Intracuff buffered lidocaine versus saline or air – A comparative study for smooth extubation in patients with hyperactive airways undergoing eye surgery

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ABSTRACT

Background: Increased cough and restlessness during emergence from general anaesthesia in patients undergoing ophthalmologic surgical procedures might result in increased intraocular pressure, ruptured sutures and suprachoroidal haemorrhage, which can be detrimental to the outcome of surgery. In hyperactive airway patients, as the cough receptors are in the hypersensitised state, the patients tend to cough more frequently and violently during extubation. Hence, in such patients, we sought to determine the benefits of filling the endotracheal tube cuff with either buffered lidocaine, saline or air, so as to prevent endotracheal tube-induced coughing during emergence from general anaesthesia.

Methods: Seventy-five patients either with a history of chronic smoking or recently treated upper respiratory tract infections were randomly assigned into three groups (n = 25), based on the type of endotracheal tube cuff inflation, as follows: Group A (air), Group B (6 ml normal saline) and Group C (6 ml 2% lidocaine + 0.5 ml 7.5% sodium bicarbonate). A second, blinded anaesthetist, graded the extubation as: Grade 0 (no cough), Grade 1 (cough < 15 s) and Grade 2 (cough > 15 s).

Results: Extubation was smooth in Group C compared with Groups B and A (p < 0.0001). Further, the incidence of sore throat was found to be lower in both liquid groups, B and C, compared with Group A at 1 h (p < 0.0001) and 24 h (p < 0.01) postoperatively.

Conclusions: Injecting buffered lidocaine into the endotracheal tube cuff, produces smooth extubation even in patients with hyperactive airways as the cough receptors in the tracheal mucosa gets blocked by the increased diffusion of uncharged base form of the drug across the hydrophobic polyvinyl chloride wall of the cuff.

Introduction

Emergence from general anaesthesia is often complicated by endotracheal tube (ETT) induced coughing.1 In hyperactive airway patients, like chronic smokers and those with recently treated upper respiratory tract infections (URTIs), the receptors meant for cough reflex, the rapidly adapting stretch receptors (RARs), upper respiratory tract infections (URTIs), the receptors meant for patients, like chronic smokers and those with recently treated URTI to study the effect on hyperactive airways. Patients who were not intubated in the first attempt, patients on ACE inhibitors (having increased cough reflex sensitivity) and those in whom C3F8/SF6 gases were used for settling the detached retina (use of N2O has to be discontinued) were excluded from the study. The following routine ophthalmic protocol was followed in all the patients: glycopyrrolate 0.005 mg/kg IM and pentazocine 0.5 mg/kg IM were used for premedication. Routine monitoring included ECG, non-invasive arterial blood pressure (NIBP), pulse oximetry and capnography. Induction was achieved with propofol 1.5 mg/kg IV and intubation facilitated with vecuronium 0.1 mg/kg IV. Tracheal intubation was done with a high-volume, low-pressure ETT tube (Portex Ltd, UK). The sizes of the ETTs used were the following: for males 8.5 mm or 8.0 mm ID and for females 7.5 mm or 7.0 mm ID. The ETT cuff was lubricated with a water-soluble gel (K-Y jelly, Johnson and Johnson). Intubated patients were subsequently randomly divided into three groups based on the ETT cuff filling as:

- Group A: Air
- Group B: 6 ml normal saline
- Group C: 6 ml 2% lidocaine HCl + 0.5 ml 7.5% sodium bicarbonate

In all the patients the ETT cuff was filled depending upon the minimal occlusion volume (volume at which no palpable leak
was felt over the trachea) of each patient and care was taken to ensure that the starting cuff pressure was approximately 25 cmH$_2$O, measured using a high volume, low-pressure cuff manometer (Portex, UK).

Anaesthesia was maintained with N$_2$O/O$_2$ (70:30%) and 0.6% isoflurane. Further neuromuscular block was maintained with intermittent boluses of vecuronium (one-quarter of the intubating dose at half-hourly intervals) and lungs were ventilated with an Ohmeda ventilator attached with closed circuit, to maintain normocarbia. After surgery isoflurane was discontinued, the circuit was flushed with O$_2$ to remove residual inhalational agent, and residual neuromuscular block was reversed with neostigmine (0.05 mg/kg) and glycopyrrolate (0.01 mg/kg). Mechanical ventilation was maintained until swallowing or spontaneous ventilation resumed, and then assisted manual ventilation was done. Final ETT cuff pressure was recorded before extubation.

