Conference Paper

Intraoperative Neuromonitoring in Thyroid Surgery

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Abstract

The purpose of the work is to estimate the efficiency of intraoperative neuromonitoring used as a means for preventing damage to the recurrent laryngeal nerve in thyroid surgery.

The basis for the work is the analysis of surgical treatment in 120 patients with various diseases of a thyroid gland, of whom 60 patients being operated using intraoperative neuromonitoring.

The surgical neuromonitor "Neurosun 400"was used for the purpose of monitoring ("INOMED", Germany). The main objectives of intraoperative neuromonitoring were the emergency detection and localization of a nerve, its exact differentiation from the surrounding tissues by means of a stimulator.

Intraoperative neuromonitoring of a recurrent laryngeal nerve by means of the Neyrosan-400 device has considerably reduced time of searching the nerve. So, the time of search was averaged 9.2±0.8 min. in the control group, whereas in the main group – 3.1±0.7 min. ($p < 0.05$). As a result, the general time of operation has decreased. The general duration of operation in the control group of patients was averaged 63.7±6.1 min., in the main group – 45.4±5.8 min. ($p < 0.05$).

The obligatory visualization is necessary for reliable prevention of damage to a recurrent laryngeal nerve during operation.

The recurrent laryngeal nerve has an accurate minimum threshold of stimulation which is - 0.5ma, no matter what the patient's age is.

Using neuromonitoring in thyroid surgery with the Neyrosan-400 device allows both conducting emergency and accurate identification of a recurrent laryngeal nerve in all cases as well as avoiding traumatic damage.

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1. Introduction

In recent years there has been an increase in the number of patients with thyroid gland pathology, and in particular, diffuse-toxic goiter. According to statistics, in economically

developed countries diffuse-toxic goiter affects almost 1-2% of the population. The disease can occur at any age, but the peak of incidence is generally among the working age people - 20-40 years [2, 3, 7, 9, 14].

In Russia, surgical intervention remains one of the main methods of treating diffuse-toxic goiter [1, 3, 4, 6, 8, 10, 12]. Despite great advances in thyroid surgery, the prevention of intraoperative complications still remains an unsolved problem.

One of the severe complications of thyroid gland surgery is the damage to a recurrent laryngeal nerve. The frequency of this complication varies considerably, accounting for 0.2-22% of all observations and significantly increases with repeated operations [5, 7, 8, 11, 13]. This variability in the frequency of damage to the recurrent laryngeal nerve is due to the medical specialist diagnosing it (surgeon or otolaryngologist), diagnosis time, the amount of available information about the patient (use of the results of clinical examination or instrumental methods of examination, and the nature of the damage itself: unilateral or bilateral, transient or resistant).

Mostly, the problem of damage to the recurrent laryngeal nerve is considered as the operation with the preservation of the posterior leaf of the fascia of the thyroid gland (OV Nikolaev's technique), but not its intraoperative imaging. With autoimmune thyroiditis, toxic goiter, its own capsule fuses with the thyroid tissue, which makes its separation very traumatic, time-consuming and, in some cases, leads to damage to the recurrent laryngeal nerve and increased blood loss. Many authors note a significantly higher incidence of damage to the recurrent laryngeal nerve during repeated operations. Thus, with recurrent goiter, the incidence of this complication may reach 35% or more [7, 11, 13].

The purpose of the work was to evaluate the efficiency of intraoperative neuromonitoring as a means for preventing damage to the recurrent laryngeal nerve when performing operations on the thyroid gland with diffuse-toxic goiter.

2. Materials and methods

The work is based on the analysis of the results of surgical treatment of 120 patients with diffuse-toxic goiter who were on treatment at the Department of Surgery of the Federal State Budgetary Institution «Federal Scientific Clinical Center of Specialized Types of Medical Care and Medical Technologies».

