

## Original Article

# Application experience of intraoperative neuromonitoring in thyroidectomy

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**Abstract:** Objective: The aim of this study is to summarize the experience of intraoperative neuromonitoring system for monitoring and protection of recurrent laryngeal nerve during thyroid surgery. Methods: There were 220 cases in this study, male 53, female 167, mean age 38.2 years old. 85 cases in the study had thyroid cancer, 19 cases had thyroid benign tumor, 90 cases had thyroid goiter, 3 cases had Hashimoto's diseases, and 23 cases had hyperthyroidism. The tumor diameters were over than 5 cm in 113 cases. In the procedure, two recording needle electrodes were put into cricothyroid muscle; one stimulator electrodes was explored in tracheo-asophageal groove, if recurrent laryngeal nerves were right there or near, doctors could see the electromyogram and hear the toot honk. With careful dissection, recurrent laryngeal nerve could be found out till explored into the larynx site. Results: 207 cases (278 sizes) of 220 were finished, electromyogram was not drawn out in 13 cases; 9 cases were false-negative because of system and anesthesia questions; needle electrodes cannot be put in properly in 4 cases because of cricothyroid muscle cancer invasion. No permanent recurrent laryngeal nerve paralysis occurred, 2 cases with transient nerve paralysis recovered in one month. Conclusion: The intraoperative neuromonitoring system can avoid damage of the recurrent laryngeal nerves when exposing the recurrent laryngeal nerve in the whole operation, therefore, with less medical complications.

**Keywords:** Monitoring, thyroidectomy, recurrent laryngeal nerve

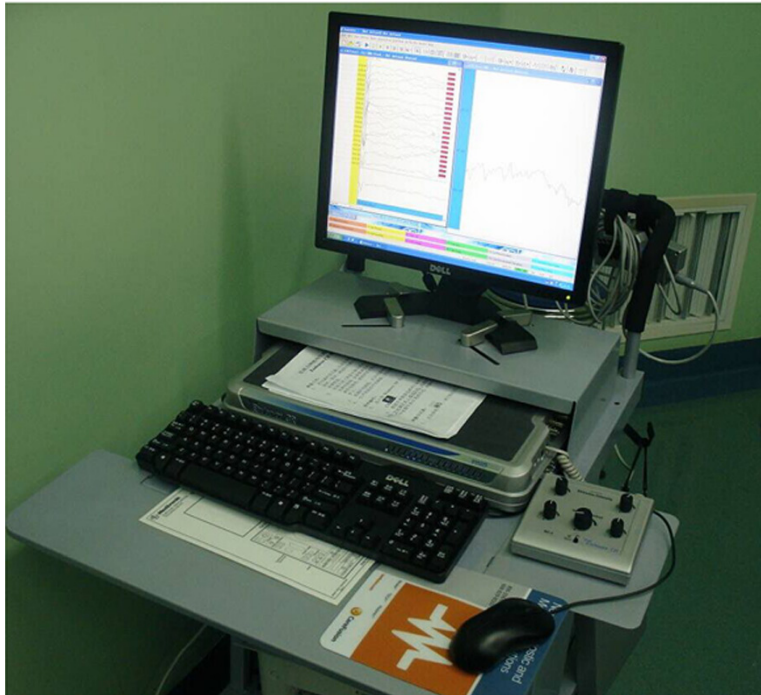
## Introduction

Recurrent laryngeal nerve defect is one of the common and serious complications caused by thyroid surgery. The recurrent laryngeal nerve defects should be repaired as early as possible, otherwise, endoneurium tubule will lose the original guidance quality, which can lead to the mismatch of some regenerative nerve fibers to the laryngeal muscle. So it's very important to find and repair the nerve defects during operation. Intraoperative neuromonitoring (IONM) refers to a method using various kinds of neurological electrophysiology techniques to monitor the function integrity [1] of the nerve system under dangerous conditions. Using recurrent laryngeal neuromonitoring during operation, especially in thyroid operation that is complicated or has been performed for more than two times, can reduce the side-injury obviously, and can improve the achievement ratio of operation.

## Subjects and methods

### General information

During November 2009 to September 2011, there were 220 cases (53 male, 167 female) of patients that received recurrent laryngeal neuromonitoring during open thyroidectomy in Yuhuangding Hospital of Yantai. The median age was 38.2 years old (22~72 years old); there were 85 cases of thyroid malignancy, 19 cases of thyroid benign neoplasm, 90 cases of nodular goiter (including behind sternum), 3 cases of Hashimoto's disease and 23 cases of hyperthyroidism. 66 cases of patients received total thyroidectomy. Among the whole cases, 15 cases were combined with neck dissections, 63 cases received unilateral thyroidal resection and total thyroidectomy at the other side, 91 cases received unilateral lobectomy and isthmectomy. 12 cases of patients received a second operation, 4 cases received a third operation. And there were 113 cases of patients whose



**Figure 1.** Neuromonitor produced by Nicolet in America, type: endeavor CR.



**Figure 2.** Image of nerve monitoring during operation.

diameter of thyroid neoplasm was larger than 5 cm.