The patient was extubated when the following criteria were met: (1) spontaneous ventilation; (2) ability to follow verbal commands (eye opening or hand grip) and (3) ability to demonstrate purposeful movements. Just before extubation a second anaesthetist blinded to the study group was called in to demonstrate purposeful movements. Just before extubation a second anaesthetist blinded to the study group was called in to grade the extubation based on the occurrence of coughing following extubation as: Grade 0 – No cough; Grade 1 – Cough lasting for < 15 sec and Grade 2 – Cough lasting for > 15 sec. The incidence of sore throat at 1 h and 24 h postoperatively was noted by the second blinded anaesthetist. The degree of sore throat was assessed as: Score 0 – No pain; Score 1 – Tolerable (mild –moderate) and Score 2 – Intolerable pain (severe).

The p < 0.05, obtained by using Fischer’s exact test for two proportions, was considered statistically significant. A pilot study done. Final ETT cuff pressure was recorded before extubation.

Discussion

During anaesthesia with N$_2$O the cuff pressure increases with time as N$_2$O diffuses into it more rapidly than it diffuses out, because of the partial pressure gradient across the PVC membrane $^{10,12-16}$ When the cuff pressure exceeds the capillary perfusion pressure (30–40 mmHg) tracheal mucosal erosion occurs, resulting in sore throat postoperatively, $^{18-21}$ as evidenced in our study. By replacing air with liquid (saline/buffered lidocaine), cuff hyperinflation problems can be avoided $^{18,17-21}$ Rapidly adapting stretch receptors in the tracheal mucosa are believed to be the irritant receptors meant for cough. $^{7}$ These receptors are highly sensitive to mechanical stimuli like touch, displacement and stretch. $^{22-24}$ Tracheal intubation with ETT, cuff inflation and the resulting hyperinflation in turn stimulate these receptors, thus producing cough in normal patients during extubation $^{23,25}$ (ETT-induced cough). In chronic smokers and those with recently treated URTI the threshold stimulation for cough receptors is reduced. $^{24}$ Long-term smoking causes neutrophilic infiltrates in vulnerable smokers that sensitise the cough-sensitive nerves by the release of sensory neuropeptides and direct stimulation of the nerves/receptors. $^{21}$ Empey et al report cough threshold values

Table I. There were no statistically significant differences in age, weight, gender and total surgical duration among the groups.

The final ETT cuff pressure measured in Group A was significantly higher compared with that in Groups B and C, p < 0.0001. There was no statistical significant increase in final ETT cuff pressure compared with initial cuff pressure in both the liquid groups, B and C (see Table II).

Sixty-eight per cent of patients in Group C were extubated smoothly, whereas only 16% and 20% of patients in Group A and B respectively had smooth extubation, p < 0.0001 (see Figure 1). One patient in Group A had laryngospasm during extubation, which was managed by ventilating with O$_2$ using the bag and mask technique.

### Results

Demographic data of the three groups of patients are shown in Table I. There were no statistically significant differences in age, weight, gender and total surgical duration among the groups.

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### Table I: Demographic data

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Groups</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Age (years)</td>
<td>30.12 ± 11.96</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>20/5</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>55.80 ± 12.32</td>
</tr>
<tr>
<td>Number of smokers</td>
<td>16</td>
</tr>
<tr>
<td>Treated URTIs</td>
<td>9</td>
</tr>
<tr>
<td>Duration of surgery</td>
<td>137.80 ± 40.88</td>
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</table>

Values are expressed in Mean ± SD. URTIs: Upper respiratory tract infection

### Table II: ETT cuff pressures measured at the start and at the end of the surgery

<table>
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<tr>
<th>Parameter</th>
<th>Groups</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>Initial cuff pressure</td>
<td>24.92 ± 2.89</td>
</tr>
<tr>
<td>(cm H$_2$O)</td>
<td></td>
</tr>
<tr>
<td>Final cuff pressure</td>
<td>56.68 ± 10.59*</td>
</tr>
<tr>
<td>(cm H$_2$O)</td>
<td></td>
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</tbody>
</table>

Results are expressed in Mean ± SD

*p < 0.0001, †p > 0.05. Final ETT cuff pressure compared with initial cuff pressure.
The incidence of sore throat was significantly higher in Group A than in Groups B and C, both at 1 h, \( p < 0.0001 \), and 24 h, \( p < 0.01 \), post operatively (see Figures 2 and 3).

