

$T_1 > 0$ and $T_4 = 0$ (i.e., $T_4/T_1 = 0$) but with $T_1/T_4 > 0$ at 30 and 50 mA, the result would have refuted their conclusion regarding the constancy of TOF ratio at different currents. It is also possible that under other conditions, TOF ratio may be 0 at 30 mA but greater than 0 at 50 mA.

The lack of constancy of TOF ratio at 20, 30, and 50 mA suggests that a supramaximal stimulating current should be used in monitoring the neuromuscular blockade.

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REFERENCE

1. Brull SJ, Ehrenwerth J, Silverman DG: Stimulation with submaximal current for train-of-four monitoring. *ANESTHESIOLOGY* 72:629-632, 1990

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Doctor . . . Are You Sure the Patient Is Paralyzed?

To the Editor:—The role of peripheral nerve stimulation in the clinical assessment of neuromuscular blockade, and the implications of submaximal stimulation on the evaluation of T_4/T_1 ratio (train-of-four [TOF]) were recently examined by Brull *et al.*¹ They state that the original motivation for the investigation was the systematic discovery and subsequent concern that several nerve stimulators in their operating room suites delivered currents of only 16 mA.² In assessing neuromuscular function in awake or recovering patients, the authors' data support the conclusion that submaximal stimulation is adequate for TOF evaluation in the interest of patient comfort. Yet, in the abstract accompanying this article, they state "that T_4/T_1 testing can be reliably accomplished *intraoperatively* and *postoperatively* using submaximal stimuli" [emphasis added]. This belief is evident throughout the article. Are "underpowered" nerve stimulators adequate for assessing neuromuscular function intraoperatively, as suggested by these investigators?

Careful reading of their article exposes interesting data secluded in the methods section; a T_4 response was unobtainable with a 20-mA stimulus in 9 of 28 anesthetized patients maintained on a continuous vecuronium infusion: a reliable T_4/T_1 ratio was attained in *all* subjects only at 30 mA or greater. These 9 were excluded from analysis in the 20-mA category (submaximal stimulus), and are never discussed again. This intraoperative population represents a statistically significant group of nonresponders to a 20-mA stimulus ($P < 0.001$; chi-squared = 33.3 as compared to 30 or 50 Hz).

Lee carefully described the need to stimulate at 2 Hz and at a spacing of 0.5 s to maximize the information gathered from the TOF.³ Kopman and Lawson showed that requirements for obtaining a maximal twitch in *all* patients when stimulating the ulnar nerve at the wrist *via* surface electrodes was at least 20 mA, or 2.75 times the current necessary to illicit the first detectable twitch.⁴ Thirty milliamperes provided supramaximal stimulation in *all* patients regardless of wrist circumference. Combined with the data from Brull *et al.* establishing that 32% of

intraoperative subjects cannot be assessed for a T_4/T_1 ratio with a 20-mA stimulus, this finding lends strong credence to the conclusion drawn in 1984: "Inadequate stimulation [current] may lead the clinician to overestimate the degree of neuromuscular blockade present."⁴ Adequately designed stimulators that can deliver high continuous current (>30 mA) will guarantee that the anesthesiologist can confidently assess the patient during *all* phases of anesthesia care. Despite the attempt of Brull *et al.* to reassure themselves and us to the contrary, the nerve stimulators lurking in New Haven, Connecticut should be cause for concern.

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4. Kopman AF, Lawson D: Milliamperage requirements for supramaximal stimulation of the ulnar nerve with surface electrodes. *ANESTHESIOLOGY* 61:83-85, 1984

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In Reply:—We were somewhat perplexed by Dr. Lawson's concern that "underpowered" nerve stimulators are "lurking in New Haven," especially in light of his paper in which it is stated that "of the commercially available battery-operated nerve stimulators available in the United States, most have maximum outputs no greater than 30 milliamperes (mA)."¹ We emphasized that the major focus of our work² was not the assessment of the stimulating power of nerve stimulators, but rather the determination of whether submaximal currents may be

used deliberately for train-of-four stimulation so as to reduce discomfort in the awake patient.

Although Lawson notes that 30 mA provided supramaximal stimulation of the ulnar nerve *via* surface electrodes in his 38-patient study,¹ we found that there was a difference in the height of the first twitch as current increased from 30 to 50 mA in our 83-patient sample. However, whether or not 30 mA constitutes supramaximal stimulation is beside the point; this question does not address the main message of