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ELECTROMYOGRAPHIC FEATURES OF INTERMITTENT INTRAOPERATIVE NEUROMONITORIZATION IN THE THYROID SURGERY

Tiroid Cerrahisinde Aralıklı İntraoperatif Nöromonitorizasyonun Elektromiyografik Özellikleri

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The present research was approved by the ethical board of the Ethics Committee of the Diyarbakir Gazi Yasargil Education and Research Hospital (02.01.2017-60).

Abstract

Aim: The aims of this study are, to summarize the trick points of intermittent intraoperative neuromonitoring (I-IONM), outlines of electrophysiologic outcomes of electromyography (EMG), and to determine the electrophysiological properties of left and right recurrent laryngeal nerve (RLN) which anatomical lengths are different from each other.

Materials and Methods: 34 thyroidectomy cases (27 of total thyroidectomy, 7 of hemithyroidectomy) with use of I-IONM, between June 2016 and June 2017 were retrospectively examined. Pre-dissection (R1, V1) and post-dissection (R2, V2) EMG waveforms of the right and left sides' vagal nerve (VN) and RLN were evaluated.

Results: There were 29 females and 5 males patients with mean age of 43.85±13.86 years. 61 nerves at risk were successfully evaluated with I-IONM. Mean R1 and R2 amplitudes of the right RLN were 280±10 μV and 270±9μV; the left RLN were 270±10μV and 260±9μV respectively. Mean V1 and V2 amplitudes of the right VN were 210±7μV and 190±7μV; the left VN were 190±5.4μV and 170±5μV respectively. Mean R1 and R2 latencies of the right RLN were 2.03±0.42mS and 2.0±0.46mS; the left RLN were 1.90 ± 0.30mS and 1.96 ± 0.33mS respectively. Mean V1 and V2 latencies of the right VN were 1.91±0.46mS and 1.82±0.52mS; the left VN were 2.01±0.34mS and 2.07±0.38mS respectively. There was no statistically significant difference between the sides in terms of EMG waveforms of the VN and RLN.

Conclusion: The left RLN has a longer anatomical length than the right RLN but we concluded that the length of the nerve does not affect the amplitude and latency.

Keywords: Recurrent laryngeal nerve, neuromonitoring, electromyography.

Öz

Amaç: Bu çalışmanın amacı aralıklı intraoperatif sinir monitorizasyonunun (I-IONM) püf noktalarını özetlemek ve anatomik uzunlukları birbirinden farklı olan sol ve sağ rekürren laringeal sinirin (RLN) elektrofizyolojik özelliklerini belirlemektir.

Materyal ve Metot: Haziran 2016-Haziran 2017 tarihleri arasında I-IONM kullanan 34 tiroidektomili hasta (27'i total tiroidektomili, 7'i hemitiroidektomili) retrospektif olarak incelendi. Pre-disseksiyon (R1, V1) ve post-disseksiyon (R2, V2) sağ ve sol tarafın vagal siniri (VN) ve RLN'nin EMG dalga formları değerlendirildi.

Bulgular: Yaş ortalaması 43.85±13.86 olan 29 kadın ve 5 erkek hasta vardı. 61 sinir I-IONM ile başarıyla değerlendirildi. Sağ RLN'nin R1 ve R2 genlikleri ortalaması sırasıyla 280±10 μV ve 270±9 μV idi; sol RLN sırasıyla 270±10 μV ve 260±9 μV idi. Sağ VN'nin ortalama V1 ve V2 genlikleri sırasıyla 210±7 μV ve 190±7 μV idi; sol VN sırasıyla 190±5.4 μV ve 170±5 μV idi. Sağ RLN'nin ortalama R1 ve R2 gecikmeleri sırasıyla 2.03±0.42 mS ve 2.0±0.46 mS; sol RLN sırasıyla 1.90±0.30 mS ve 1.96±0.33 mS idi. Sağ VN'nin ortalama V1 ve V2 latensleri sırasıyla 1.91±0.46 mS ve 1.82±0.52 mS idi; sol VN sırasıyla 2.01±0.34 mS ve 2.07±0.38 mS idi. VN ve RLN'nin EMG dalga formları açısından taraflar arasında istatistiksel olarak anlamlı bir fark yoktu.

Sonuç: Sol RLN'nin sağ RLN'den daha uzun anatomik uzunluğu vardır, ancak sinirin uzunluğunun genlik ve gecikmeyi etkilemediği sonucuna vardık.

