Study the Normal Range of Intraoperative Neuromonitring EMG during Thyroid Surgery*

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ABSTRACT Objective: To investigate normal range of the recurrent laryngeal nerve EMG during the intraoperative nerve monitoring (IONM). Methods: There were 300 cases in the study of IONM,in the department of Thyroid Surgery, Yantai Yuhuangding Hospital from November 2009 to January 2012. In the procedure, a needle loop electrode was put in the skin obliquely, of which the diameter was 2cm in the same side, two needle recording electrode obliquely piercing the cricothyroid muscle, at the same time, hand-held to stimulate probe vertical stimulate neural issued a "toot toot" tone, the monitor display electromyographic waveforms and record the latency and amplitude values. Results: 285 cases (386 sizes) showed Electromyogram clearly, Electromyogram were not drawed out in 15 cases, while 10 were false-negative because of system and anesthesia questions, 5 were needle electrodes can not put in properly. There was no permanent recurrent laryngeal never injure, 2 transient nerve injure cases recovered in one month. V1 95% confidence interval:482.66 ～574.28 μV, R1 95% confidence interval: 521.85 ～615.05 μV, V2 95% confidence interval:440.92 ～531.84μV, R2 95% confidence interval:489.25 ～582.05 μV, T 95% confidence interval is 19.88 ~ 20.12ms. Conclusion: Study the normal range of the recurrent laryngeal nerve EMG, to determine the integrity of the nerve function for a basis, reducing the rate of recurrent laryngeal nerve injury, which will help judge the recurrent laryngeal nerve injury, and look for the reasons of injury.

Key words: Recurrent laryngeal never(RLN); Neuromonitring; Thyroid surgery; EMG; The normal range

Chinese Library Classification (CLC):R653 Document code: A

Article ID: 1673-6273(2012)19-3668-05

Introduction

The recurrent laryngeal nerve injure (RLNi) is the most common and most serious complications of thyroid surgery, one side of the RLNi can cause a hoarse voice. Bilateral RLNi can cause suffocation and affect the patient quality of life seriously, the patient disputes could be produced easily. To the naked eye to identify the recurrent laryngeal nerve intraoperative had been shown to reduce the probability of nerve injury, and was recognized as the gold standard to find the recurrent laryngeal nerve. At home and abroad the continuity of RLN was identified with the naked eye combined with intraoperative real-time neural monitoring (IONM) the functional integrity of RLN, which was a significant reduction in the rate of RLNi. IONM refers to the integrity of the nervous system functions in a dangerous state in the application of neural electrophysiological monitoring technique [1]. The IONM can not only be used to locate and identify the RLN, but also predict the neurological function and clarify the RLNi mechanism. This technology has been carried out in a foreign country for many years, and formed a complete surgical monitoring system across multiple disciplines, 62% of the penetration rate. But it is late in the domestic and is short of standardization. Most studies have reported that the IONM EMG normal prediction of RLNi higher accuracy rate (92% -100%), vocal cord dysfunction has a large variation (10% -90%) when EMG lost [2]. This study was to establish a standardized of the IONM method, and preliminary specifications of the index parameters.

1 Materials and Methods

1.1 The clinical data

300 cases of open thyroid surgery with IONM from November 2009 to January 2012 in same Hospital, Male 55 cases, 245 cases of female (male: female = 1:4.5) , Age 21-75 (48.21 ± 7.52) years. 102 cases were thyroid malignancy, 33 cases were benign thyroid nodular goiter (including 123 cases of the sternum), eight cases were lymphocytic thyroiditis, 34 cases were hyperthyroidism. Total thyroidectomy was performed in 74 cases, including joint and neck lymph node dissection 20 cases, thyroid unilateral resection + contralateral sub-total resection of 91 cases, unilateral lobe and isthmus resection in 108 cases, unilateral lobectomy 17 cases of thyroid unilateralnear total resection of 10 cases. Initial surgery were 273 cases, the second operation were 20 cases, 7 cases were third or above surgery. The goiter diameter was greater than 5cm of 145 cases. 212 were the anatomy of the left side of the RLN, 187 were the right RLN, 212 were the left vagus nerve, 187 were the right vagus nerve, 2 were nonrecurrent laryngeal nerve (NRLN).

