USE OF THE POST-TETANIC COUNT TO MONITOR RECOVERY FROM INTENSE NEUROMUSCULAR BLOCKADE IN CHILDREN

C. L. GWINNUTT AND G. MEAKIN

Following the administration of an intubating dose of a non-depolarizing neuromuscular blocker, the degree of neuromuscular blockade is frequently so intense that all response to train-of-four [1] stimulation is abolished. Moreover, during recovery, the time from the return of the first train-of-four response to the point where blockade becomes inadequate may be short, especially when the newer intermediate-acting agents are used [2].

Viby-Morgensen and colleagues [3] have described a method for monitoring intense neuromuscular blockade. It consists of applying a 50-Hz tetanic stimulus to the ulnar nerve for 5 s, followed by single twitch stimulation at 1 Hz. The number of twitches observed in the period of post-tetanic facilitation, the post-tetanic count, correlates inversely with the degree of neuromuscular blockade.

The present study was designed to investigate the use of the post-tetanic count during anaesthesia in children. One of five neuromuscular blockers was given to a group of six children during nitrous oxide-oxygen-halothane anaesthesia. During recovery, the first train-of-four response to the point where blockade becomes inadequate may be short, especially when the newer intermediate-acting agents are used [2].

Patients and Methods

The study was approved by the District Ethics Committee. Thirty children aged between 1 and 10 yr were studied during elective surgical procedures where non-depolarizing neuromuscular blocking agents would be used normally as part of the anaesthetic technique. All were ASA class I and none was receiving drugs known to interfere with neuromuscular transmission. Patients were allocated randomly to one of five groups to receive a predetermined dose of a different agent (table I).

Premedication with oral trimeprazine 3 mg kg⁻¹, was given 2 h before operation. Anaesthesia was induced with thiopentone 5 mg kg⁻¹ and maintained with 70% nitrous oxide and 1% halothane in oxygen. Tracheal intubation was performed without the aid of neuromuscular blockade, and ventilation of the lungs was controlled using the
paediatric attachment of the Blease ventilator. Minute volume was adjusted to maintain the end-tidal carbon dioxide partial pressure in the range 4.8–5.4 kPa. The ECG was monitored throughout the procedure and rectal temperature maintained between 36.5 and 37.5 °C.

Neuromuscular transmission was monitored initially by the method of Ali, Utting and Gray [1]. The ulnar nerve was stimulated supra-maximally at the wrist using cutaneous electrodes. Trains-of-four square pulses of 0.2 ms duration at a frequency of 2 Hz were repeated every 10 s using a peripheral nerve stimulator (Bard) modified suitably to deliver sequences of stimuli. The hand and forearm were immobilized in a splint and the force of adduction of the thumb measured using a Grass FT03 force displacement transducer. Data were recorded on a pen-and-ink recorder (Grass polygraph).

After a 10-min period during which the train-of-four responses was allowed to stabilize, the pre-selected dose of neuromuscular blocking drug was administered via a fast running i.v. infusion. Subsequently, neuromuscular transmission was monitored using the following sequence of stimuli:

(a) 1 Hz applied for 10 s
(b) 3-s pause
(c) tetanic stimulation, 50 Hz for 5 s
(d) 3-s pause
(e) 1 Hz for 30 s (post-tetanic count)
(f) 10-s pause
(g) train-of-four every 10 s for 40 s. This sequence was repeated automatically, generating a post-tetanic count every 2 min. If the initial dose of blocking drug was insufficient to abolish the post-tetanic count, supplementary doses equal to 25% of the initial dose were given until this was achieved.

The following data were recorded during spontaneous recovery:
(i) The time from administration of the blocker to the onset of the first post-tetanic response. Where multiple doses were required, the time was taken from the last dose given.
(ii) The time from the first post-tetanic response to the appearance of the first train-of-four response.
(iii) The post-tetanic count at the first train-of-four response.

In all cases the first response was defined as a twitch height equal to or greater than 3% of the control.

Before statistical analysis, post-tetanic counts were transformed to square-root values. This transformation normalizes data in the form of counts, which have a Poisson distribution [4]. Significant differences between the groups were determined by analysis of variance and the Least Significant Difference test. The Null hypothesis was rejected when $P < 0.05$.

### RESULTS

There were no significant differences between the five groups of children with regard to age or weight (table I).

Complete suppression of train-of-four and post-tetanic responses occurred following a single dose of vecuronium, atracurium or pancuronium. However, three patients given alcuronium and all six patients given tubocurarine required increments of up to 50% of the initial doses to achieve this.

During recovery, the first post-tetanic response (PTC1) always preceded the first train-of-four response (T1). The recovery time from injection to the appearance of PTC1 was significantly less for vecuronium than for the other agents ($P < 0.01$) (table II). Subsequently, the appearance of T1 occurred more rapidly in patients given vecuronium or atracurium compared with those

### TABLE I. Details of patient groups (median values and range)

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Dose of blocker (mg kg⁻¹)</th>
<th>Age (yr)</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vecuronium</td>
<td>6</td>
<td>0.08</td>
<td>4.5 (2.6–9.5)</td>
<td>15.3 (13.4–31.0)</td>
</tr>
<tr>
<td>Atracurium</td>
<td>6</td>
<td>0.5</td>
<td>5.2 (1.8–7.3)</td>
<td>14.5 (11.1–33.3)</td>
</tr>
<tr>
<td>Pancuronium</td>
<td>6</td>
<td>0.1</td>
<td>4.1 (1.4–10.0)</td>
<td>17.5 (11.2–27.5)</td>
</tr>
<tr>
<td>Alcuronium</td>
<td>6</td>
<td>0.3</td>
<td>5.5 (3.8–7.3)</td>
<td>23.6 (13.0–29.5)</td>
</tr>
<tr>
<td>Tubocurarine</td>
<td>6</td>
<td>0.5</td>
<td>4.0 (1.6–7.8)</td>
<td>15.5 (13.9–21.9)</td>
</tr>
</tbody>
</table>
POST-TETANIC COUNT IN CHILDREN