## Methods

**Recurrent laryngeal neuromonitoring system:** The recurrent laryngeal neuromonitoring system was produced by Nicolet in America, type: endeavor CR. The system was composed of monitor mainframe, viewing screen of monitoring image, stimulating probe of recurrent laryn-

geal nerve, reception electrode needle and printer etc, (**Figures 1 and 2**).

**Operation:** The skin was disinfected routinely after inducing anesthesia by general anesthesia drugs; anterolateral approach can be performed for operations that have been performed for more than two times and that contain huge mass. The middle thyroid veins, isthmus of thyroid gland and berry ligament were cut off and the low and up polar vessels were ligated using ultrasonic scalpel making the thyroid loose. The gland was pulled toward outside and downside; the outboard envelop of thyroid moderately was peeled. Two acupuncture-recording electrode was used to penetrate into cricothyroid muscle in an inclined direction, and the trachea esophagus groove was stimulated using concentric circles stimulating electrodes. The sound switch was opened, and if there were recurrent laryngeal nerves or similar tissues nearby, the machine would make a prolonged sound of "du, du, du". The monitoring started at the position near the inferior thyroid artery which was separated carefully, the recurrent laryngeal nerve up to the inlet of throat was dissected completely. The thyroid lobectomy can be performed quickly and successfully. When stimulating the

recurrent laryngeal nerve with electric current, the laryngeal muscle that dominated by it would produce an action potential; at this moment, the surgeon can observe a rough electromyogram (EMG) (**Figure 3**).

## Results

207 cases (278 pieces) of bilateral recurrent laryngeal nerve appeared clearly from the position near low polar vessels to the position

