Effect of tetanic stimulation on subsequent train-of-four responses at various levels of vecuronium-induced neuromuscular block

Y. Saitoh, A. Masuda, H. Toyooka and K. Amaha

Summary
Tetanic stimulation influences subsequent neuromuscular responses. In addition, the tetanus-induced changes in neuromuscular responses differ according to the level of neuromuscular block at which tetanic stimulation is delivered. We studied the tetanus-induced effect on subsequent train-of-four (TOF) responses at various levels of vecuronium-induced neuromuscular block in 45 anaesthetized patients. Tetanic stimulation was applied when a twitch height of T1 returned to 25%, 50% and 75% of its control twitch height (T0) (groups 1, 2 and 3, respectively) after administration of vecuronium 0.1 mg kg⁻¹. Maximum post-tetanic percentage increases in TOF responses in groups 1, 2 and 3 were 257 (SD 119)%, 107 (75)% and 68 (54)% for T1/T0 (P < 0.001 for group 1 vs 2; P < 0.001 for group 1 vs 3) and 535 (259)% and 292 (171)% for T4/T1 (P < 0.01 for group 1 vs 3), respectively. Durations of post-tetanic increases in TOF responses in groups 1, 2, and 3 were 52 (19)s, 37 (14)s and 32 (13)s for T1/T0 (P < 0.05 for group 1 vs 2; P < 0.01 for group 1 vs 3) and 53 (17)s, 46 (15)s and 35 (12)s for T4/T1 (P < 0.05 for group 1 vs 3), respectively. These data suggest that the tetanus-induced effect on subsequent TOF is more apparent and lasts longer at greater degrees than at lesser degrees of neuromuscular block. (Br. J. Anaesth. 1994; 73: 416-417)

Key words

Brull and colleagues [1] reported that the post-tetanic increases in T1/T0 and T4/T1 were 38% and 93% and that the augmenting effects lasted 34 and 34 s, respectively. It was also shown that enhancement of the neuromuscular response after tetanic stimulation differed according to the level of neuromuscular block at which tetanic stimulation was applied [2, 3]. Therefore, augmentation of neuromuscular response after tetanic stimulation should be assessed according to the level of neuromuscular block. However, there have been no detailed studies on both the degree and duration of the tetanus-induced effect on the subsequent neuromuscular response at various levels of neuromuscular block during clinical anaesthesia. In this study we have determined the tetanus-induced effect on subsequent TOF responses when the twitch height of T1 had returned to 25%, 50% and 75% of its control twitch height (T0) during spontaneous recovery from vecuronium 0.1 mg kg⁻¹-induced neuromuscular block.

Methods and results
After obtaining Human Investigation Committee approval and written informed consent, we studied 45 adult patients (24 male), ASA I–II, undergoing elective general anaesthesia with artificial ventilation. No patient had neuromuscular, renal or hepatic disorders and none was receiving any drug known to influence neuromuscular function. They were allocated randomly to three groups of 15 patients each as described below.

All patients received atropine 0.01 mg kg⁻¹ i.m. and hydroxyzine 1 mg kg⁻¹ i.m. 30 min before operation. Stimulating surface electrodes were positioned over the ulnar nerve at the elbow and recording electrodes over the corresponding abductor digiti minimi muscle. Anaesthesia was induced with thiamylal 5 mg kg⁻¹ and suxamethonium 1 mg kg⁻¹ i.v. and was maintained with 67% nitrous oxide in oxygen and 1.2% end-tidal concentration of isoflurane. Patients' lungs were ventilated to maintain normocapnia (end-tidal carbon dioxide 4.8–5.3 kPa).

The TOF stimuli consisted of four 200-μs square-wave impulses delivered at 50 mA every 12 s, and for tetanic stimulation a 50-Hz tetanus was applied for 5 s at 50 mA using an electrical stimulator (SEN-3201, Nihon-Kohden Inc, Tokyo, Japan). The EMG responses were amplified (AVB-11, Nihon-Kohden Inc, Tokyo, Japan) and displayed on an oscilloscope (VC-11, Nihon-Kohden Inc, Tokyo, Japan). A personal desk-top computer (PC-9801 UX, NEC Inc, Tokyo, Japan) was used for overall control of automatic stimulation and data collection.