TABLE II. Mean (SEM) recovery times from injection of neuromuscular blocker to appearance of the first post-tetanic response (PTC1), and from the appearance of PTC1 to appearance of the first train-of-four response (Tl). Significant differences (P<0.01): **compared with other agents in column; †† compared with remaining three agents in column

<table>
<thead>
<tr>
<th>Group</th>
<th>Injection-PTC1 (min)</th>
<th>PTC1-T1 (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vecuronium</td>
<td>10.4 (0.9)**</td>
<td>5.8 (0.3)††</td>
</tr>
<tr>
<td>Atracurium</td>
<td>18.8 (1.9)</td>
<td>7.8 (0.5)††</td>
</tr>
<tr>
<td>Pancuronium</td>
<td>24.9 (4.3)</td>
<td>19.8 (3.0)</td>
</tr>
<tr>
<td>Alcuronium</td>
<td>22.5 (4.8)</td>
<td>29.3 (3.3)</td>
</tr>
<tr>
<td>Tubocurarine</td>
<td>26.0 (6.0)</td>
<td>33.3 (3.3)</td>
</tr>
</tbody>
</table>

who received pancuronium, alcuronium or tubocurarine (P<0.01).

The mean post-tetanic counts at the onset of Tl for alcuronium and tubocurarine were significantly less than those for vecuronium, atracurium and pancuronium (P<0.05) (table III).

DISCUSSION

The results of the present study indicate that the post-tetanic count is a useful method of monitoring intense neuromuscular blockade in children. The time from the appearance of PTC1 to the onset of Tl was typically 5–10 min for intermediate-acting agents and 20–30 min for long-acting drugs. A post-tetanic count of 6 with alcuronium and tubocurarine, or 7 with vecuronium, atracurium and pancuronium, indicated that recovery of Tl was imminent.

The intervals between PTC1 and T1 for vecuronium, atracurium and pancuronium (table II) appeared somewhat shorter than those measured previously in adults (mean adult values 8.3, 9.0 and 33 min, respectively) [3, 5, 6]. This is consistent with earlier studies indicating that recovery from the effects of these blockers is more rapid in children [7–9], although the rates of recovery of our patients may have been enhanced by the frequent use of tetanic stimulation (every 2 min) [10].

The post-tetanic counts at the onset of Tl for vecuronium, atracurium and pancuronium (table III), are comparable with data published previously from children [11] and adults [3, 5, 6]. The small difference in post-tetanic counts at the onset of Tl between alcuronium, tubocurarine and the other blocking drugs is interesting, as it may indicate that the former possess a greater affinity for pre-junctional acetylcholine receptors. This suggestion is supported by observations that a greater degree of fade is produced by these drugs compared with vecuronium, atracurium and pancuronium [12–14]. Train-of-four and tetanic fade are believed to occur because pre-junctional receptor blockade inhibits the mobilization of acetylcholine during repetitive stimulation [15]. Such inhibition during the period of tetanus preceding single twitch stimulation, may have resulted in the lower post-tetanic counts we observed with alcuronium and tubocurarine. Furthermore, the failure of some initial doses of these blocking drugs to abolish the post-tetanic count may have been the result of relatively weak post-junctional block.

The post-tetanic count is useful in a number of clinical situations. Following tracheal intubation, when neuromuscular block is usually greatest, it may be used to confirm correct positioning of electrodes for monitoring neuromuscular transmission. When intermediate-acting neuromuscular blockers are used, it permits the use of a quantifiable level of intense neuromuscular blockade, thus avoiding the problems associated with very rapid recovery [5]. Finally, when intense neuromuscular blockade is present at the conclusion of anaesthesia, the post-tetanic count allows the onset of Tl to be predicted, at which point antagonism of blockade can be achieved using conventional doses of anticholinesterases [16].

In summary, the post-tetanic count provides a useful method of monitoring intense neuromuscular blockade in children. The interval between PTC1 and T1 is characteristic for intermediate and long-acting blocking drugs, and a post-tetanic count of 6 or 7 indicates that

TABLE III. Mean (SEM) post-tetanic count (PTC) at the onset of the first train-of-four response (T1). * Significantly (P<0.05) smaller values than for vecuronium, atracurium and pancuronium

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>PTC at onset of Tl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vecuronium</td>
<td>6</td>
<td>7.3 (0.8)</td>
</tr>
<tr>
<td>Atracurium</td>
<td>6</td>
<td>7.2 (0.4)</td>
</tr>
<tr>
<td>Pancuronium</td>
<td>6</td>
<td>7.2 (0.5)</td>
</tr>
<tr>
<td>Alcuronium</td>
<td>6</td>
<td>6.3 (0.4)*</td>
</tr>
<tr>
<td>Tubocurarine</td>
<td>6</td>
<td>5.7 (0.4)*</td>
</tr>
</tbody>
</table>

Downloaded from https://academic.oup.com/bja/article-abstract/61/5/547/280243 by guest on 20 March 2019
recovery of $T_1$ is imminent. The $PTC_{1-T_1}$ intervals for vecuronium, atracurium and pancuronium in children were less than those reported previously in adults.

ACKNOWLEDGEMENTS

The authors wish to thank Mr K. Smith and the Department of Medical Physics for modifying the Bard nerve stimulator, Mr W. Adshead for technical assistance and the Research Sub-Committee of Royal Manchester Children’s Hospital for funding this study.

REFERENCES