All patients were divided into 2 groups: I - the main one, including 60 patients operated using the intraoperative neuromonitoring technique and II – the control one, in which 60 patients underwent traditional surgery without using this technique.

All patients were performed 2 types of operations for diffuse-toxic goiter: thyroidectomy and extremely subtotal resection of the thyroid gland. In the main group, 33.3% of thyroidectomy and 66.7% of extremely subtotal resections of the thyroid gland were performed, and in the control group, 30% and 70%, respectively.

Intraoperative monitoring of recurrent nerves was performed in all patients with diffuse-toxic goiter in the main group. For this purpose, a surgical neuromonitor Neurosun 400 (INOMED, Germany) was used, which allows tracing the pathways of motor nerves, which are at increased risk during various surgical interventions, to prevent their damage (Figure 1).

Figure 1: Exterior of Neurosun 400.

The main task of using intraoperative neuromonitoring is to quickly detect and localize the nerve, to distinguish it from the surrounding tissues with the help of a stimulator. **Fig**. 2 schematically shows the arrangement of the electrodes on the endotracheal tube.

After installing the endotracheal tube of the appropriate size, the vocal cords were examined to ensure whether the electrodes had been correctly installed (Figure 3).

Neurosun-400 registers muscular activity by means of the needle electrodes located in the relevant muscles, which are controlled, in turn, by nerves, monitored by

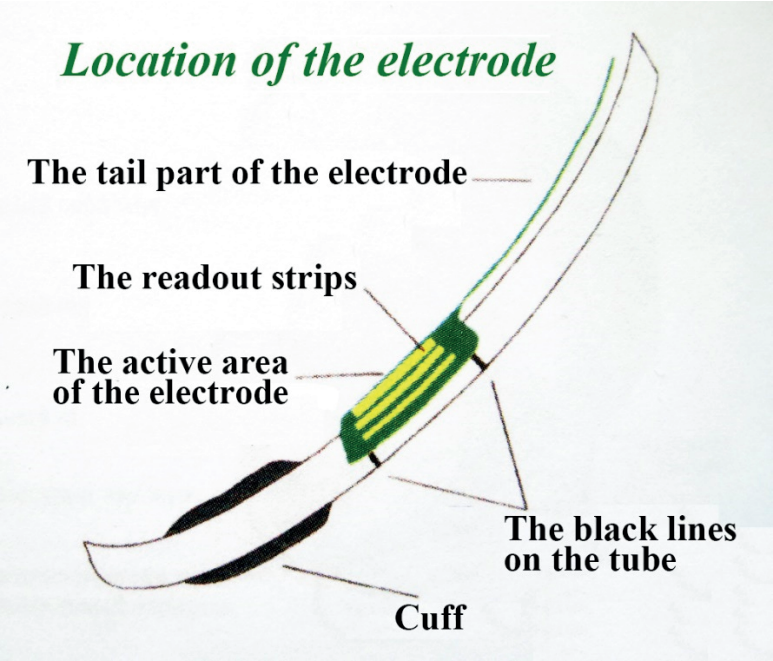

Figure 2: An electrode arrangement on an endotracheal tube.

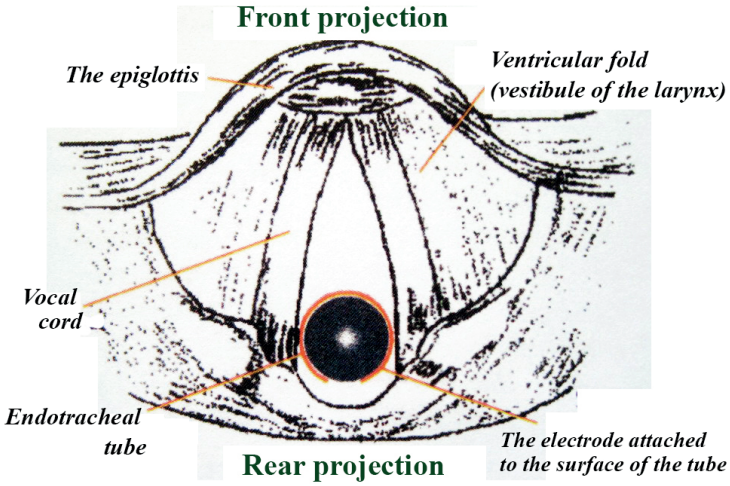

Figure 3: A type of a throat (via the endoscope) after installing the endotracheal tube.

