Evaluation of pressure changes in a new design tracheal tube cuff, the Portex Soft Seal, during nitrous oxide anaesthesia

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We have measured pressure changes in a newly designed tracheal tube cuff, the Portex Soft Seal, during nitrous oxide anaesthesia compared with a Mallinckrodt Lo-Contour tube and a Portex Profile tube. The pressure increases in both control groups were significantly greater than those with the new design (P<0.0001 in each case). The mean increase in pressure in the Mallinckrodt Lo-Contour tube cuff was 9.9 (SD 3.4) mm Hg compared with 10.3 (1.8) mm Hg in the Portex Profile tube cuff and 2.1 (1.5) mm Hg in the Portex Soft Seal tube cuff. We conclude that the Portex Soft Seal cuff prevented a significant increase in intracuff pressure during nitrous oxide anaesthesia.

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The increase in pressure in a tracheal tube cuff during anaesthesia with nitrous oxide is well documented. Intracuff pressure increases steadily and reaches a level high enough to impede the microcirculation in the tracheal mucosa within 1 h. The Portex Soft Seal design is claimed to limit diffusion of nitrous oxide into the cuff. In this study, we have examined pressure changes in the tracheal tube cuff during nitrous oxide anaesthesia using the Portex Soft Seal tube compared with two controls, the Mallinckrodt Lo-Contour tube and the Portex Profile tube.

Method and results

After obtaining approval from the Ethics Committee and patient written informed consent, we studied 90 ASA I–II patients. The anaesthetic technique comprised oral oxazepam 10 mg as premedication, and induction with morphine 0.1 mg kg\(^{-1}\), propofol 2–3 mg kg\(^{-1}\) and vecuronium 0.1 mg kg\(^{-1}\). Tracheal intubation followed in 90–120 s. Anaesthesia was maintained using IPPV with 1–2% isoflurane and 66% nitrous oxide in oxygen. Size 7.5 mm id tracheal tubes were used for women and size 8.5 mm id for men. The procedures consisted of joint replacement (total knee replacement (n=37), total hip replacement (n=29)) and abdominal surgery (right hemicolecotomy (n=15), anteroposterior resection (n=9)).

Patients were allocated randomly to one of three groups. Group I had a Mallinckrodt Lo-Contour (Mallinckrodt Medical (UK) Ltd, North Portway Close, Round Spinney, Northampton, NN3 4RQ, UK) tracheal tube inserted, group II received a Portex Profile (SIMS Portex Ltd, Hythe, Kent CT21 6JL, UK) tracheal tube and group III had a Soft Seal Portex tracheal tube inserted. The Lo-Contour and Profile tubes were the standard tracheal tubes used in this hospital. The size of the cuffs was the same in all three groups. The tubes were not lubricated. Patients’ lungs were ventilated to an end-tidal carbon dioxide partial pressure of 4–4.5 kPa.

The trachea was intubated by the investigators and cuff pressure measurements were determined by independent anaesthetists (two consultants and one SpR). Using a 10-ml syringe, the tracheal tube cuffs were inflated with room air until the leak past the cuff ceased. Cuff pressure readings were performed at 5-min intervals for 60 min after switching off the ventilator to prevent changes in airway pressure from affecting cuff pressure. Cuff pressures were measured using a pressure transducer (Medex Medical transducer/Datex AS3 monitor) connected to the pilot tube via saline-filled manometer tubing. The transducers were zeroed to air and placed on the patient’s shoulder throughout the study. Patients were asked if they had any sore throat 24 h after operation.

Patients aged 18–70 yr were included. Exclusion criteria were those who required rapid sequence induction, laparoscopic surgery (because of inflation of carbon dioxide and possible diffusion into the cuff), the Trendelenburg position or an F\(_{\text{I}O_2}\) of more than 40%.

Differences between groups were assessed using Kruskal–Wallis analysis of variance, as the differences in pressure were not normally distributed. The chi-square test was used to compare the incidence of sore throat.

