EVALUATION OF THE LEARNING CURVE FOR INTRAOPERATIVE NEURAL MONITORING OF THE RECURRENT LARYNGEAL NERVES IN THYROID SURGERY*

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Intraoperative neuromonitoring facilitates identification of the recurrent laryngeal nerves (RLN) and allows for predicting their postoperative function. Nevertheless, the outcome of thyroid surgery monitoring is affected by both the experience of the operator and his mastering of the technique. The aim of the study was the assessment of the learning curve for intraoperative RLN neuromonitoring.

Material and methods. The prospective analysis included 100 consecutive thyroid operations performed by a single surgeon during implementation of RLN neuromonitoring in a district surgical ward in Staszów. RLN neuromonitoring was performed in keeping with the recommendations of the International Neural Monitoring Study Group using a C2 NerveMonitor (Inomed, Germany). The outcomes of initial 50 procedures (group I: 08/2012-07/2013) were compared with the results of subsequent 50 operations (group II: 08/2013-07/2014). The evaluation included demographic and intraoperative data along with predictive value of the method and complications.

Results. In group II as compared to group I, a significant reduction of operative time was noted (102.1±19.4 vs 109.9±19; p=0.045), along with an increased percentage of identified RLNs (99% vs 89.2%; p=0.006), a decreased percentage of correction-requiring technical errors (8% vs 24%; p=0.029), an improved negative predictive (99% vs 89.3%; p<0.001) and positive value (75% vs 55.6%; p<0.001), as well as a decreased percentage of RLN injuries (3% vs 14%; p=0.006).

Conclusions. Mastering the technique of intraoperative RLN neuromonitoring in thyroid surgery requires the surgeon to perform independently approximately 50 monitored procedures, what allows for achieving the predictive value of the method that is comparable to outcomes published by referral centers.

Key words: thyroid surgery, intraoperative neuromonitoring, recurrent laryngeal nerve

For many years now, intraoperative identification (visualization) of the recurrent laryngeal nerves (RLNs) has been recognized a standard in thyroid surgery; it allows for reducing the risk of iatrogenic nerve injury (1-5). In 1966, Sheddet et al. were the first to propose employing an electric neurostimulator for RLN identification in humans (6). Recently, the technique has been considerably improved and at present, modern systems for intraoperative monitoring of RLN function are available (7) and the method itself has been standardized thanks to the activities of the International Neural Monitoring Study Group in Thyroid

* The study was performed using equipment purchased under the project co-financed by the European Union funds and entitled „Equipping of a new surgical suite pavilion and endoscopy labs in order to initiate research and development-related activities in the Public Health Care Medical Center, Staszów”.

and Parathyroid Surgery (8, 9). Hence, intraoperative RLN neuromonitoring has been gaining increasing acceptance as a method that complements the standard of visual RLN identification in thyroid surgery, since intraoperative assessment of preservation of functional integrity of the nerve is of a significant importance in predicting its postoperative function and affects both minimizing the risk of RLN injury and surgical tactics, including staged thyroidectomy as a means of preventing bilateral RLN injury (10-13).

Nevertheless, the outcomes of thyroid operations performed employing intraoperative RLN neuromonitoring depend on the experience of the surgeon and on his mastering the complex technique (14, 15). Only absolute mastering of the methodology of intraoperative neuromonitoring combined with understanding the algorithm of problem solving do allow for appropriate assessment of the predictive value of preserving the normal signal or its intraoperative loss. Hence, it is so important for the surgeon to receive practical training in electrophysiological RLN neuromonitoring in thyroid surgery prior to implementing the method in his surgical center, followed by assessment of the learning curve and gaining mastery in employing the technique while supported by the educator (16, 17, 18). The assessment of the learning curve is often employed at the stage of implementing new surgical techniques or medical technologies in a center that currently is not experienced in their using. The purpose is on the one hand to assess the repeatability of the technique, and on the other, it is associated with evaluating the safety of its employment (19).

The objective of the study was the assessment of the learning curve for intraoperative RLN neuromonitoring at the stage of its implementation in a district general surgery ward.

