LOW RESISTANCE DOUBLE-LUMEN ENDOBRONCHIAL TUBES

BY

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SUMMARY

A new double-lumen endobronchial tube, suitable for thoracic anaesthesia is described. Both left- and right-sided versions have been developed, in three sizes, suitable for adults and adolescents. It has been designed to have the maximum possible size of lumen. This ensures low resistance to gas-flows, and facilitates the use of suction catheters. The resistance has been compared with that of Carlens tubes under conditions simulating those of actual use. The tubes have been in constant use for more than a year, and have been found clinically satisfactory. They are durable and comparatively inexpensive.

The principle of independent control of each lung through a double-lumen endobronchial tube is now well established. A double-lumen bronchoscope, with inflatable cuffs was introduced by Frenckner (1934) for bronchospirometry, and Zavod (1940) employed a double-lumen catheter of latex rubber for the same purpose.

Although a number of workers had devised endobronchial tubes and "blockers" for use during surgery of the lung, Carlens introduced the first double-lumen tube suitable for this purpose. His tube was originally intended for bronchospirometry (1949) but Björk and Carlens soon reported its successful use in twenty lung resections (1950).

Carlens catheter has been widely used in thoracic surgery. In addition to providing control of secretions in "wet-lung" cases, as reported by Björk and Carlens (1950), and allowing reinflation of the collapsed lung whenever surgery or physiological needs required, the new tube made possible new surgical techniques, for example those involving the maintenance of an open bronchus for long periods (Björk, Carlens and Crafoord, 1952; Hunter, 1958).

Despite its many advantages, Carlens' catheter has not found universal acceptance among thoracic surgeons and anaesthetists. The difficulties of placing it correctly can soon be overcome. A more serious objection is the smallness of each lumen. The consequent resistance to gas-flows is largely overcome by the use of controlled respiration, but Jenkins and Clarke (1958) have suggested that the increased resistance to expiration may represent a contraindication to its use in cases with gross emphysema. The passage of suction catheters of sufficient size to deal with thick purulent secretions is also difficult.

During left pneumonectomy it is, of course, necessary to withdraw the tube into the trachea, or even to replace it with a standard Magill tube before the bronchus is divided (Jenkins and Clarke, 1958). Obstruction of the left main bronchus prevents its use altogether. White (1960), however, has introduced a modified version for these cases.

After some years of experience with Carlens catheters, an effort has been made to develop a similar double-lumen tube with the largest possible lumina. The main tube is an extruded section. In addition to the twin lumina which are roughly semicircular or D-shaped, capillary cuff-inflation tubes have been included in the wall anteriorly and posteriorly, as this arrangement was found to be least liable to kinking, and gives the best utilization of available space (fig. 1). The tubes are similar in general layout to those of Carlens, but the two connecting tubes (into which endotracheal connections are fitted) are left longer, and may be cut to a suitable length if a shorter tube is preferred. Their junction with the main double lumen tube normally lies between the teeth or gums. Inflatable cuffs similar to those of standard British Magill tubes are used, as these have been found to be at least as durable as other types, and are
Low resistance double-lumen endobronchial tubes

The least bulky. A new rubber compound is used for the cuffs. It is slightly firmer than that hitherto used for Magill tubes and is not easily damaged by overdistension or boiling. Its better elasticity avoids the localized over-distention sometimes seen on Magill's tube cuffs after use. The cuff-inflating tubes will fit both Luer and Record tipped syringes. They are coloured for identification: red, as usual, for the tracheal cuff, and blue for bronchus (though some early production tubes are coloured the other way round).

The curve of the tubes is the result of considerable experiment. That finally adopted enables the tubes to lie in place easily without strain or kinking, but also without reducing the ease of their insertion into the larynx without a stilette.

Large, medium and small sizes are being made, corresponding roughly to Magill tubes of size 12, 10 and 8. The two larger sizes are suitable for most men and women respectively. The small size, less often needed, is suitable for small women and has also been found of value in children of about 14 years suffering from bronchiectasis.

Left-sided tubes, corresponding to those of Carlens, are most often used. The tip of the left lumen is provided with a cuff and angled at 45° to enter the left main bronchus, while the right lumen terminates above the carina. When the left bronchial and tracheal cuffs are inflated, the right lumen communicates only with the right main bronchus.

The right-sided tubes have a tip angled at 20° to enter the right main bronchus. This follows the principles described by Green and Gordon (1955, 1957) and has a slotted endobronchial cuff to allow inflation of the right upper lobe. Care has been taken to ensure that the cuff inflates above the upper lobe slot to seal it from the trachea and left main bronchus. In the large tube the left lumen terminates 5 cm above the slot and communicates with the left lung, since Green and Gordon found that the distance between the carina and right upper lobe bronchus varied from 1 cm to 4 cm with a mean of 1.8 cm.

Intubation.

Neither tube has a carinal hook. This has not proved to be any disadvantage and makes intubation easier. It is most easily accomplished with
the author's own laryngoscope (to be reported) or that of Macintosh, as these allow more room in the mouth than the Magill or other tubular patterns. When the double lumen portion is in the larynx, the laryngoscope is discarded and the tube is slid gently down the trachea. When in position, the bronchial cuff is inflated and the lung on this side inflated by manual compression of the bag. Auscultation over the upper lobe indicates when the tube is correctly placed. When this is established, and there are no leaks past the bronchial cuff, the tracheal cuff is inflated and the other lung tested for free inflation. In the absence of obstruction of the bronchus by tumour or other anatomical abnormality, failure to inflate freely indicates that the bronchial cuff is causing obstruction at the carina and must be adjusted.

