78% decrease in the incidence of cough, showing the efficacy of intracuffed lidocaine in reducing EP symptoms for the first 24 hours following surgery. Based on these results many practitioners began using this lidocaine and sodium bicarbonate admixture routinely to fill ETT cuffs to decrease EP symptoms in their patients; however, this process requires additional steps in ETT placement, precluding it from routine use in many anesthesia practices.

The Sheridan Catheter Corporation (Argyle, New York) introduced a specially designed ETT, the laryngo-tracheal instillation of topical anesthesia (LITA) tube, in 1992 (Table). The LITA has a specialized injection port at its proximal end that can be used to administer medications directly onto airway structures without breaking the integrity of the tube or placing a specific admixture into the ETT cuff. Studies have shown that a small volume of local anesthetic solutions can be administered easily, safely, and directly onto airway structures using the specialized port, resulting in a decrease in the incidence and severity of EP in a wide variety of patients.^{10,14,20}

Gonzalez et al¹⁰ performed the first study to evaluate the efficacy of the LITA tube. They compared the effect of 100 mg of intravenous (IV) lidocaine to 100 mg of lidocaine injected through the LITA tube specialized port on the incidence of immediate postoperative cough. Gonzalez et al noted that the patients given lidocaine via the LITA tube had a 51% reduction in postoperative cough compared with an 18% reduction in the IV administration group. Gonzalez et al concluded that the LITA tube is an effective and safe method that can be used easily to prevent immediate postoperative cough in patients receiving ETT intubation.

Diachun et al¹⁴ reported the efficacy of the LITA tube on postoperative cough in another study that compared the injection of lidocaine vs saline through the LITA specialized port in patients receiving ETT intubation. Diachun et al reported a 75% incidence of postoperative cough suppression in patients receiving lidocaine compared with an 18% suppression in patients administered normal saline. Diachun et al concurred with the conclusion reached by Gonzalez et al.^{10,14}

Based on the results of these studies many practitioners began using the LITA tube in their clinical practices.

Although these studies assessed the incidence of immediate postoperative cough, they did not adequately address the effect of the LITA tube on other EP symptoms, most notably sore throat and dysphonia. They also did not address symptoms beyond the immediate postoperative period. The studies in which intracuffed lidocaine was used did address these symptoms and followed the patients for an extended period of time leading to questions about the true efficacy of the LITA tube on long-term EP prophylaxis.

In review of the literature we could find no direct comparison studies between the LITA tube and intracuffed lidocaine, and because of the dissimilarities in the research designs used in the aforementioned studies we designed a study to compare the methods. To address the efficacy of the LITA tube on all EP symptoms beyond the immediate postoperative period our design included a 24-hour follow-up.

Materials and Methods

Following institutional review board approval and informed consent all patients scheduled for a surgical procedure of greater than 1 hour requiring general anesthesia and an ETT were approached for inclusion in this prospective, randomized study. Exclusion criteria included ASA class IV or above, age under 18 years, acute respiratory tract infection symptoms, nose and throat surgery patients, predicted difficult intubation (Mallampati class III or above), laryngeal-tracheal abnormalities, current treatment for gastroesophageal reflux disease, or requirement of a postoperative nasogastric tube. Informed consent was obtained from all enrolled patients. The patients were randomized using a computer-generated randomization process into either the LITA or intracuff group. The LITA group was scheduled to receive an instillation of 2 mg/kg of 4% lidocaine injected through the LITA port approximately 30 minutes before extubation, and the intracuff group was scheduled to receive 2 mL of 2% lidocaine (40 mg) plus 3 mL to 7 mL of 8.4% sodium bicarbonate injected into the ETT cuff at intubation.

Before initiation of this protocol all anesthesia and postoperative nursing care personnel were oriented to the parameters, methodologies, and evaluation tools of this study. Specific measurement variables were defined to include cough, sore throat, hoarseness, or dysphonia and dysphagia. Cough was defined as "the sudden expellation of air from the lungs with an explosive noise." Sore throat was defined as "discomfort and pain in the throat." Hoarseness or dysphonia was defined as "an alteration in the voice pattern, noted as a rough or harsh sound," and dysphagia as "difficulty in swallowing."

