MYOTONIC AND NEUROMUSCULAR BLOCKING EFFECTS OF INCREASED DOSES OF SUXAMETHONIUM IN INFANTS AND CHILDREN

G. MEAKIN, R. W. M. WALKER AND O. R. DEARLOVE

SUMMARY

The myotonic effects and duration of action of several doses of suxamethonium were determined in 24 infants and 16 children during thiopentone–fentanyl–nitrous oxide anaesthesia. Infants received suxamethonium 2, 3 or 4 mg kg⁻¹; children received 1 or 2 mg kg⁻¹. The increase in muscle tone during onset of neuromuscular block was independent of dose. Onset of block was faster in children who received suxamethonium 2 mg kg⁻¹ compared with those who received 1 mg kg⁻¹, and in infants given 2 mg kg⁻¹ than in children given the same dose. Compared with adults given suxamethonium 1 mg kg⁻¹, infants required 3–4 mg kg⁻¹ and children at least 2 mg kg⁻¹ to produce 6–8 min of neuromuscular block. These results provide a clear indication for increasing the intubating doses of suxamethonium in infants and children, and an explanation for the unduly high rate of "masseter spasm" in some paediatric centres.

KEY WORDS


Geometric mean intubating doses of suxamethonium in infants and children during thiopentone–fentanyl–nitrous oxide anaesthesia.

METHODS AND RESULTS

Following Ethics Committee approval, we studied 40 healthy surgical patients: 24 infants aged 9 days–10 months and 16 children aged 1–7 yr.

No premedication was given to the infants; older children received trimeprazine 3 mg kg⁻¹ 2 h before operation. Anaesthesia was induced with thiopentone 6–8 mg kg⁻¹ and fentanyl 1–3 µg kg⁻¹ and maintained with 70% nitrous oxide in oxygen, supplemented with thiopentone as required. Intubation of the trachea was performed without the aid of neuromuscular block. Ventilation was controlled and end-tidal carbon dioxide tension was maintained at 5.0–5.5 kPa. Rectal temperature was maintained at 36.5–37.5 °C.

Neuromuscular transmission was monitored using the method described previously [1]. Briefly, the ulnar nerve was stimulated at the wrist using surface electrodes. Trains-of-four were repeated every 10 s and the resulting force of thumb adduction was recorded.

Following a period of 6–10 min to allow stabilization of the train-of-four responses, suxamethonium was administered by rapid i.v. injection. Infants were allocated randomly to three subgroups of eight, to receive suxamethonium 2, 3 or 4 mg kg⁻¹, preceded by atropine 20 µg kg⁻¹. Children were allocated randomly to two groups of eight to receive suxamethonium 1 or 2 mg kg⁻¹ without prior administration of atropine.

HIGH-DOSE SXAMETHONIUM IN PAEDIATRIC PATIENTS

TABLE I. Mean (SEM) [range] degree of myotonia, onset and recovery times following suxamethonium (Sux.). Significant differences: ***P < 0.001 between infants and children; †P < 0.05, ‡P < 0.01, ‡‡P < 0.001 between subgroups of infants and children; ‡P < 0.05, ‡‡P < 0.01 between infants and children given suxamethonium 2 mg kg⁻¹

