Tactile evaluation of fade of the train-of-four and double-burst stimulation using the anaesthetist’s non-dominant hand

Y. Saitoh1*, Y. Narumi1, Y. Fujii2 and M. Ueki3

1Department of Anaesthesiology, Toride Kyodo General Hospital, 2–1–1, Hongo, Toride City, Ibaraki, 302-0022, Japan. 2Department of Anaesthesiology, Institute of Clinical Medicine, University of Tsukuba, Ibaraki, Japan. 3Department of Anaesthesiology and Critical Care Medicine, Faculty of Medicine, Tokyo Medical and Dental University, Tokyo, Japan

*Corresponding author

We have studied detection of fade in response to train-of-four (TOF), double-burst stimulation3,3 (DBS3,3) or DBS3,2, assessed tactiley by the anaesthetist using the index finger of the non-dominant hand and the thumb of the patient, compared with that assessed when the index finger of the dominant hand was used. The probability of detection of any fade in response to TOF or DBS3,3 using the non-dominant hand was significantly less than when the dominant hand was used (P<0.05). The probability of identification of fade in response to DBS3,2 assessed using the non-dominant hand was comparable with that evaluated using the dominant hand when TOF ratios were 0–0.9, but when TOF ratios reached 0.91–1.00, detection using the non-dominant hand was significantly less common than with the dominant hand (12% vs 33%; P<0.05). Using the non-dominant hand, the probability of detection of fade in response to ulnar nerve stimulation was less than that with the dominant hand and only the absence of DBS3,2 fade ensured sufficient recovery of neuromuscular block.

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When recovery from neuromuscular block is evaluated tactiley using train-of-four (TOF) or double-burst stimulation3,3 (DBS3,3), residual neuromuscular block tends to be missed.1–3 In contrast, when DBS3,2 is applied, recovery from neuromuscular block is often regarded as insufficient because fade in response to this technique is palpable even when TOF ratios have returned to more than 0.9.2

The presence or absence of fade in response to nerve stimulation is usually evaluated using the index finger of the dominant hand of the anaesthetist. However, no previous study has investigated tactile assessment of fade using the non-dominant hand. In right-handed people, the dominant or major side of the brain is the left hemisphere, and the right hemisphere is “mute or dumb”.4 In right-handed persons, the sensation of feeling in the left hand (i.e. the non-dominant hand) is less sensitive than that in the right hand.5 We hypothesized that if fade in response to ulnar nerve stimulation was assessed tactiley using the non-dominant hand, the probability of detection of fade would be less than that evaluated using the dominant hand.

Patients and methods

We studied 90 adult patients, ASA I or II, undergoing elective general anaesthesia. The study was approved by the Local Ethics Committee and written informed consent was obtained from each patient. Patients were allocated randomly to one of three groups: TOF (n=30), DBS3,3 (n=30) or DBS3,2 (n=30). No patient had neuromuscular, hepatic or renal disorders, or was receiving any drugs known to interfere with the action of neuromuscular blocking agents.

Premedication comprised atropine 0.01 mg kg⁻¹, and hydroxyzine 1.0 mg kg⁻¹ was administered i.m., 30 min before induction of anaesthesia. Surface stimulating electrodes (Vitrodes, M-150, Nihon-Kohden, Tokyo, Japan) were positioned over the ulnar nerve of both forearms at the wrist. On the left arm (control arm) a force displacement transducer was attached to the thumb. The right arm (test arm) was unrestrained.

Anaesthesia was induced with propofol 1.5 mg kg⁻¹ i.v., and after loss of the eyelash reflex, TOF stimuli were applied using a nerve stimulator (Myotest DBS, DBS-000E, Biometer International, Odense, Denmark) on the control arm every 12 s at 10, 20, 30, 40 and 50 mA, in this order. Four single twitch stimuli consisting of 0.2-ms duration square waves were delivered at a frequency of 2 Hz. Adduction of the thumb was measured mechanically using
a neuromuscular transmission analyser (Myograph 2000, Biometer International, Odense, Denmark). If the supramaximal response to T1 (first response in the TOF) was elicited at currents ≤40 mA, TOF, DBS₃,₃ or DBS₃,₂ was delivered at 50 mA. If the supramaximal response to T1 was obtained at 50 mA, TOF, DBS₃,₃ or DBS₃,₂ was applied at 60 mA. The height of T1 measured at supramaximal current was regarded as control twitch height. After control recordings had been obtained, vecuronium 0.1 mg kg⁻¹ i.v. was given to facilitate tracheal intubation. DBS₃,₃ and DBS₃,₂ consisted of two burst stimuli separated by 750 ms. Each burst stimulation of DBS₃,₃ consisted of three tetanic stimuli of 0.2-ms duration. For DBS₃,₂, the first burst consisted of three tetanic stimuli of 0.2-ms duration at 50 Hz, and the second of two 50-Hz tetanic stimuli of 0.2-ms duration at 50 Hz.