Anahtar Kelimeler: Rekürren larengeal sinir, sinir monitorizasyonu, EMG.

INTRODUCTION

A part from hypoparathyroidism and hematoma, recurrent laryngeal nerve (RLN) palsy is the most common and serious complication after thyroid surgery [1]. Rate of recurrent laryngeal nerve injury

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during thyroid surgery is estimated to be between 0.3% and 18.9% [2]. These rates increase in recurrent surgeries. Visual identification and gentle manipulation of the RLN in thyroid surgery are still the best ways to prevent vocal cord dysfunction [1]. However, an anatomic intact nerve identified by visualization does not mean normal neural function. For the purpose of preventing neural injury, the intraoperative neuromonitoring (IONM) technique first was described by Flisberg and Lindholm in 1969 [3]. These devices electrically stimulate the nerves, so as to conduct the signal up to the innervated muscles. The resulting muscle activity is then turned into acoustic and electromyographic signals [4]. For this, continuous or intermittent monitoring techniques (I-IONM) can be used in IONM.

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.

Due to reports in the literature suggesting significant inaccuracies from the nonstandard application of monitoring techniques we aimed to present this retrospective study, to summarize the trick points of intermittent IONM. Also, we described outlines of electrophysiologic outcomes of electromyography (EMG), and determine the electrophysiological properties of left and right RLN which anatomical lengths are different from each other.

METHODS

Patients

The present research was approved by the ethical board of the Ethics Committee of the Diyarbakir Gazi Yasargil Education and Research Hospital (02.01.2017-60). In this retrospective study, 34 patients who underwent total thyroidectomy or hemithyroidectomy with the use of I-IONM in our general surgery department between June 2016 and June 2017 were examined. Approval was received from the Ethics Committee of Diyarbakir Gazi Yasargil Training and Research Hospital for this study in 2017 (02.01.2017-60).

Standards in Anesthesia

An essential ingredient in successful neuromonitoring is to being in a partnership with the anesthesiologist. It is important to discuss with the anesthesiologist about the need to have no muscle relaxation during the monitoring before the initiation of a neural monitoring program. In our practice, low-dose muscle relaxants are used in the induction of anesthesia. No muscle relaxants were used when spontaneous breathing or muscle functions returned after intubation.

Intermittent Intraoperative Neuromonitoring Technique and Surgical Procedure

All patients were intubated with a standard reinforced EMG endotracheal tube that electrodes made of stainless-steel wire. The largest tube to contact the vocal cords of the patient was selected. During this procedure, no lubricant gel or liquid was applied to the endotracheal tube and the oropharynx was aspirated before intubation. The anesthesia team made sure that the electrodes touched the medial face of the vocal cords. To ensure the endotracheal surface electrodes' position was routinely checked after the neck was placed at hyperextension. Then the cable of the tube and electrodes are fixed to the rim.

A 4-step procedure was carried out in all procedures. During all steps, I-IONM was used and 1.5 mA stimulation was performed with monopolar probes.

Step 1: Thyroidectomy was performed with a standard Kocher incision. After the anatomical layers were passed and the thyroid was medialized, the carotid sheath was dissected. The Vagus nerve (VN) was found and impulse was given. The basal amplitude and latency of the VN were measured and recorded before resection (V1). If this signal was not received, the electrodes in the endotracheal tube or cable connections in the device were checked.

Step 2: After the thyroid was medialized, the RLNs were routinely identified by visualization and completely exposed. Than the basal amplitude and latency of the RLN were measured and recorded before resection (R1). (If the RLN cannot be seen and no signal can be obtained in the tracheoesophageal sulcus but the signal is received from the VN, it was thought that there may be a non-recurrent laryngeal nerve.)

Step 3: After the thyroid resection, RLN was re-stimulated from the most proximal point where it was dissected in the Berry ligament. The final amplitude and latency of the RLN were measured and recorded before resection (R2).

Step 4: Finally, after the resection was completed, the VN was stimulated again and the function of the nerve was checked. The final amplitude and latency of the VN were measured and recorded after resection (V2).

Statistical Analysis

Statistical analysis was done with SPSS software. Minimum, maximum, mean, and standard deviation values of all these data were determined. Mann Whitney U and Student T were performed for comparison.