1.2 Methods

*Foundation items: Science and Development Foundation of Yantai (2011228)

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(Received:2012-03-30 Accepted:2012-04-25)

1.2.1 Machine The recurrent laryngeal nerve monitoring system manufactured by American Nicolet company, Model: endeavor CR. Including the composition of the monitor host monitor image display, nerve stimulation probe, the loop electrode and receiving electrode, printers, etc.

1.2.2 Anesthesia All surgical patients preoperation were used efficiency of muscle relaxants such as rocuronium. Vecuronium also belong to the efficiency of the muscle relaxant, but because of muscle relaxation time longer than rocuronium, which may affect the detection results. The surgery is no longer an additional muscle relaxant. low concentrations of isoflurane and propofol infusion also be used, which is neither inhibition of the recurrent laryngeal nerve electromyography activity, but also to reduce the cardiovascular stress response[3].

1.2.3 Surgery The initial surgery feasible cervical midline approach ; and the second surgery and a huge goiter surgery is feasible lateral approach. The harmonic scalpel coagulation cut thyroid vein, thyroid isthmus and Berry ligament continue to be occluded thyroid, very vascular, thyroid was loose outside, the lower side traction glands. A needle loop electrode oblique line piercing the skin of the ipsilateral incision outer edge of the diameter of 2cm range,the two records needle electrodes oblique piercing the cricothyroid muscle, and all connections and records by the Uniform Nurse operation. Make sure the connections are correct. Chiang[4] proposed IONM four-step : the first step to open the ipsilateral carotid sheath to expose the vagus nerve, hand-held nerve stimulator probe to stimulate the nerves, recorded as the V1; The second step to reveal the value of the recurrent laryngeal nerve measured in the tracheoesophageal groove, recorded as R1 (Sun Hui[5] reported that "many points" and the "trilogy" of anatomy: "many points" have below the inferior thyroid glands, under the very dorsal, inferior thyroid artery, recurrent laryngeal nerve and choking at the fixed points to find, the most commonly was under the very bottom and glands very dorsal; "trilogy," namely, "to find, to recognize and protect"); Third step when fully anatomy the RLN to the ligament of Berry, the test proceeds of its recent end as R2; Fourth step complete hemostasis in the operative field test vagus nerve, recording V2. Fiberoptic laryngoscopy before and after surgery all patients by the same doctors.

2 Results

2.1 285 cases (386 sizes) the RLN from the inferior thyroid vessels near the beginning, to the RLN choking Department are clear.

All patients without a hoarse voice, no drinking cough. The laryngoscopy showed good vocal cord movement. The was 15 cases no EMG, of 10 cases was mechanical failure or anesthetic factors, postoperative articulate, the fiberoptic no exception; Five cases of tumor-infiltrating cricothyroid muscle does not insert a recording electrode. There was no permanent recurrent laryngeal nerve injury occurred; two cases of temporary recurrent laryngeal nerve injury, after 1 month recovery.

2.2 Pairs met the inclusion criteria, 268 cases of recurrent laryngeal nerve EMG were statistically analyzed (Table 1)

The average of incubation period (T) is 20.00ms, standard deviation is 1.04ms, 95% confidence interval is 19.88 ~ 20.12ms.

The results showed that: (1) the V1 signal led and within normal range, instructions instrument connected correctly, vagus nerve without injury; the V1 signal led but weakened, showed that the vagus nerve suspicious injury; the V1 signal did not lead to, first of all to exclude machine failure, check the connections, whether the electrode off, followed by considering whether there is the NRLN. (2) the R1 signal led and in the normal range, indicating that the RLN without injury; R1 signal led, but weakened, showed that the RLN in suspected tumor infiltration or large tumor stretch nerve reason; The R1 signal was not elicited, first exclude the machine malfunctions, check the electrode, the second suspected the presence of NRLN, or the nerve injury was serious. (3) R2, the signal led in the normal range, indicating good functional integrity during surgery; R2 signal led, but weakened, suspicious during surgery nerve non-from the end of injury; R2, the signal was not elicited, first ruled out the machine malfunctions, checked electrode with or without off, followed by considering the serious nerve damage. (4) V2 signal led to the normal range, smooth operation, can be assured that the wound closure; V2 signal weakened or to elicited suspicious vagus nerve damage, check whether the electrodes off. (5) extend the incubation period t indicating the presence of nerve injury.