Anaesthesia was maintained with 1.0% end-tidal isoflurane and 66% nitrous oxide in oxygen. The patients’ lungs were ventilated to maintain normocapnia ($$\text{PACO}_2$$ 4.1–5.0 kPa). The concentration of isoflurane and $$\text{PACO}_2$$ were monitored continuously using a multiple gas analyser (Capnomac Ultima, S-31–03, Datex Inc., Helsinki, Finland). The temperature over the adductor pollicis muscle was monitored using a surface skin thermometer (Terumo-Finer, CTM-303, Terumo Inc., Tokyo, Japan). During spontaneous recovery from neuromuscular block, TOF stimuli were delivered at 50 or 60 mA to the control arm at more than 20-s intervals. When TOF stimulation was delivered to the control arm, TOF, DBS₃,₃ and DBS₃,₂ were performed simultaneously on the test arm at 50 or 60 mA. On the test arm, another nerve stimulator (Myotest DBS, DBS-000E, Biometer International, Odense, Denmark) was used.

One of 20 observers (all anaesthetists who was not aware of the true TOF ratio or the pattern of nerve stimulation, tactically assessed the presence or absence of fade in response to TOF, DBS₃,₃ and DBS₃,₂. Five of the observers had worked as anaesthetists for less than 6 months, and four for less than 2 yr. None had any special interest in neuromuscular monitoring. Two had worked as anaesthetists for 5–8 yr but had no special interest in neuromuscular monitoring. Two had been anaesthetists for 7 yr and were experienced in neuromuscular monitoring. Three had been anaesthetists for more than 10 yr and were experienced in neuromuscular monitoring.

Before tactile assessment of fade, we asked each observer to evaluate the presence or absence of fade in response to TOF, DBS₃,₃ and DBS₃,₂ in the routine manner used in the clinical setting. In this way, we determined if each observer assessed the presence or absence of fade using his dominant or non-dominant hand. For tactile evaluation of fade at the thumb of the test arm of the patient, the observer examined the presence or absence of fade using the index finger of the dominant or non-dominant hand. Each observer took part in the evaluation of the presence or absence of fade in the same patient no more than twice. When one observer assessed the presence or absence of fade twice, one assessment of fade was performed with his non-dominant hand and the other with his dominant hand more than 30 min later. In some patients, an additional dose of vecuronium 0.01–0.02 mg kg⁻¹ was given to achieve a more intense level of neuromuscular block. When the TOF ratio reached a minimum value after the bolus dose of vecuronium, tactile evaluation of fade was again started. In this way, tactile evaluations were repeated many times, and the probabilities of detection of any fade in response to TOF, DBS₃,₃ and DBS₃,₂ were determined.

All results are expressed as number or mean (sd or range). Patient characteristics in the three groups were compared using analysis of variance (ANOVA) and Scheffe’s multiple comparison. Comparison between the probability of detection of fade in response to TOF, DBS₃,₃ or DBS₃,₂, assessed using the non-dominant or dominant hand, was made using the chi-square test and Fisher’s exact probability test. P<0.05 was considered statistically significant. Statistical analyses were performed using a statistical package (Stat 123, Sinkoukoueki Inc., Tokyo, Japan) running on a personal computer (NEC PC-9821 Na NEC Inc., Tokyo, Japan).

### Results

Patient characteristics were comparable in the three groups (Table 1). All observers were right-handed men, aged 27–47 yr.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Patient characteristics in the TOF, DBS₃,₃, and DBS₃,₂ groups. Values are mean (sd or range) or number. No significant differences between groups</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TOF</td>
</tr>
<tr>
<td>n</td>
<td>30</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>16/14</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>49.8 (27–79)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.7 (12.0)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>59.6 (11.5)</td>
</tr>
</tbody>
</table>

In all patients, the supramaximal response to T1 was elicited at 20–40 mA. Therefore, during tactile assessment of fade, TOF, DBS₃,₃ and DBS₃,₂ were applied at 50 mA.

When we asked each observer to assess tactically the presence or absence of fade in response to TOF, DBS₃,₃ and DBS₃,₂ in the way he usually performed it in the clinical setting, all observers evaluated fade using the dominant hand. The presence or absence of fade in response to TOF, DBS₃,₃ and DBS₃,₂ was assessed manually using the dominant hand 401, 396 and 303 times, respectively, and using the non-dominant hand 404, 404 and 309 times, respectively.

When control TOF ratios were 0.31–0.70, the probabilities of detection of any fade in response to TOF stimulation assessed using the non-dominant hand of the anaesthetist were significantly less than when using the dominant hand ($$P<0.05$$) (Fig. 1). When TOF ratios were 0.31–0.60, the probabilities of detection of DBS₃,₃ fade assessed using the non-dominant hand were significantly less than when using the dominant hand ($$P<0.05$$) (Fig. 2). When TOF ratios
Evaluation of neuromuscular fade using the non-dominant hand

Fig 1 Probabilities of tactile detection of any fade in response to TOF using the non-dominant and dominant hands at varying TOF ratios. Values are probability (%). *P<0.05.

