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My Thoughts/My Surgical Practice

Novel method for confirming appropriate nerve integrity monitor (NIM) endotracheal tube positioning

Surgical injury to the recurrent laryngeal nerve (RLN) is a significant complication of head and neck surgery due to the potential for permanent functional disability. Temporary paresis has been reported to occur from 0.4% to 12%, and permanent RLN palsy up to 26%.[1–5] Incidence of RLN injury can vary depending on surgeon experience.[1–3,5,6] Originally recommended by Lahey in 1938, intraoperative identification and protection of the nerve remains the gold standard for minimizing RLN injury and subsequent protection during surgery.[1–6] The Snyder et all study showed RLN injury occurred more often than expected in grossly intact and anatomically normal-appearing nerves.[7]

Currently, 40–45% of all United States endocrine surgeons, 53% of general surgeons, and 65% of otolaryngologists are using intraoperative nerve integrity monitoring (NIM) of the RLN.[4,8] A common technique used to confirm appropriate placement of the NIM endotracheal tube is the Tap Test (TT) in which the clinician taps over the trachea resulting in an artifact. However, this may simply be a mechanical artifact and not a true EMG response. Although both the current Nervana system and the newer NIMs systems currently utilize the measurement of impedance across the circuit to verify the indwelling endotracheal tube-electrodes are in optimal position possible for neuromonitoring; it remains our practice and to our understanding, still a part of most NIM system manufacturer preoperative protocols for verifying proper set up to use a TT to double check the system.

This study demonstrates a novel method to accurately ensure placement of the NIM device called a train of four (TOF), which was compared to TT and direct vagus stimulation.

The Michigan State University Institutional Review Board (IRB) approval was obtained in December of 2014. Informed written consent was obtained from 176 patients enrolled in this prospective clinical trial of partial thyroidectomy, near total thyroidectomy, and total thyroidectomy surgeries with RLN monitoring. All patients were placed under general anesthesia and intubated with a NIM™ EMG Endotracheal Tube, which has four embedded electrodes that contact the vocal cords to facilitate electromyographic (EMG) monitoring. All patients were recorded when they received TT (percussion of midline trachea) and TOF (facial electrical pads conducting electrical four square-wave pattern to contract facial musculature and vocal cords).

We analyzed and applied McNemar, paired nominal test to evaluate significant difference. Six of the 176 patients consented to direct stimulation of the vagus nerve as a control for the study. The voltages of these tests were also recorded through the NIMs device and compared to the TOF and TT values.

Of the 176 patients, 131 had a positive TT (74.4%) and 170 had a positive TOF (96.6%). Using the McNemar test, the TOF peripheral nerve stimulation was significantly more positive than the TT, $p < 0.001$ (Fig. 1).

Six control patients received direct vagus stimulation with positive intraoperative recordable voltages of: 6 from TOF (100%), 5 from vagus (83%), and 3 from TT (50%). One of these patients had recordable results only with TOF. Two patients had positive TOF and vagus results, but no stimulation with the TT. The median (Interquartile range) of voltages of TOF, vagus, and TT were respectively: 2567 μV (150, 5907), 195 μV (102, 458), and 36 μV (0, 118). Of the 3 control patients who had recordable TT, the TOF voltage was consistently the highest, followed by the direct vagus stimulation, and the lowest recording consistently was with the TT (Fig. 2).

This investigation represents a prospective clinical study to assess the sensitivity of TOF (96.6%) compared to TT (74.4%) in assessing the correct positioning of the NIM device ($p < 0.001$). While scientific innovations continue to produce new ways to enhance medical care, it is essential we learn how to best incorporate these technologies into our surgical practices. The TT is used by many surgeons to confirm proper NIM system placement. However, mechanical movement of the larynx could potentially produce a false positive (FP) result despite improper NIM endotracheal tube placement, or equally important, the absence of a positive EMG event on the NIM could be mistaken for improper placement when proper placement exists.

The most accurate method to ensure proper placement of the NIM device is by direct stimulation and contraction of the vocal cords through stimulation of the vagus nerve. Our study had 6 controls who received direct vagal stimulation, TOF, and TT. Eighty-three percent of the controls had true positives (TP) with positive vagus recordings. Only 60% of the control patients had TP values with TT. TOF had a positive test in all 6 patients, which would include 1 FP in addition to the 5 TP. Interestingly, TOF testing produced higher voltages than direct vagus testing in all of our controls. We conclude from our control focused study, the TOF testing is even more sensitive than TT respectively with number of TP (100% vs 60%) and higher voltages (2567 μV vs 36 μV). Further, our results show the TOF is more sensitive in higher voltages (2567 μV) than even direct vagus testing (195 μV), which we postulate is related to endotracheal tube position.

TOF creates higher voltages than TT and direct vagus stimulation. In the control cohort, the TOF had one FP while TT had two false negatives (FN). Possibly, similarly to the TT, the TOF results in some laryngeal contraction, which results in a higher voltage

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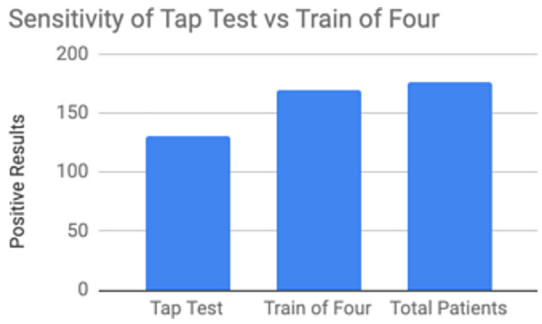

Fig. 1.

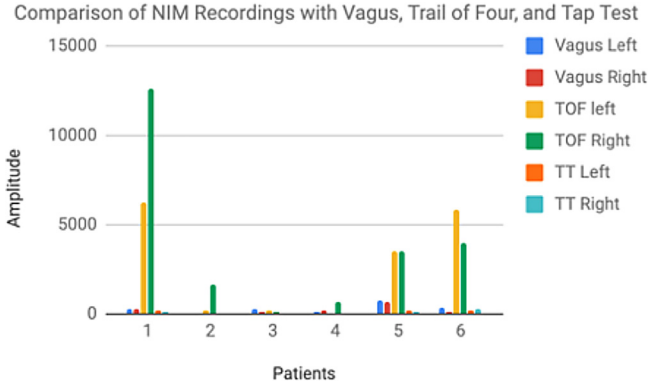

Fig. 2.

than the vagus control and gives rise to FP. Arguably, it is more desirable to have a sensitive test with higher FP and less FN, when it comes to enabling the surgeon to protect a nerve at risk within the surgical field. TOF produces a higher true positive rate for detecting accurate placement of NIM endotracheal tube-based system than does the TT.

In conclusion, TOF test has a higher sensitivity (96.6%), higher voltage, and less FN than TT (74.4%) ($p < 0.001$) in detecting accurate positioning of the NIM device which could help minimize the risk of RLN injury during thyroid surgery.

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The authors have nothing to disclose.

Declaration of competing interest

There are no conflicts of interest.

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Abigail Engwall*, Ian Behr
Department of Surgery, Michigan State University, East Lansing, and Sparrow Hospital, Lansing, MI, USA

Andrea Hess, Pam Haan
Michigan State University, East Lansing, MI, USA

Michael K. McLeod
Department of Surgery, Michigan State University, East Lansing, and Sparrow Hospital, Lansing, MI, USA

* Corresponding author. Sparrow Hospital, Department of Surgery, 1215 East Michigan Ave, Lansing, MI, 48912, USA.
E-mail address: engwalla@msu.edu (A. Engwall).

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