Table 1 Intraoperative monitoring EMG waveform reference value results

	Mean	Standard devitation	95% confidence interval
V1	432.50μV	382.59μV	386.69～478.31μV
R1	568.45μV	389.23μV	521.85～615.05μV
R2	505.65μV	340.52μV	454.88～546.42μV
V2	369.38μV	330.65μV	329.78～408.98μV

2.3 NRLN

Intraoperative confirmed NRLN two cases, two cases of preoperative thyroid B super-normal "Y" sign of vascular out of shape [6]; thyroid enhanced CT see Lusoria path variation of the right sub-

clavian artery [7]. IONM identify, confirm and accurate protection NRLN.

3 Discussion

3.1 IONM history

The 2nd century AD, Galen described walk the line of the RLN in the first time , and explains its function as the dominant vocal cord movement. The Lahey (1938), Riddell (1956) reported that thyroid surgery clearly revealed the RLN can more reduce the damage than the non-recognition. Thereafter, IONM as the gold standard of ensure the safety of RLN during thyroid surgery [8]. Even so, the recurrent laryngeal nerve injury rate was still higher [9-14]. 1969, Fishberg and Lindhom used IONM to identify the RLN in thyroid surgery, thus it effectively reducing the rate of RLNi[15]. 1985, Jmaes found that electrical stimulation of the RLN, observation or palpation of the cricoarytenoid muscle movement, to insure the nerve without injury [16]. Thereafter, gradually developed with IONM to assess the integrity of RLN function. At present, with the nerve monitor receiver to EMG electrode can be divided into four kinds: with the laryngoscope into the vocal cord muscle the electrode[17]; Electrode through the cricothyroid ligament into the vocal cord muscle[18]; role arytenoid cartilage surface area electrodes; Endotracheal tube into the electrode [19]. In recent years, the endotracheal tube into the electrod has become the mainstream of IONM, but the sensitivity was 75%. The experimental application of the second: electrode through the cricothyroid muscle piercing vocal cord muscle, because of its direct contact with the vocal cords, accuracy of 100%[20].

3.2 IONM technical principle

The IONM technology is the application of neural electrophysiological characteristics, intraoperative use of the stimulus probe direct contact with the RLN or nearby tissue,the recording electrode to receive signal, and record the EMG, at the same time listen "toot toot" sound, which eyes and ears to locate and identify the RLN. We can read the EMG waveform, amplitude and latency on the display, to clear variation nerve tissue, to identify with or without injury, and look for damage points to variation nerve tissue, to identify with or without injury, look for damage points, and to help determine the site of nerve repair, predict the function of the vocal cords to avoid a second surgery in patients with the pain.

3.3 IONM indications

Sun Hui[21] reported the indications of use of IONM: (1) thyroid tumor in the gland dorsal, suspicious recently of bleeding, or thyroid cancer; (2) thyroid cancer need to line the neck lymph node dissection; (3) scend thyroid surgery, anatomy-level disorder, tissue adhesion heavier; (4) substernal goiter, consider the RLN displaced; (5) preoperative visceral shift or subclavian artery variation, suspicious NRLN; (6) one vocal cord paralysis, contralateral lobe need surgical; (7) RLNi to repair after surgery. Foreign scholars also had this consensus[22-25].

3.4 Experimental Note

(1) This set of experimental applications through the cricothyroid muscle to insert the electrode of the vocal cord muscles, first to expose the cricothyroid muscle, a needle loop electrode insert the same side outer edge of the diameter 2 cm range of skin,two needle recording electrode obliquely piercing the cricothyroid muscle. The electrode is easy to fall off in the IONM, if the absence of signal you should first check if the electrode reign. When electrode piercing the cricothyroid muscle, maybe lead to puncture injury, it concluded that should be the first puncture success, gentle operation carefully, to avoid the electrode off, repeated puncture; electrodes should be parallel and oblique line into the cricothyroid muscle, to avoid vertical insertion; (2) The stimulation probe should be perpendicular to stimulate the nerve in order to reduce the dose of stimulation, reduce the damage of nerve vice; (3) Exposure in the anatomy of the cricothyroid muscle, avoid injury to the cricothyroid muscle. Because that patients with impaired cricothyroid muscle, may be have no EMG. The principle to be further investigated.