<table>
<thead>
<tr>
<th></th>
<th>Maximum myotonic effect (% control)</th>
<th>Time from injection to 95% block (s)</th>
<th>Time from injection to 5% recovery (min)</th>
<th>Time from injection to 90% recovery (min)</th>
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<tbody>
<tr>
<td><strong>Infants</strong></td>
<td></td>
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<tr>
<td>Sux. 2 mg kg⁻¹</td>
<td>21 (4)***</td>
<td>28 (2)‡</td>
<td>4.1 (0.3)†‡‡</td>
<td>6.5 (0.5)†‡‡</td>
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<td></td>
<td>[21-40]</td>
<td>[2.8-5.4]</td>
<td>[4.2-8.3]</td>
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<tr>
<td>Sux. 3 mg kg⁻¹</td>
<td>17 (5)</td>
<td>32 (3)</td>
<td>4.6 (0.6)</td>
<td>7.3 (0.8)</td>
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<td></td>
<td>[21-38]</td>
<td>[2.5-8.1]</td>
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<tr>
<td>Sux. 4 mg kg⁻¹</td>
<td>24 (4)</td>
<td>31 (3)</td>
<td>6.9 (0.5)</td>
<td>10.2 (0.9)</td>
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<td></td>
<td>[19-40]</td>
<td>[4.3-8.8]</td>
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<tr>
<td><strong>Children</strong></td>
<td></td>
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<tr>
<td>Sux. 1 mg kg⁻¹</td>
<td>6 (1)</td>
<td>46 (3)†</td>
<td>3.5 (0.4)†‡‡</td>
<td>6.2 (0.5)†‡‡</td>
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<td></td>
<td>[39-65]</td>
<td>[2.4-6.3]</td>
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<tr>
<td>Sux. 2 mg kg⁻¹</td>
<td>4 (1)</td>
<td>36 (3)</td>
<td>5.8 (0.4)</td>
<td>9.7 (0.7)</td>
</tr>
<tr>
<td></td>
<td>[27-49]</td>
<td>[4.6-7.4]</td>
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Elevation of the baseline, expressed as a percentage of the control twitch, was used to measure the myotonic effect of suxamethonium. Onset of neuromuscular block was measured from injection of suxamethonium to 95% depression of the first twitch of the train-of-four sequence. Duration of action was measured from injection to 5% and 90% recovery of the first twitch of the train. Significant differences between the groups were determined using analysis of variance and Student's t test. The null hypothesis was rejected at P < 0.05.

No significant difference was found in the degree of increased muscle tone produced by different doses of suxamethonium (table I). However, in agreement with our earlier observations, maximum myotonic activity was significantly greater in infants than in children.

Onset of neuromuscular block was faster in children who received the larger of the two doses of suxamethonium, but there were no significant differences in onset times between subgroups of infants (table I). Both onset and recovery were faster in infants than in children given the same dose of suxamethonium (2 mg kg⁻¹). Increasing the dose of suxamethonium increased the duration of neuromuscular block in all patients, but the train-of-four ratio remained greater than 95% throughout recovery, indicating that none developed phase II suxamethonium block [2].

COMMENT

The finding that the mean increase in muscle tone following administration of suxamethonium was independent of dose is in agreement with recent work on jaw tension in adults [3]. Interestingly, the increases observed were only 60-100% greater than those we observed previously with 10% of the doses used in the present study. This suggests that there is a ceiling to the myotonic effect of suxamethonium which is exceeded by all clinically-used doses.

Although the increase in muscle tone was significantly greater in infants than in children (table I), this result may reflect differences in the attenuation of the transducer signal. Twitch tension was frequently less in infants, so that greater amplification was required. However, this should not invalidate comparisons between patients of similar ages who received different doses of suxamethonium.

In adults, a standard i.v. dose of suxamethonium 1 mg kg⁻¹ is followed by a period of complete neuromuscular block lasting 6-8 min [4, 5]. Comparison with the recovery times shown in table I indicates that the equivalent doses of suxamethonium in paediatric patients are 3-4 mg kg⁻¹ for infants and at least 2 mg kg⁻¹ for children. These doses are somewhat greater than would be expected on the basis of potency alone [1], and indicate that rapid redistribution of the drug away from its site of action may be significant in determining the shorter duration of action in younger patients.

The finding of a very brief recovery time in children given suxamethonium 1 mg kg⁻¹ supports our earlier suggestion that underdosage is the principal cause of the high incidence of "masseter spasm" seen in some children's hos-
Optimum conditions for tracheal intubation exist when the first twitch of the train-of-four is less than 5% of control [6]. Subtracting the time to 95% block from the 5% recovery time in table I indicates that, in children given suxamethonium 1 mg kg⁻¹, this period averaged less than 3 min, with a minimum of 1.7 min. Thus many children given the standard adult dose of suxamethonium may undergo tracheal intubation at a time when effective neuromuscular block has worn off. The adoption of 2 mg kg⁻¹ of suxamethonium as the minimum intubation dose in children should reduce this problem substantially.

ACKNOWLEDGEMENTS
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REFERENCES