MATERIAL AND METHODS

A prospective study was carried out in the Department of General Surgery, Public Health Care Center in Staszów, in the period between August 2012 and October 2014, using equipment purchased under the project co-financed by the European Union funds and entitled „Equipping of a new surgical suite pavilion and endoscopy labs in order to initiate research and development-related activities in the Public Health Care Medical Center, Staszów”. The investigation included consecutive 100 patients aged 18 to 80 years of life with non-neoplastic thyroid diseases requiring surgical treatment, who were qualified for thyroidectomies in the period of implementing the method of intraoperative RLN neuromonitoring in the said center and gave their informed consent to participate in the study. The exclusion criteria included chronic neurological diseases affecting the neuromuscular conductivity, suspected differentiated or non-differentiated thyroid cancer, ASA IV (American Society of Anesthesiology), pregnant and lactating females, lack of informed consent to participate in the study. The assessment included the demographic data of the patients, duration of surgical procedure, percentage of identified RLNs, percentage of intraoperative loss of signal, its predictive value and percentage of early and permanent RLN injuries as evaluated by videolaryngoscopy up to 6 months postoperatively. The outcomes were compared in two groups of patients. Group I consisted of 50 patients operated on in the period between August 2012 and July 2013, while group II included subsequent 50 patients operated on in the period from August 2013 to July 2014. All the patients were operated on by the same surgeon (K.P.).

The study was approved by the Bioethical Committee of the Świętokrzyska Chamber of Physicians in Kielce.

Preoperative preparation

Prior to the operation, all the patients were evaluated by a specialist in endocrinology; the assessment included their medical history, physical examination, TSH, fT3 and fT4 determinations, results of neck ultrasonography and verification of focal lesions of the thyroid by fine needle aspiration biopsy combined with cytology in keeping with the Bethesda system. Patients with abnormal thyroid function (hyperthyroidism or hypothyroidism) were prepared for surgery by an endocrinologist and were euthyroid the time of the procedure. In cases of tracheal compression or suspected retrosternal or mediastinal goiter, X-ray imaging targeted to the trachea or else CT of the neck and chest were was additionally performed.
Prior to surgery, all the patients included into the study were consulted by an anesthesiologist, who assessed the operative risk in keeping with the ASA (American Society of Anesthesiology) scale, as well as by a laryngologist; the patients were also subjected to laryngoscopy and their vocal folds mobility was assessed by videolaryngoscopy. Indications for surgery included hyperthyroid nodular goiter or Graves’ disease that did not meet the criteria for radioiodine therapy, neutral nodular goiter with tracheal compression symptoms, retrosternal or mediastinal goiter, as well as recurrent goiter meeting one of the above criteria.

Surgical technique

The procedure was performed under general anesthesia with endotracheal intubation. The patients were placed on the operating table with the head tipped backward. The operator adopted the rule of commencing the procedure of total thyroidectomy from excising the lobe with a predominant lesion, or – in cases of a comparable volume of both lobes – from resecting the left thyroid lobe. In primary procedures, the low collar Kocher’s incision was employed. The length of the incision was adjusted to goiter size. Subsequently, the superior and inferior musculo-cutaneous flap was formed. The anterior jugular veins were dissected and ligated only in cases of large goiters. The sternohyoid and sternothyroid muscles were divided in the midline from the level of the thyroid cartilage to the jugular notch of the sternum, thus exposing the thyroid. In cases of large goiters, the sternohyoid and sternothyroid muscles were additionally transversely dissected at 1/3 of their height on the side of the predominant thyroid lobe and sutured at the end of the procedure.

In reoperations, no muscle division was performed in the midline, but rather the lateral approach was used extending between the sternohyoid and sternocleidomastoid muscles. Subsequently, the predominant thyroid lobe was mobilized towards the midline following a blunt removal of the sternocleidomastoid muscle; the middle thyroid vein and the inferior thyroid artery were exposed. The jugular vessels situated on the operated side were exposed; a blunt dissection executed between the common jugular artery and internal jugular vein visualized a 1-2 cm segment of the vagus nerve and subsequently, the EMG response was evaluated following nerve stimulation (V1). The procedure was continued in case of a normal signal. Having exposed the thyroid, the neuromapping technique was employed to stimulate the tissues surrounding the inferior thyroid artery between the trachea and esophagus in order to locate RLN prior to its visual identification. Having identified RLN, the trachea was exposed, the thyroid vessels were ligated and dissected and the posterior part of the thyroid lobe continued to be dissected in the cephalad direction. The Zuckerkandl’s tubercle, under which RLN extends, was identified; subsequently, using the technique of repeated tissue stimulation, the further RLN course towards the Berry’s ligament was mapped. Having divided RLN from the Berry’s ligament, the posterior part of the thyroid lobe was dissected free from the trachea. Subsequently, placing interior and lateral traction on the thyroid lobe, the space between the cricothyroid muscle and the superior thyroid pole was bluntly dissected. At this stage of the procedure, the operator employed stimulation of tissues situated in the region of the vessels extending over the superior thyroid lobe in order to identify the external branch of the superior laryngeal nerve (EBSLN), which in some cases may be situated in this area.