When neuromuscular function returned approximately 10 min after administration of suxamethonium, the T1 twitch height was designated as the control twitch height (T0). Thereafter, vecuronium 0.1 mg kg⁻¹ was administered to produce...
complete neuromuscular block. When T1/T0 returned to 25%, tetanic stimulation was delivered (group 1). Similarly, tetanic stimuli were delivered when T1/T0 returned to 50% (group 2) and 75% (group 3), and the 12-s interval TOF stimuli were resumed 3 s after tetanic stimulation. In this way we calculated the maximum percentage increases in T1/T0 and T4/T1 compared with pre-tetanic values at various levels of neuromuscular block. Also, we calculated the intervals during which the increased T1/T0 and T4/T1 after tetanic stimuli became equal to pre-tetanic values. The post-tetanic T1/T0 and T4/T1 were regarded as equivalent to pre-tetanic values when the increased T1/T0 and T4/T1 returned to within 10% of their respective pre-tetanic values. This method was used also by Brull and colleagues [1].

There were no significant differences in patient characteristics in the three groups.

Maximum post-tetanic increases in T1/T0 and T4/T1 were observed 3 s after tetanic stimuli in all patients.

Maximum post-tetanic percentage increases in T1/T0 and T4/T1 compared with pre-tetanic values differed significantly between groups (table 1). Also, the durations of post-tetanic increases in T1/T0 and T4/T1 differed significantly between groups.

Table 1

<table>
<thead>
<tr>
<th></th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
</tr>
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<tbody>
<tr>
<td>Maximum increase (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1/T0</td>
<td>257 (119)**</td>
<td>107 (75)</td>
<td>68 (54)</td>
</tr>
<tr>
<td>T4/T1</td>
<td>535 (259)‡</td>
<td>421 (213)</td>
<td>292 (171)</td>
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<tr>
<td>Duration of increase(s)</td>
<td></td>
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<tr>
<td>T1/T0</td>
<td>52 (19)†††</td>
<td>37 (14)</td>
<td>32 (13)</td>
</tr>
<tr>
<td>T4/T1</td>
<td>53 (17)‡</td>
<td>46 (15)</td>
<td>35 (12)</td>
</tr>
</tbody>
</table>

Comment

It has been observed that the degree of post-tetanic potentiation varied according to the level of neuromuscular block in humans [2] and that the duration of post-tetanic potentiation altered according to the degree of neuromuscular block in the rat [3]. The present study has also demonstrated that in the clinical setting enhancement of TOF responses after tetanic stimuli were greater and lasted longer at intense levels of neuromuscular block than at light levels.

Gissen and Katz [2] observed that in anaesthetized patients receiving tubocurarine, enhancement of single twitch responses after tetanic stimulation decreased as neuromuscular block became lighter and that the stronger the neuromuscular block, the greater the degree of post-tetanic potentiation. No previous studies, however, have measured post-tetanic changes in TOF responses.

Liley and North [3] reported that, in the phrenic nerve—diaphragm preparation of the rat, post-tetanic increases in electromyographic amplitudes lasted longer in a heavily curarized preparation than in a lightly curarized one. This phenomenon presumably reflected the duration of acetylcholine release in the neuromuscular junction being longer at deeper neuromuscular block. The enhancement of neuromuscular responses after tetanic stimulation were short-lived both in the present study and in that by Brull and colleagues [1]. On the other hand, Katz [4] showed that the post-tetanic increase in neuromuscular responses persisted for as long as 2–11 min. However, they also noted that this prolonged post-tetanic potentiation could be observed in the absence of neuromuscular block. Therefore, the short post-tetanic potentiation observed in this study reflected the state of blocked neuromuscular transmission after administration of vecuronium.

In this study we assessed neuromuscular block using electromyography (EMG), whilst in previous studies [1, 2] mechanical twitch responses (MTR) were used. Katz [4] noted that neuromuscular block measured with MTR was greater than that with EMG. Kopman [5] also reported that MTR frequently showed significantly greater block than that suggested by simultaneously recorded EMG. Thus the present data may have differed from those obtained using MTR in previous studies.

References


