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REVIEW

Continuous monitoring of the recurrent laryngeal nerve in thyroid surgery: a critical appraisal

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ABSTRACT

Background and Purpose: Intraoperative neuromonitoring (IONM) contributes in several ways to recurrent laryngeal nerve (RLN) protection. Notwithstanding these advantages, surgeons must be aware that the current, intermittent, mode of IONM (I-IONM) has relevant limitations. To overcome these I-IONM limitations, a continuous IONM (C-IONM) technology has been proposed.
Methods: A PubMed indexed literature review of the current limitations of I-IONM is presented and a commentary about C-IONM is provided presenting the preliminary results of research on this topic.
Main findings: I-IONM, despite the advantages it produces, presents some important limitations; to overcome these drawbacks a C-IONM technology has been introduced.
Conclusions: RLN traction injury is still the most common cause of RLN injury and is difficult to avoid with the application of I-IONM in thyroid surgery. C-IONM is useful to prevent the imminent traction injury by detecting progressive decreases in electromyographic amplitude combined with progressive latency increases. C-IONM seems to be a technological improvement. Likely, C-IONM by vagal nerve stimulation should enhance the standardization process, RLN intraoperative information, documentation, protection, training, and research in modern thyroid surgery. Although C-IONM is a promising technology at the cutting edge of research in thyroid surgery, we need more studies to assess in an evidence-based way all its advantages.

1. Introduction

Intraoperative neuromonitoring (IONM) contributes in several ways to recurrent laryngeal nerve (RLN) protection. Notwithstanding these advantages, surgeons must be aware that the current, intermittent, mode of IONM (I-IONM) has relevant limitations. To overcome these I-IONM limitations, a continuous IONM (C-IONM) technology has been proposed.

2. Methods and materials

A PubMed indexed literature review of the current limitations of I-IONM is presented, followed by a technical commentary about the C-IONM.

3. Results

IONM contributes to RLN protection in several ways:

a. Early and definite localization of RLN (thus avoiding excessive traction and perceiving the identification of extra-laryngeal branches, anatomical variation, distorted RLN, and non-RLN). [1,2]
b. Confirmation of RLN (preventing visual RLN misidentification). [2]
c. As shown in one prospective randomized study, significant potential for reduction of temporary palsy rate. [3]

Notwithstanding these advantages, surgeons must be aware that the current, intermittent, mode of IONM (I-IONM) has relevant limitations. With I-IONM, assessment of the functional integrity of the RLN is limited to the short time interval of direct nerve stimulation. Moreover, with I-IONM the integrity of the laryngeal nerve is assessed

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only at the site of direct nerve stimulation: for proximal neurogenic lesions of the RLN, distal stimulation near the larynx may produce a false negative, "normal", IONM signal.[4] Thus, during thyroidectomy the RLN is still at risk for damage (1) proximally to the site of surgeon's stimulation and/or (2) in the temporal gap between two nerve stimulations. As to the first point, a standardized IONM technique with vagal nerve (VN) stimulation has been described, applied and emphasized[5]: VN stimulation essentially recognizes any RNL lesions, even the most proximal.[4]

De facto, I-IONM tests the integrity of the RLN just following a thyroid dissection, allows the evaluation of the RLN solely at the moment of stimulation, and detects RLN injury merely after insult has occurred.

4. Discussion

The major advantage of I-IONM is at the first dominant side of a thyroid procedure as it reduces the risk of bilateral RLN palsy by staging the thyroidectomy.[5] To overcome these I-IONM limits, a continuous IONM (C-IONM) technology has been proposed.[6–9] C-IONM comprises automatic periodic stimulation (APS) of the VN with an automatic software-based assessment of changes in electromyographical (EMG) amplitude during surgery. According to preliminary observations this mode of IONM provides permanent visual and acoustic feedback to the surgeon of the current RLN conductivity, allows to test for the integrity of the RLN throughout the dissection, and allows continuous evaluation of the RLN.[6–9]

The introduction of C-IONM merits further consideration.