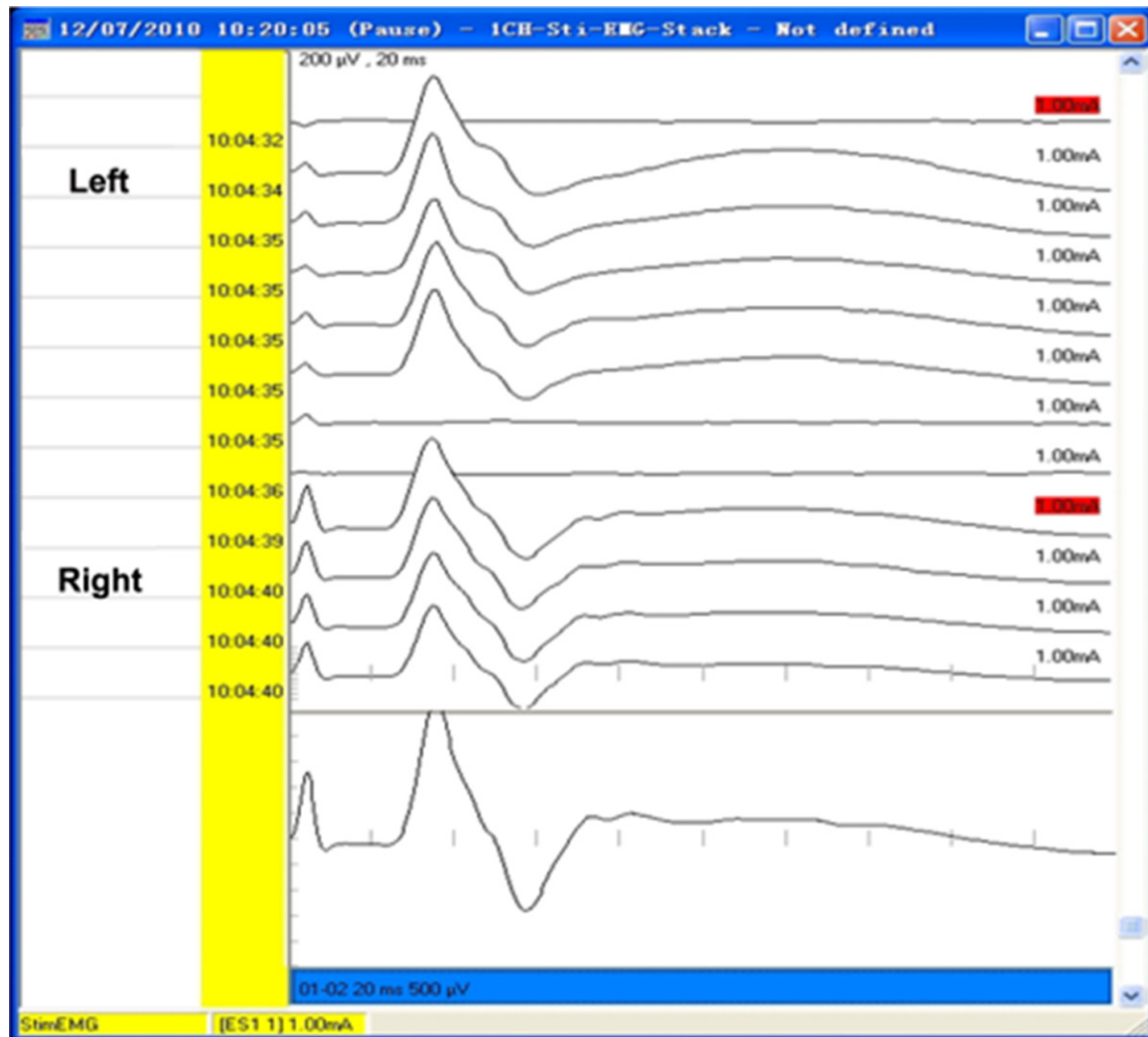


Figure 3. Results of recurrent laryngeal neuromonitoring.

where recurrent laryngeal vessel entered into the throat. The patients' pronunciation was all clear after operation, and no bucking happened when drinking water. There were 13 cases of patients with no generation of electrical waveform, in which 9 cases were caused by the false negative due to machine and anesthesia factors. Fine articulation was obtained after operation, and there were no abnormality in the fibro-laryngoscope monitoring process. 4 cases of patients cannot be inserted with the record electrode because of the tumor infiltration with cricothyroid muscle. Transient numbness in hands and feet appeared in 11 cases of patients after operation, temporary nerve injury appeared in 2 patients, which were both recovered in 1 month after operation. No permanent hypocalcemia or recurrent laryngeal nerve defects happened.

## Discussion

### *The importance of recurrent laryngeal nerve recognition in thyroid operation*

In 1938, Lahey etc. reported that the clear exposure of recurrent laryngeal nerve could obviously reduce the damage rates. After that, recurrent laryngeal nerve recognition became a golden standard for safety insurance in thyroid operation. Even a practiced thyroid surgeon cannot guarantee a zero side injury facing with a fickle recurrent laryngeal nerve; especially for a nondisruptive injury. The integrity [2] of recurrent laryngeal nerve cannot be figured out by naked eyes. Posterior branch of multiple-branched recurrent laryngeal nerve (sensory nerves) can be easily mistook for the main branch of recurrent laryngeal nerve which would lead to a praximus (motor nerve) injury.

Using intraoperative neuromonitoring method, the motor nerves of recurrent laryngeal nerve can be recognized and the non-recurrent laryngeal nerve can be precisely alarmed, which shows an obvious advantage [3].

### *The method of intraoperative neuromonitoring during thyroid operation*

In 1988, Lipton [3] etc. proposed a intraoperative monitoring method: inserting an electrode into vocal cords with the help of a laryngeal mirror, holding a nerve stimulating electrode to perform local detection and recording the myoelectricity activity of laryngeal muscle using recording equipment of myoelectric apparatus. In 1996, Eisele etc. [5] reported the method of monitoring recurrent laryngeal nerve by combining the intraoperative electromyography and tracheal intubation: putting the electrode of surface electromyography and tracheal tube at the position of vocal cords, stimulating the recurrent laryngeal nerve with a needle electrode; when the latter got a electric current, the muscle dominated by it would produce an action potential.

The working principle of IONM is using electrode to contact with the recurrent laryngeal nerve or neighboring tissues directly, followed with the conduction of the electrical stimulation into the throat by recurrent laryngeal nerve, dominating the musculus vocalis to produce myoelectric signals. At last, the recording electrode receives the electric signal and the monitor records the signal with a sound of “dudu”. If the surgeon sees the waveform on the displayer at the same time, it can prove that the recurrent laryngeal nerves are nearby which need a careful separation. IONM can not only locate and identify the recurrent laryngeal nerve, pinpoint the variant nervous tissues, find the impaired loci, assist in the position determination of neural restoration process, but also can predict the vocal cords function after operation.

### *The application status of recurrent laryngeal neuromonitoring in thyroid operation*

In developed countries, the clinical application history of IONM has been lasting for more than 20 years, and it has gradually grown up to a whole multi-disciplinary intraoperative monitoring system. At present, there are various equipments that have been applied at home and abroad. It can be divided into four groups

according to myoelectrical receiving electrodes:

① electrodes that were inserted into the musculus vocalis with the help of laryngoscope; ② electrodes that were inserted into the musculus vocalis by going through the cricothyroid ligament; ③ surface and insertion electrodes acting on the back zone of cricoarytenoid; ④ Surface electrode of tracheal intubation conduit. There are little reports on the application in thyroid operation at home. Mary Hospital in HongKong [6], Gaoxiong University in Taiwan [7], China-Japan Fellowship Hospital in Jilin University [8], have carried out the relative clinical application in recent years.

