

Article

Not peer-reviewed version

Trend-Based Intermittent Neuromonitoring in Thyroid and Parathyroid Surgery: A Prospective Preliminary Observational Study

[Paolo Del Rio](#)*, Tommaso Loderer, Gianluca Pasquini, Alessandro Facchinetti, Cristiana Madoni, Elena Bonati

Posted Date: 17 December 2025

doi: 10.20944/preprints202512.1461.v1

Keywords: thyroidectomy; parathyroidectomy; intraoperative neuromonitoring; NIM Vital; NerveTrend; recurrent laryngeal nerve; EMG trend; loss of signal



Preprints.org is a free multidisciplinary platform providing preprint service that is dedicated to making early versions of research outputs permanently available and citable. Preprints posted at Preprints.org appear in Web of Science, Crossref, Google Scholar, Scilit, Europe PMC.

Copyright: This open access article is published under a [Creative Commons CC BY 4.0 license](#), which permit the free download, distribution, and reuse, provided that the author and preprint are cited in any reuse.

Article

Trend-Based Intermittent Neuromonitoring in Thyroid and Parathyroid Surgery: A Prospective Preliminary Observational Study

Paolo Del Rio ^{1,*}, Tommaso Loderer ¹, Gianluca Pasquini ¹, Alessandro Facchinetti ¹,
Cristiana Madoni ² and Elena Bonati. ¹

¹ Department of General Surgery, Academic Hospital of Parma, Italy

² Department of General Surgery, II° Unit of Anesthesiology, Academic Hospital of Parma, Italy

* Correspondence: paolo.delrio@unipr.it

Abstract

Background/Objectives: Intraoperative neuromonitoring (IONM) has improved safety in thyroid and parathyroid surgery, yet intermittent IONM (I-IONM) may miss traction injuries developing between stimulations. We evaluated the feasibility and clinical utility of a trend-based intermittent monitoring mode (NIM Vital NerveTrend®) that records closely spaced stimulations and plots amplitude and latency over time. **Methods:** We conducted a prospective observational study at a high-volume endocrine surgery unit (January–September 2025). Forty-four consecutive patients undergoing thyroidectomy and/or parathyroidectomy with NerveTrend® were enrolled. EMG responses were categorized as Green (amplitude >50% of baseline and latency <110%), Yellow (amplitude <50% or latency >110%), Red (amplitude <50% and latency >110%), and Loss of Signal (LOS: amplitude <100 µV). Primary outcomes included LOS prevalence and the association between stimulation frequency and the appearance of Yellow trends. **Ethical approval:** AVEN protocol 486/2024/OSS/AOUPR; informed consent obtained. **Results:** Of 71 nerves at risk (NAR), 55 had a valid baseline and were analyzed; LOS occurred in 3/55 NAR (5.5%). The mean number of stimulations per NAR was 4.5 (range 1–9). Cases with both Green and Yellow points had a significantly higher mean number of stimulations than cases with only Green points (5.1 vs. 3.8; Student's t-test $p = 0.0059$). One Red measurement occurred in a case that progressed to LOS. **Conclusions:** NerveTrend® provided near real-time functional feedback while maintaining the simplicity of I-IONM. Increased stimulation frequency was associated with early Yellow trend alerts, potentially signaling traction stress and enabling timely surgical adjustments. Larger multicenter studies and protocol standardization are warranted.

Keywords: thyroidectomy; parathyroidectomy; intraoperative neuromonitoring; NIM Vital; NerveTrend; recurrent laryngeal nerve; EMG trend; loss of signal

1. Introduction

Intraoperative neuromonitoring (IONM) has revolutionized thyroid surgery by enhancing identification and functional assessment of the recurrent laryngeal nerve (RLN). Intermittent IONM (I-IONM) remains widely used but may fail to capture progressive traction injuries occurring between stimulations. Continuous IONM[1] (C-IONM) provides real-time feedback but requires vagal clip electrodes and adds cost and complexity. The NIM Vital NerveTrend® mode (Medtronic, Jacksonville, FL) [2–4] bridges these approaches by plotting amplitude and latency trends from closely spaced, surgeon-triggered stimulations, offering near real-time feedback without a vagal electrode. We report our prospective experience with NerveTrend® in thyroid and parathyroid surgery at a high-volume center, focusing on feasibility, LOS prevalence, and the relationship between stimulation frequency and early trend alerts.

