The economic advantages of day-case surgery have been questioned (Lord, 1984), but there is little doubt that it permits a more efficient use of scarce hospital resources (Hatch, 1983). General anaesthesia for laparoscopy requires controlled ventilation in a paralysed patient (Cognat, Gerald and Vignaud, 1976), and since the operating time can be as short as 10 min, suxamethonium is the neuromuscular blocking agent most often used for this operation. Atracurium is potentially attractive for use in day-case surgery because there is a pathway of inactivation which is independent of metabolism.

PATIENTS AND METHODS

Healthy female patients in the age range 18–35 yr undergoing either laparoscopic sterilization or elective laparoscopy (where immediate laparotomy was considered unlikely) were included in the study which had been approved by the hospital ethics committee. The patients were admitted to the gynaecology department at 7 a.m. on the day of operation, having fasted since midnight. They were interviewed by one of the investigators, and a control hand-grip strength measured. Diazepam 10 mg was given orally for premedication 30–90 min before the operation. In the operating theatre, the patients were allocated randomly to two groups of 15 to receive either atracurium or suxamethonium. If laparoscopy proceeded to laparotomy, the patient was withdrawn from the study and replaced by the next patient.

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SUMMARY

I.v. atracurium 0.3 mg kg⁻¹ and suxamethonium 1.6 mg kg⁻¹ plus infusion were compared for use in outpatient laparoscopy. Thirty patients were randomly assigned to receive one of the two blocking drugs. Both drugs proved suitable for use in outpatient laparoscopy, but atracurium may have advantages if the operation proceeds directly to laparotomy.

Anaesthesia was induced with thiopentone 4–6 mg kg⁻¹ i.v., preceded by atropine 0.5 mg i.v., and maintained with 1–1.5% enflurane in 33% oxygen in nitrous oxide with spontaneous breathing from a non-rebreathing circuit using a well fitting face mask. When a stable control recording of muscle activity had been made, the patients were given either atracurium 0.3 ± 0.04 mg kg⁻¹ i.v. or suxamethonium 1.6 ± 0.25 mg kg⁻¹ i.v. Controlled ventilation with 1% enflurane in oxygen was continued for 3 min in the atracurium group, or until after the fasciculations in the suxamethonium group, and then the trachea was intubated. Controlled ventilation during laparoscopy was with 1–1.5% enflurane in 33% oxygen in nitrous oxide with a combined flow rate of 7–9 litre min⁻¹ from a non-rebreathing circuit. An infusion of suxamethonium 2 mg ml⁻¹ in glucose 5 mg ml⁻¹ from a paediatric burette, or an increment of atracurium 5 mg was given as required clinically. At the end of the operation, the enflurane was discontinued, and either the suxamethonium infusion stopped or atropine 1 mg with neostigmine 2.5 mg given as appropriate. The lungs were then ventilated with 50% nitrous oxide in oxygen 3.5–4.5 litre min⁻¹ until spontaneous respiration was considered adequate, at which point the tracheal tube was removed.

The activity of the adductor pollicis brevis muscle in response to ulnar nerve stimulation was
ATRACURIUM V. SUXAMETHONIUM

Table I. *The mean (±SD) age, weight, height, time to blockade and number of patients receiving atracurium or suxamethonium*

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of patients</th>
<th>Age (yr)</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
<th>Time to blockade (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atracurium</td>
<td>15</td>
<td>33 ± 7</td>
<td>60.7 ± 9.5</td>
<td>165 ± 5.4</td>
<td>20.1 ± 6.1</td>
</tr>
<tr>
<td>Suxamethonium</td>
<td>15</td>
<td>32 ± 7</td>
<td>57.7 ± 5.8</td>
<td>167 ± 4.6</td>
<td>18.7 ± 8.6</td>
</tr>
</tbody>
</table>

Table II. *The mean (±SD) intubating dose, total dose, time to blockade, recovery time, and hand-grip strength (% of control)*

<table>
<thead>
<tr>
<th></th>
<th>Atracurium</th>
<th>Suxamethonium</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intubating dose (mg kg⁻¹)</td>
<td>0.33 ± 0.04</td>
<td>1.62 ± 0.25</td>
<td></td>
</tr>
<tr>
<td>Total dose (mg kg⁻¹)</td>
<td>0.35 ± 0.04</td>
<td>2.63 ± 0.81</td>
<td></td>
</tr>
<tr>
<td>Time to blockade (s)</td>
<td>60.7 ± 21</td>
<td>26.3 ± 8</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Recovery time (min)</td>
<td>6.8 ± 3.2</td>
<td>3.6 ± 2.6</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Hand-grip strength (%)</td>
<td>88 ± 17</td>
<td>99 ± 20</td>
<td>&lt; 0.1</td>
</tr>
<tr>
<td></td>
<td>95 ± 17</td>
<td>96 ± 24</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td></td>
<td>90 ± 18</td>
<td>88 ± 18</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td></td>
<td>95 ± 18</td>
<td>102 ± 30</td>
<td>&lt; 0.5</td>
</tr>
</tbody>
</table>

RESULTS

The two groups were comparable in respect of height, weight, age and operating time (from injection of blocking agent to the end of surgery) (table I). Table II summarizes the time to blockade (to no response in adductor pollicis brevis), the recovery time (from the end of the suxamethonium infusion or the administration of neostigmine), and the results of the hand-grip strength testing, expressed as a percent of the control value for each patient. All the results are reported as the mean and the standard deviation. The intubating conditions are shown in table III.