**Figure 1:** Incidence of patients with smooth extubation: cough lasting less than 15 sec and more than 15 sec

**Figure 2:** Incidence of patients with sore throat at 1 h postoperative time interval

**Figure 3:** Incidence of patients with sore throat at 24 h postoperative time interval
to be significantly low for up to two weeks following URTIs. However, it was recently reported that cytokines may suppress coughing during emergence from general anaesthesia. Simulation of these receptors also results in the release of substance P (which causes mucosal vasodilatation, plasma exudation and airway mucus secretion), calcitonin gene-related peptide (causes mucosal vasodilatation) and neurokinin A (causes bronchoconstriction).

Activation of RARs is believed to constrict airways. However, this view does not have a substantial basis and has been challenged. The sample size used in the present study may be too small to detect a significant difference in the incidence of laryngospasm between the groups during extubation – a rather uncommon finding.

Preventing ETT-induced cough is of utmost importance in patients undergoing eye surgery. Cough can increase the intracuff pressure up to 50 mmHg. The Valsalva effect produced by coughing can lead to vessel wall rupture due to a sudden increase in venous pressure, resulting in suprachoroidal haemorrhage (SCH), a serious complication following eye surgery. Cases of delayed non-expulsive type of SCH have been reported after trabeculectomy following straining and bucking at the time of extubation.

Intravenous and topical administration of lidocaine has been used to help reduce cough during emergence from general anaesthesia. Intravenous lidocaine (IVL) is known to suppress cough through its central nervous system depressant effect (cough centre in the medulla) and hence it requires a minimal serum concentration (> 3 µg/ml) to be effective. IVL produces delayed emergence from anaesthesia. Moreover, the efficacy of IVL in suppressing cough is of short duration (5–20 minutes).

Topical administration of lidocaine is known to produce its irritant effect long before its cough suppressant effect appears. Other disadvantages encountered with this technique are that it requires a specially designed instrument for its application and the tracheal mucosa in direct contact with the ETT cuff wall is effectively shielded from exposure to lidocaine applied by this technique.

Injecting lidocaine alone into the ETT cuff causes a low diffusion rate across the cuff (1% released during a 6-hour period). Higher doses of lidocaine (200–500 mg) are required to produce a clinical effect. Hence this had no advantages over saline, and could be dangerous if the cuff ruptures. By filling the ETT cuff with buffered lidocaine, diffusion of the unchanged base form of the drug occurred across the hydrophobic PVC walls of the ETT cuff. Lidocaine, as a weak base and lipophilic drug, binds avidly to the respiratory mucosa. The absorption characteristics of the mucosa, epithelial thickness, number of membrane pores and tissue pH also serve to delay absorption. Thus the tracheal mucosa in direct contact with the ETT cuff wall can be anaesthetised locally with a longer than expected effect of lidocaine and with intact supraglottic reflexes, preventing aspiration in these patients.

Butting the only effect in increasing the diffusion of the drug in our study but also allowed us to use lower doses of lidocaine (without exceeding the toxic limits). From our previous in vitro study, using high performance liquid chromatography, we found that by filling the ETT cuff with a mixture of 6% lidocaine HCl + 0.5 ml NaHCO3, the minimum concentration of lidocaine (Cm = 155 µg/ml) that is required for blocking the cough receptors was obtained at the end of 90 min across the cuff walls. Hence in this in vivo study we used the above lidocaine buffered mixture for filling the ETT cuff in patients undergoing surgery with a minimum duration of 90 min.

This technique can also be used for patients requiring postoperative ventilation, as it has been shown to have documented that ETT tolerance is improved significantly by filling the ETT cuff with buffered lidocaine. They might require lesser doses of narcotics for tube tolerance. Tracheostomised patients who have to keep the tube in for a long time and whose discomfort seems to arise mainly from the inflated cuff could benefit from use of this technique, as diffusion was found to occur across the tracheostomy tube cuff also.

The limitations to our study were the inability to include children, and surgical procedures lasting less than 90 min duration, since the minimum concentration of lidocaine that is required for activation of the cough receptors was obtained in our in vitro study at around a 90 min interval.

Conclusions

Intravenous buffered lidocaine into the ETT cuff not only reduces the incidence of sore throat but also enables improved ETT tolerance and helps in producing smooth extubation in patients with hyperactive airways.