State of the Art Neuromonitoring in Thyroid Surgery

UCSF Otolaryngology Update
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- No disclosures

Overview

- Rationale for IONM
- Set-up
- Loss of signal
- Troubleshooting
- Management of the invaded nerve

Why IONM?

- Visualization of an intact nerve does not mean intact function
- Mechanisms of injury
  - Traction (71%)
  - Thermal (17%)
  - Compression (4.2%)
  - Clamping/suction/ligature entrapment/transection

Evidence of benefit?

- Challenging to study
  - Outcome of VFP is relatively uncommon (5-15%)
  - Non-uniform performance of preoperative and postoperative laryngoscopy
- Dralle et al. estimated "n" for adequately powered study
  - 40,000 cases per arm for cancer
  - 9 million cases per arm for benign thyroid surgery

Dralle et al., *Surgery* 2004

Evidence of benefit?

- Meta-analyses: IONM vs. visual identification
  - Zheng et al.
    - Decreased rates of transient RLN paralysis
    - No difference in rates of permanent paralysis
  - Higgins et al.
    - No difference
  - Pisanu et al.
    - No difference

Zheng et al., *J Formos Med Assoc* 2013
Higgins et al. *Laryngoscope* 2011
Pisanu et al. *J Surg Res* 2014

Evidence of benefit?

- High risk groups
  - Wong et al., meta-analysis
    - Decreased overall rate VFP in reoperative surgery
    - Decreased rate of transient VFP in malignancy
  - Barczynski et al., randomized trial
    - Decreased incidence of transient VFP in high-risk cases

Wong et al., *IntJ Surg* 2017
Barczynski et al., *Surgery* 2009

Guideline-directed use

- AAO-HNS
  - Facilitates neural mapping and prognostication
- AHNS
  - All cases of thyroid malignancy, especially with preoperative RLN dysfunction
- German Association of Endocrine Surgery, International Neuromonitoring Study Group (INMSG)
  - All cases of thyroid and parathyroid surgery

Chandrasekhar et al. *Otolaryngol Head Neck Surg* 2013
Shindo et al. *Head Neck* 2014
Musholt et al. *Langenbecks Arch Surg* 2011

INMSG guidelines for standard use

The Laryngoscope

Contemporary Review

International Neural Monitoring Study Group Guideline 2018 Part I: Staging Bilateral Thyroid Surgery With Monitoring Loss of Signal

The Laryngoscope
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Contemporary Review

International Neuromonitoring Study Group Guidelines 2018: Part II: Optimal Recurrent Laryngeal Nerve Management for Invasive Thyroid Cancer—Incorporation of Surgical, Laryngeal, and Neural Electrophysiologic Data

Applications/Benefits - #1

- Intraoperative neural identification and mapping
  - Electrical neural identification precedes visual identification
  - Increases speed of RLN identification compared with visual identification alone

Snyder et al., Surgery 2013
Sari et al., IntJ Surg 2010

Applications/Benefits -#2

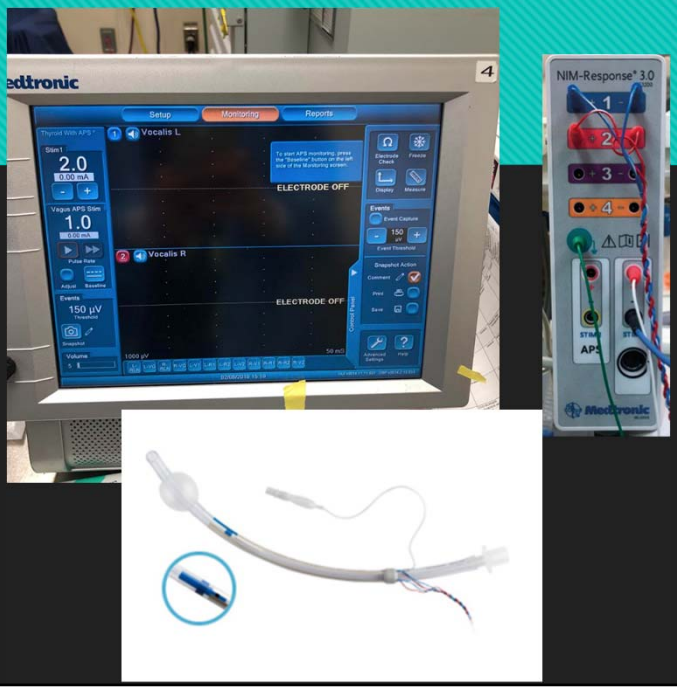
- Facilitation of neural dissection
  - Differentiation between neural and non-neural structures
  - Identification of anatomic variants (ie. extralaryngeal branching)

