

Neural monitoring in thyroid surgery

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Abstract

Numerous operating tools and technology transfers are available for thyroid surgery teams performing open, endoscopic and robotic procedures but none, or very few, of them constitutes a mandatory prerequisite. Over the past decade, the choice of intraoperative neural monitoring (IONM) of the recurrent laryngeal nerve (RLN), has been reached certain consensus. Identification and intraoperative assessment of the RLN seems to be more effectively performed with IONM than solely visually or endoscopically. Today, IONM has evolved sufficiently to increase the likelihood of successful functional outcomes in many patients. The transition from the concept of *intermitted* neural monitoring of the RLN to that of *continuous* functions evaluation that must be appreciate requires highly skilled knowledge of IONM. This goal will be more likely achieved in Centers highly specialized in thyroid surgery.

Keywords: Neural monitoring, thyroid surgery, recurrent laryngeal nerve, IONM

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Introduction

Intraoperative neurophysiology (IONM) has emerged over the last two decade, as one of the main avenues of progress within surgery. The idea of applying techniques traditionally used in clinical neurophysiology within the operating room is not novel (1).

IONM have been used for many years during neurosurgical procedures, spine surgery, vascular, plastic, ENT, etc. (1).

Victor Riddel wrote in 1970 on the British Journal of Surgery (2):

"... It is the author inflexible rule never to resect the second lobe in a bilateral procedure until the integrity of the recurrent laryngeal nerve (RLN) has been proved..."

"... stimulation of the RLN by electrical current will establish its integrity palsy ..."

".. stimulation will determine if an unidentified strand of tissue is the RLN or not..."

In the recent past, there has been a renewed drive toward the implementation of these techniques in thyroid surgery, thanks to the advent of new methods, such as non-invasive monitoring throughout dedicated EMG endotracheal tubes.

IONM simplification has allowed for an increase in the indications for IONM and has also

expanded clinical and experimental research of the RLN and external branch superior laryngeal nerve (EBSLN) (3).

Intraoperative neurophysiology is aimed at either identifying functional structures which cannot be recognized purely on the basis of anatomical landmarks (*mapping*) or to continuously assess the functional integrity of neural pathways which can be injured during surgery (*monitoring*) (Figure 1) (4).