2. Materials and Methods

The protocol was designed as a prospective observational study conducted at the Department of General Surgery, Azienda Ospedaliero-Universitaria di Parma (January–September 2025).

We have standardized the use of NIM TriVantage® endotracheal tube with integrated electrodes and the neuromuscular management as INMSG recommendations [5–7]. The stimulations delivered with a monopolar probe at 1 mA, 100 µs pulse width, 4 Hz.

The monitoring protocol was the collection of a baseline established via repeated stimulations (≥20) of the vagus or RLN and subsequent stimulations performed at 3–5 min intervals or during traction-risk maneuvers at the same nerve site. Trend thresholds followed INMSG criteria: latency increase ≥10% and amplitude decrease ≥50% from baseline.

- The results of stimulation were calssified as:
- Green (amplitude >50% and latency <110% of baseline),
 - Yellow (amplitude <50% or latency >110%),
 - Red (amplitude <50% and latency >110%),
 - LOS (amplitude <100 µV).

The protocol was approved by AVEN (protocol 486/2024/OSS/AOUPR); written informed consent obtained from all participants.

Statistics: Descriptive analyses and Student’s t-test for group comparisons; significance set at p < 0.05.

3. Results

We collected Forty-four consecutive patients undergoing thyroidectomy and/or parathyroidectomy with IONM using NIM Vital NerveTrend®;44 patients (32 female, mean age 57.2 years; 12 male, mean age 53 years) treated with 26 total thyroidectomies, 15 hemithyroidectomies, 1 total thyroidectomy + parathyroidectomy, and 2 focused parathyroidectomies; five minimally invasive approaches[8,9](Table 1).

Table 1. Demographic and clinical characteristics.

Variable	Value
Number of patients	44
Mean age (years)	56.2
Sex	32 F (72.7%); 12 M (27.3%)
Surgery type	26 total thyroidectomies (59.1%); 15 hemithyroidectomies (34.1%); 1 total thyroidectomy + parathyroidectomy (2.3%); 2 parathyroidectomies (4.5%)
Minimally invasive approach	5 cases (11.4%)
Preoperative cytology (Bethesda 2023)	28 benign; 8 indeterminate(class 4); 8 malignant (class 6).
Preoperative therapy	5 levothyroxine; 9 methimazole 13 (29.5%)
Compressive symptoms	

Table 2. Intraoperative NerveTrend® monitoring data.

Variable	Value
Total nerves at risk (NAR)	71

NAR excluded (no valid baseline)	16 (22.5%)
NAR analyzed	55 (77.5%)
Loss of Signal (LOS)	3 (5.5%)
Mean stimulations / NAR	4.5 (range 1–9)
Mean Green measurements / NAR	3.5
Mean Yellow measurements /case	2.0
Cases with Red measurements	1 (associated with LOS)
	3.8 vs. 5.1 stimulations; p = 0.0059
Comparison (only Green vs. Green+Yellow)	

The nerves at risk were 71 total NAR: 16 excluded due to invalid baseline; 55 analyzed. LOS occurred in 3/55 NAR (5.5%). The mean stimulations in NAR were 4.5 (range 1–9). The mean number of Green measurements were 3.5; in Yellow trends observed in 26 cases (mean 2 Yellow recordings / case). A total mean of 5.1 were recorded in Green+Yellow cases). One Red measurement was recorded in a case progressing to LOS.

Association between stimulation frequency and Yellow trends: Cases with Green+Yellow trends had a higher mean number of stimulations than cases with exclusively Green trends (5.1 vs. 3.8; p = 0.0059).