RESULTS

There were 29 females (85.3%) and 5 males (14.7%) with a mean age of 43.85±13.86 years. Normal vocal fold function before surgery was found in all 34 patients. Total thyroidectomy was performed in 27 patients (79.4%), and hemithyroidectomy in 7 (20.6%).

The histopathologic analysis in 20 cases (58.9%) reported benign multinodular goiter, in 9 cases (26.4%) papillary thyroid carcinoma, and in 5 cases (14.7%) thyroiditis was documented. A total of 61 at-risk RLNs were evaluated in 34 patients. Four of 7 hemithyroidectomy cases underwent right lobectomy and 3 underwent left lobectomy. Therefore, 30 of 61 of the nerves evaluated were on the left side and 31 were on the right side.

Basal (V1 and R1) and final (V2 and R2) parameters of EMG were evaluated. Electromyographic features of the right and left VN and RLN are compared in Table 1 and Table 2 respectively. Mean R1 and R2 amplitudes of the right RLN were 280±10 μV and 270±9 μV; the left RLN were 270±10 μV and 260±9 μV respectively. Mean V1 and V2 amplitudes of the right VN were 210±7 μV and 190±7 μV; the left VN were 190±5.4 μV and 170±5 μV respectively. Mean R1 and R2 latencies of the right RLN were 2.03±0.42 mS and 2.0±0.46 mS; the left RLN were 1.90±0.30 mS and 1.96±0.33 mS respectively. Mean V1 and V2 latencies of the right VN were 1.91±0.46 mS and 1.82±0.52 mS; the left VN were 2.01±0.34 mS and 2.07±0.38 mS respectively. There was no statistically significant difference between the right and left sides in terms of electromyographic waveforms of the VN and RLN.

Table 1. Comparison of amplitude and latency of the VN by the side

		V1 Amplitude (µV)	V2 Amplitude (µV)	V1 Latency (mS)	V2 Latency (mS)
Right (n=31)	Mean	210	190	1,91	1,82
	Standard deviation	7	7	0,46	0,52
	Median	200	190	1,90	1,90
	Minimum	110	100	1,10	1,00
	Maximum	440	410	2,90	3,20
Left (n=30)	Mean	190	170	2,01	2,07
	Standard deviation	5.4	5	0,34	0,38
	Median	180	180	1,92	2,10
	Minimum	137	100	1,55	1,60
	Maximum	350	300	2,90	3,20
p		*0,511	**0,416	*0,880	*0,169

* : Mann Whitney U Test was performed µV: microvolts
** : Student T Test was performed mS : Milliseconds

Table 2. Comparison of amplitude and latency of the RLN by the side

		R1 Amplitude (µV)	R2 Amplitude (µV)	R1 Latency (mS)	R2 Latency (mS)
Right (n=31)	Mean	280	270	2,03	2,00
	Standard deviation	10	9	0,42	0,46
	Median	280	270	2,10	2,00
	Minimum	120	132	1,00	0,23
	Maximum	508	458	3,10	3,10
Left (n=30)	Mean	270	260	1,90	1,96
	Standard deviation	10	9	0,30	0,33
	Median	280	260	2,00	1,90
	Minimum	120	113	1,00	1,00
	Maximum	480	491	2,30	3,10
p		**0,720	**0,767	*0,055	*0,384

* : Mann Whitney U Test was performed µV: microvolts
** : Student T Test was performed mS : Milliseconds

No signal loss or no transient ≥50% decrease in amplitude during dissection was observed in patient. It was determined that only one patient had hoarseness on the first postoperative day and steroid treatment was started. In the postoperative 15th day, it was seen that the patient's voice and vocal cord examination were normal.

DISCUSSION

Intraoperative visual identification has been the gold standard for securing the laryngeal nerves during thyroid surgery. However, an anatomically intact nerve identified by gross visualization does not confirm a functional nerve [5]. Dralle et al. stated three main aims of performing thyroidectomy accompanied by IONM. First of them is the opportunity that IONM provides a better evaluation of anatomic variations of the RLN which is non-recurrent or extra-laryngeal branching [6]. The second, IONM provides an intraoperative assessment of RLN's function when a functional nerve is a piece of evidence under unfavorable conditions like reoperations and the third is to distinguish changes related to RLN trauma from voice changes that are not related to the operation [6].

Intraoperative neuromonitorization is based on the principle of revealing EMG waves formed by stimulating the motor neurons that go to the larynx muscles and move the vocal cord muscles [7].