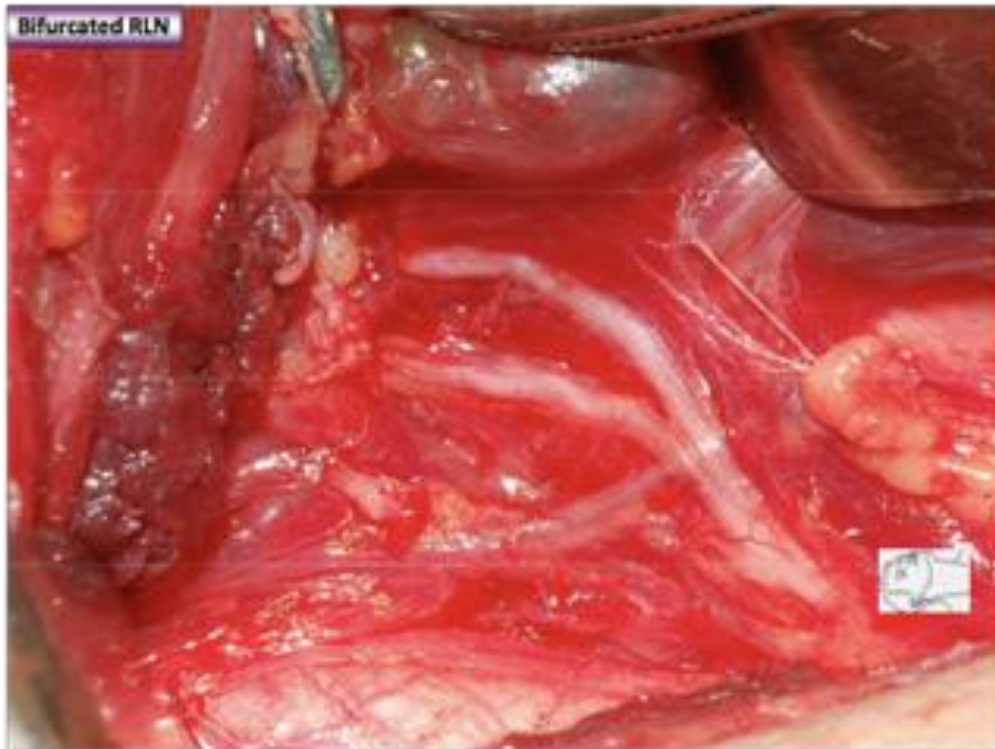


Figure 1. Intraoperative identification of a bifid recurrent laryngeal nerve

The rationale and indications for IONM have substantially changed in the last 5 years. Methodologies have to some extent evolved, although the basic principles of monitoring and mapping techniques remain the same. Nevertheless, IONM has undoubtedly become more and more accessible and extensively used than it has been in the past. The growing interest for this discipline is well documented by the increasing number of publications in this field, both in the form of peer-reviewed papers and edited books as well as by the number of scientific meetings dedicated to intraoperative neurophysiologic monitoring (4-6).

The spectrum of expertise and advancements in this field varies quite considerably across different countries, but there is no doubt that the driving force is not limited to Europe, Asia, North America and involves, to a different extent, virtually all five continents.

The Surgeon and IONM

Intraoperative neurophysiology is favored by many endocrine surgeons nowadays, but this has not always been the case.

In 2007, Loch-Wilkinson et al., wrote that: “*IONM technique can not never be cost-effective if measured as a cost real for lesion of the avoided nerve*” (7).

At same time, false-negative and false positive results, namely a patient waking up from anesthesia with a RLN deficit in spite of intraoperatively preserved EMG signal or patient waking up from anesthesia without a RLN deficit in spite of intraoperatively changed or loss of signal, could occur, and this detracted from the reliability of IONM (8).

Furthermore, IONM was erroneously considered useful merely for predicting the outcome but not for preventing RLN deficits and this also contributed to its lack of popularity among some surgeons. The feeling of “wasting time” when performing IONM techniques is still a concern for a number of surgeons, as well as the technological, generational hurdle, the personal pride, the lack of audit, absent postoperative laryngeal examination, to still sustain that RLN palsy does not exist in their practice (7, 8).

In analogy to the introduction of the laparoscopy in the 1980s, far from being widely accepted at that time, IONM had to find its way to become welcome in the operating room.

The idea of a different professional figure (namely the surgeon and the anesthesiologist) working more hand in hand in the operating room and cooperating for the proper EMG tube position, induction and maintenance of anesthesia, the concordance of intraoperative surgical strategy (abort second side surgery in case of loss of EMG signal at first resected side to prevent bilateral RLN injury) became readily acceptable to both professionals.

The reluctance to use IONM has significantly changed today, together with an increasing acknowledgement of the reliability and value of IONM in our endocrine surgery practice. Yet, some resistance to the use of IONM still exists nowadays and relies mainly on the criticism that the use of IONM is not “*evidence-based*” (1).

Is it evidence-based?

There is discussion about the fact that IONM is not based on class I evidence. Yet, we may ask ourselves what level of evidence we do need to justify the use of IONM.

Although the level of evidence for the benefit of IONM is limited to class II and class III studies, it should be recognized that the same level of evidence applies to most of our clinical practice within thyroid surgery and any other technology applied as energy based device utility, iPTH, endoscopic or robotic procedures, florescence, etc. (9).

From the other surgical procedures using IONM as spinal surgery to that of vascular, brain surgery,

even the more accredited analyses (such as Cochrane reviews) fail to demonstrate class I evidence (1, 10-12).

So, after all, we have to admit that the level of evidence based medicine in IONM is not worse than that found in general surgery generally and in thyroid surgery in particular (1).

It is very unlikely that class I studies will ever occur in the field of IONM (13). There are at least two reasons for this. First, the likelihood of preventing a transient RLN deficit using IONM is low that a controlled study where patients are randomly assigned to a control group or a monitored group would be unethical and unacceptable to patient and surgeon alike (13).

Moreover, the incidence of severe and permanent RLN complications is even lowest. Thus, IONM would aim at further reducing a number that is already small to begin with (13). A power calculation study would therefore predict that the number of patients needed for such a study would surpass the number of patients enrolled in most single-institution and, most likely, multicenter studies (13).

We should therefore accept that in the future, the benefit of IONM will continue to be based on good clinical outcomes, historical control studies, and cost–benefit evaluations (1).

