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ORIGINAL ARTICLE

Continuous intraoperative neural monitoring in thyroid surgery: a Mexican experience

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Abstract Intraoperative continuous neural monitoring (C-IONM) during thyroid surgery has been recognized as a useful tool to identify and confirm recurrent laryngeal nerve integrity. The aim of the present study is to analyze electromyographic features and thresholds for normal vocal fold function in our initial experience with C-IONM in thyroid surgery. C-IONM was utilized in 57 patients who underwent thyroid surgery between July 2012 and December 2015. EMG parameters were analyzed looking for potential predictors of postoperative vocal fold dismotility. There were 54 females (94.7%) and 3 males (5.3%) with a mean age of 46.7 ± 11.6 years. C-IONM was successfully registered in 89 of 107 nerves at risk (83.1%). Mean basal amplitude was 727.31 ± 471.25 µV and mean final amplitude was 650.27 ± 526.87 µV (P = 0.095, CI 95% 13.83–167.91). Mean basal latency was 5.23 ± 1.42 mS and mean final latency was 5.18 ± 1.50 mS (P = 0.594, CI 95% 0.39–0.24). Four patients had transient postoperative vocal fold paresis. None of these four patients had loss of signal (LOS), three had transient decrease in amplitude, and one had a normal registry throughout the operation. C-IONM is a useful tool to identify patients in whom intraoperative RLN is at risk during surgery. Final amplitude above 500 µV and no LOS is associated with RLN integrity and normal postoperative vocal fold function.

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Introduction

Intraoperative neural monitoring (IONM) in thyroid surgery is a useful tool to confirm the functional integrity of the recurrent laryngeal nerve (RLN) and has gained acceptance among surgeons and otolaryngologists [1–3]. IONM helps to identify the RLN and a normal functioning nerve at the end of the operation, having a positive predictive value for normal postoperative vocal fold function close to 98%. The negative predictive value (NPV) corresponds to 37% [4]. The use of IONM has been restricted by some groups for difficult cases where nerves are at a higher risk whereas for others, it is an adjunct for all surgical procedures [5].

Visual identification and gentle manipulation of the RLN in thyroid surgery are still the best ways to prevent vocal cord dysfunction. However, an anatomic intact nerve identified by visualization does not translate in normal function [6]. Several studies have shown that only 10–14% of injured RLN nerves are intraoperatively identified [7, 8].

Identification of the external branch of the superior laryngeal nerve (EBSLN) is more challenging [6] during surgery. The reported rate of EBSLN visualization is close to 53%, and it is even more difficult to recognize in obese patients [9]. Identification of the EBSLN during IONM can be achieved by either the cricothyroid muscle twitch or by a distinctive waveform and conduction pattern on electromyography (EMG).

IONM of the RLN can be continuous or intermittent. For the continuous IONM (C-IONM), an automatic probe stimulator device (APS) needs to be placed around the vagus nerve (VN). This probe delivers a low level electric stimulation at a previously set period of time, with automatic real time feedback and data register. Intermittent stimulation on the other hand is achieved by placing the stimulation probe directly on the RLN.

Some electromyographic parameters associated with postoperative normal vocal fold function have been suggested [10]. The aim of the present study is to analyze EMG features and thresholds for normal vocal fold function in a group of Hispanic patients in whom C-IONM was used in thyroid surgery.

Patients and methods

A total of 57 patients underwent thyroid resection by three surgeons using C- IONM between July 2012 and December 2015. C-IONM was performed using either a Neuromonitoring system NIM™ Response 3.0 System (Medtronic, Jacksonville, FL, USA) with NIM Contact™ EMG endotracheal tubes, or an Innomed C2 Nerve Monitor® (Emmendingen, Germany) with the SELECT laryngeal electrode.

The ipsilateral carotid sheath was opened in a longitudinal fashion with blunt dissection and monopolar cautery, the VN was dissected circumferentially and the APS settled and set at 1 mA with VN stimulation of 100 mS every 6 s. Initial amplitude above 500 μV was established as an indicator of an adequate electrode position and function. If the baseline amplitude was less than 500 μV, the anesthesiologist repositioned the endotracheal tube to obtain an adequate voltage. Amplitude and latency were recorded with EMG and auditory response.

A decrease $\geq$50% in the amplitude and increase $\geq$10% in the latency or the presence of loss of signal (LOS), defined as $<$1% of the basal amplitude or complete loss of recognizable RLN electromyographic signal (amplitude $<$100 μV with vagal stimulation) were considered as potential indicators of RLN damage [11, 12].

EBSLN was identified by means of EMG waveform, cricoarytenoid muscle contraction (laryngeal twitch) or auditory response with probe stimulation. A certified otolaryngologist performed fibrolaryngoscopy in 50 patients before and after surgery.

Results

There were 54 females (94.7%) and 3 males (5.3%) with a mean age of 46.7 ± 11.6 years. Normal vocal fold function before surgery was found in all 50 patients undergoing preoperative laryngoscopy. Total thyroidectomy was performed in 50 patients (87.7%), subtotal thyroidectomy in 4 patients (7.0%) and hemithyroidectomy in 3 (5.3%). A central neck compartment lymph node dissection was also performed in 26 of the 50 patients undergoing total thyroidectomy. The histologic analysis in 12 patients (21.1%) reported benign disease, in 44 cases (77.2%) differentiated papillary thyroid carcinoma was documented and in one patient (1.8%) a medullary carcinoma.