EBSLN identification was achieved based on observations of positive tissue stimulation (a contraction of the ipsilateral homonymous cricothyroid muscle, which is well visible on the anterior surface of the larynx). In cases of negative stimulation of tissues situated in the region of the superior thyroid pole, individual paracapsular ligation of the superior thyroid artery branches was employed. Subsequently, the pyramidal lobe was identified close to the midline, which was dissected free and combined with the tissue block together with the isthmus. Having completed dissection of the predominating thyroid lobe, the EMG response following RLN stimulation (R2) and vagus nerve stimulation on the operated side (V2) were assessed.

In cases of bilateral thyroid surgery, the above-described elements were repeated in order to perform a total resection of the thyroid as a single tissue block. Closed Redon suction drainage of the site of the resected thyroid was employed routinely. Following meticulous hemostasis control, the wound was closed with
layered sutures. In the majority of cases, the skin was closed with subcuticular sutures. A preparation of the resected thyroid was referred for histopathology.

Intraoperative RLN monitoring

RLN monitoring was carried out in keeping with the recommendations of the International Neural Monitoring Study Group (8, 9), employing a C2 NerveMonitor (Inomed, Germany). Electromyographic (EMG) signal acquisition from the vocal muscle was based on surface electromyography of the vocal muscles by means of adhesive laryngeal surface electrodes glued to an intubation tube (Inomed, Germany) No.7.0 for female and No.7.5 for male patients. The surface electrodes fixed to the intubation tube were placed centrally between the vocal folds by an anesthesiologist in the course of intubation under direct laryngoscopic control. For the duration of intubation, short-action relaxants were employed; no long-action relaxing agents were used during the procedure. Verification of proper positioning of the surface electrodes between the vocal folds was achieved by means of assessing “respiratory variation” of the EMG amplitude displayed on the neuromonitor, the “top test” test, and – in dubious cases – repeated direct laryngoscopy.

During the procedure, the surgeon stimulated the dissected tissues using a monopolar electrode, what allowed for neuromapping of RLN position and identification of the nerve based on intraoperative EMG recording, oftentimes prior to its visual identification. The surface electrodes on the intubation tube allow for non-invasive measuring of contraction function of the vocal muscle following stimulation of the ipsilateral RLN, what is registered as EMG recording on the neuromonitor, the “top test” test, and – in dubious cases – repeated direct laryngoscopy.

Nerve stimulation was achieved using a monopolar probe and employing the intermittent stimulation technique with current output of 1-2 mA, impulse duration of 100 ms and current frequency of 4 Hz. The recording was computerized using an analog-to-digital converter; a report was prepared for each procedure, which included a complete set of data that were archived in the study database based on Microsoft Excel.

Intraoperative neuromonitoring signal loss was defined as absence of EMG signal following stimulation of the ipsilateral vagus nerve, EMG signal amplitude below 100 µV following stimulation with current output of 1-2 mA, absence of palpated “laryngeal twitch” in a dry operative field or absence of visible larynx motion following stimulation of the ipsilateral vagus nerve. In order to differentiate true from false signal loss, the problem-solving algorithm proposed by the International Neural Monitoring Study Group in Thyroid and Parathyroid Surgery was employed intraoperatively (9).

While evaluating the neuromonitoring method, the definition proposed by Chan and Lo (15) was employed. The percentage of RLN dysfunctions was calculated in reference to the number of RLNs at risk rather than to the number of patients. Signal loss following vagus nerve stimulation after thyroid lobe resection (V2) was classified as a positive test result, which prognosticated ipsilateral paralysis of the vocal fold. The test was interpreted as true positive when laryngoscopy confirmed paralysis of the ipsilateral vocal fold and as false positive when the mobility of the ipsilateral vocal fold was normal. Preserved normal signal after vagus nerve stimulation following lobectomy (V2) was classified as negative testing, which prognosticated normal mobility of the vocal fold after the operation. The test was interpreted as true negative when laryngoscopy demonstrated normal mobility of the ipsilateral vocal fold after the operation and as false negative when ipsilateral paralysis of the vocal fold was observed postoperatively.
Functional assessment of the larynx was performed in all the patients on the first postoperative day by means of indirect laryngoscopy performed by an otolaryngologist being a specialist in phoniatrics. In cases of postoperative dysfunction of the vocal folds, their mobility was evaluated by videolaryngoscopy performed up until 6 months postoperatively (at 2, 4, and 6 months after the procedure). No vocal fold mobility 6 months after the procedure was considered permanent damage.