The anesthetic protocol used allowed for provider preference throughout; however, all medications were recorded and later evaluated for statistical significance.

	LITA group	Intracuff group	P value
Smokers (no.)	18	18	0.963
Surgical time, mean (SD), min	85 (56)	82 (53)	0.732
Anesthesia time, mean (SD), min	168 (66)	158 (63)	0.337
PACU time, mean (SD), min	40 (11)	44 (15)	0.081
SDSU time, mean (SD), min	166 (75)	159 (71)	0.629
Preoperative analgesic requirements, fentanyl, mean (SD), µg	57 (20)	49 (24)	0.193
Intraoperative analgesic requirements, fentanyl, mean (SD), µg	124 (50)	126 (52)	0.808
Age, mean (SD), y	34 (11)	35 (11)	0.640
Weight, mean, (SD), kg	83 (19)	86 (19)	0.238
Gender (no.)			
Male	37	44	0.215
Female	38	30	
Ethnicity (no.)			
White	51	53	
Black	12	19	
Hispanic	8	2	
Asian*	4	0	0.027*

Table. Patient Demographics

*Significant *P* value < .05. It is unclear if the ethnicity difference of *P* < .027 relates only to the Black cohort or is a metric of the combined subgroups given the 8/2 and 4/0 cohort differences.

Following induction of general anesthesia, an appropriate-sized ETT (6.0-8.0 mm internal diameter) was inserted using a standard direct laryngoscopy. All subjects assigned to the intracuff group had the ETT cuff inflated using a 2-step method. Step 1 was to inject 2 mL of 2% lidocaine solution (40 mg) and step 2 was to inject 3 mL to 7 mL of 8.4% sodium bicarbonate solution incrementally to achieve a minimal occlusive pressure less than or equal to 25 mm Hg with controlled ventilation. Subjects assigned to the LITA group were intubated using a similar technique, but the ETT cuff was inflated with 3 mL to 10 mL of normal saline solution to establish minimal occlusive pressure less than or equal to 25 mm Hg. Then the ETT was secured using a standard taping technique.

Initial minimal occlusive pressure for both groups was established by auscultating for an air leak over the suprasternal notch using a stethoscope. Minimal occlusive pressure was also measured in both groups using a Posey Quality cufflator #8199 (Posey Quality, Arcadia, California), recorded at intubation, and monitored every 30 minutes until extubation to ensure pressures were controlled at less than or equal to 25 mm Hg. All subjects were placed on volume control ventilation at 5 mL to 10 mL/kg to maintain an end-tidal carbon dioxide concentration of 30 to 40 mm Hg. Anesthesia was maintained using inhalational agents (isoflurane, sevoflurane, and desflurane, with or without nitrous oxide) and narcotic analgesics of provider preference. Volatile agent concen-

trations and medication doses were documented and later analyzed for statistical significance. A patient's requirement of placement of an oral or nasal gastric tube or a rigid oral airway during the surgical procedure was noted and recorded. Thirty minutes before extubation, the patients assigned to the LITA group received 2 mg/kg of 4% lidocaine (maximum dose, 200 mg) via the LITA tube injection port onto the laryngotracheal mucosa. Neuromuscular blockade was reversed if needed using neostigmine and glycopyrrolate.

Extubation was performed once the patient met standardized extubation criteria. The presence of cough was noted before extubation. All residual liquid was withdrawn from the ETT cuff during extubation and the volume was recorded. At time of extubation, all patients were assessed for the presence of EP symptoms (coughing, sore throat, dysphonia) in the operative suite for 4 minutes and then transferred to the postanesthesia care unit (PACU) for additional monitoring.