Patient characteristics are given in Table 1. The initial sealing pressure in the three groups was not significantly different (Table 1). The increases in pressure in groups I and II were significantly greater than those in the Soft Seal...
Table 1 Patient data (mean (SD or range)), initial sealing pressure and increase in pressure in the Mallinckrodt Lo-Contour tube (group I), Portex Profile tube (group II) and Portex Soft Seal tube (group III) groups. Groups I and II were compared with group III. Pressure changes in groups I and II were significantly greater than those in group III. ***P<0.0001, Kruskal–Wallis analysis of variance

<table>
<thead>
<tr>
<th></th>
<th>Group I</th>
<th>Group II</th>
<th>Group III</th>
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<tbody>
<tr>
<td>n</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>13/17</td>
<td>14/21</td>
<td>11/19</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>46 (19–68)</td>
<td>49 (17–66)</td>
<td>47 (17–69)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>64.3 (2.4)</td>
<td>61.9 (2.3)</td>
<td>65.1 (2.5)</td>
</tr>
<tr>
<td>Initial sealing pressure (mm Hg)</td>
<td>27.7 (ns)</td>
<td>27.6 (ns)</td>
<td>28.1</td>
</tr>
<tr>
<td>Pressure increase (mm Hg)</td>
<td>9.9 (3.4)***</td>
<td>10.3 (1.8)***</td>
<td>2.1 (1.5)</td>
</tr>
<tr>
<td>% Mean pressure increase</td>
<td>36%</td>
<td>37%</td>
<td>7%</td>
</tr>
<tr>
<td>Median</td>
<td>11.4</td>
<td>9.9</td>
<td>1.9</td>
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</table>

Fig 1 Mean changes in intracuff pressure every 5 min in the three groups. Group I=Mallinckrodt Lo-Contour tube, group II=Portex Profile tube and group III=Portex Soft Seal tube.

tube group (Table 1). Figure 1 shows mean changes in pressure every 5 min for 60 min in the three groups.

There was no correlation between increase in cuff pressure and initial pressure in any group. Although the mean duration of surgery was 144 min, measurements were obtained only for the first 60 min. The incidence of sore throat in group I was 40%, group II 43% and group III 37% (ns).

Comment

Although there is conflicting clinical evidence regarding the effect of a high intracuff pressure on the mucosa of the trachea, it is thought that overfilling the cuff should be avoided. The increase in intracuff pressure when it is filled with air is a result of: diffusion of oxygen into the cuff; warming of gases inside the cuff; and mainly, diffusion of nitrous oxide into the cuff. Various factors affect the rate of diffusion of nitrous oxide, including the difference in partial pressure of nitrous oxide inside and outside the cuff, the area available for diffusion and the cuff material.

Various methods have been described to limit the increase in intracuff pressure in a tracheal tube. Filling the cuff with the anaesthetic gas mixture can lead to leaks and loss of airway seal. This is thought to be a result of the fact that the partial pressure of nitrous oxide in the cuff is greater than that in the inspired gas because the pressure inside the cuff at the start of the procedure is above atmospheric pressure. This causes a partial pressure gradient across the cuff, resulting in diffusion of nitrous oxide out, thus decreasing pressure and volume in the cuff. Filling the cuff with saline is reliable but messy and initial adjustment of cuff pressure is more difficult. Specially designed tubes, such as the Brandt tube and devices that control cuff pressure have been described but are not used widely because of cost and personal preference.

Most modern tracheal tube cuffs are made of polyvinyl chloride (PVC). Diffusion of nitrous oxide into the cuff is dependent on the permeability coefficient of the cuff wall and inversely proportional to the thickness of the cuff wall. In the new Portex Soft Seal tube cuff, the plasticizer added to soften the PVC makes the cuff less permeable to nitrous oxide. This implies that the Soft Seal cuff is thinner than the Portex Profile cuff and yet it is still less permeable to nitrous oxide. Mean cuff thickness of the Soft Seal is 0.06 mm compared with 0.12 mm for the Profile tube and 0.06 mm for the Lo Contour.

The incidence of sore throat in the three groups was similar and in agreement with other studies. It is thought that cuff pressure alone does not have a strong correlation with sore throat. The process of intubation per se, use of tracheal lubricant, pressure of the tube on arytenoid and glottic mucosa, and the mucosal drying effect of an open mouth for tracheal intubation during anaesthesia are equally important.

In summary, we believe that the new Portex Soft Seal tracheal tube cuff prevents significant increases in intracuff pressure during nitrous oxide anaesthesia.

References