Statistical analysis

The resultant data were analyzed statistically using the MedCalc statistical software (version 13, MedCalc Software, Belgium). Variability of the analyzed properties was presented by mean values, standard deviations (SD), minimum and maximum values (min – max) and percentage of prevalence (%). The intergroup comparison of particular properties was achieved using the χ² test (non-parametric variables) and the t test (parametric variables). To assess the diagnostic accuracy of intraoperative neuromonitoring, the ROC (Received Operating Characteristic) curves were analyzed. This served as the basis for calculating the predictive value of the positive result and the predictive value of the negative result. 

RESULTS

In group I, the assessment included 93 RLNs at risk of damage in the course of the initial 50 thyroid procedures performed with the use of neuromonitoring, while in group II, 100 RLNs at risk of injury during the subsequent 50 operations with neuromonitoring were evaluated. The demographic data of the patients are presented in tab. 1.

Comparing the results obtained in group I and group II, the following significant differences were observed: shortening of the mean operative time from 109.9±19 min to 102.1±19.4 min (p=0.045), an increased percentage of nerves visualized intraoperatively in the surgical field from 83/93 (89.2%) RLNs to 99/100 (99%) RLNs (p=0.006), a decreased percentage...
of correction-requiring technical problems involving equipment setup from 12/50 (24%) to 4/50 (8%) \((p=0.029)\), an improvement in the positive predictive value from 55.6% to 75% \((p<0.001)\), an improvement of the negative predictive value from 89.3% to 99% \((p<0.001)\), a decrease of the percentage of early RLN injuries from 13/93 (14%) to 3/100 (3.0%) of nerves at risk of damage \((p=0.006)\). Detailed data are presented in tab. 2, 3, 4. The duration of the series of 100 procedures performed with the use of RLN neuromonitoring (the learning curve) is presented in fig. 1.

**DISCUSSION**

On April 15-16, 2011, there was held in Cracow the First conference of the Polish Neural Monitoring Study Group, Polish Club of Endocrine Surgery (PCES). Summarizing the conference, the members of the group unanimously decided equipping thyroid surgery centers with neuromonitoring systems to be warranted. Having analyzed the literature worldwide and basing their opinions on the experience of the members, a need was recognized of implementing a program of routine training in the standardized recurrent laryngeal nerve monitoring technique and employing the method in operations performed in selected thyroid diseases \((20, 21)\). In the Cracow center, 2-day training sessions in electrophysiological neuromonitoring of recurrent laryngeal nerves in thyroid surgery have been held cyclically since 2010, with the frequency of 3-4 courses per year; to date, 42 surgeons have been trained (unpublished data as of

<table>
<thead>
<tr>
<th>Technical problem</th>
<th>Group I n = 50 operations (08/2012–07/2013)</th>
<th>Group II n = 50 operations (08/2013–07/2014)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Problems involving surface electrodes on the intubation tube</td>
<td></td>
<td></td>
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<tr>
<td>– rotation of electrodes</td>
<td>2 (4)</td>
<td>1 (2)</td>
<td>0.021</td>
</tr>
<tr>
<td>– electrodes situated too deeply</td>
<td>3 (6)</td>
<td>1 (2)</td>
<td></td>
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<tr>
<td>– electrodes situated too shallowly</td>
<td>1 (2)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>– intubation tube too narrow</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Problems involving grounding electrodes</td>
<td></td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>– electrode detachment</td>
<td>1 (2)</td>
<td>1 (2)</td>
<td></td>
</tr>
<tr>
<td>Razem / total</td>
<td>12 (24)</td>
<td>4 (8)</td>
<td>0.029</td>
</tr>
</tbody>
</table>