Upon admission to the PACU, an assessment of sore throat was performed by the anesthesia provider using the 0 to 10 verbal analogue scale (VAS) for which a score of 0 indicated "no pain or throat discomfort" and a score of 10 indicated "the worst imaginable sore throat or discomfort." These VAS measurements were obtained every 15 minutes thereafter by the PACU nurse until discharge from the PACU. All patients were observed for the presence of cough every 5 minutes for the first 15 minutes following

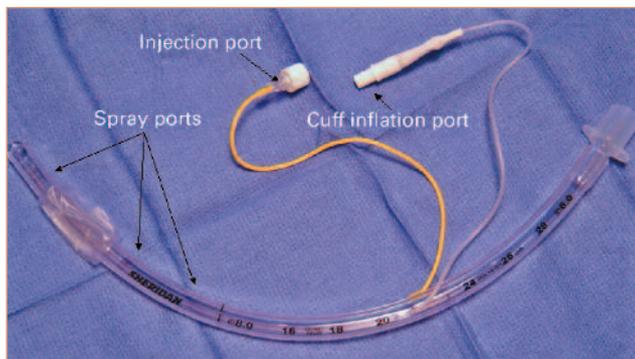


Figure 1. Laryngotracheal Instillation of Topical Anesthetic (Sheridan Catheter Corporation, Argyle, New York)

PACU admission and every 15 minutes thereafter until discharge. The presence of a cough was recorded using a binary yes/no scale. Evaluations of other symptoms of emergence phenomena (hoarseness and dysphonia) were also noted and recorded. Immediately before discharge from the PACU all patients were evaluated for the presence or absence of a swallowing reflex or dysphagia by asking them to chew and swallow ice. If the swallowing reflex was absent, the patient would remain in the PACU until the reflex returned to normal.

Following discharge from the PACU all patients were transported to the same day surgery unit (SDSU), where the incidence of cough and sore throat was noted and recorded by the SDSU nurse using a similar method as in the PACU. All patients were also evaluated for sore throat on admission and discharge from the SDSU using the 0 to 10 VAS scale. All SDSU data was noted and recorded on a data collection sheet. While the patient was in the PACU and SDSU all supplemental medication requirements for the treatment of pain were noted and analgesics were converted to morphine equivalents before data analysis. All incidences of postoperative nausea and vomiting and antiemetic medications were noted and recorded. All patients were discharged from the SDSU to home or admitted to an inpatient ward with instructions to note any incidence of EP (sore throat, cough, dysphonia, dysphagia) and to report it during the postoperative follow-up phone call each patient would receive approximately 24 hours following discharge from the hospital.

In the follow-up phone calls, investigators asked patients to rate their level of sore throat discomfort using the 0 to 10 VAS scale and note the presence of cough or dysphonia they experienced since discharge from the hospital. In addition, investigators asked the patients to rate their overall levels of satisfaction regarding their anesthetic experience using a 1 to 5 point Likert scale, in which a 1 indicated “total dissatisfaction” and a 5 indicated “complete satisfaction.” If the patient had been admitted overnight, the same information was collected at the patient’s bedside.

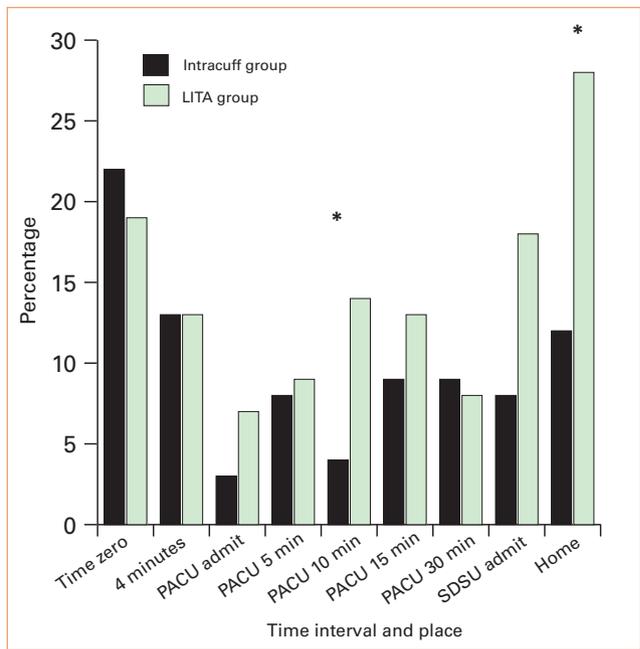


Figure 2. Incidence of Cough

PACU indicates postanesthesia care unit, SDSU, same day surgery unit.