Application/Benefits - #3

- Identification of impending neurologic injury
  - Evolving EMG responses can predict impending neuropraxia
    - Opportunity to cease injurious maneuvers
    - Elucidate site of neurologic injury: learning opportunity

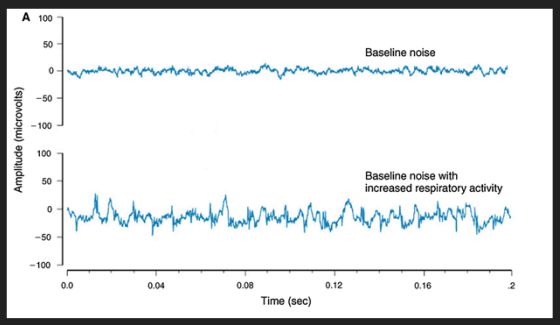
Applications/Benefits - #4

- Neural prognostication at termination of surgery
  - Predict functional status of RLN
  - Determine need for staging of contralateral surgery



Set-up

- Establish correct positioning of electrodes
  - Repeat DL
  - Respiratory variation (30-70 μV)



Randolph et al. *World J Surg* 2015

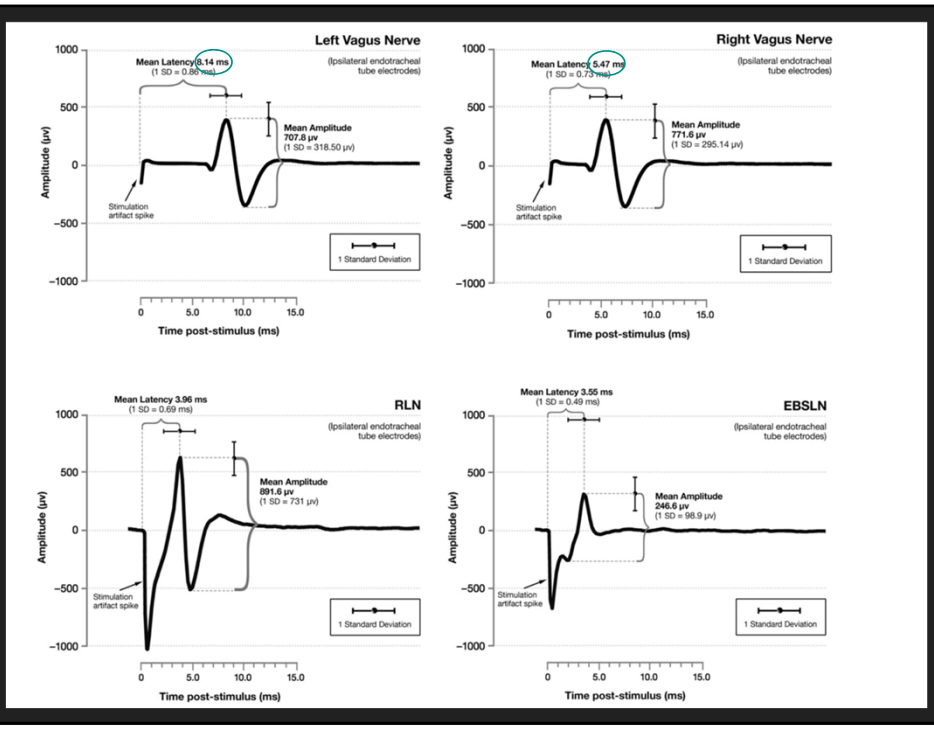
Interpreting EMG data

- Stimulation of vagus/RLN/SLN produces EMG signal with characterizable amplitude, latency, waveform

