Abstract Title: Intraoperative Management of Deep Neuromuscular Blockade: The Case for Quantitative Electromyographic Monitoring of Single Twitch Recovery (T1/T1 control)

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Introduction: Numerous studies have demonstrated the unreliability of clinical assessment of adequate recovery from neuromuscular blockade (NMB) (train of four ratio [TOFR] ≥90% before extubation). However, the TOFR has minimal intraoperative utility because surgical levels of NMB eliminate the 4th twitch (TOFR=0). Clinical assessment of NMB is typically performed using the number of twitches present following train of four (TOF) stimulation (the train of four count, TOFC), with redosing of relaxant to maintain the TOFC=1 or 2. Quantitative assessment of NMB most commonly utilizes acceleromyography (AMG). However, AMG is often unsuitable intraoperatively because patient positioning interferes with free thumb motion, and inverse fade (i.e., baseline and/or recovery TOFR >1.0) is common. Furthermore, single twitch recovery, defined as the ratio of the first twitch (T1) in the TOF to the control T1 value (Tc), is often unreliable with AMG. The T1/Tc ratio is what has been used for pharmacodynamic assessment of NMB drugs. In contrast, assessment of NMB by electromyography (EMG) is not subject to inverse fade, the T1/Tc is reliable, and free thumb motion is not required for accurate measurement. We postulated that the EMG measurement of the T1/Tc is a more precise and consistent indicator of the depth of intraoperative block than the TOFC at the adductor pollicis following TOF stimulation of the ulnar nerve.

Methods: We obtained raw monitor output files for N=19 patients receiving rocuronium from a recent intraoperative study comparing the TOFR from an EMG device (TetraGraph, Senzime AB, Sweden) to an AMG device (TOF-Watch SX, Organon Teknika BV, The Netherlands).[1] Full spontaneous recovery of the TOFR was intended by protocol, resulting in a wide range of values. The control T1 (Tc) was obtained just before rocuronium administration; the T1 and T4 amplitudes were determined at 15-sec intervals along with the corresponding TOFC. The T1/Tc and TOFR were calculated for each TOF stimulation, and noise was filtered by fitting to an order-15 polynomial. Smoothed values were used for comparisons at each TOF time. We determined the T1/Tc corresponding to the return of each successive twitch (T1, T2, T3, T4) in the TOF. We calculated the mean, median, and interquartile range of the T1/Tc among patients. Data are presented as the mean and standard error (SE) or the median and interquartile range (IQR).

Results: Recovery of NMB in a sample patient is shown in the Figure. In all patients, responses were abolished (TOFC=0) following the intubating dose. The T1/Tc returned to 25% in a mean of 27.6 min (standard error [SE] 2.7 min, median 27.0 minutes (IQR 21.5 to 36.6 min). Values of the T1/Tc at the time of TOFC recovery are shown in the table.

Table. Value of the T1/Tc at the initial time of sustained appearance of a TOFC of 1, 2, 3, and 4

T1/T1c	1st Twitch	2nd Twitch	3rd Twitch	4th Twitch
Mean (SE)	9.2% (1.6%)	21.0% (3.0%)	34.7% (4.2%)	36.8% (4.3%)
Median (IQR)	8.2% (4.3 −13.0%)	17.7% (11.3%−29.7%)	34.6% (18.8%−48.1%)	35.2% (21.8%−52.4%)

Conclusions: Re-dosing muscle relaxants based on the TOFC will result in substantial variation among patients in the T1/Tc during surgery. Thus, relying on the TOFC to guide redosing of relaxants may lead to suboptimal surgical conditions when deep levels of NMB are needed. Titration to maintain the T1/Tc at a surgical level of NMB would avoid this problem. Given the lack of reliability of AMG during many surgical procedures and the improved performance of EMG vs. AMG when assessing baseline values and recovery of the TOFR,[1] quantitative monitoring of NMB using EMG rather than AMG provides advantages.
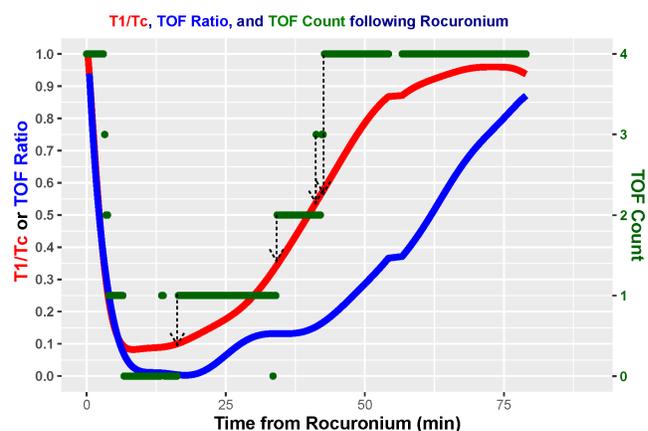

Figure. **Recovery from NMB in a typical patient. The arrows of the green dotted lines indicate the T1/Tc at the time of sustained recovery of the indicated TOF Count (green circles).**

Reference

[1] Nemes R, et al. Anesthesiology 2021;135:597–611