* Significance $P < .05$

Data analysis was accomplished using descriptive and inferential statistics. Results are presented as mean (SD), median (range) or frequency. Data were analyzed using an unpaired student’s t test for parametric data and a Mann-Whitney test for nonparametric data. Frequency of event data was evaluated using a χ^2 test. Correlational data was evaluated using a Pearson correlation coefficient. A P value of less than .05 was considered significant.

Before initiation of this investigation a sample size calculation was performed using a 2-proportion power analysis and existing data that indicated a 40% incidence of immediate postoperative cough in the intracuff group and a 25% incidence in the LITA group.¹⁴ Using an α level of .05 and a β level of .20 we determined that we would need 72 patients per group to achieve significance. Factoring in a 10% attrition rate this increased our sample size requirements to 80 patients per group (160 total).

Results

A total of 160 patients were enrolled in this investigation but 11 patients were withdrawn because of: protocol violations (5), procedural cancellations (3), unanticipated difficult intubations (2), and postoperative intensive care unit admission (1), leaving 149 patients for final analysis. The postoperative intensive care unit admission was due to a surgical complication. The only study-related adverse event was 1 report of dysphagia in the LITA group that was noted on extubation and that resolved spontaneously before discharge from the PACU. This 1 adverse event was attributed to the patient receiving

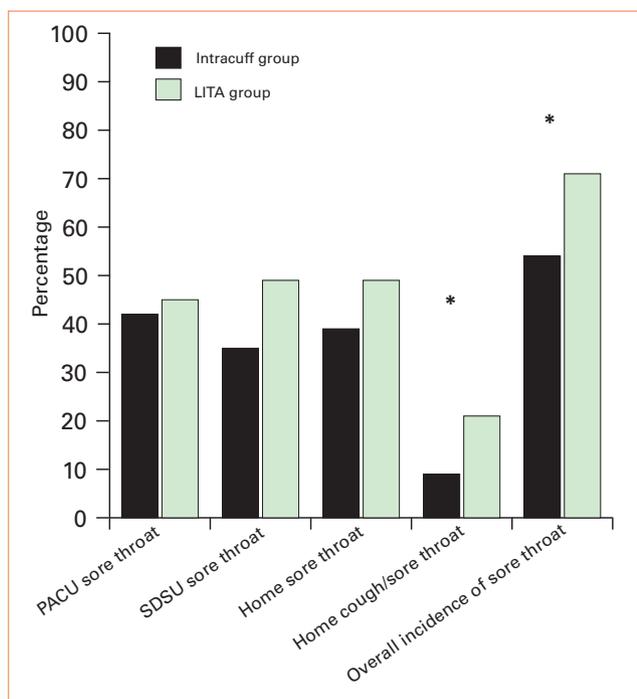


Figure 3. Incidence of Sore Throat and Home Cough/Sore Throat

PACU indicates postanesthesia care unit; SDSU, same day surgery unit.

* Significance $P < .05$

more than 200 mg lidocaine via the LITA tube based on his weight of more than 100 kg. This event occurred early in the study, and, as a result, the investigators changed the protocol to limit the dose of lidocaine administration via the LITA to 200 mg. No further incidences of early onset dysphasia were noted.

No differences between the groups in history of smoking; surgical, anesthesia, PACU, and SDSU times; preoperative and intraoperative analgesic requirements; and demographic variables, with the exception of ethnicity, were noted (Figure 1). No differences in use of an oral airway, laryngoscopy attempts, laryngoscopy blade used, surgical procedure performed, volatile agent administered, or intraoperative antiemetic requirements were noted. A difference was noted when intraoperative orogastric tube placement was analyzed. In the intracuff group, 18 patients (24%) had an orogastric tube placed compared with 31 patients (41%) in the LITA group ($P = .046$). A subanalysis revealed, however, that no correlation existed between the use of an intraoperative orogastric tube and any of the variables of interest ($P > .05$).