Table III. *Intubation score (after Lund and Stovner (1970)). Grade 1 = Easy passage of tube, no laryngeal movement; grade 2 = easy passage of tube, slight coughing or bucking; grade 3 = poor intubating conditions, moderate coughing or bucking; grade 4 = intubation not possible*  

<table>
<thead>
<tr>
<th>Grade</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Atracurium (n = 9)</td>
<td>3   6  0  0</td>
</tr>
<tr>
<td>Suxamethonium (n = 7)</td>
<td>5  2  0  0</td>
</tr>
</tbody>
</table>
DISCUSSION

The use of a nerve stimulator to help regulate the degree of neuromuscular blockade has been recommended for infusions of suxamethonium (Viby-Mogensen, 1982) and atracurium (Gramstad, Lilleaasen and Minsaas, 1983). While we support both these recommendations, we believe that anaesthesia for laparoscopy is conducted without the benefit of a nerve stimulator in most hospitals. This study was designed so that the response to the nerve stimulator was hidden from the anaesthetist giving the anaesthetics.

Laparoscopy demands greater flexibility in use from a neuromuscular blocking drug than most other operations. The operating time can vary from less than 10 min to 40 min or more, and there is usually no indication that the operation is nearing completion until the laparoscope is withdrawn. Suxamethonium is, in many ways, an excellent neuromuscular blocking drug with a long record of safe use, but it is not without its drawbacks, such as the problems of atypical plasma cholinesterase (Viby-Mogensen and Hanel, 1978), the risk of phase II block if the total dose of suxamethonium exceeds 3–6 mg kg⁻¹ (De Cook, 1980; Ali, Lebowitz and Ramsey, 1981), postoperative muscle pain (Atkinson, Rushman and Lee, 1982) and the rare association between suxamethonium and malignant hyperpyrexia (Dendborough, 1984).

The Wellcome Foundation recommend an intubating dose of atracurium 0.4–0.6 mg kg⁻¹. However, in a study of similar patients drawn from the same geographical population (Gramstad and Lilleaasen, 1982), excellent intubating conditions were reported after atracurium 0.29 mg kg⁻¹. We chose a dose of 0.3–0.35 mg kg⁻¹ because we wanted to be able to antagonize the neuromuscular block after 10–15 min. Furthermore, the enflurane used in present study has been shown to potentiate neuromuscular block (Waud and Waud, 1979).

The excellent intubating conditions obtained with atracurium 0.29 mg kg⁻¹ were found to correlate with a 95% twitch depression of adductor pollicis brevis (Gramstad and Lilleaasen, 1982). We observed 100% twitch depression after atracurium 0.33±0.04 mg kg⁻¹. Intubating conditions were noted especially in nine patients in the atracurium group. Two had spontaneous respiration (with very small tidal volumes) 3 min after atracurium, and six had slight laryngeal movement and mild bucking in response to intubation.

The time to blockade (to 100% depression of adductor pollicis brevis) after suxamethonium 1.62±0.25 mg kg⁻¹ was 26.3±8 s. This is significantly faster than the time to 95% twitch depression of 49.2±7.5 s reported by Blackburn and Morgan (1978) after suxamethonium 1 mg kg⁻¹ (t = 8.66, P < 0.001). Similarly, the time to blockade after atracurium in the present study (60.7±21.1 s) was significantly quicker (P < 0.001) than the time to maximum blockade reported by Gergis and colleagues (1983) (5.9±2.24 min) or Hughes and Payne (1983) (6.1±0.4 min after atracurium 0.3 mg kg⁻¹). The more rapid and complete blockade which we obtained in this study is presumably the result of a potentiating effect of enflurane on neuromuscular block.

Phase II block, which can cause prolonged paralysis, can occur when the total dose of suxamethonium exceeds 3 mg kg⁻¹ (De Cook, 1980). Four patients in this study received more than suxamethonium 3 mg kg⁻¹, and two of them showed evidence of phase II block (T4/T1 ratio < 0.5). The phase II block was not clinically apparent, and all the patients who had received suxamethonium made a rapid and complete recovery when the suxamethonium infusion was discontinued.

Antagonism of the atracurium block depended on the degree of spontaneous recovery which had occurred before the neostigmine was given. As a general rule, there should be some spontaneous recovery before the antagonism of a non-depolarizing block is attempted with neostigmine (Katz, 1971), and antagonism of a 100% blockade from pancuronium is virtually impossible. Antagonism of a 100% atracurium blockade proved possible with neostigmine 2.5 mg (preceded by atropine 1 mg), but took much longer than when there was some degree of spontaneous recovery. Recovery time to a T4/T1 ratio > 0.7 was 7.3±3.03 min (n = 10) if there was no response to ulnar nerve stimulation, but only 4±1.63 min (n = 4) if there was a single twitch response to train-of-four stimulation (t = 2.395, P <0.05). All the patients (in both groups) were able to perform a sustained head-lift for more than 5 s when they were sufficiently awake to co-operate.

Hand-grip strength was measured every 1 h for 4 h, and expressed as a percentage of the preoperative control reading for each patient. We found no difference between the two groups, and there was no evidence of re-curarization. The rubber bulb and aneroid manometer which we
used to measure grip strength form a relatively crude and insensitive instrument, but our results are consistent with those of other workers who have investigated the recovery from pancuronium with more sophisticated techniques (Kopman, 1979).

All the patients in the study were fit for discharge from hospital on the day of the operation. On average, about 5% of the patients who have undergone laparoscopic sterilization at our hospital stay overnight. This figure, however, includes many patients whose stay in hospital must be considered to be socially rather than medically indicated.

Both the neuromuscular blocking drugs used in this study were suitable for use in day-case laparoscopies. Atracurium is a useful alternative to suxamethonium for routine laparoscopies, and would have advantages in those cases where laparoscopy proceeds directly to laparotomy.

ACKNOWLEDGEMENTS
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REFERENCES