Interpretation of changes relies on adequate baseline signal

Amplitude >500μV at 1-2 mA stimulus

detectable laryngeal twitch



Schneider et al.
Laryngoscope 2018

Interpreting EMG data

- Stimulation of vagus/RLN/SLN produces EMG signal with characterizable amplitude, latency, waveform
- Interpretation of changes relies on adequate baseline signal
  - Amplitude >500µV at 1-2 mA stimulus
  - detectable laryngeal twitch

Loss of signal

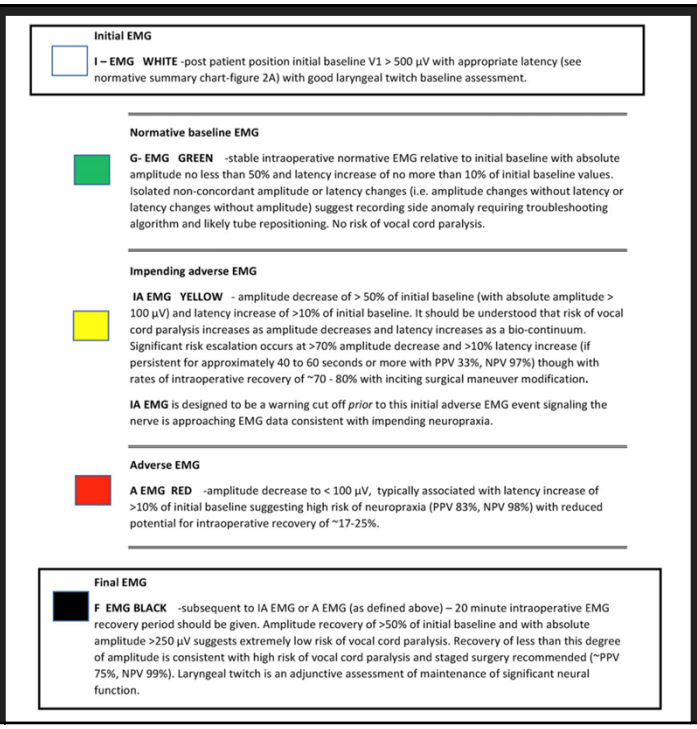
- Surgical manipulation can cause adverse EMG changes; marker of of impending neuropraxia
  - Amplitude decrease >50%
  - Latency increase >10%
- *EMG changes are reversible in 70-80% of cases if maneuver stopped within 40-60 seconds*

Loss of signal

- With repeated neural insults, changes become less reversible
- LOS = amplitude response <100μV
  - High risk of neuropraxia
  - 15-20% likelihood of intraoperative recovery

Loss of signal

- If intraoperative recovery occurs, will be within 20 min
- If LOS present at conclusion of surgery, INMSG recommends 20 minute period of waiting
- If signal >50% of baseline or 250 μV, low risk of VFP
- If signal < 250 μV, consider staging



Initial EMG

I – EMG WHITE -post patient position initial baseline V1 > 500 μV with appropriate latency (see normative summary chart-figure 2A) with good laryngeal twitch baseline assessment.

Normative baseline EMG

G- EMG GREEN -stable intraoperative normative EMG relative to initial baseline with absolute amplitude no less than 50% and latency increase of no more than 10% of initial baseline values. Isolated non-concordant amplitude or latency changes (i.e. amplitude changes without latency or latency changes without amplitude) suggest recording side anomaly requiring troubleshooting algorithm and likely tube repositioning. No risk of vocal cord paralysis.

