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CLINICAL APPLICATION AND RESULTS OF THE ELECTROPHYSIOLOGICAL LARYNGEAL NERVES IDENTIFICATION IN SURGERIES IN CASE OF GOITER

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Abstract

Background. Analysis of the results of clinical application of the developed method of laryngeal nerves electrophysiological identification.
Material and methods. Electrophysiological identification of the recurrent and superior laryngeal nerves was performed intraoperatively in 200 patients operated on goiter. A total of 354 studies of laryngeal nerves were conducted to identify them. Among them, there were 45 unilateral researches and 308 bilateral.
Results. In the first region, nerves were identified in 327 cases and unidentified – in 27 cases. In the second region, among the tissues of the surgical wound, nerves were identified in 337 studies and unidentified – in 17. Regarding unidentified nerves in 3 patients on both sides, there were two cases of thyroid cancer and one – multinodular recurrent goiter. In the third section among 354 patients, the external branch of the superior laryngeal nerve was identified in 329 (92.9 %)

Résumé

Application clinique et résultats de l'identification electrophysiologique des nerfs laryngés dans les operations de goitre

Introduction. Analyse des résultats de l'application clinique de la méthode élaborée de l'identification électrophysiologique des nerfs laryngés.
Méthodes. L'identification électrophysiologique des nerfs laryngés récurrents et supérieurs a été réalisée en peropératoire chez 200 patients opérés pour un goître. Au total on a fait 354 recherches des nerfs laryngés pour les identifier. Parmi celles-ci, 46 recherches unilatérales et 308 bilatérales.
Résultats. Dans la première section les nerfs identifiés sont dans 327 cas et non identifiés – dans 27 cas. Dans la deuxième section parmi les tissus de la plaie opératoire les nerfs sont identifiés en 337 recherches et ne sont pas identifiés – en 17. En ce qui concerne des

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and unidentified in 25. Unidentified nerves are those cases where the nerves are not electrophysiologically isolated among the tissues of the surgical wound, but clearly defined their places of passing. There were no intraoperative injuries of the laryngeal nerves.

Conclusions. The technology of intraoperative identification of the laryngeal nerves can identify both the recurrent and superior nerves of the larynx, or determine the probable areas of its passage and prevent their injuries during the surgery.

Key words: laryngeal injuries, prophylaxis, intraoperative electrophysiological identification, results.

nerfs non identifiés chez 3 patients de deux côtés, il y avait deux cas de cancer de la glande et un cas de goître multinodulaire récidivé. Dans la troisième section parmi les 354 patients la branche externe du nerf laryngé supérieur est identifiée chez 329 (92,9%) patients et n'est pas identifiée chez 25. Les nerfs non identifiés ce sont les cas ou les nerfs ne sont pas déterminés du point de vue électrophysiologique parmi les tissus de la plaie opératoire, mais les zones de leur passage sont clairement définies. Il n'y avait pas de traumatismes intra-opératoires des nerfs laryngés.

Conclusions. La technologie d'identification intra-opératoire des nerfs laryngés permet d'identifier à la fois les nerfs laryngés récurrents et supérieurs ou de déterminer les zones probables de son passage et de prévenir leurs traumatismes lors d'une intervention chirurgicale.

Mots-clés: les traumatismes des nerfs laryngés, la prévention, l'identification électrophysiologique intra-opératoire, les résultats.

Introduction

The frequency of injuries of the recurrent laryngeal nerves is from 0.3 to 12 % and, despite the application of different methods of neuromonitoring, has no tendency to decrease. In order to reduce the frequency of injuries of the recurrent and superior laryngeal nerves in surgeries regarding goiter, we developed a method of electrophysiological identification of the laryngeal nerves among the tissues of the surgical wound[1,2]. The analysis of clinical application and its results are presented in this work.

Objective

Analysis of results of clinical application of the developed method of electrophysiological laryngeal nerves identification.

Material and Methods

Electrophysiological identification of the recurrent and superior laryngeal nerves was performed intraoperatively in 200 patients who underwent surgical intervention of goiter. Among them there were 14 men and 186 women aged 21 to 74 years. Indications for surgery in 46 cases were unilateral nodular goiter with compression syndrome; in 79 – bilateral nodular and in 11 – recurrent goiter with compression on the neck; in 21 – cancer of the thyroid gland and in 43 – toxic goiter. A total of 354 studies was conducted on the identification of laryngeal nerves. Among them, there were unilateral studies – 46 and bilateral ones– 308 .

