ANAESTHETIC MANAGEMENT OF A 2-MONTH-OLD INFANT FOR LASER RESECTION OF VOCAL CORD GRANULOMA

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SUMMARY
A 2-month-old infant underwent excision of granulomata of vocal cords with a carbon dioxide laser. High frequency jet ventilation was given through a surgical metal suction tube during the operation. The anaesthetic technique for the infant and the problems of the use of carbon dioxide laser in laryngeal surgery are discussed.

KEY WORDS

The use of carbon dioxide laser in laryngeal surgery poses many problems in anaesthetic management. These include airway control, the necessity for adequate surgical exposure and immobility of target tissue. Various anaesthetic techniques have been described for laser surgery in adults and older children. In the present case report, the anaesthetic management of a 2-month-old infant undergoing laser excision of laryngeal granuloma is described and discussed.

CASE REPORT
A full term 1-month-old infant was admitted to our hospital with meningitis and respiratory failure: oxygen haemoglobin saturation (pulse oximetry) was 70%; the partial pressure of carbon dioxide in arterial blood (\(P_{a,CO_2}\)) was 9.9 kPa. Convulsions developed and he was resuscitated successfully after tracheal intubation using a polyvinylchloride (PVC) tracheal tube, 3.5 mm internal diameter (i.d.) and mechanical ventilation. The meningitis was controlled after 1 week and he was weaned from the ventilator. However, several attempts at tracheal extubation during the following 2 weeks failed because of recurrent upper airway obstruction soon after the tracheal tube was removed. Direct laryngoscopy and bronchoscopy performed under general anaesthesia in the third week revealed multiple granulomata on both vocal cords. Excision of these granulomata with carbon dioxide laser was planned in the following week.

The infant presented for surgery at 2 months old (body weight 4.69 kg) with a 3.5-mm i.d. PVC nasotracheal tube in situ. Monitoring of this infant included continuous pulse oximetry (Ohmeda Biox 3700); transcutaneous carbon dioxide (Ptc\(_{CO_2}\)), electrocardiogram (ECG), rectal temperature (Kontron Supermon 7210) and arterial pressure (Critikon Dinamap Vital Sign Monitor 1846). The following items of apparatus were prepared: a paediatric microlaryngoscope (Storz) 11 cm long, i.d. 1.2 cm at its tip; a stainless steel suction tube (Storz No. 10381C) 30 cm long with i.d. and o.d. of 1.2 mm and 2.0 mm, respectively, having both end and side holes. The suction tube was marked with marking pen and a silk thread tied at 14 cm from its tip so that it protruded 3 cm beyond the microlaryngoscope.

The infant was premedicated with atropine 0.1 mg i.m. 30 min before operation. General anaesthesia was induced with isoflurane in nitrous oxide and oxygen using an Ayre's T-piece with Jackson-Rees modification. Atracurium 5 mg was given i.v. and ventilation was controlled manually. After positioning, the infant was given 2% isoflurane in oxygen for 3 min. The nasotracheal tube was then removed. The vocal cords were...
CO₂ LASER FOR PAEDIATRIC LARYNGEAL SURGERY

TABLE I. Data on HFJV settings and monitored variables

<table>
<thead>
<tr>
<th>Time after start of HFJV (min)</th>
<th>0</th>
<th>15</th>
<th>30</th>
<th>40</th>
<th>60</th>
<th>75</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ventilator settings</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspiratory oxygen (%)</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Ventilatory frequency (b.p.m.)</td>
<td>400</td>
<td>400</td>
<td>250</td>
<td>250</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Driving pressure (bar)</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Inspiratory phase (% of cycle)</td>
<td>50</td>
<td>50</td>
<td>30</td>
<td>40</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Measured inspiratory tidal volume (ml)</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td><strong>Monitored variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(SP_{O_2}) (%)</td>
<td>100</td>
<td>100</td>
<td>94</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>(P_{tcCO_2}) (kPa)</td>
<td>3.8</td>
<td>7.1</td>
<td>4.9</td>
<td>3.8</td>
<td>4.1</td>
<td>3.8</td>
</tr>
<tr>
<td>Arterial pressure (mm Hg)</td>
<td>88/60</td>
<td>140/90</td>
<td>100/66</td>
<td>130/85</td>
<td>110/80</td>
<td>90/60</td>
</tr>
<tr>
<td>Heart rate (beat min⁻¹)</td>
<td>144</td>
<td>160</td>
<td>140</td>
<td>166</td>
<td>140</td>
<td>135</td>
</tr>
<tr>
<td>(P_{aO_2}) (kPa)</td>
<td>34.09</td>
<td>34.09</td>
<td>34.09</td>
<td>34.09</td>
<td>34.09</td>
<td>34.09</td>
</tr>
<tr>
<td>(P_{aCO_2}) (kPa)</td>
<td>4.33</td>
<td>4.33</td>
<td>4.33</td>
<td>4.33</td>
<td>4.33</td>
<td>4.33</td>
</tr>
</tbody>
</table>

Exposed by the microlaryngoscope. The suction tube was then inserted into the trachea through the microlaryngoscope under direct vision to the depth marked by the silk thread. The silk thread was used also to stabilize the suction tube within the microlaryngoscope, and with this arrangement some degree of flexibility was allowed in case the surgeon needed to adjust the tube position for adequate exposure. High frequency jet ventilation (HFJV) was administered through the suction tube with an Acutronic 1000 ventilator via a Luer lock connection with the initial and subsequent settings as indicated in table I.

During HFJV, general anaesthesia was maintained with ketamine 10 mg i.v. followed by a continuous i.v. infusion of 5 mg h⁻¹. Supplementary i.v. 2.5-μg boluses of fentanyl were given (total dose 10 μg) when anaesthesia lightened. Intermittent i.v. doses of atracurium were given for maintenance of muscular relaxation.

