CATHETER INFLATION VENTILATION IN TRACHEAL STENOSIS

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SUMMARY

Catheter inflation ventilation using simple apparatus is described and its use in a case of tracheal stenosis is reported. The suitability of the method was tested first on a model. Monitoring of blood-gas tensions showed that the patient could be hyperventilated without cardiovascular disturbance for a period of 197 min.

The resection of a tracheal stenosis poses the problem of how to ensure adequate ventilation with the minimum of interference to the surgical procedure. High frequency positive pressure ventilation (Heijman et al., 1972) has provided excellent results, but requires specialized equipment (Eriksson and Sjöstrand, 1974; Eriksson et al., 1975). The method described here is an adaptation of the catheter inflation technique described by Carden and Crutchfield (1973), and which has developed from the injector techniques of Sanders (1967) and Spoerel and colleagues (Spoerel, 1969; Spoerel, Narayanan and Singh, 1971; Spoerel and Greenway, 1973). Using simple apparatus, catheter inflation ventilation was found to be safe and easy to perform, with no demonstrable effect on the circulation.

THE PATIENT

An obese, short-necked male of 68 yr with chronic bronchitis was admitted to hospital with a fracture of the tibia and multiple rib fractures. He developed respiratory failure, and after 9 days of artificial ventilation through a nasal endotracheal tube a tracheostomy was performed. A further 8 days were required to wean him from the respirator. The site of the tracheostomy became infected by a strain of penicillin-resistant Staphylococcus aureus; later a tracheal stenosis developed, with inspiratory and expiratory stridor. Reopening of the tracheostomy was necessary twice, and, on a third occasion, a silicone tube was inserted. It was removed later as it could not be retained in position.

Seven months after the admission of the patient, it was proposed to make a transthoracic resection of the stenosed tracheal segment, with end-to-end anastomosis. The segment extended from 2 cm below the vocal cords for a further 2.5 cm and had an internal diameter of 5–6 mm.

As conventional ventilation under anaesthesia via an endotracheal tube was considered unlikely to be adequate or even impossible, it was planned to use catheter inflation ventilation up to the point where the resection of the stenosis was complete, a normal-sized endotracheal tube being used for the remainder of the operation.

APPARATUS

(Figure 1.) Cylinder oxygen at a reduced pressure of 5 atm and nitrous oxide at 5–7 atm were connected to the two inlets of an “Oxymix” mixing chamber (Simonsen and Weel, Copenhagen). The mixing chamber was used to regulate the oxygen: nitrous oxide ratio.

For control of the inflation pressure, an adjustable pressure regulator with pressure gauge (Teknova Mini Regulator 236 A; 0–8 atm (Teknova, Nivå, Denmark)) was attached to the outlet of the mixing chamber. A suitable length of tubing connected the regulator to a commercial on/off release valve of the pistol type (as used for inflating car tyres with compressed air). At the pressures used, this type of release valve has a light but positive action. It was fitted with
a Luer lock at the outlet. The non-tapered reinforced plastic end of the Steritex catheter No. 12 fits firmly over the male Luer fitting.

The "Oxymix" is made for mixing oxygen and compressed air from separate (central supply) sources, yielding a controllable oxygen concentration (21-100%) at the outlet. There are two flow rates: up to 25 litre/min, and from 25 to 100 litre/min, selected by turning the control knob clockwise and anticlockwise, respectively. It is calibrated easily for use with nitrous oxide by measuring the oxygen tension (Radiometer, Copenhagen) of gas samples collected at different settings of the "Oxymix" (table I). The higher flow rate (about 60-80 litre/min) is required for the catheter inflation technique.

**TABLE I. "Oxymix" used for oxygen/nitrous oxide mixture**

<table>
<thead>
<tr>
<th>Scale setting (%)</th>
<th>Actual oxygen percentage</th>
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<tbody>
<tr>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>60</td>
<td>52</td>
</tr>
</tbody>
</table>

**PRELIMINARY TESTING**

The apparatus was tested by ventilating a glass carboy which had been designed to simulate lung compliance (Mushin et al., 1969). Water and metal shavings were utilized as a heat reservoir to minimize temperature changes. By ventilating a 3-litre rubber bag within the carboy, it was possible to measure tidal volume together with oxygen concentration while also measuring pressure changes. An oral endotracheal tube with 6 mm internal diameter was used to represent the stricture. A Steritex No. 12 plastic catheter was passed through this endotracheal tube.

It was found that adequate ventilation would be possible through the stricture and that the pressure within the carboy would not exceed a momentary peak insufflation pressure of 20 cm H$_2$O, provided that the normal short "puff" of about 0.5 sec duration was not exceeded greatly. An adequate expiration time was approximately 2 sec.