Results and discussions

The peculiarities of the developed method application of electrophysiological identification of the laryngeal nerves are the strict observance of the proposed methodology and conducting the studies in strictly selected areas, particularly in those where the most likely surgical trauma of the laryngeal nerves occurs. This is the area of the lower pole of the thyroid particles (I), region of Berry's ligament and entry of the recurrent nerve to the larynx (II) and the region of the upper pole of the thyroid particles, where the external branch of the upper laryngeal nerve (III) passes (Fig.1).

The results of the research on the laryngeal nerves identification among the tissues of surgical wound are presented in the Table 1. Thus, in 200 patients, we performed 354 studies on the identification among the surgical wound tissues of the recurrent and superior laryngeal nerves. Among them, 46 patients underwent unilateral studies in hemithyroidectomy surgeries in case of unilateral nodular goiter (46) and 154 patients – bilateral studies in thyroidectomy.

In the first region, at the level of the lower poles of the thyroid gland, we identified nerves in 327 cases and did not identify them in 27 cases. Situation with unidentified nerves took place predominantly in surgeries in case of thyroid cancer and recurrent nodular

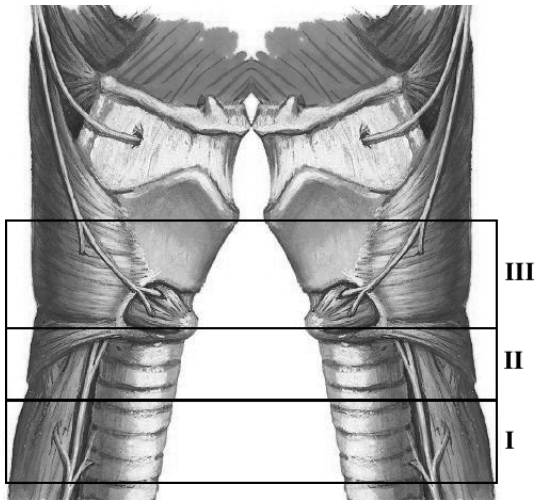

Fig. 1. (author's drawing, dissertation Shidlovskyi OV, 2012). Regions of the study on the laryngeal nerves identification of: I – the lower poles of the thyroid gland; II – entry of the recurrent nerve into the larynx; III – the upper poles of the thyroid gland, the external branch of the upper laryngeal nerve.

goiter with substernal localization of nodules (Table 1). In the identified cases, the typical course of the nerve was behind the gland in 321 (98.2 %) studies; on the front surface of trachea – 5 (1.5 %) and in one patient there was a non-recurrent rightward – (0.3 %).

In the second region, among the tissues of surgical wound, we identified recurrent nerves in 337 studies and didn't identify – in 17. Regarding the unidentified nerves in 3 patients on both sides, there were two cases of thyroid cancer and one was of a multi-nodular recurrent goiter. In a patient with recurrent goiter, the nerves were not identified in the first region. However, in all cases of unidentified nerves with the help of the developed method, the areas of their passage were established. This allowed during surgical interventions to bypass these zones, or operate them with special care. Motor disorders and violations of laryngeal phonatory function were not detected laryngoscopically after surgery in these cases from the side of vocal cords.

Compared to the first region in the second region, the total number of unidentified nerves decreased on 10 cases. It is subject to all operated nosological units except a recurrent goiter, in which it increased by one observation and was 22.7 %.

The topography and anatomical relationship between the nerve and the lower thyroid artery and its branches and the peculiarities of the nerve involvement in the larynx are important for the technical performance of the surgery, visual and electrophysiological identification of recurrent nerves. The conducted researches showed that the cases of nerve placement behind the arteries prevailed – 287 (81.1 %). Between the atrial branches, it passed in 39 (11.0 %) cases, along the anterior-lateral surface of the trachea – in 11 (3.1 %) and in front of the artery or its branches – in 17 (4.8%). Dangerous in terms of injury to the nerve is its location along the anterior-lateral surface of the trachea. In such cases, when mobilizing the gland from the trachea with the intersection of the medial ligament and the Gruber's ligament, the recurrent nerve falls into the manipulation area and under such conditions may be traumatized.