Impending adverse EMG

IA EMG YELLOW - amplitude decrease of > 50% of initial baseline (with absolute amplitude > 100 μV) and latency increase of >10% of initial baseline. It should be understood that risk of vocal cord paralysis increases as amplitude decreases and latency increases as a bio-continuum. Significant risk escalation occurs at >70% amplitude decrease and >10% latency increase (if persistent for approximately 40 to 60 seconds or more with PPV 33%, NPV 97%) though with rates of intraoperative recovery of ~70 - 80% with inciting surgical maneuver modification.

IA EMG is designed to be a warning cut off *prior* to this initial adverse EMG event signaling the nerve is approaching EMG data consistent with impending neuropraxia.

Adverse EMG

A EMG RED -amplitude decrease to < 100 μV, typically associated with latency increase of >10% of initial baseline suggesting high risk of neuropraxia (PPV 83%, NPV 98%) with reduced potential for intraoperative recovery of ~17-25%.

Final EMG

F EMG BLACK -subsequent to IA EMG or A EMG (as defined above) – 20 minute intraoperative EMG recovery period should be given. Amplitude recovery of >50% of initial baseline and with absolute amplitude >250 μV suggests extremely low risk of vocal cord paralysis. Recovery of less than this degree of amplitude is consistent with high risk of vocal cord paralysis and staged surgery recommended (~PPV 75%, NPV 99%). Laryngeal twitch is an adjunctive assessment of maintenance of significant neural function.

Schneider et al. *Laryngoscope* 2018

Loss of signal

INMSG recommendation I.
The INMSG recommends that neural monitoring information should be obtained and utilized in the strategy of a planned bilateral procedure by staging the surgery in the setting of ipsilateral LOS. This algorithm should be shared and discussed with the patient during the preoperative informed consent process.

Schneider et al.
Laryngoscope 2018

Loss of signal

- 17% risk of bilateral VFP after LOS without staging

Goretzki et al.
World J Surg 2010

Loss of signal

INMSG recommendation II.
The INMSG feels a surgeon should prioritize concern for the obvious significant medical and psychological morbidity of bilateral VCP and possible tracheotomy (even temporary) over perceived surgical convenience, the routine of doing the "planned procedure" or the potential perceived impact on surgical reputation by openly acknowledging the surgical complication of ipsilateral loss of signal. The full benefit of neural monitoring information in this surgical setting is appreciated through both optimization of the patient's quality of life as well as surgical cost.[102]

Schneider et al.
Laryngoscope 2018

Troubleshooting

LOS = positive test

- False positives
  - ETT malposition
  - Inadequate stimulation (blood, fascia)
  - Neuromuscular blockade
- False negatives
  - Stimulation distal to injured segment
  - Injury after last stimulus
  - Evolving EMG changes

Troubleshooting algorithm

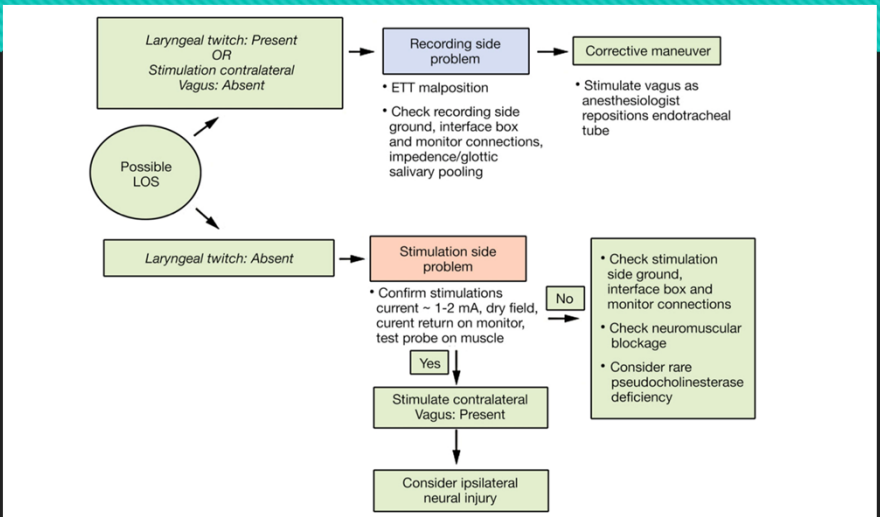


Fig. 1. A. Troubleshooting algorithm.[9] ETT = endotracheal tube; LOS = loss of signal.

