COMPARISON OF ATRACURIUM-INDUCED NEUROMUSCULAR BLOCK IN RECTUS ABDOMINIS AND HAND MUSCLES OF MAN

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SUMMARY
We have compared neuromuscular block in the rectus abdominis and the hand muscles in 11 adult patients. Atracurium 0.5 mg kg\(^{-1}\) was administered by single bolus and anaesthesia maintained with isoflurane and nitrous oxide in oxygen. Train-of-four (TOF) stimulation was applied to the 10th intercostal space in the anterior axillary line and to the ulnar nerve at the wrist. Electromyographic (EMG) responses were recorded over the rectus abdominis and hypothenar muscles. Neuromuscular block had a significantly faster onset in the rectus abdominis (mean 1.6 (SEM 0.2) min) than in the hand (2.4 (0.3) min) (P < 0.001). Recovery occurred more rapidly in the rectus abdominis: time to 25% TOF recovery was 39 (3) min at rectus abdominis and 51 (4) min at the hand (P < 0.001). Time to 75% TOF recovery was 56 (4) min at rectus abdominis and 72 (6) min at the hand (P < 0.001).

KEY WORDS

Abdominal muscle relaxation is desirable for some types of surgery, particularly within the upper abdominal cavity. As these muscles participate in the cough reflex and aid ventilation, it is necessary that prompt return of neuromuscular transmission occurs in abdominal muscles at the completion of surgery.

Neuromuscular block is commonly monitored using supramaximal train-of-four (TOF) stimulation of the ulnar nerve with observation or recording of force of contraction of the adductor pollicis muscle. However, compared with hand muscles, other muscle groups have been shown to differ in sensitivity, onset and recovery characteristics in relation to neuromuscular blocking drugs [1-4].

This study was designed to compare the onset and recovery of atracurium-induced neuromuscular block on the rectus abdominis and hand muscles.

PATIENTS AND METHODS
The study was approved by the Hospital Ethics Committee and informed consent was obtained from all patients. We studied 11 adults, ASA physical status I or II, undergoing surgery of anticipated duration of 1 h or greater. All patients were free from neuromuscular, renal or hepatic disease, and were not taking drugs known or suspected to interfere with neuromuscular function.

Anaesthesia was induced with thiopentone 3-5 mg kg\(^{-1}\), and maintained with 66% nitrous oxide and 1-3% isoflurane in oxygen while baseline neuromuscular measurements were made. The evoked integrated compound action potential of the hypothenar muscles was recorded with a Datex Relaxograph. Supramaximal TOF stimulation was applied to the ulnar nerve with the nerve stimulator incorporated into the Datex unit (pulse width 100 μs, constant current, 0-70 mA range). The evoked compound action potential in the rectus abdominis muscle was acquired as follows. Two surface electrodes were placed in the anterior axillary line adjacent to each other, inferior to the 10th rib. A stimulus passed through these electrodes activated the 10th intercostal nerve and produced a visible and reproducible twitch in the rectus abdominis muscle. The supramaximal TOF stimulus was provided by a Myotest (Biometer, Odense, Denmark) peripheral nerve stimulator. Three additional surface electrodes were placed over the long axis of the rectus abdominis muscle. The first was placed over the insertion of the muscle into the lowermost ribs, the second over the mid portion of the muscle mass and the third (earth) electrode was placed lateral to the others (fig. 1). The signal was amplified and displayed on a Tektronix (Guernsey, Channel Islands) 5310N oscilloscope. The stimulus provided by the nerve stimulator triggered the display on the oscilloscope screen, so that the four EMG responses from TOF stimulation were superimposed exactly. Fourth and first twitch heights were measured on the screen to derive TOF ratios.

A single dose of atracurium 0.5 mg kg\(^{-1}\) was administered after satisfactory baseline measurements had been made with the neuromuscular monitoring devices. Times to TOF ratios of zero were measured at both muscles. Tracheal intubation was performed and anaesthesia continued with intermittent positive pressure ventilation, 0.5-1% isoflurane and fentanyl 2-5 μg kg\(^{-1}\). Monitoring was continued during the spontaneous recovery of neuromuscular function until TOF ratios had reached 0.95 at both muscle sites.
EFFECTS OF ATRACURIUM ON RECTUS ABDOMINIS

The abdominal muscles to the central circulation, and abdo-
minals is probably a result of closer proximity of this agent on these muscles was not investigated.