Neurosun-400. The device is able to record a 4-channel electromyogram even significantly below the threshold of visible muscle contractions, thereby substantially increasing the safety of the operations performed (Figure 4).

Performing surgery in the zone of the recurrent laryngeal nerve, being at increased risk, causes associated contractions of the motor muscle groups. In response to them, the device produces a distinctive sound signal, whose level of strength is proportional to the stimulation experienced by the nerve. The recurrent laryngeal nerve can also be subjected to direct stimulation via a stimulating sensor using a weak current (0.5 mA, 30 Hz). Muscular stimulation is performed only if the neuromuscular blockade is

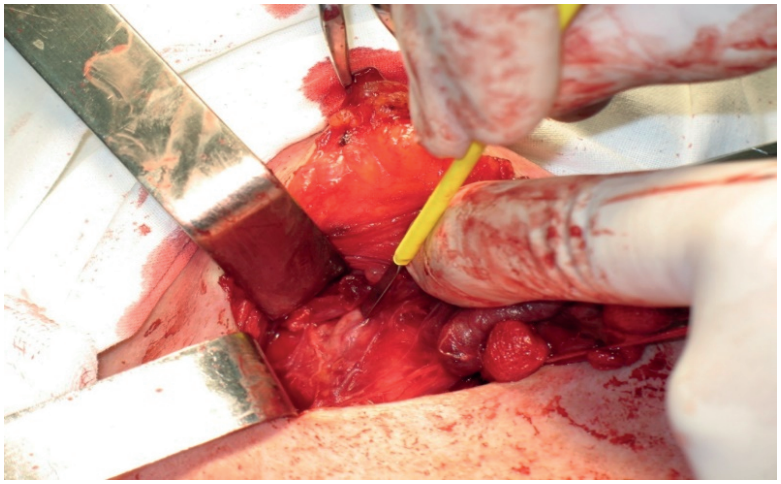

Figure 4: Identification of a recurrent laryngeal nerve during operation.

absent, or limited. "Neurosun 400" is equipped with a number of outputs for connecting instruments and tools: an electromyograph, an oscilloscope, a tape recorder or a computer. A specially developed software package ensures the ease of data collection and analysis of types of signals.

The recurrent laryngeal nerve has an accurate minimum threshold of stimulation borders. This minimum threshold is approximately 0.5mA, but some patients need to increase this value to 1.0mA, and sometimes to 2mA. At the same time, the age of the patient is of no fundamental importance. In our study, both groups were representative and comparable in terms of sex, age, and other criteria analyzed (Table 1).

Table 1: Age and sex distribution of patients.

Age, years	Main group (n = 60)				Control group (n = 60)			
	men		women		men		women	
	абс.	%	абс.	%	абс.	%	абс.	%
26–30	4	23.5	5	11.6	2	14.3	6	13
31–40	5	29.4	17	39.5	5	35.7	20	43.5
41–50	4	23.5	10	23.3	4	28.6	9	19.6
51–60	3	17.6	6	14	2	14.3	7	15.3
61–70	1	6	4	9.3	1	7.1	3	6.5
71–80	0	0	1	2.3	0	0	1	2.1
In total	17	100	43	100	14	100	46	100

Among the 60 patients of the main group there were 17 (28.3%) men and 43 (71.7%) women aged from 26 to 72 years old. The average age of the patients was 32.1 ± 2.9

years, of which 90% were of the working age (up to 60 years old). This fact emphasizes particular social significance of the problem under consideration.