Schneider et al. *Laryngoscope* 2018

IONM: management of the invaded RLN

- Superficial invasion: shave excision appropriate
- More extensive invasion: preserve versus resect
  - In DTC, no difference in survival for resection vs. preservation

Shindo et al., *Head Neck* 2014

IONM: management of the invaded RLN

- Preserve or resect?
  - Preoperative VF function
  - Intraoperative proximal stimulability
  - Location and extent of neural infiltration
  - Patient- and disease-related characteristics

IONM: management of the invaded RLN

- Preoperative knowledge of VF function is critical to intraoperative decision-making
  - 45% of invaded nerves have intact preoperative VF function
  - Nerve preservation favored in functioning RLN
  - Contralateral pre-existing VFP: consider careful shave excision or leaving a small amount of residual gross disease

IONM: management of the invaded RLN

- Ability to proximally stimulate impacts decision to preserve or resect
  - 60% of invaded nerves, including 33% of invaded nerves with VFP can be electrically stimulated
  - Resection of a nerve with preserved neural function can lead to worsening of glottic function

Kamani et al., *Otolaryngol Head Neck Surg* 2013

IONM: management of the invaded RLN

- Location and extent of neural infiltration
  - Epineurium: macroscopic resection can be achieved with shave excision
    - LOS with shave excision shows long-term recovery in majority
  - Perineurium/Endoneurium: gross resection should be considered
  - Invasion near laryngeal entry point: consider resection

Kihara et al., *Surgery* 2014

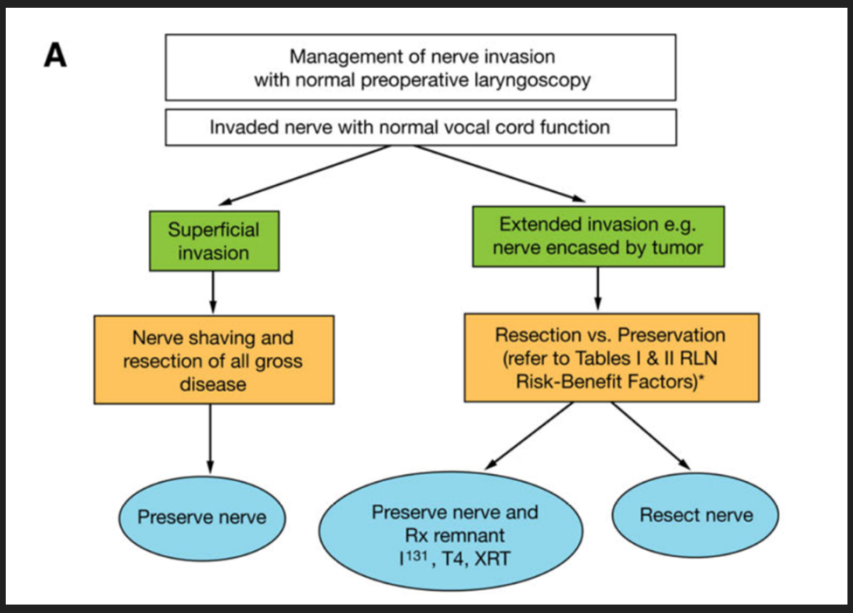
IONM: management of the invaded RLN

- Disease- and patient-related characteristics play an important role
  - Tumor histology/aggressiveness
  - Efficacy of adjuvant therapy
  - Presence of unresectable or distant disease
  - Patient age, preference

