

$T_1 > 0$ 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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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

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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

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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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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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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

our paper, which is that the T_4/T_1 ratio remained constant at 20, 30, and 50 mA.

Lawson and Sosis claim that data regarding patients who did not exhibit a T_4 response were either "secluded" in the methods section or "manipulated." The data were referred to in our results, and in our discussion, we clearly stated that "in the intraoperative setting, however, stimulation at low currents did not always elicit detectable contractions in patients with a marked degree of blockade."² We do not dispute that when the fourth twitch is 0, the T_4/T_1 ratio is 0. We feel that to take issue with this particular point is to miss the main message of our paper. If both a T_4 and a T_1 twitch response are present, then in the range of blockade evaluated, the T_4/T_1 ratio remains constant at stimulating currents of 20, 30, and 50 mA. With respect to the nine patients who did not evidence a T_4 response at 20 mA: the T_4/T_1 ratios at 30 and 50 mA were 36.5 ± 16.7 and 34.7 ± 15.9 , respectively; they differed by 1.7% ($P = NS$).

The potential value of our findings is that the anesthesiologist is able to test neuromuscular transmission at submaximal (and therefore less painful) currents. If a fourth twitch is not apparent in response to the less painful stimulus, then the current should be increased to obtain a detectable T_4/T_1 ratio. It should be emphasized that our findings and conclusions do not necessarily apply to visual or tactile assessment. As we stated,² our assessment entailed quantification with a mechanogram.

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Double-lumen Tube Design Fault

To the Editor:—We wish to bring to the attention of your readers a potential problem with the PVC Broncho-cath[®] Double-Lumen Tube (DLT) (Mallinckrodt Anesthesia Care Products).

Case 1

A 15-yr-old girl was scheduled for a right pneumonectomy for a destroyed bronchiectatic right lung. Initially, a size 37f left Broncho-cath[®] DLT was introduced but was found to be too large. This was replaced by a size 35f DLT, which was inserted after minimal resistance at the cricopharynx. As in all our cases of DLT insertion, correct positioning was confirmed by direct visualization with a flexible fiberoptic bronchoscope through the tracheal lumen, and by reassessment of tube positioning upon left lateral positioning. The inflation pressure was noted to be 60 cm H₂O, and an arterial blood gas determination 20 min postintubation with a fractional inspired O₂ concentration (F_IO₂) of 1.0 showed a pH of 7.22, a PaO₂ of 569 mmHg, and a PaCO₂ of 68.4 mmHg. Fiberoptic bronchoscopy was repeated with inspection through both the right and left lumens undertaken. It was noted that the tip of the endobronchial tube was occluded by the medial wall of the left main stem bronchus (fig. 1A). Attempts to improve patency and to reduce the inflation pressure failed. These attempts included deflation of the bronchial cuff and inward or outward displacement of the DLT. At this stage, a repeat arterial blood gas showed a pH 7.1, a PaO₂ of 476 mmHg, and a PaCO₂ of 93.8 mmHg (F_IO₂ = 1.0). As a consequence, the DLT was removed and replaced by a single-lumen endotracheal tube, which resulted in a reduction of the inflation pressure to 35 cm H₂O. An arterial blood gas 15 min later showed a pH of 7.29, a PaO₂ of 430 mmHg, and a PaCO₂ of 49.9 mmHg. While a capnograph was not being used, the oxygen saturation measured *via* pulse oximeter remained above 97% throughout the procedure, which was otherwise uneventful.

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Case 2

A 65-yr-old woman was scheduled for esophagogastrectomy for carcinoma of the esophagus. A 37f left-sided PVC Broncho-cath[®] DLT was inserted, and correct placement confirmed with a fiberoptic bronchoscope passed through the tracheal lumen. The inflation pressure with two-lung ventilation was 18 cm H₂O, and a left thoracotomy was performed. With the bronchial lumen clamped, the inflation pressure

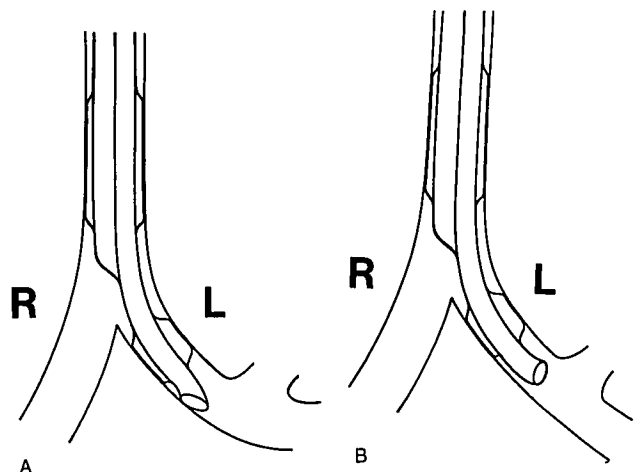


FIG. 1. (A) Left-sided Broncho-cath[®] DLT with bevel facing toward medial wall of left main stem bronchus. (B) Left-sided DLT with suggested alteration to bevel of bronchial lumen.