One of the concerns relating to guidelines in the field of IONM is related to their medicolegal implications (13-19). Some reports suggest that the courts are applying new clinical practice guidelines in their decision-making processes, it is worthwhile to anecdotally recall a case in which a patient sustained RLN palsy after thyroid surgery, and the plaintiffs' expert supported the view that IONM was considered the standard of care (13-19).

The Authors of this paper argue that the benefits of the IONM are not legal, but certainly clinical-intraoperative. It is really a pity that the concept of usefulness of the IONM is limited solely to legal medical matters.

Cost–benefits

A few papers have addressed the issue of costs and benefits in neuromonitoring in thyroid surgery (20-23).

A detailed evaluation of the costs of IONM should include not merely those of the equipment and disposables (electrodes, probes, etc.) but also that of training, learning curve, nerve early and definitive identification, the aid in nerve dissection, the continuous nerve function evaluation, cataloging anatomy variability, intraoperative surgical strategy and synchronization of surgical maneuvers, injury mapping, the cost of responding to a IONM warning (false vs. true signals) , the EBSLN identification and monitoring, teaching tool, IONM use in less experience surgeons, legal issues and the research imprint (20-23).

From a purely economic standpoint, benefits of IONM generally include the avoidance of RLN complications in terms of both rehabilitation costs, prevention of bilateral nerve injury, severe permanent injury, selective use and economic compensation for malpractice lawsuits (20-23).

Although most of the papers published conclude that benefits slightly outweigh costs, it is obvious that the cost for each monitored procedure decreases along with the increasing number of cases monitored at a single institution (1, 20-23).

The cost–benefit argument is not trivial as it is the one that influences hospital administrators when they decide to invest. The impression is that hospital administrators are increasingly sensitive to the value of IONM as to decrease malpractice claims is one of the goals (1).

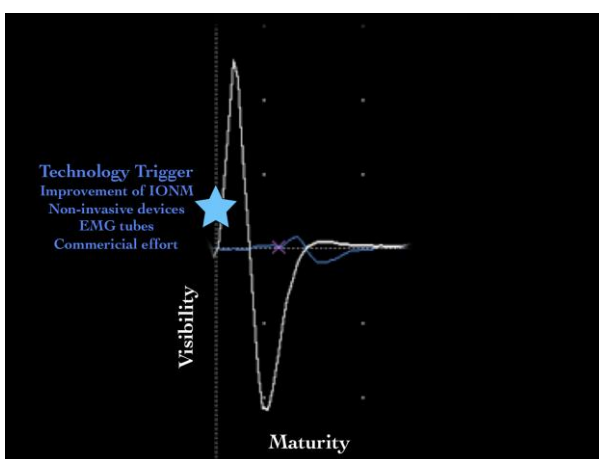
IONM equipment is not particularly expensive when compared to the other tools that we use daily in the operating room for thyroid surgery as energy based devices, robots, endoscopy, etc...

An average IONM system ranges between 15 and 20,000 euros. In the majority of Western countries, this does not represent an insurmountable cost.

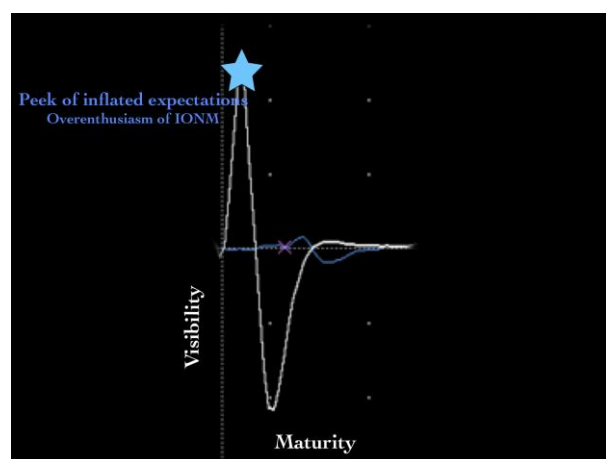
The true limitation is lack of IONM training with an appropriate IONM curriculum, and what are the appropriate IONM credentials remain a matter of debate (1).