Clinical manifestation of diffuse-toxic goiter in the main group within 1-3 years was observed in 22 (36.7%) patients, from 3 to 5 years - in 27 patients (45%), over 5 years - in 11 (18.3%). 34 (56.7%) patients had previously undergone repeated inpatient or outpatient conservative treatment.

The clinical picture of diffuse-toxic goiter in patients of the main group was characterized by a clear symptomatology of the disease that has certain inherent features. The patients complained of increased mental excitability, irritability, anxiety, fussiness, inability to concentrate (86.7%), pressure sense in the neck (58.3%); difficulty in swallowing (38.3%); a feeling of a constant heartbeat, irregularities in the heart (43.3%); permanent diffuse sweating (63.3%). Examination revealed a diffuse uniform increase in the thyroid gland to various degrees. Eye symptoms (ophthalmopathy) were observed in 44 patients (73.3%).

The distribution of patients in the control group by sex was as follows: out of 60 patients, there were 14 (23.3%) men and 46 (76.7%) women aged between 26 and 71 years old. The proportion of men to women in the control group was comparable to the main group ($p < 0.05$), and the average age was 33.4 ± 2.4 years, with 86% of patients being of working age (up to 60 years old).

The clinical manifestations of the disease accounted for 3-5 years in the majority of patients in the control group and accounted for 51.7% of all patients (31 patients) for a period of 1 to 3 years, symptoms of diffuse-toxic goiter were observed in 28 patients (46.7 %), and for a period of more than 5 years - in 11 patients (18.3%). 34 patients of the control group (56.7%) repeatedly underwent courses of conservative therapy on an outpatient basis or in a hospital.

Patients' complaints in the control group were similar to those in the main group.

The examination program included: a general blood test and general analysis of urine; biochemical analysis of blood; immunological blood analysis: contents B- and T lymphocytes, subpopulations of T-lymphocytes, immunoglobulins, thyreostimulating immunoglobulins, the circulating cell-bound immune complexes; research of a functional condition of a thyroid gland: determination of content in blood T3, T4, thyroxin-connecting thyreoglobulin (if impossible to determine the level of thyroid hormones in blood – capture ^{131}I a thyroid gland); ultrasound examination of a thyroid gland; electrocardiogram; consultations of specialists: cardiologist, endocrinologist, oculist, (eyeground research); chest X-ray examination. In some cases, computed tomography of the thorax was performed, which allowed assessing not only the degree of the

squamous location of the thyroid tissue, but also its relationship with the surrounding tissues, the degree of their compression.

Laboratory testing revealed the following characteristic changes in both groups of patients:

- moderate normochromic anemia, small reticulocytosis, a tendency to leukopenia, relative lymphocytosis in the general blood test;
- a decrease in the cholesterol content, lipoproteins, total protein, albumin, with a significant liver damage - an increase in the bilirubin content and alanine aminotransferase; increase in the level of gamma globulins, glucose in the biochemical analysis of blood;
- a decrease in the amount and functional activity of total T-lymphocytes and T-lymphocytes of suppressors, an increase in the content of immunoglobulins, the detection of thyroid-stimulating immunoglobulins, antibodies to thyroglobulin and microsomal antigen in the immunological blood test;
- a diffuse increase, uneven change in tissue echogenicity during the ultrasound examination of the thyroid gland;
- a sharp increase in the rate of absorption of I^{131} by the thyroid gland after 2-4 and 24 hours;
- increase of T3 and T4 in the blood (a radio immune method);
- at reflexometry (an indirect method of determining the function of the thyroid gland), the time of the Achilles tendon reflex was significantly shortened (characterizes the peripheral action of thyroid hormones).

In the main group there were 70% of patients with an average severity of thyrotoxicosis and 30% with a severe degree of thyrotoxicosis, whereas in the control group - 73.3% and 26.7%, respectively.