Table 1. Identification of laryngeal nerves in operated patients

Thyroid disease	*Recurrent nerves*				*Superior nerves*	
	Identified		*Unidentified*		*Identified*	*Unidentified*
	A	*B*	*A*	*B*		
Nodular unilateral goiter n=46	46 100 %	45 97.8 %	–	1 2.2 %	46 100 %	
Nodular bilateral goiter n=79	150 94.9 %	153 96.8 %	8 5.1 %	5 3.2 %	148 93.8 %	10 6.2 %
Thyroid cancer n=21	33 78.6 %	38 90.5 %	9 21.4 %	4 9.5 %	39 92.8 %	3 7.2 %
Toxic mixed goiter n=25	47 94.0 %	49 98.0 %	3 6.0 %	1 2.0 %	48 96.0 %	2 4.0 %
Diffuse toxic goiter n=18	33 91.7 %	35 97.2 %	3 8.3 %	1 2.8 %	31 86.1 %	5 13.9 %
Recurrent goiter n=11	18 81.8 %	17 77.3 %	4 18.2 %	5 22.7 %	17 77.3 %	5 22.7 %
	327 92.4 %	337 95.2 %	27 7.6 %	17 4.8 %	329 92.9 %	25 7.1 %

Note: unidentified nerves are the very cases when nerves are not allocated electrophysiologically among the tissues of an operational wound, but clearly defined a place of their passage; A – the first region, B – the second region.

Anatomically recurrent nerve can enter the larynx as a trunk, or several branches (spreading type). In the course of research, we found that among 337 identified recurrent nerves in 260 (77.2 %) cases, the nerve entered into the larynx as a trunk and in 77 (22.8 %) – as a spreading type. The number of branches may be different, preferably from 2 to 5. Separation of the nerve trunk on the branches may be at a distance of 4 to 18 mm to the entrance to the larynx. In this case, the topographic relationship between these branches of the nerve with the lower thyroid artery and its branches may be with different variants of interweaving. We found that the injury of one of the nerve branch is reflected on the vocal laryngeal function. This is confirmed by the results of the electrophysiological verification analysis of the recurrent nerve and its branches in the second region. It was found that the highest both amplitude and signal frequency is when stimulating the nerve trunk before dividing it into branches. The stimulation of each branch gives a signal-response, which is lower than the signal at the stimulation of the nerve trunk in terms of frequency and amplitude. Therefore, for the difference in the amplitude and frequency of the signal in the second region, in comparison with the signal in the first region, one can suspect the spreading type of the nerve entry into the larynx and, accordingly, allocate each of these twigs, protecting them from injury.

In the third region, the visualization and identification among the tissues of the operative wound of the external branch of the superior laryngeal nerve were performed. To ensure sufficient access to this site, the dissection and dilution of the anterior cervical muscles along the middle line of the neck is carried out to the hyoid bone. The stern-hyoid muscle is located laterally in the upper part of it. The medial edge of attachment of the stern-thyroid muscle is crossed over 5-7 mm to open access to the cricothyroid muscle (Fig. 2). With a damp instrument (compressor or open scissors) pass into the cellular space between the larynx divider and medial surface of the thyroid upper pole and remove the gland from the muscle. This technique greatly facilitates the further manipulation of the upper pole of the gland for the separation and bandaging of blood vessels and the external branch of the superior laryngeal nerve identification among them.

The conducted studies on the electrophysiological identification of the external branch of the superior laryngeal nerve confirmed the literature data that in this area, that is, the upper pole of the gland, the nerve goes one trunk, and then on the lateral wall of the larynx is divided into two branches. One of them