‡ – test \(\chi^2\) / ‡ – \(\chi^2\) test

<table>
<thead>
<tr>
<th>V2 signal</th>
<th>Mobility of ipsilateral vocal fold</th>
<th>Predictive value (%)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>normal</td>
<td>lack of mobility</td>
</tr>
<tr>
<td></td>
<td>Group I: RLN = 93 (08/2012-07/2013)</td>
<td></td>
</tr>
<tr>
<td>Preserved</td>
<td>TN = 75</td>
<td>FN = 9</td>
</tr>
<tr>
<td>Loss of signal</td>
<td>FP = 4</td>
<td>TP = 5</td>
</tr>
<tr>
<td>Group II: RLN = 100 (08/2013-07/2014)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Preserved</td>
<td>TN = 95</td>
<td>FN = 1</td>
</tr>
<tr>
<td>Loss of signal</td>
<td>FP = 1</td>
<td>TP = 3</td>
</tr>
</tbody>
</table>

RLN – recurrent laryngeal nerve, TN – true negative result, FN – false negative result, FP – false positive result, TP – true positive result, ‡‡ – \(p<0.001\)

<table>
<thead>
<tr>
<th>RLN paralysis</th>
<th>Group I RLN = 93 (100%) (08/2012–07/2013)</th>
<th>Group II RLN = 100 (100%) (08/2013–07/2014)</th>
<th>P‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transient</td>
<td>7 (7.5)†</td>
<td>2 (2)</td>
<td>0.068</td>
</tr>
<tr>
<td>Permanent</td>
<td>6 (6.5)</td>
<td>1 (1)</td>
<td>0.043</td>
</tr>
<tr>
<td>Total</td>
<td>13 (14)</td>
<td>3 (3)</td>
<td>0.006</td>
</tr>
</tbody>
</table>

RLN – recurrent laryngeal nerve † 1 patient demonstrated transient bilateral RLN paralysis; ‡ – \(\chi^2\) test
October 31, 2014). According to the PCES estimates, in 2011, only approximately 1% of around 25 thousands thyroid operations performed annually in Poland were monitored, while only eight surgical wards were equipped with neuromonitoring systems. At present, neuromonitoring equipment can be found in approximately 40 surgical wards and around 5% of thyroid operations performed in Poland are aided by neuromonitoring (unpublished data as of October 31, 2014).

It should be emphasized that the percentage of surgical procedures employing neuromonitoring differs in various countries. The highest percentage of thyroid procedures with neuromonitoring is noted in Germany, where more than 90% of the 100 thousands thyroid operations performed annually are monitored using the method (12). In the United States, approximately 40%-45% thyroid operations are monitored; the percentage predominantly includes procedures carried out by surgeons below 40 years of age and those employed by centers performing more than 100 thyroid operations per year (22, 23). Reports published to date support the notion that laryngeal nerve neuromonitoring is believed to be a valuable method not only when employed by younger, less experienced surgeons, but also by operators with long-term experience in thyroid surgery and profound knowledge of surgical field anatomy (24, 25). In the near future, we should expect further popularization of the method of laryngeal nerve neuromonitoring in thyroid surgery both in Poland and elsewhere, mostly due to standardization of the method and the increasing availability of neuromonitoring equipment.

In 2011, the International Neural Monitoring Study Group in Thyroid and Parathyroid Surgery published recommendations addressing standards of application of RLN neuromonitoring, and in 2013 – also in EBSLN neuromonitoring (8, 9). The recommendations were based on long-term multi-center experience of the study group members and focused on two fundamental aspects: standardization of preoperative preparation of the equipment setup and evaluation of the correctness of placing the surface electrodes on the intubation tube, as well as standardization of the management algorithm in cases of intraoperative signal loss which would allow for precise differentiation between true signal loss allowing for predicting RLN injury and false signal loss resulting from various technical errors in application of the method (26, 27, 28).

The discussed paper presents the results obtained while implementing the method of intraoperative RLN neuromonitoring in a district general surgery ward in Staszów in the group of 100 consecutive thyroid procedures performed by the same operator (K.P.). Despite the fact that the team of surgeons and anesthesiologists that performed the said procedures did participate in the 2-day practical course on electrophysiological RLN neuromonitoring held in the Cracow center, nevertheless, at the stage of implementing the method in their original center, they had to cope with numerous technical problems, mainly during the initial 50 procedures. The most common
Learning curve for intraoperative neural monitoring in thyroid surgery

problems involved improper positioning of the surface electrodes, including lateral rotation of the intubation tube or its being placed in a too shallow or too deep position, what necessitated repeated laryngoscopy in order to revise the placement of the surface electrodes with respect to the vocal folds (tab. 2). Similar observations were made by Dionigi, who noted that in 15 (10%) of 152 thyroid operations performed in his center at the stage of implementing the method between August 2007 and July 2008, the positioning of the intubation tube required revision; in 14 (93%) of the aforementioned 15 cases, the revision involved positioning of the surface electrodes with respect to the vocal folds (18).