During HFJV, development of hypercapnia was associated with hypertension and tachycardia. After adjustment of the frequency of ventilation and inspiratory phase, normocapnia was achieved but \(SP_{O_2}\) decreased. Upon re-setting the inspiratory phase, optimal respiratory conditions were achieved. Subsequent hypertension and tachycardia were associated with the use of adrenaline 1:200 000-soaked swabs by the surgeon for haemostasis.

The total duration of HFJV was 95 min and operating conditions were excellent. After completion of the procedure, 100% oxygen was administered by HFJV for 3 min and the metal suction tube was removed. A 3.5-mm i.d. Portex nasotracheal tube was inserted and secured. Residual neuromuscular block was antagonized with i.v. neostigmine and atropine. The infant resumed stable spontaneous ventilation through the nasotracheal tube. He was able to sustain an \(SP_{O_2}\) of 93% while breathing room air 30 min after antagonism of the block. He was returned to the paediatric intensive care unit awake and alert.

Postoperative recovery was uneventful. There was no clinical evidence of barotrauma. Recurrence of vocal cord granuloma necessitated a total of four laser operations using a similar technique. Subsequent anaesthesia was smoother than the first time with the benefits of previous experience. The nasotracheal tube was not reinserted after the last operation.

**DISCUSSION**

Post-intubation vocal cord granuloma causing airway obstruction is uncommon in children [1]. The use of the carbon dioxide laser in laryngeal surgery is now well established [2], especially for excision of superficial soft tissue lesions [3]. It allows good haemostasis and is associated with minimal inflammatory reactions and oedema of surrounding tissues [4]. However, the use of the carbon dioxide laser does create many anaesthetic problems in laryngeal surgery.

*Airway control. PVC or rubber tracheal tubes...*
are flammable in oxygen concentrations as low as 25%. Several measures have been suggested to overcome this problem. First, non-flammable tubes such as metal (Norton) or metallic coated tubes (Xomed) may be used. Second, PVC or rubber tubes may be protected from the laser beam by wrapping with metal (aluminium or copper) foils or muslin [7], but this inevitably increases the diameter of the tube. Third, the larynx and tracheal tube may be packed with wet swabs [7, 8], although the swab becomes flammable if it becomes dry. Fourth, the tracheal tube can be removed intermittently during firing of the laser [9]. Finally, one can use jet ventilation via a non-flammable metal tube from above or below the vocal cords [10, 11].

**Immunity of the target tissue.** Movement of target may cause unintended injury to surrounding tissues [12]. Immobility may be achieved by using muscle relaxants [9] or maintaining spontaneous ventilation under deep general anaesthesia [13, 14].

**Inhalation of smoke and debris.** Smoke and debris are generated during laser firing to the larynx. Although the theoretical toxic effect and infective properties of the smoke and debris have not been sustained by either in vitro or in vivo studies [15], it is undesirable to insufflate them into the tracheobronchial tree.

**Hazards to theatre personnel.** In our case, the larynx was too small for a conventional metal or wrapped tracheal tube. Spontaneous ventilation was not possible because of significant airway obstruction and intermittent removal of the tracheal tube was impractical because multiple intubation and extubation inflict more injury on the larynx. More importantly, the time available for aiming and firing of the laser would be short in an apnoeic infant after extubation. Consequently, we decided to use a small metal tube for jet ventilation throughout the procedure because of the following advantages: the patient could be paralysed and his lungs ventilated without a tracheal tube or an air-tight seal [16]; the small size of the jet tube allowed adequate surgical exposure and escape of expiratory gas despite partial airway obstruction; the use of a metal tube avoided the danger of ignition inside the airway. The tip of the jet tube was positioned 3 cm beyond the tip of the paediatric microlaryngoscope so that it was located approximately 1 cm above the carina. Smoke and debris generated by the laser were evacuated by expiratory gas instead of propelled inwards by the jet. The use of HFJV in this infant had two additional advantages: because a much smaller tidal volume and smaller peak inspiratory pressure were used, less barotrauma was expected. Minute mucosal tears may be inflicted by the metal catheter tip or by a misdirected laser beam, and the jet of gas mixture in conventional jet ventilation may cause pneumomediastinum, pneumothorax [10] or pneumopericardium [17] with the high gas pressure and volume involved. The problem of excessive vocal cord vibration [10] in the gas current during conventional jet ventilation may be avoided as a smaller tidal volume is used with HFJV.

Initially, a tidal volume of 3 ml kg\(^{-1}\) was set and a ventilatory frequency of 400 b.p.m. was chosen empirically [18]. However, the initial \(P_{tc_{co_2}}\) was high, although \(Sp_{O_2}\) was adequate. As the efficacy of carbon dioxide elimination is impaired when ventilatory frequency is increased beyond a certain optimal value [19–21], the ventilatory frequency was adjusted according to \(P_{tc_{co_2}}\). The inspiratory phase was reduced in conjunction with the reduction in ventilatory frequency in an attempt to minimize vocal cord movement (smaller delivered tidal volume), but this was associated with a decrease in \(Sp_{O_2}\). After careful adjustment of ventilatory frequency and inspiratory phase according to \(P_{tc_{co_2}}\) and \(Sp_{O_2}\), satisfactory gas exchange was eventually achieved. The disadvantage of HFJV is that the minute ventilation and tidal volume cannot be predicted or measured accurately [16]. Optimal gas exchange may be achieved only by close monitoring. The \(P_{tc_{co_2}}\) (90% response time in less than 60 s) is particularly valuable as it provides continuous information on elimination of carbon dioxide, and this correlates well with \(Pa_{co_2}\).

**REFERENCES**