Intubation and correct positioning of the left tube is usually easy, but if it is pushed too far down the left upper lobe may be obstructed, hence auscultation should not be omitted. Such obstruction is also possible, owing to anatomical variations, even when a carinal hook is present on the tube. Intubation with the right slotted tube is even easier, but positioning requires rather more care to ensure that the upper lobe is inflating via the slot. Care is also essential to inflate the cuff firmly enough to make a seal between bronchus and trachea. Although over-inflation must be avoided, it will be found that the cuff when inflated, opens the slot rather than the reverse.

**Bronchial aspiration.**

For suction Neoplex plastic catheters have been found most suitable. They are firm without being hard, and the smooth surface allows a catheter of adequate size to be passed easily into the bronchi, especially if it is lubricated with dilute cetrimide solution. The D-shaped lumen of the tube is not fully occluded by the largest usable catheter, thereby avoiding the risk of applying strong suction to the whole lung.

**Restriction.**

In order to make an assessment of the resistance to peak flow during respiration, these tubes were connected to a Blease Pulmofoator set to deliver a tidal volume of 500 ml fairly rapidly. A straight endotracheal connector was used in each case to avoid turbulence effects. The same respirator settings were used throughout and the bronchial ends of the tubes were open to air. Expiratory pressure was set to $-4$ cm of water.

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**TABLE I**

*Resistance to peak flow. New tubes (left).*

<table>
<thead>
<tr>
<th>Size:</th>
<th>Large</th>
<th>Medium</th>
<th>Small</th>
<th>Small</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal volume (ml)</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>350</td>
</tr>
<tr>
<td>Left lumen resistance (cm H$_2$O)</td>
<td>+7.5 +2</td>
<td>+9.5 -2.25</td>
<td>-14.25 -2.75</td>
<td>+12.5 -2.5</td>
</tr>
<tr>
<td>Right lumen resistance (cm H$_2$O)</td>
<td>+7.5 -2</td>
<td>+11 -2.5</td>
<td>+14.25 -2.75</td>
<td>+12.5 -2.5</td>
</tr>
</tbody>
</table>

**TABLE II**

*Resistance to peak flow. Carlens tubes.*

<table>
<thead>
<tr>
<th>Size:</th>
<th>41</th>
<th>39</th>
<th>37</th>
<th>35</th>
<th>35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal volume (ml)</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>500</td>
<td>350</td>
</tr>
<tr>
<td>Left lumen resistance (cm H$_2$O)</td>
<td>8 -2</td>
<td>9.5 -2.5</td>
<td>12.25 -2.5</td>
<td>19 -3</td>
<td>16.5 -3</td>
</tr>
<tr>
<td>Right lumen resistance (cm H$_2$O)</td>
<td>9.5 -2.5</td>
<td>11 -2.5</td>
<td>13.5 -2.5</td>
<td>17 -3</td>
<td>15 -3</td>
</tr>
</tbody>
</table>
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with the tube occluded. Only one lumen was connected in each test. The results are given in table I as measured in cm H2O pressure on the manometer of the Pulmoflator. For comparison, similar figures for Carlens tubes are given in table II. Figures for the small tubes and for Carlens 35 for a tidal volume of 350 ml are also given, as this is nearer the volume likely to be used with these tubes.

The new tubes in their present form have now been in use for more than a year and are proving satisfactory. Their resistance is lower than that of the Carlens tube which could be used in any given patient. The use of an established manufacturing technique has enabled the cost of the tubes to be kept within reasonable limits.

ACKNOWLEDGMENTS

Thanks are due to my colleague, Dr. E. G. Rees Jones, and to our surgical colleagues for their co-operation and encouragement, and to Dr. Eric Carlens for his kindly interest. It is also a pleasure to acknowledge our gratitude to the Leyland and Birmingham Rubber Co., of Preston, Lancs, for their unfailing courtesy and helpfulness.

The tubes are obtainable from Medical and Industrial Equipment Ltd., 10/12 New Cavendish Street, London, W.1.

REFERENCES


SOMMAIRE

Description d’un tube endobronchique à double lumière, convenant pour anesthésie thoracique. Des versions gauches et des versions droites ont été mises au point, en trois tailles, appropriées pour adultes et adolescents.

Le tube, par son dessin, a le lumen le plus grand possible. Il en résulte un minimum de résistance au flux des gaz et de la facilité pour l’utilisation des sondes à succion. La résistance a été comparée avec celle des tubes de Carlens dans des conditions imitant celles de l’utilisation pratique.

Les tubes de l’auteur ont été utilisés constamment pendant plus d’un an et on a été satisfait cliniquement de leur emploi. Ils sont d’un usage prolongé et comparativement peu coûteux.

ZUSAMMENFASSUNG


Es wurde entworfen, um ein möglichst großes Lumen zu erhalten. Das garantiert bei Gas-Durchstömung geringen Widerstand und erleichtert die Anwendung von Saugkathetern. Unter Bedingungen, die denen bei echter Anwendung entsprachen, wurde der Widerstand mit dem von Carlens Kathetern verglichen.

Die Katheter waren seit mehr als einem Jahr in ständiger Verwendung und erwiesen sich als klinisch ausreichend. Sie sind haltbar und verhältnismässig billig.