In Dionigi’s material, the gravest problems were noted at the beginning of the learning curve, in the group of the 50 initial operations; Dionigi recognized the above number of procedures as the minimum allowing for departing from the steeply sloping downward segment of the „learning curve” (18). Jonas et al. analyzed their initial experience in implementing neuromonitoring in thyroid surgery in the years 1999-2004 based on the group of 937 consecutive operations and noted that visible improvement of results (a decreased percentage of permanent RLN injuries) occurred only in the perspective of several years, what supports the notion of a significantly longer period needed to learn the method (17); the opinion is shared by other authors (27, 28, 29). As assessed by Duclos et al., the learning curves in case of neuromonitoring also depended on individual characteristics of particular surgeons and most of all on their ability to modify their surgical technique based on newly acquired experience (24). Interesting results were presented by Alesina et al., who analyzed 1116 thyroid procedures performed by residents in their center in the years 2005-2012 (25). The data were compared in two groups: in the first group, operations without neuromonitoring were done by residents assisted by an experienced surgeon (765 procedures performed in the years 2005-2010) and the percentage of transient RLN injuries was 2.6%, while in the second group, procedures with neuromonitoring were performed by residents assisted by specialists with limited experience (below 100 operations) in thyroid surgery (351 procedures performed in the years 2011-2013), with the percentage of transient RLN injuries equaling 2.7%. Hence, the authors concluded that although neuromonitoring could not replace standard RLN identification, yet in case of surgeons with limited experience in thyroid surgery, it allowed for achieving results that were comparable to the results obtained by more experienced surgeons, and thus, it constituted a significant adjunct in education and training of residents.

A comment is due to a relatively high percentage of early RLN injuries sustained in the course of the initial 50 operations in the present material (group I) that amounted to 13/93 RLNs (14%); the number included 7/93 (7.5%) transient injuries and 6/93 (6.5%) permanent injuries (tab. 4). Although the outcomes are within the broad range of values published by other authors (0%-20%), it should be emphasized that the result is poorer than that achieved by surgeons who perform more than 200 thyroid operations per year (3, 4, 5). The causes of this phenomenon may be found in a relative lack of experience in thyroid surgery on the part of the operator (below 50 operations per year), but also in the fact that 21 (42%) of 50 operations performed in the presented patients constituted procedures associated with an increased risk of RLN injury, which include procedures for toxic goiter and reoperations for recurrent goiter.

Interestingly, the outcomes achieved in the subsequent 50 operations (group II) in the present material were statistically significantly better, since transient injuries were noted only in 2/100 (2%) RLNs (p=0.068), and permanent injuries were observed in 1/100 RLNs (1%) (p=0.043). A comparison of group I with group II easily demonstrates the cause of the phenomenon, since there was noted an increase in the percentage of nerves intraoperatively identified and visualized in the surgical field from 83/93 (89.2%) RLNs to 99/100 (99%) RLNs (p=0.006), with a simultaneous drop in the percentage of correction-requiring technical problems involving equipment setup from 12/50 (24%) to 4/50 (8%) (p=0.029), improvement of the positive predictive value from 55.6% to 75% (p<0.001), improvement of the negative predictive value from 89.3% to 99% (p<0.001) and a parallel shortening of mean operative time from 109.9±19 min to 102.1±19.4 min (p=0.045). The data support adopting the number of 50 independently performed thyroid procedures with neuromonitoring as sufficient experience allowing for using the technique
CONCLUSIONS

In summary, it can be stated that at the stage of implementing intraoperative RLN neuromonitoring in thyroid surgery, correction-requiring technical problems involving equipment setup are common, what results in lengthening operative time and limits the predictive value of the method in the course of the initial several score procedures. Nevertheless, mastering the fundamentals of employing intraoperative RNL neuromonitoring requires the operator to perform unassisted only approximately 50 monitored procedures, what is sufficient to achieve the predictive value of the method that is comparable to the results published by referral centers.

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