THE EFFECTS OF CUFFED ENDOTRACHEAL TUBES ON THE TRACHEAL WALL

D. B. MATHIAS AND J. R. WEDLEY

SUMMARY

Direct tracheoscopy was employed to assess tracheal damage following prolonged intubation. Comparison of conventional and low-pressure cuffs showed that there was less trauma from the low-pressure cuff. Comparison of tube sizes showed a reduction in injury with 8-mm diameter tubes compared with larger ones.

Knowledge of tracheal damage following prolonged endotracheal intubation has depended hitherto upon analysis of retrospective evidence, postmortem specimens and animal experimentation. The opportunity was taken to compare the effects of standard cuffed Portex Blue-line tubes with those of low-pressure (floppy) cuffs using a fibreoptic laryngoscope. The tubes were all made of the same material and had been sterilized with ethylene oxide by the manufacturers.

The object of the present study was to utilize a technique which would enable the observer to visualize the tracheal mucosa at the time of extubation. The patients in this series were undergoing cardiopulmonary bypass surgery, and were ventilated (IPPV) for an average of 15 hours. All patients returned to the intensive care unit after operation, accurate records of their cardiovascular state and drug administration being available for retrospective analysis.

METHOD

Forty patients were allocated randomly to two groups (table I). The control group was intubated with conventional Portex Blue-line tubes and the test group with Portex Blue-line low-pressure cuffed tubes which were available for test purposes. These tubes are now commercially available and they possess cuffs identical to the present "floppy" Portex endotracheal and tracheostomy tubes. At the onset of the study we were restricted to the use of 8-mm low-pressure cuffed tubes. At a later stage 9-mm low-pressure cuffed tubes became available and tubes larger than 8 mm were used in both groups.

After operation patients were ventilated artificially using Cape ventilators, the duration of intubation being determined by the clinician in charge of the patient. The tube remained in situ until the patient reached cardiovascular equilibrium, at which time most patients were breathing 50% nitrous oxide and oxygen (Entonox).

The procedure for the removal of the tube followed a standard pattern. The patient was ventilated with 100% oxygen and the intention of removing the endotracheal tube was explained to the patient. Once spontaneous respiration had been established the pharynx was carefully sucked out using a Yankauer pharyngeal sucker and the cap of the Magill connector was removed. No attempt was made to carry out bronchial suction at this stage. An Olympus fibre optic laryngoscope was passed down the endotracheal tube and the cuff deflated when the tracheal lumen was seen. Any secretions present were sucked out. With the tip of the scope at the distal end of the tube, both were withdrawn, thus enabling the observer to inspect the entire tracheal lumen and subglottic region. Patients experienced no more discomfort than at normal extubation but were resistant to prolonged inspection at the point at which the cuff passed through the vocal cords. One observer performed all the endoscopic examinations and was unaware of the type of endotracheal tube used until his observations had been recorded.

Tracheal damage was assessed on a points system, oedema being awarded 0–3, ulceration 4–6, and bleeding 7–9. On this basis any single tube could be awarded a maximum score of 18 points (table II). The results were analysed using an unpaired Student t-test.

RESULTS

Pressure on the tracheal wall by the cuff.

The patients were intubated for differing periods; the mean duration for the low-pressure cuffed group...
TABLE I. Composition of series.

<table>
<thead>
<tr>
<th>Group</th>
<th>Diameter (mm)</th>
<th>No.</th>
<th>Male</th>
<th>Female</th>
<th>Mean height (cm)</th>
<th>Mean weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>8.0</td>
<td>12</td>
<td>1</td>
<td>11</td>
<td>159.2</td>
<td>53.5</td>
</tr>
<tr>
<td>Control</td>
<td>&gt;8.0</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>166.4</td>
<td>67.8</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>20</td>
<td>6</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low pressure</td>
<td>8.0</td>
<td>13</td>
<td>4</td>
<td>10</td>
<td>160.1</td>
<td>58.4</td>
</tr>
<tr>
<td>Low pressure</td>
<td>&gt;8.0</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>170.6</td>
<td>69.4</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>19</td>
<td>8</td>
<td>11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE II. Scoring system (+ indicates severity of the lesion as assessed by the observer).

<table>
<thead>
<tr>
<th></th>
<th>+</th>
<th>++</th>
<th>+++</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oedema</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Ulceration</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Bleeding</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

was 17.8 hours compared with 11.3 hours for the controls. This difference is significant (P<0.05). Despite this, the mean score for the low pressure cuffed tubes was 4.1, and that for the controls was 8.0 (P<0.025, table III).

TABLE III. Comparison of overall mean scores.