### *The security of recurrent laryngeal neuromonitoring in thyroid operation*

Marcus etc. [9] monitored the recurrent laryngeal nerve using surface electrode in throat during the thyroid operation, pinpointed the minimum stimulation electric current and average stimulus threshold after cutting the tumor for the first time, and discovered that the electric stimulus threshold at tumor-cutting side was higher than that at nontumorous side, considered that IONM was a safe, simple and efficient method. Choby [10] reported that the minimum stimulus current of nerve before cutting the thyroid tumor was 0.5 mA, and the average stimulus current reduced to 0.47 mA after operation. Animal model indicated that even the current stimulation is 3 mA, it won't be harmful to nerve and muscle. The voltage can reach 400 v because the current of electric stimulation in detector can reach 100 mA. Inappropriate operation can be dangerous enough for patients in anesthesia condition shocked by electricity or even cause their death. The group generally started at 0.5 mA, the action potential can be detected if there is little covered membrane in recurrent laryngeal nerve. And the maximum current can reach 2 mA in a complex operation, there were no side effects after operation.

### *The indication of recurrent laryngeal neuromonitoring*

Sunhui etc. [8] reported the indication of recurrent laryngeal neuromonitoring as follows: ① patients that are doubted for thyroid cancer or bleeding in bladder in recent period with the thyroid tumor located in the back side of the gland; ② patients that need cervical lymph



node dissection in thyroid cancer especially for that accompanied with central lymphadenectomy; ③ reoperation of thyroid ④ goiter at substernal; ⑤ there exists viscera transposition or subclavian artery variation before operation; ⑥ patients that have unilateral vocal cords paralysis with the other side need an operation; ⑦ repair operation after the recurrent laryngeal nerve injury above conditions conform to the practice principle of this group.

### *Matters needing attention in this method*

① Because the record electrode records the myoelectricity action of vocal cords muscles in throat by acupuncture cricothyroid muscle, the cricothyroid muscle of recurrent laryngeal nerve at ipsilateral side of should be dissected at first; ② Stimulation electrode should be perpendicular to the monitored tissue to reduce the dosage of stimulation and relieve the side damage to nerve; ③ avoiding the false negative of anesthesia drugs; ④ Middle efficiency muscle relaxants should be used, rocuronium bromide, for example. Vecuronium bromide also belongs to middle efficiency muscle relaxants, but it may influence the detect result due to its longer action time compared with rocuronium bromide. Isoflurane of low concentration combined with propofol infusion can also be used which can not only avoid the inhibition of the electricity activity of recurrent laryngeal nerve, but also reduce the cardiovascular stress reaction.

### *The advantages and disadvantages of this method*

Advantages: ① Sun Hui etc. [8] reported that the operation time was  $(17.02 \pm 5.48)$  min when monitoring was not applied, while  $(3.57 \pm 1.26)$  min when applied, which exhibited an obvious difference; ② stimulation electrode and record electrode can both be reused with inexpensive cost, and monitoring equipment for tracheal intubation is NIM-Response™ real time electromyography monitor, which is produced by Xomed Medtronic in America with higher cost and can't be reused; ③ give patients and relatives a sense of security; ④ Electromyography formed in operation is an evidence for successful operation, which dramatically reduces medical dispute.

Disadvantages: ① Reception electrode is insecure, which can fall off due to the traction during monitoring, and there also exists a probability of puncture damage; ② The response sig-

nal can't be exactly received if it's a second-time operation, or cricothyroid muscle is infiltrated by tumor, or the tumor is too giant to let the record electrode insert in accurately, which can lead to the failure of monitoring process; ③ In the first-time or low-risk thyroid operation, the application of IONM can't reduce the damage rate of recurrent laryngeal nerve, on the contrary, it can increase the dependency of surgeon to equipment which can reduce their operative skills [11].

### *Different views toward IONM*

Barczyński etc. [12] considered that IONM couldn't reduce the rate of perpetual recurrent laryngeal nerve damage, but could reduce the rate of transient one. There is a reduction of 2.9% in patients who is suffered from thyroid cancer or receive complex operation for more than two times ( $P < 0.05$ ); but it's not significant in benign or first-time operation with a reduction of only 0.9% ( $P > 0.05$ ). With the technique development and method improvement of IONM, the monitoring technique is believed to make a further progress.

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### **Disclosure of conflict of interest**

None.

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