Fig 2 Probabilities of tactile detection of any fade in response to DBS 3,3 using the non-dominant and dominant hands at varying TOF ratios. Values are probability (%). *P<0.05.

Fig 3 Probabilities of tactile detection of any fade in response to DBS 3,2 using the non-dominant and dominant hands at varying TOF ratios. Values are probability (%). *P<0.05.

were 0.91–1.00, the probabilities of detection of DBS 3,2 fade assessed using the non-dominant hand were significantly less than when using the dominant hand (P<0.05) (Fig. 3).

Peripheral temperature did not decrease to less than 32°C in any patient.

Discussion

We have shown that the probability of tactile detection of any fade in response to nerve stimulation using the non-dominant hand of the anaesthetist was less than if the dominant hand was used. But when assessed using the non-dominant hand, the absence of fade in response to DBS 3,2 confirmed that recovery of neuromuscular block was sufficient. In right-handed people, the dominant side of the brain is the left hemisphere and the sensation of feeling in the left hand (non-dominant) is less sensitive than that in the right (dominant). Moreover, patients in whom disconnection of the cerebral hemispheres has been performed have difficulty in identifying familiar object such as a pencil, cigarette, comb or a coin placed in the non-dominant hand. This could be related to the probability of detection of any fade assessed using the non-dominant hand being less than when the dominant hand is used.

A TOF ratio >0.9 correlates well with signs of adequate recovery from neuromuscular block. However, our study demonstrated that even when assessed using the dominant hand, at a TOF ratio of 0.9, no fade in the TOF or DBS 3,3 was palpable. This result is similar to previous findings. When the non-dominant hand was used, detection of fade was less likely. Therefore, when assessed either with the dominant or non-dominant hand, absence of fade in response to TOF or DBS 3,3 does not ensure adequate recovery of neuromuscular block. The probability of detection of fade in response to DBS 3,2 was greater than when using TOF or DBS 3,3 at varying degrees of neuromuscular block. But when assessed using the dominant hand, fade in response to DBS 3,2 was felt more frequently in as many as 33% of cases, even at a TOF ratio >0.9. This finding is also comparable with previous data. Thus when the presence of fade in response to DBS 3,2 is detected using the dominant hand, adequate recovery of neuromuscular block may be regarded as insufficient. The probability of detection of fade in response to DBS 3,2 assessed using the non-dominant and dominant hand was similar at TOF ratios <0.9. But when TOF ratio returned to more than 0.9, the probability of detection of DBS 3,2 fade assessed using the non-dominant hand was as low as 12%. Hence, when the presence of fade in response to DBS 3,2 is evaluated using the non-dominant hand, the risk of over-estimation of the degree of residual neuromuscular block even at TOF ratios >0.9 decreases. However, at TOF ratios of 0.51–0.60, 0.61–0.70, 0.71–0.80 and 0.81–0.90, fade in response to DBS 3,2 was identified using the non-dominant hand in 96%, 79%, 69% and 54% of data sets, respectively.

Several attempts have been made to diagnose adequate recovery from neuromuscular block clinically. We have reported tactile evaluation of fade in response to DBS 3,3 using the index finger of a patient; visual assessment of fade in response to DBS 3,3 at the thumb which was kept abducted using a rubber band; double-burst stimulation (DBS 2,3) and modified double-burst stimulation (modified DBS). Although insufficient recovery of neuromuscular block (TOF ratio 0.7–0.8) can be diagnosed easily using such methods, an adequate level of recovery (TOF ratio >0.9) cannot be ensured. Baurain and colleagues showed that the absence of fade in response to 100-Hz, 5-s tetanic stimulation at the adductor pollicis muscle was related to sufficient recovery of neuromuscular block (TOF ratio
However, the degree of residual neuromuscular block is very often evaluated in awake patients in the post-anaesthetic care unit (PACU). As tetanic stimulation is too uncomfortable for awake subjects, 100-Hz, 5-s stimulation is not thought to be suitable to assess recovery in these circumstances. In this respect, assessment of fade in response to DBS\textsubscript{3,2} using the non-dominant hand is of clinical use.

In this study, all of the observers were right-handed men. It has been shown that in left-handed people, the difference in dominance between the bilateral hemispheres of the brain is less apparent than in right-handed persons.\textsuperscript{12} If a left-handed anaesthetist examines fade in response to nerve stimulation tactiley using the non-dominant right hand, the difference between the probability of detection of fade assessed using the dominant and non-dominant hand may be slight.

In our study, the experience of the anaesthetists varied among the 20 observers. It has been shown previously that the probability of tactile or visual identification of fade in response to TOF, DBS\textsubscript{3,3} and DBS\textsubscript{3,2} does not differ significantly between novice and experienced observers.\textsuperscript{13,14} Individual variation in evaluation of fade in response to nerve stimulation is not thought to be important.

References

5. deSperati C, Stucchi N. Recognizing the motion of a graspable object is guided by handedness. Neuro Report 1997; 8: 2761–5