<table>
<thead>
<tr>
<th>Cuff type</th>
<th>No.</th>
<th>Mean score</th>
<th>SD</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>All low pressure</td>
<td>19</td>
<td>4.1</td>
<td>±5.09</td>
<td>&lt;0.025</td>
</tr>
<tr>
<td>All controls</td>
<td>20</td>
<td>8.0</td>
<td>±6.03</td>
<td></td>
</tr>
</tbody>
</table>

Size of tube relative to tracheal lumen.

The low-pressure cuffed 8-mm tubes scored significantly lower than the low-pressure cuffed tubes larger than 8 mm (table IV). The control 8-mm tubes scored less than the larger control tubes although the difference was not significant (table V).

Cardiovascular state during intubation.

Nine of the 39 patients had a systolic arterial pressure of less than 60 mm Hg for 30 min or more. These did not score differently from the remainder (table VI). Thirty patients in the series received isoprenaline or adrenaline intravenously in the postoperative period, two receiving both drugs. The scores for these patients did not differ significantly from those not receiving vasopressor drugs. Of the 39 patients, seven received cardiopulmonary perfusion for less than 1 hour and 10 for more than 2 hours. Comparing these groups we were unable to show any statistically significant difference in score.

Sex and age of patient.

Males scored higher overall than females but the mean values were not significantly different (table VII).

Assessment of the other possible factors involved in the production of tracheal damage was not within the scope of this study.

DISCUSSION

Cuffed endotracheal and tracheostomy tubes used in the treatment of respiratory insufficiency have been shown to cause tracheal damage (Shelly, Dawson and May, 1969; Christensen and Duvall, 1968; Hedden et al., 1969). Studies on experimental animals have led to an understanding of the histopathological processes involved in the production of such damage (Cooper and Grillo, 1969a) and similar evolutionary changes have been shown to occur in man (Cooper and Grillo, 1969b). From this evidence it would seem that with the exception

TABLE IV. Comparison of mean scores for 8 mm and larger than 8 mm diameter low pressure cuffed tubes.

<table>
<thead>
<tr>
<th>Cuff type</th>
<th>No.</th>
<th>Mean duration of intubation (hr)</th>
<th>SD</th>
<th>Mean score</th>
<th>SD</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low pressure 8 mm</td>
<td>14</td>
<td>19.25</td>
<td>±13.6</td>
<td>2.5</td>
<td>±3.67</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Low pressure &gt;8 mm</td>
<td>5</td>
<td>15.7</td>
<td>±14.7</td>
<td>8.6</td>
<td>±6.19</td>
<td></td>
</tr>
</tbody>
</table>
of the tracheostomy stoma, the single most important factor is the cuff and its pressure characteristics.

In an attempt to avoid cuff damage, other methods have been devised to create a seal in the trachea such as the use of flanged cuffs (Miller and Sethi, 1970), but such techniques have not yet been generally accepted.

Recent work on low-pressure cuffs (McGinnis et al., 1971; Cooper and Grillo, 1972) has suggested their advantages over traditional cuffs, and such cuffs are now being made by several manufacturers.

The incidence of tracheal damage following intubation is difficult to assess as only a minority of patients are liable to sustain damage of sufficient severity to produce symptoms (Davidson et al., 1971). Attention has been drawn to the possible contributing factors:

Pressure on the tracheal wall by the cuff.
Size of tube relative to tracheal lumen.
Duration of intubation.
Cardiovascular state during intubation.
Movement of tube during intubation.
Material from which cuff is manufactured.
Possible adverse effects of steroids, etc.
Sex and age of patient.
Nature of sterilizing and lubricating agents.
Presence of contaminated material at cuff site.

(Bryce, Briant and Pearson, 1968; Stoelting and Procter, 1968; Editorial, 1973.)

The present study was designed to compare conventional cuffed tubes with low-pressure cuffed tubes and to assess some of these other factors which might contribute to tracheal damage.

Our results suggest that the main factor responsible for tracheal damage is the cuff pressure of the endotracheal tube utilized and that such damage may be reduced by the use of low-pressure cuffs. Furthermore, this work confirms the theoretical observations (McGinnis et al., 1971) of the advantages of small-diameter tubes. During prolonged IPPV it would appear justifiable to use a tube of smaller diameter than would be deemed appropriate for spontaneous respiration.

We were unable to confirm the commonly held belief that hypotensive episodes exacerbate tracheal damage, though the numbers involved were not sufficiently large to confirm this finding statistically. Additionally, we were unable to show any relationship between the sex of the patient and the incidence of tracheal damage.

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REFERENCES