Analysis of postoperative cough found no differences between the groups within the first 4 minutes following extubation, but there was a difference later in the PACU. The overall incidence of cough in the PACU was higher in the LITA group (28%) compared with the intracuff group (16%) but only reached statistical significance at 10

minutes following admission ($P = .042$). In the SDSU the incidence of cough was higher in the LITA group (17%) compared with the intracuff group (8%) but did not achieve statistical significance ($P = .91$). Following discharge to home, 28% in the LITA group reported cough within the first 24 hours following surgery compared with 12% in the intracuff group ($P = .016$) (Figure 2).

A higher incidence of sore throat was reported in the LITA group compared with the intracuff group at all time intervals, but the incidence did not achieve statistical significance ($P > .05$). When the overall incidence of sore throat was analyzed, however, 71% of the LITA group had at least 1 incidence of sore throat during the study compared with 54% of the intracuff group ($P = .036$). A higher incidence of a combination of cough and sore throat was noted in the LITA group (21%) compared with the intracuff group (9%, $P = .045$) (Figure 3). The VAS scores were higher in the LITA group but did not achieve statistical significance ($P > .05$). The incidence of hoarseness was similar between the groups in all settings (PACU, SDSU, and home); however, following discharge to SDSU a higher incidence of dysphonia occurred in the LITA group ($n = 8$) compared with the intracuff group ($n = 2$), but did not achieve statistical significance ($P = .052$). Analgesic and antiemetic requirements were similar between groups. Both groups reported a median satisfaction score of 4 on a 1 to 5 scale, indicating they were satisfied with their anesthesia regimens.

Discussion

The prevention of EP is important because coughing and straining on emergence from anesthesia can have serious patient safety implications in the immediate postoperative period. Also, postoperative sore throat is one of the most frequent patient concerns following general anesthesia.^{3-6,11} Therefore, determining a simple method for the prevention of EP that can be easily implemented into clinical practice may result in higher patient satisfaction, lower postoperative morbidity, and possibly, lower institutional and patient costs.

Our initial hypothesis was that administration of lidocaine via the LITA ETT would be more effective than the intracuff method in EP prophylaxis; however, the results of our study did not support this hypothesis. We speculate that the intracuff method was potentially more effective than the LITA method because of time of exposure and site of application of the local anesthetic. Perhaps the net effect of slow, continuous diffusion of lidocaine across the polyvinyl chloride cuff directly onto the site of irritation from the ETT cuff provides preemptive analgesia with greater efficacy than the delayed application of lidocaine via the LITA method. The application of lidocaine via LITA tube with the cuff inflated conceivably prevents adequate distribution of the local anesthetic to the areas of the tracheal membrane that are in direct contact with

the ETT cuff.¹⁸ Thus an inadequate nociceptor blockade may result. Future researchers may consider deflating the ETT cuff before administration of lidocaine via the LITA tube to facilitate the spread of the local anesthetic to the affected tracheal structures.

During the data collection phase of our study, Estebe et al continued to refine the use of intracuff alkalinized lidocaine by evaluating the use of 8.4% sodium bicarbonate intracuff compared with a lower concentration of 1.4% sodium bicarbonate intracuff.²⁴ Citing the potential of tracheal irritation with cuff rupture, their purpose was to prepare the most efficient solution for delivering local anesthetic while approximating a physiologic pH. Initial tests were performed in vitro and demonstrated that the 1.4% sodium bicarbonate mixture had a slower rate of diffusion of lidocaine (15% at 3 hours) vs an 8.4% mixture (25% at 3 hours). In vivo evaluation, however, demonstrated no significant difference in EP between the 2 treatment groups, suggesting that using 1.4% sodium bicarbonate intracuff may be as effective as using 8.4% sodium bicarbonate.²⁴

Using the intracuff method of lidocaine application to the trachea is safe and effective because there have been no reports of cuff rupture in both in vivo and in vitro investigations. In addition, anesthesia is provided to a limited area within the trachea, thereby preserving the protective airway mechanisms.^{4,7,17,24}

Conclusion

In conclusion, the LITA group experienced more EP symptoms than the intracuff group, and we cannot recommend the LITA as a method to prevent EP. We do recommend using a solution of 40 mg lidocaine with 3 mL to 7 mL of sodium bicarbonate solution to reduce the incidence and severity of EP following general endotracheal anesthesia in surgical procedures of more than 60 minutes.

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