**ANAESTHESIA**

Diazepam 15 mg i.m. was given 1 hr before the induction of anaesthesia using dehydrobenzperidol 25 mg and fentanyl 0.5 mg.

After spraying the larynx with bupivacaine 4%, oral endotracheal intubation was attempted unsuccessfully with tubes of 7.5 mm and 7 mm i.d., respectively. Finally, using an introducer, a tube with an internal diameter of 5 mm was passed apparently through the stricture. When the trachea was later opened it was found that the tip of this tube was in, but not through, the stenosed section. Gallamine triethiodide was used for muscle relaxation. The Steritex No. 12 catheter, previously marked for length relative to the tube, was then inserted, connected to the pistol-type release valve, and the high pressure catheter inflation ventilation was commenced. The catheter was adjusted to find the optimal position for both inspiration and expiration, as judged by auscultation. The pressure regulator was then adjusted to give a ventilation which was deemed satisfactory on clinical grounds. The pistol-type release valve was placed, trigger uppermost, on the patient's pillow, and required only a light fingertip pressure to function.

Thereafter, the catheter inflation ventilation, at a pressure of 3.5 atm, was continued for 197 min, and no significant effects on the general circulation were detected. The pulse (+4 to −6 beats/min) and mean arterial pressure (+10 to −7 mm Hg) remained virtually unchanged throughout. The remainder of the anaesthesia was achieved using conventional apparatus. Arterial gases were measured at hourly intervals (table II).

The recovery after surgery was without complication.

**TABLE II. Arterial gases**

<table>
<thead>
<tr>
<th></th>
<th>$P_{aO_2}$ (mm Hg)</th>
<th>$P_{aCO_2}$ (mm Hg)</th>
<th>pH (units)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before anaesthesia</td>
<td></td>
<td></td>
<td>7.39</td>
</tr>
<tr>
<td>After endotracheal intubation</td>
<td>84</td>
<td>40</td>
<td>7.37</td>
</tr>
<tr>
<td>After 1 hr</td>
<td>133</td>
<td>41</td>
<td>7.40</td>
</tr>
<tr>
<td>After 2 hr</td>
<td>118</td>
<td>34</td>
<td>7.47</td>
</tr>
<tr>
<td>After 3 hr</td>
<td>184</td>
<td>28</td>
<td>7.53</td>
</tr>
</tbody>
</table>

**DISCUSSION**

It was considered desirable first to reproduce the problems of ventilating through a stricture on a model. From this the technique best suited to the individual could be found. However, the management of the patient was found to be easy; the time taken for emptying of the "lung" in the model correlated well with the clinical experience. The presence of hyperventilation without circulatory depression indicates a margin of safety in the method.
Because of the difficulty in ventilating the patient using a mask, muscle relaxants were not used until an oral endotracheal tube had been inserted. The use of the endotracheal tube, although too small for adequate ventilation by conventional methods, restricted the movement of the catheter, which could also be fixed in position conveniently, while allowing for later adjustments (particularly after the trachea was opened), and it ensured an outlet for the expiratory phase, essential for this technique.

No sign of trauma to the tracheal mucosa was seen.

ACKNOWLEDGEMENTS

Simonsen and Weel, Copenhagen (U.K. address: Simonsen & Weel Ltd, Hatherley House, Hatherley Road, Sidcup, Kent), loaned the “Oxymix” mixing chamber, reduction valve and pistol-type release valve.

REFERENCES


VENTILATION PAR DILATATION DU CATHETER DANS LES CAS DE STENOSE DE LA TRACHEE

RESUME

La ventilation par dilatation du cathéter à l'aide d'un appareil simple est décrite dans cet article et on y signale son employ dans un cas de sténose de la trachée. On a d'abord essayé sur un modèle pour voir si cette méthode convenait. La surveillance de la tension sang-gaz a montré que le malade pouvait être hyperventilé sans aucun dérangement cardiovasculaire pendant une période de 197 minutes.

KATHETER-FÜLLUNGSBELÜFTUNG BEI TRACHEALSTENOSE

ZUSAMMENFASSUNG


VENTILACION POR INSUFLACION DEL CATHETER EN LAS ESTENOSIS TRAQUEAL

SUMARIO

Se describe la ventilación por insuflación del catéter mediante el uso de un aparato sencillo y se reseña su utilización en un caso de estenosis traqueal. La utilidad del método se probó primero con un modelo. El control de las tensiones de gas en la sangre demostró que se podía hiperventilar al paciente sin que se produjeran trastornos cardiovasculares durante un tiempo de 197 min.