The average volume of the thyroid gland in the main group was 96.1±4.2 ml^3, in the control group – 85.2±3.7 ml^3. The average level of T3, T4 and TSH in the main and control groups is presented in *tab. 2*.

Table 2: The average level of hormones in the blood.

Hormone	Main group (n = 60)	Control group (n = 60)
T3 (nmol/l)	148±7.6	146±6.9
T4 (nmol/l)	3.4±0.3	3.36±0.4
TSH (μmol/l)	0.58±0.07	0.61±0.05

The retrosternal position of the thyroid gland in the main group was observed in 15 patients, and in the control group– in 12 patients.

Difference reliability was evaluated by the method of a two-selective t-test with various dispersions. Differences were considered reliable at $p < 0.05$. Mathematical calculations were carried out on a personal computer "Pentium Dual-Core CPU", using a package of standard statistical programs "Statistica 6".

Research results and their discussion. Intraoperative neuromonitoring of the recurrent laryngeal nerve using Neurosun-400 has significantly reduced the time for its search (Fig. 5).

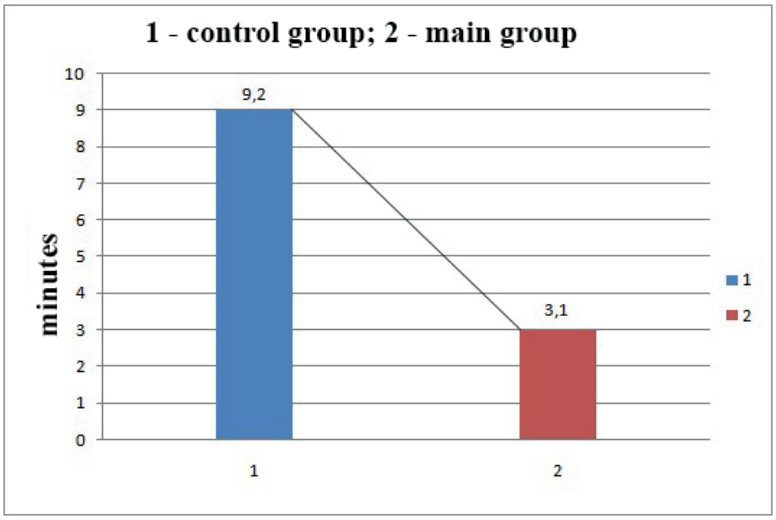

Figure 5: Average time for search of a recurrent nerve (min.).

Thus, in the control group, the search time amounted to 9.2 ± 0.8 min, whereas in the main group - 3.1 ± 0.7 min. ($p < 0.05$). As a result, the total operation time has also decreased (the total duration of the operation in the control group patients was equal to 63.7 ± 6.1 minutes, in the main group - 45.4 ± 5.8 minutes ($p < 0.05$).

All patients had to be examined by an ENT- specialist on the third day to evaluate the state of the vocal cords. In the control group, 2 patients (3.3%) with unilateral transient paresis of the vocal cords were detected, whereas, in the main group, such problems were not identified. 2 patients in the control group had a complication (a transient unilateral paresis of the larynx), which was completely jugulated within the next 4-6 months.

Thus, the use of Neurosan-400, which is capable of performing neuromonitoring of the recurrent laryngeal nerve, allowed differentiating the recurrent laryngeal nerve intraoperatively in all the cases (60), which significantly reduced the search time and probability of its damage.

3. Conclusions

1. To reliably prevent damage to the recurrent laryngeal nerve, it is obligatory that it were visualized during surgical operations.
2. The recurrent laryngeal nerve has an accurate minimum threshold of the stimulation borders - 0.5 mA, no matter what the patient's age is.
3. Using intraoperative neuromonitoring in the thyroid surgery with Neurosan-400 makes it possible to quickly and clearly identify the recurrent laryngeal nerve in all cases and thereby prevent their traumatic damage.

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