4. Discussion

Our experience supports the feasibility of NerveTrend® as a trend-based extension of I-IONM that provides actionable, near real-time feedback without a vagal electrode. The observed LOS rate (5.5%) aligns with reports for intermittent monitoring, while the association between higher stimulation frequency and Yellow trend alerts suggests that surgeons tend to increase monitoring during complex or traction-prone phases, potentially enabling early recognition of impending neuropraxia and adjustment of maneuvers. Randomized trials have shown that NerveTrend® may reduce progression to LOS and staged thyroidectomy compared with conventional I-IONM, and is non-inferior to continuous monitoring (NerveAssure®) regarding POD1 RLN injury risk. Our single-center cohort is limited by sample size, operator dependence, and exclusion of cases with invalid baseline due to interference. Standardized stimulation protocols and multicenter validation are needed.

5. Conclusions

NIM Vital NerveTrend® offers dynamic intraoperative feedback while preserving the simplicity of intermittent monitoring. Early Yellow trend alerts may flag traction stress, allowing timely modification of surgical maneuvers and potentially preventing LOS. Broader studies and protocol harmonization are warranted to define sensitivity, specificity, and clinical impact.

Author Contributions: Conceptualization, P.D.R.; methodology, P.D.R., E.B.; validation, T.L., E.B., G.P.; formal analysis, P.D.R., L.P.; investigation, E.B., L.P.; resources, E.B., T.L.; data curation, E.B., A.F., C.M.; writing—original draft preparation, P.D.R., G.P.; writing—review and editing, E.B.; visualization, E.B., T.L.; supervision, E.B., C.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee AVEN (protocol 486/2024/OSS/AOUPR).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: De-identified datasets and study materials are available from the corresponding author upon reasonable request.

Acknowledgments: We thank the operating room staff and the anesthesia team for their support.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Schneider R, Machens A, et al. Superiority of continuous over intermittent IONM in preventing vocal cord palsy. *Br J Surg*. 2021;108:566–573.
2. Barczyński M, Konturek A. Clinical validation of NerveTrend versus conventional I-IONM mode of NIM Vital: randomized controlled trial. *Head Neck*. 2024;46:492–502.
3. Barczyński M, Dworak M, et al. Clinical validation of NerveTrend vs. NerveAssure: randomized controlled trial. *Ann Surg*. 2025;[Epub ahead of print].
4. Pino A, Frattini F, Sun H, et al. An improved RLN-monitoring device: technical note for NIM Vital™. *Surg Technol Int*. 2021;38:109–24.
5. Randolph GW, Dralle H, et al. Electrophysiologic RLN monitoring during thyroid and parathyroid surgery: international standards guideline statement. *Laryngoscope*. 2011;121(S1):S1–S16.
6. Schneider R, Randolph GW, Dionigi G, et al. INMSG guideline 2018 part I: staging bilateral thyroid surgery with monitoring LOS. *Laryngoscope*. 2018;128(S3):S1–S17.
7. Del Rio P, Polistena A, Chiofalo MG, et al. Management of surgical diseases of thyroid gland indications of the United Italian Society of Endocrine Surgery (SIUEC). *Updates Surg*. 2023 Sep;75(6):1393-1417. doi: 10.1007/s13304-023-01522-7. Epub 2023 May 18. PMID: 37198359
8. Del Rio P, Vicente Diego, Maestroni U. et al. A comparison of minimally invasive video-assisted parathyroidectomy and traditional parathyroidectomy for parathyroid adenoma *Journal of Cancer* Article Open Access 2013 DOI: 10.7150/jca.6755
9. Del Rio P, Berti M, Sommaruga L et al. Pain after minimally invasive videoassisted and after minimally invasive open thyroidectomy--results of a prospective outcome study. *Langenbecks Arch Surg*. 2008 May;393(3):271-3. doi: 10.1007/s00423-007-0229-7. Epub 2007 Oct 2. PMID: 17909847

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.