C-IONM of both RLN was fully accomplished in 32 (64%) of 50 patients undergoing bilateral resection and in one side in the remaining patients. In terms of the nerves at risk, C-IONM was successfully registered in 89 nerves (83.1%) of 107 nerves at risk. Mean basal amplitude was 727.31 ± 471.25 μV and mean final amplitude was 650.27 ± 526.87 μV (P = 0.095, CI 95% 13.83–167.91). Mean basal latency was 5.23 ± 1.42 mS and mean final latency was 5.18 ± 1.50 mS (P = 0.594, CI 95% 0.39–0.24).

A transient $\geq$50% decrease in amplitude during dissection was observed in 29 nerves (27%). Mean time of an amplitude decrease $\geq$50% was 12.9 ± 12.8 min. A $\geq$10% increase in latency during dissection was observed in 20 nerves (18%), with a mean time of 3.4 ± 3.34 min. Combined events (decreased amplitude and increase in latency) were present in three patients. No patient had LOS during the procedure.

Postoperative laryngoscopy documented vocal cord paresis in four patients, none of them had combined events. In two of these cases, C-IONM showed transient $>$50% decrease in amplitude; in one additional patient, basal amplitude was below 100 μV since the moment when the APS was placed, the last patient had normal C-IONM throughout the procedure. In all patients with vocal fold dismotility, vocal cord dysfunction recovered to normal motility within 12 weeks. A total of 65 of 107 EBSLN were identified with acoustical signal and waveform (60.7%). There were no cases of intraoperative or postoperative clinical cardiac, pulmonary, or gastrointestinal adverse effects.

Discussion

IONM is now considered a valuable aid to traditional visualization of RLN [13]. Neurophysiologic parameters evaluated during IONM are amplitude and latency. Amplitude is correlated with the number of muscle fibers participating in the polarization during standard laryngeal EMG and corresponds to the magnitude of the EMG wave measured in microvolts [14]. Amplitude in IONM is variable between patients and may be affected by several factors, such as blood in the operating field between the nerve and the probe, environmental temperature, and the quality of contact between the endotracheal electrodes and the vocal cords [14]. A persistent amplitude decrease

>50% from basal values is highly suggestive of RLN damage [11]. Latency symbolizes the speed of depolarization of the nerve fibers. It depends on the distance of the stimulation point to the ipsilateral vocal cord [14] and it is measured in milliseconds [15]. An increase >10% from the basal values may also be associated to nerve damage. Combined events (an increase of latency >10% and a decrease of amplitude >50%) as well as LOS should be considered as alarming signs that demand prompt attention to potential RLN injury [11]. According to Phelan et al., combined events have a positive predictive value for vocal fold paralysis of 33%, a negative predictive value of 97% and are reversible during surgery in 73%. LOS on the other hand, has a positive predictive value of 83%, a negative predictive value of 98% and is reversible only in 17% [12].

As described in the 2009 recommendations of the Neurolaryngology Study Group on Laryngeal EMG, the normal talking laryngeal myoelectric pattern has a short duration (3–7 mS) and small amplitudes (100–800 μV) [16]. Lorenz et al. in 2010 described the standard IONM EMG parameters from a study on 1289 patients undergoing IONM with 1996 nerves at risk. The median amplitude of the left VN was 469 μV (range 138–1241) with a latency of 3.91 mS (range 3.13–4.69), and the median amplitude of the right VN of 512 μV (range 168–1593) with a latency of 5.90 mS (range 5.00–7.03). [15].

In a different study, Caragaciaru et al. [10] suggested as the adequate initial parameters, amplitude of 898 ± 644 μV and mean final amplitude of 1179 μV (range 152–3843) in a group of 125 patients who underwent thyroidectomy under IONM. Vocal cord mobility was assessed by postoperative laryngoscopy. Patients with postoperative abnormal laryngoscopy had average initial amplitude of 378 μV and final amplitude outside their 5th–95th percentile. Genther et al. also correlated IONM values with immediate postoperative vocal fold function after thyroid and parathyroid surgery in 1000 nerves at risk [17]. A final amplitude ≥200 μV was predictive of normal cord mobility with sensitivity, specificity, positive and negative predictive values and accuracy of 95.5, 99.2, 72.4, 99.9, and 99.1%, respectively.

In our study four patients presented transient vocal fold dismotility in the postoperative laryngoscopy. Two of these patients had normal basal and final values of amplitude and normal latency values, but had presented transient >50% decrease of amplitude which lasted 9 min in one patient and 20 min in the other.

The value of IONM to prevent RLN injury during thyroid surgery has not been demonstrated yet. In a meta-analysis that included 64,699 nerves at risk, the transient and permanent RLN injury rates were similar in patients undergoing the operation under IONM than in patients in whom nerve was identified by visualization alone [18]. Other studies have reported inconsistent findings [14]. Among the factors that may explain the lack of a significant impact on the reduction of the RLN injury rate perhaps the most important is that most studies were performed in highly specialized centers where the rate of RLN damage is extremely low. We believe that the use of IONM may be beneficial during the training process and that is also valuable to predict postoperative vocal cord function [19].

In these small series we were able to demonstrate that the use of C-IONM is safe and helpful to identify periods of excessive traction that may cause vocal fold dismotility from RLN damage. C-IONM was also an excellent predictor of postoperative nerve function, since none of the patients with normal IONM parameters at the end of the procedure developed permanent RLN palsy.

Our study has several limitations, one is the small number of patients with only 107 nerves at risk, other is that successful C-IONM was achieved in only 83.1% of the cases, and finally the EBSLN was not searched routinely. It is important to highlight that the endotracheal tubes used in the study from one of the companies, are those with electrodes on the sides. The development of tubes with circumferential electrodes will undoubtedly enhance the success rate of IONM.

Compliance with ethical standards

Conflict of interest All authors declared that they have no potential conflict of interest.

Ethical approval All procedures performed in the participants of our study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain actions performed on animals.

Informed consent For this type of study formal consent was not required.

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