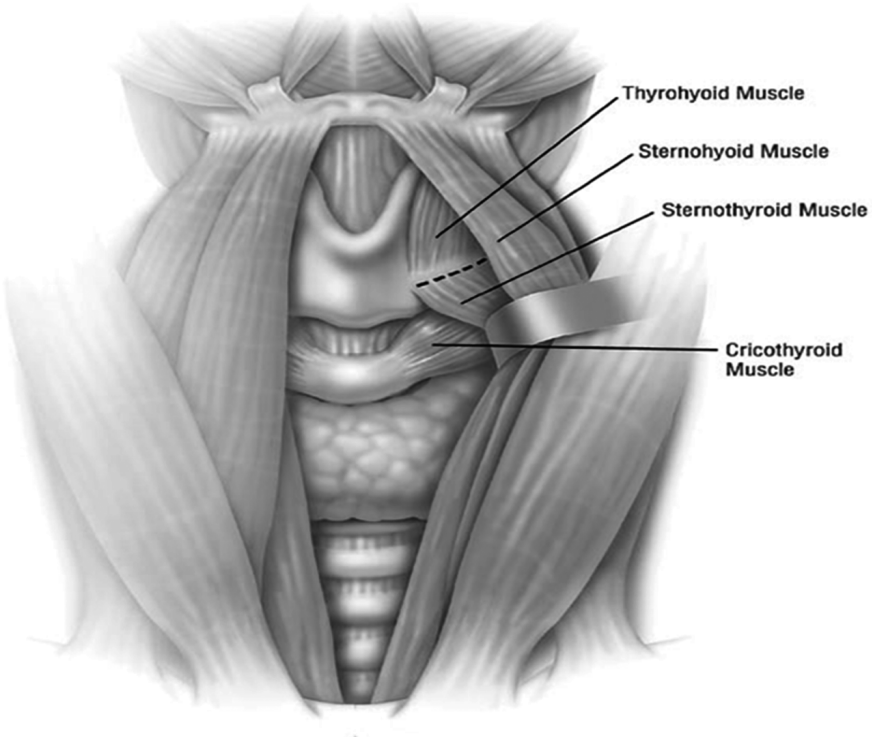

Fig. 2. (Author's drawing, dissertation Shidlovskyi OV, 2012). Scheme of access to the cricothyroid muscle. The dotted line shows the cross-section of the attachment of the sternothyroid muscle.

goes to the cricothyroid muscle, and the second – to the lower larynx divider[4].

When manipulating the upper pole of the gland and the external branch of the superior laryngeal nerve identifying, we used the anatomical classification of the external branch of the superior laryngeal nerve location proposed by Cernea C.R. et al[5], which is based on the topography of the passage and placement of the nerve in relation to the upper vessels of the thyroid gland and its upper pole. The first type – I, when the external branch of the superior laryngeal nerve trunk crosses the vessels of the gland at a distance of more than 1 cm from the entrance of the vessels to the gland. The second type – II „A", when the distance is less than 1 cm. The third type – II „B" – cases when the nerve trunk in the gland crosses the vessels and passes to the lower larynx divider. The literature data indicate that type II „B" is the most dangerous for probable injury of the nerve, a „risk zone" and requires careful and anatomically grounded manipulation on mobilization of the upper pole of the gland[3–6].

Among the tissues of an operational wound among 354 the external branch of the superior laryngeal nerve, 329 (92.9%) were identified. The first type of nerve topography is found in 142 (43.3%) studies. These were cases with an increased part or parts of the gland and the substernal goiter. Type II „A" was noted in 49 (14.8%) observations with slightly enlarged gland or one of its parts. Option II „B" took place in 138 (41.9%) studies and mainly in cases of significantly enlarged gland with dimensions of more than 7 cm in length and 5 cm in width. Taking into account this fact, we separately analyzed the types of topographies of the external branch of the superior laryngeal nerve in patients with large goiter size.

In 41 patients with the goiter size on both sides more than 7 cm in length and 5 cm in width we identified 82 external branches of the superior laryngeal nerve. Among them, in 5 (6.1%) we found the type I, in 12 (14.6%) – the type II „A" and in 65 (79.3 %) the type II „B". Thus, with the increase in the goiter size, apparently due to the high placement of the upper poles of the gland and changes in their topography, the type II „B" is the predominant placement of the external branch of the superior laryngeal nerve, which creates a high risk of injury to them.

We consider it expedient to emphasize the fact that in cases of large-sized goiters, taking into account these types of topography, the external branch of the superior laryngeal nerve is the leading link in preventing their iatrogenic lesions. With gradual and cautious mobilization and pull-up in the wound of the upper pole of the gland, the conditions are created for the accurate control of the site of the vessels entering the parenchyma of the gland and the identification of the external branch of the superior laryngeal nerve.