If tracheal intubation is therefore timed until after visible twitch has disappeared at the hand, coughing or other muscle movement should not occur.

Isoflurane and nitrous oxide were used to supplement anaesthesia to enable baseline measurements to be made without discomfort to the patient, and to minimize the risk of awareness.

TOF ratios are measured commonly with evoked mechanical twitch response. It is not possible to use this technique to measure rectus abdominis twitch response, because there is no convenient point on the abdomen on which to connect a strain gauge apparatus. Evoked EMG responses were used, therefore, for both muscle groups. Hypothenar muscle EMG recording has become common in recent years; artefact is reduced because the muscles are more superficial and affected less by hand movements than are thenar muscles. During recovery from neuromuscular block, EMG response correlates well with mechanical response [6], although reports of overestimation [7] and underestimation [8] have been made.

The Datex Relaxograph is designed to measure TOF ratios on hand muscles, and would not reliably record rectus abdominis muscle activity. The EMG of this muscle was amplified, therefore, and displayed on an oscilloscope. Before commencing the study, we verified that the TOF ratios derived on both machines were comparable, by monitoring simultaneously the onset and recovery of atracurium block on the hand.

The hand response to ulnar nerve stimulation is used commonly to measure neuromuscular block during anaesthesia, because the arm is usually accessible and the results are readily reproducible. However, reliance on the hand response to TOF stimulation may mislead the observer on the adequacy of abdominal muscle relaxation. Substantial neuromuscular recovery may have occurred at rectus abdominis when little response is evident at the hand. The situation in which abdominal muscle relaxation appears inadequate despite minimal hand muscle twitch to ulnar nerve stimulation is encountered frequently clinically.

It is becoming apparent that recovery of neuromuscular function from non-depolarizing neuromuscular blocking drugs is delayed in the hand muscles. For example, it has been demonstrated previously that diaphragmatic [1], masseter [3], orbicularis oculi [2] and laryngeal muscles [4] recover more rapidly than those in the hand. This prolonged recovery of hand muscles is an important clinical event. If hand muscles have recovered from neuromuscular block, other more vital muscles have already returned to full function. Ulnar nerve stimulation is therefore a sensitive indicator of residual paralysis.

TABLE I. Times to train-of-four ratios of 0.25, 0.5, 0.75 and 0.95 (mean (SEM))

<table>
<thead>
<tr>
<th>TOF ratio</th>
<th>Rectus abdominis</th>
<th>Hand muscles</th>
<th>P</th>
</tr>
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<tbody>
<tr>
<td>0.25</td>
<td>39 (3)</td>
<td>51 (4)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>0.5</td>
<td>48 (3)</td>
<td>59 (5)</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>0.75</td>
<td>56 (4)</td>
<td>72 (6)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>0.95</td>
<td>69 (5)</td>
<td>88 (8)</td>
<td>&lt; 0.01</td>
</tr>
</tbody>
</table>

Because hypothermia may potentiate neuromuscular block [5], we attempted to minimize heat loss through the arm by placing it adjacent to the body and covering it with drapes.

RESULTS

Mean age was 40 (SEM 6) yr; mean weight was 67 (3) kg. Time to maximum TOF depression was 1.6 (0.2) min at rectus abdominis and 2.4 (0.3) min at the hand (P < 0.001).

Recovery occurred sooner at rectus abdominis than at the hand in all patients (table I).

DISCUSSION

This study has demonstrated that both onset and recovery times to atracurium-induced neuromuscular block are faster at rectus abdominis than at the hand. As our intent was to assess the effects of an intubating dose of atracurium, the relative potency of this agent on these muscles was not investigated.

The faster onset of neuromuscular block at rectus abdominis is probably a result of closer proximity of the abdominal muscles to the central circulation, and the greater blood flow to this muscle group. This phenomenon has been described in other muscle groups also [1-4].

REFERENCES


FIG. 1. Electrode configuration for rectus abdominis muscle EMG recording.