Standard parameters' of EMG values have not described and vary in each patient. Surgeons often use wave changes to understand neural injury. Therefore, it was important to use the standard and correct technique [8]. Chiang et al. standardized the use of IONM in 4 steps. These steps were based on the principle of stimulating of **V1 (pre-dissection VN), R1 (pre-dissection RLN), R2 (post-dissection RLN) and, V2 (post-dissection VN)** respectively [9]. We use I-IONM as defined by them as standardized. On the other hand, the choice of stimulation probes, monopolar or bipolar, single or reusable probes, and tip design used in many studies was at the discretion of the individual surgeon as reports showed no relevant difference in the resulting quantitative EMG activity [8,10]. In our study, we only used the monopolar probes.

EMG 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 (µV) [11]. It is measured in EMG by the height difference between the first electronegative peak and the deepest electropositive peak. In order to detect an amplitude in EMG, the nerves must be given at least 0.3-0.4 milliamps (mA). Latency is the time between stimulation points to the ipsilateral vocal cord. In EMG, it is the time between the first wave of electrical activity and the first peak (It may have occurred in the positive or negative direction). It is measured in milliseconds (mS). According to our results, latency values of RLN (all R1 and R2) ranged from 0.23-3.10 mS and VN (all V1 and V2) ranged from 1-3.20 mS.

Only a few studies described quantitative parameters of IONM. Satoh from Nagasaki performed larengeal nerve monitoring with using intramuscular electrodes, and found recurrent laryngeal nerve latency of 1.5 to 2.5 mS, amplitudes from 500 to 100 µV [12]. In our study, the amplitude values of RLN ranged from 113 to 508 µV and latency values of RLN ranged from 0.23 to 3.10 mS. As can be seen amplitude parameters of our cases are similar to Satoh's series but latency is not. In an experimental animal model, VN evoked with 0.43±0.98 mA, and the latency of the VN was 6.7±1.39 mS without relevant side differences [13]. In a multicenter cohort study, the amplitude of left VN were ranged from 138 to 1241 µV, right VN were ranged from 168 to 1593 µV. The latency of right VN were ranged from 5.00- 7.03 mS, left VN were ranged from 3.13-4.69 mS [8]. In our series, amplitude values of VN ranged from 100 to 440 µV and latency values of VN ranged from 1 to 3.20 mS. It was seen that the VN values in our series did not similar to the values in this cohort study. This may be because the standard method was not used in their study. In our study, we routinely stimulate the nerves with 1.5 mA but it is not clear in this cohort study.

In our study, other purpose was to investigate that does anatomical length affects the EMG parameters or not. The recurrent laryngeal nerve has a characteristic loop around the aortic arch on the left before returning up to achieve the tracheoesophageal groove and then the larynx. The right RLN courses around the subclavian artery and often does not reach the tracheoesophageal groove until near the cricothyroid muscle. Therefore, the left RLN has a longer anatomical length than the right RLN. Due to the difference of nervous length, it may be thought that the latency may be longer for the left VN than right. Satoh mentioned that right NV latency is 2-3 mS shorter than left in his cases [12]. In another study, Lorenz et al. described the standard IONM EMG parameters from a study on 1289 patients undergoing IONM with 1996 nerves at risk. Overall "normal IONM parameters" in this study, resulted in significantly greater median values of amplitude for the right VN compared to the left. They found no explanation for this finding. Contrary, the latency of the left VN was observed to be significantly longer than on the right, contributable to the anatomically longer course [8]. Both studies have found that the left side VN latency was longer. The authors claim that this is related to long anatomy. In our study, there was no difference between the nerve parameters of the two sides contrary to the literature. Therefore, we concluded that the length of the nerve does not affect the quantitative EMG parameters.

A persistent amplitude decrease of 50% from basal values is highly suggestive of RLN damage due to the lack of standard EMG parameters in IONM [11]. There was no signal loss in our study. However, postoperative transient hoarseness was detected in one of our patients and the voice returned to normal after 15 days. We believe that this may be due to axonal damage in RLN due to traction, although the nerve is anatomically and physiologically normal.

Our study has several limitations, the first is that there are few patients, and the other is that we do not know the actual length of the nerves.

CONCLUSION

As a conclusion, there is no standard value of EMG in IONM. Large meta-analyses will may determine standard values. Also, our study showed that EMG parameters were not affected by the length of the nerves despite the literature.

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