The EMG Signal

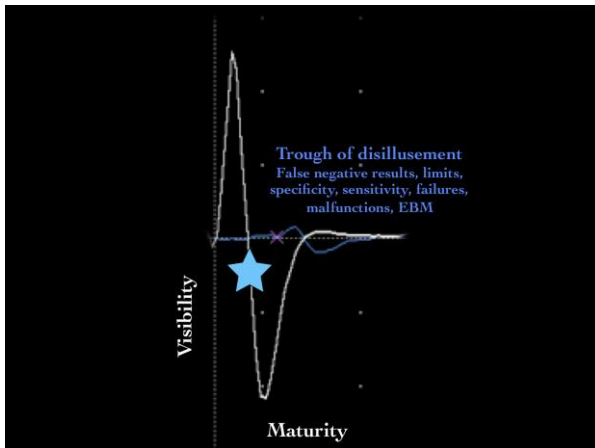
In conclusion, we may see the development of IONM during the past 10–15 years in thyroid surgery being well represented by the EMG signal (1). The EMG signal is the graphic representation of the maturity and adoption of IONM technologies (Figure 2a,b,c,d,e) (1).



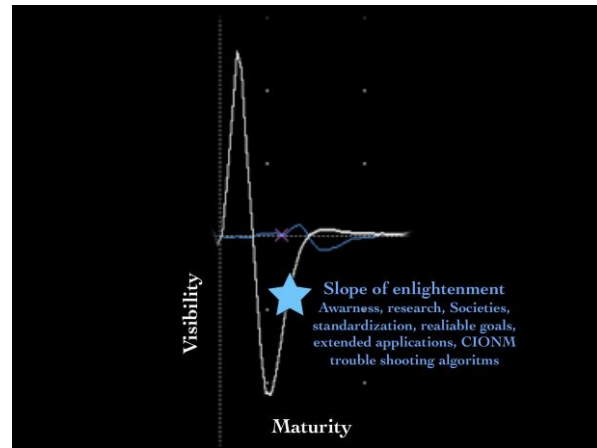
a)



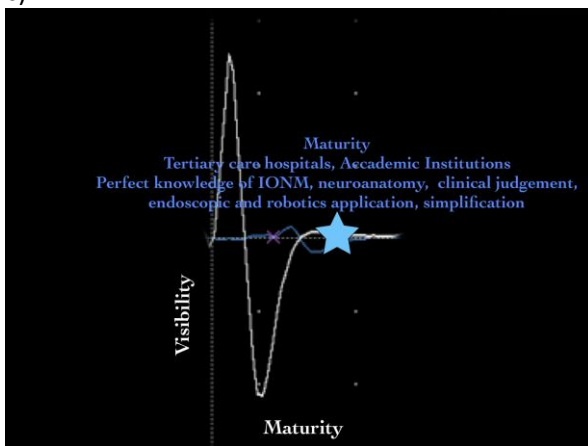
b)



c)



d)



e)

Figure 2a,b,c,d,e. The EMG signal for IONM in thyroid surgery. (a) *Technology trigger*: This is the first phase, a breakthrough that occurs when IONM is launched on the market generating interest and attraction, due mainly as a non-invasive devices (EMG tubes) and commercial effort. (b) *Peak of inflated expectations*: This is what happens when overenthusiasm and unrealistic expectations are generated. In this phase, successful applications and failures of a technology occur (first false-negative and false positive results appearing in the literature).

(c) *Trough of disillusionment*: This is what happens when expectations are not met and technologies become unfashionable. This may correspond to IONM limits evidence, false negative results, specificity, sensitivity, failures, malfunctions, evidence based medicine lacking.

(d) *Slope of enlightenment*: This is the phase of maturity, when in spite of some failures, research continues to grow, identify reliable goals, and extend applications.

Furthermore IONM societies development, standardization, extended applications, CIONM, trouble shooting algorithms application. (e) *The plateau of productivity*: In tertiary care hospitals and academic institutions where it is performed according to both the highest professional level and standards of care, perfect knowledge of IONM, neuroanatomy, clinical judgement, endoscopic and robotics application, simplification of technology.

Compliance with ethical standards

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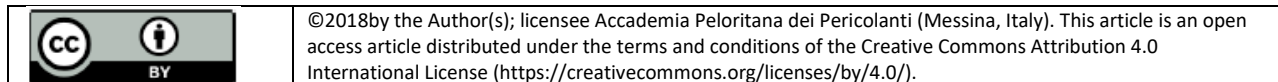
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