State of the Art
Neuromonitoring in Thyroid Surgery

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- No disclosures
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

Rationale for IONM

Set-up

Loss of signal

Troubleshooting

Management of the invaded nerve
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
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., Int J 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

Shindo et al. Head Neck 2014
Musholt et al. Langenbecks Arch Surg 2011
INMSG guidelines for standard use

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 (i.e., extralaryngeal branching)

Applications/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 $\mu$V)

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 $>500\mu$V at 1-2 mA stimulus
detectable laryngeal twitch
Interpreting EMG data

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Loss of signal

- Surgical manipulation can cause adverse EMG changes; marker 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
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

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

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

Schneider et al., Laryngoscope 2018

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

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

- 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

Factors in favor of nerve preservation:
- Young patients with iodine-avid PTC
- Expected effectiveness of adjuvant therapy (RAI or EBRT)
- Elderly patients (increased risk of aspiration pneumonia)
- Contralateral vocal fold paralysis
- Active distant disease

Factors in favor of nerve sacrifice:
- Aggressive histopathologic and genetic variants
- Iodine-refractory disease; previous EBRT
- Healthy young patients
- Normal contralateral vocal fold function
- No/indolent distant disease

Wu et al., Laryngoscope 2018
Management of nerve invasion in an only functioning nerve (contralateral VCP)

No surgery
- $^{131}$I, XRT or observation

Surgery
- Careful nerve shaving with adjuvant treatment ($^{131}$I, T4, XRT)
- Rare cases: nerve resection and immediate treatment of bilateral VCP

Wu et al., Laryngoscope 2018