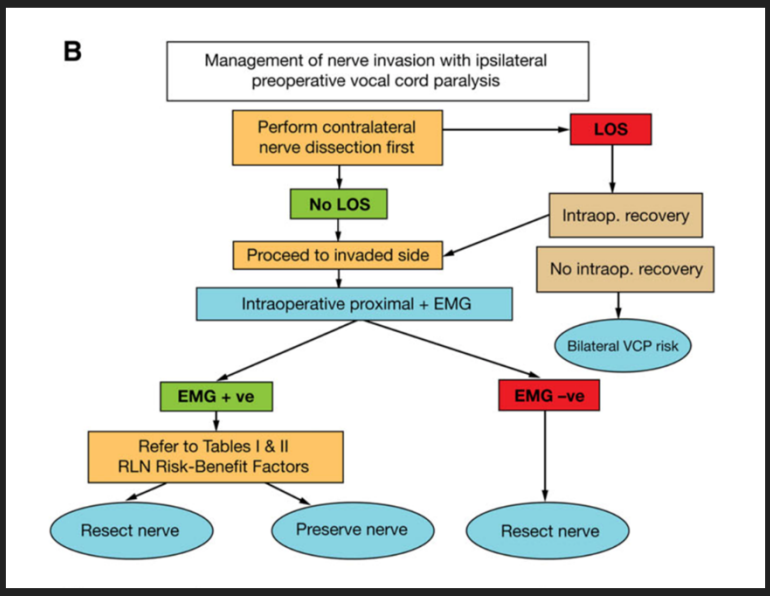
IONM: management of the invaded nerve

Factors in favor of nerve preservation	Factors in favor of nerve sacrifice
Young patients with iodine-avid PTC	Aggressive histopathologic and genetic variants
Expected effectiveness of adjuvant therapy (RAI or EBRT)	Iodine-refractory disease; previous EBRT
Elderly patients (increased risk of aspiration pneumonia)	Healthy young patients
Contralateral vocal fold paralysis	Normal contralateral vocal fold function
Active distant disease	No/indolent distant disease

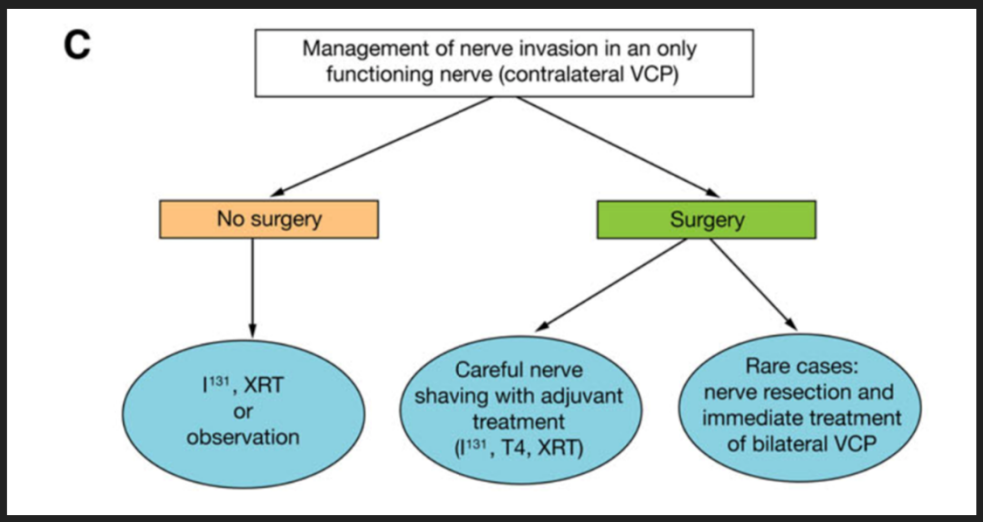
Wu et al,. *Laryngoscope* 2018



Wu et al,. *Laryngoscope* 2018



Wu et al,. *Laryngoscope* 2018



Wu et al,. *Laryngoscope* 2018