C-IONM might detect imminent and/or increasing RLN risk intraoperatively. In principle, in case of a weak and decreased EMG signal, the surgeon may react early intraoperatively to RLN stress, and RLN injury becomes reversible. Theoretically, the surgeon can avoid an eventual further injuring of RLN and the nerve is restored by relieving the pressure and damage early. This may occur in neuropraxia, however not in the case of a more significant disruption or complete division of a nerve such as in the case of neurotmesis or axonotmesis.

Further clinical research, especially in neurophysiology and neuropathology, is necessary to make a qualitative and quantitative analysis and interpretation of the signal changes detected with C-IONM before using it widely on patients.[10,11] These data are essential for the surgeon's intraoperative decision making.

The quality of the EMG signal is fundamental. A critical evaluation of neuromonitoring devices available to date is essential for the development and introduction of this new IONM method. Moreover, under EMG endotracheal surface electrodes, it is difficult to tell whether a change of EMG amplitude is caused by a change in contact situation between the electrodes and vocal cords or by true nerve injury. In addition, the EMG signal detected by C-IONM might be affected by the type of anesthesia, manipulation of the trachea and dislocation of the vagal nerve electrode (acute signal loss indicates electrode dislocation).[12–14] The stimulating electrodes must be configured in such a way that they are protected against dislocation and against variations in their distance from the nerve during surgical manipulation within the surgical site.

The VN electrode for C-IONM should be versatile. The location of the VN in relation to the common carotid artery (CCA) and internal jugular vein (IJV) can be anterior (classified as A), posterior (P), posterior to the IJV (PJ), or posterior to the CCA (PC).[11,15] Most vagal nerves (95%) lay in the posterior region of the carotid sheath in the groove between these two vessels. The P location of the VN is the most common configuration observed on either side followed by the PC (15%) and PJ (8%) locations. Overall, less than 5% of cases have A location. Moreover, the medial location of the CCA and anterolateral or lateral location of the IJV are the most common configurations in the carotid sheath. Few cases of medial IJV position are observed. Tortuosity, kinking, or coiling of the extracranial carotid arteries may be observed with advancing age. Aplasia or agenesis of the carotid artery is an extremely rare vascular anomaly mostly of the internal carotid artery and occurring in less than 0.01% of the population.[11,15]

It is equally essential that the safety of a new procedure is established before it is widely used on patients. Usually for the I-IONM mode of application a minor and partial dissecting effort of the carotid sheath and VN is used: the VN is exposed by dissecting the carotid sheath from just a 1-cm pouch; thus, not all of the carotid sheath is completely and routinely dissected. Moreover, in using I-IONM to expedite VN identification, or if the surgeon is not confident with carotid sheath dissection (in case of fatty areolar tissue, redo surgery, large goiter, hostile neck, endoscopic thyroidectomy or gross lateral metastatic lymph nodes that may displace the VN), the VN identification and stimulation may be facilitated simply by increasing amplitude to 2–3 mA with the probe on the carotid sheath without dissection of the neck vessel sheath. Most C-IONM methods, however, need to dissect the VN circumferentially (360°) to place the VN electrode on it. This procedure can be difficult, time-consuming, or even harmful to the VN and carotid sheath while positioning the electrode, during surgery and at removal of the electrode. The electrode placement should be tension-free. Experimental histologic evaluation on the VN after probe positioning and repeated stimulation is necessary. C-IONM systemic safety has been already evaluated.[8]

A study aimed to assess the technical feasibility of C-IONM in the performance of endoscopic thyroidectomy would be intriguing.

RLN traction injury is still the most common cause of RLN injury and is difficult to avoid with the application of I-IONM in thyroid surgery. C-IONM is useful to prevent the imminent traction injury by detecting progressive decreases in EMG amplitude combined with progressive latency increases. Finally, we would like again emphasize the importance of I-IONM: a traditional manual stimulator should still additionally be used in combination with C-IONM mode of application. C-IONM seems to be a technological improvement. Likely, C-IONM by vagal nerve stimulation should enhance the standardization process, RLN intraoperative information, documentation, protection, training, and research in modern thyroid surgery.

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The authors have no conflicts of interest to declare.

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