Regarding the technical features of the electrophysiological determination among the wound tissues of the external branch of the superior laryngeal nerve the evaluation of its results it is necessary to identify the area of the trunk before dividing it into branches. When the trunk is irritated, the signal-response will be the corresponding amplitude and frequency, and visually or palpated it is possible to fix the contraction of the ring-shaped thyroid muscle and the lower larynx divider. Reducing only the cricothyroid muscle indicates that the front nerve branch is stimulated, not the trunk, and its searches need to be continued.

There are unclear situations of unidentified 10 cases of the external branches of the superior laryngeal nerve. In this case, postoperative studies showed unchanged phonation in all of these patients. It is possible that these cases are due to a combination of two or more factors. This is a high withdrawal of the upper laryngeal nerve from the vagal nerve and the high incidence of the external branches of the superior laryngeal nerve under the lower larynx divider and passage all along it (option no. 3 by M. Friedman et al[3]) (Fig. 3).

The technology developed by us allowed in critical situations to establish areas of passing recurrent nerve and to protect them from injuries, and patients – from larynx paresis.

In the early and remote postoperative periods, no patient showed either permanent or transient paresis of the larynx. In the early postoperative period, in some patients, voice disorders (voice changes) were due to trachea and laryngeal injuries – as a consequence of surgery.

As a result of the research carried out on the development and implementation into the clinical practice of the technology of the laryngeal nerves identification, it should be noted that the method and technology of its implementation allow to unambiguously identify intraoperatively both the recurrent and superior nerves of the larynx. The possibility of the superior laryngeal nerves identification is of special note.

Technical supply of the method is not expensive. The technique of intraoperative identification of the laryngeal nerves is simple and unpretentious, has no influence of external factors and conditions on the results of the study. It does not take much time; it takes a total of 7-12 minutes. The research is carried out with the participation of a technician-operator, who by the corresponding computer programs fixes the received data. There are no contraindications to the application of the method.

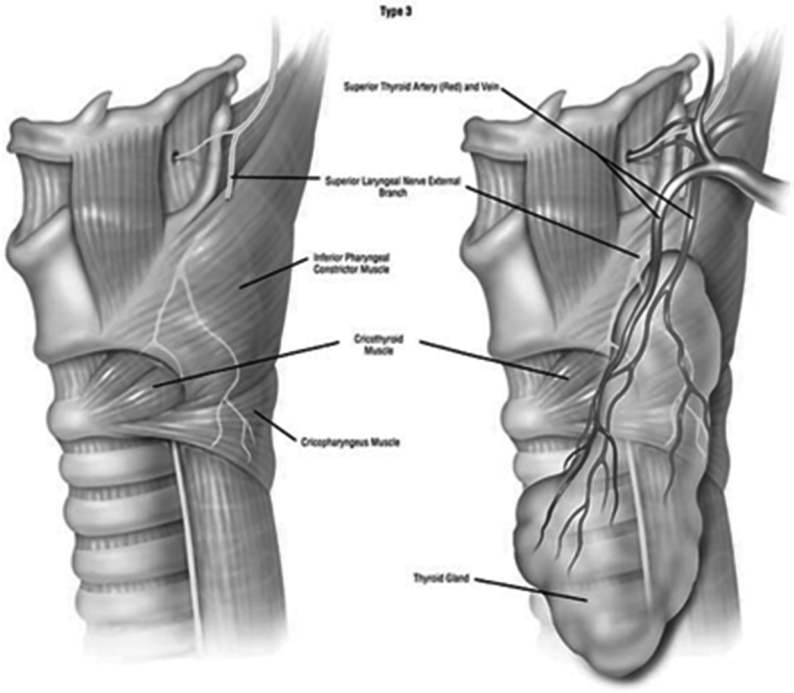

Fig. 3. (Author's drawing, dissertation Shidlovskyi OV, 2012).
Option of high entry of the external branch of the superior laryngeal nerve under the lower larynx divider.

Compliance with Ethics Requirements:

„The authors declare no conflict of interest regarding this article"

„The authors declare that all the procedures and experiments of this study respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2008(5), as well as the national law. Informed consent was obtained from all the patients included in the study"

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