3.5 EMG Interpretation

The result of this experiment: the four data of V1, R1, R2, V2. Most scholars identify the RLN continuity with the naked eye and IONM confirmed the integrity of the RLN function to determine the RLN with or without injury. End of surgery, completing hemostasis of the operative field, using high-resolution camera to take photographs record the RLN continuity; compareV2 and V1, R2 and R1, the signal no significantly decreased, prove that the RLN functional integrity. However, there was very few reports about physiological range of the four data and related studies. Sun Hui [26] preliminary statistical analysis of R1 index parameters, and prove that the V1 and V2, R1 and R2 were significantly associated with. In this study, statistical analysis of the the IONM EMG physiological range, aimed to provide normal reference range for IONM during thyroid surgery, and further to establish the standard method of IONM.

With analysis the EMG waveform, amplitude, latency change, to check whether the RLNi occurred. EMG waveform, latency and amplitude decreased to predict the RLNi severity[27-28]. Along the exposed RLN, from the side detection signal of significantly weakened or can not led to signal, to detect the nerve distal, until you get the signal within the normal range, you can accurately locate the damage point. Find the reason of injury, to avoid permanent RLNi.

IONM in thyroid surgery, on the basis of previous experience, this study further analyzed the characteristics of the RLN EMG and physiological range, to identify and verify that RLN, and to determine the integrity of the nerve function, reduce the rate of RLNi. However, due to the few sample, and the lack of literature reference value, can not finalize the physiological range of RLN

EMG; There are many reasons of RLNi, how to read the EMG to determine the damage reasons, help the thyroid surgeon to avoid permanent RLNi; Whether there are differences with the left and right RLN. We believe that with the development of IONM in thyroid surgery, further standardization of monitoring conditions ,the further popularity of the monitoring equipment, the RLN EMG characteristics and normal reference range will be further clarified, to reduce the incidence of RLNi in postoperative complications surgery. Thyroid surgical techniques will get at a new level.

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研究中国人术中喉返神经监测肌电信号的正常值范围 *

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摘要 目的:应用术中神经监测技术(intraoperative neuromonitoring IONM),探讨国人喉返神经肌电信号的正常值范围。**方法**:烟台毓璜顶医院甲状腺外科自 2009 年 11 月到 2012 年 1 月对 300 例甲状腺开放手术行术中喉返神经实时监测,术中一根回路电极斜行刺入同侧切口外缘直径约 2 cm 范围皮肤,两根记录电极斜行刺入环甲肌,手持刺激探针垂直刺激神经,发出"嘟 嘟 嘟"提示音,同时监测仪显示器显示肌电波形,并记录潜伏期及波幅值。**结果**:285 例(386 条)清晰显示肌电波形;15 例未引出肌电波形,其中 10 例因机器故障和麻醉因素造成假阴性,5 例因肿瘤浸润环甲肌,无法插入记录电极造成。无永久性喉返神经损伤,暂时性神经损伤 2 例,术后 1 月内恢复。V1 95%可信区间 482.66～574.28 μV,R1 95%可信区间 521.85～615.05μV,V2 95%可信区间 440.92～531.84 μV,R2 95%可信区间 489.25～582.05 μV, T 可信区间 19.88～20.12ms。**结论**:明确喉返神经肌电信号正常值范围,为识别、确认喉返神经及通过肌电信号判断神经功能完整性提供依据,降低喉返神经损伤率,利于判断喉返神经非离端性损伤,并寻找损伤原因。

关键词:喉返神经;监测;甲状腺手术;肌电图;正常值

中图分类号:R653 **文献标识码**:A **文章编号**:1673-6273(2012)19-3668-05

* **基金项目**:烟台市科技发展计划基金项目(2011228)

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(**收稿日期**:2012-03-30 **接受日期**:2012-04-25)