Evaluating the introduction of intraoperative neuromonitoring of the recurrent laryngeal nerve in thyroid and parathyroid surgery

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Abstract

Introduction: Paresis of the recurrent laryngeal nerve (RLN) is a complication of thyroid surgery. Neuromonitoring as is gaining acceptance among surgeons. The aim of the study was to assess the number of technical problems in the initial phase of intraoperative neuromonitoring (IONM) use and the specificity, sensitivity, positive predictive value and negative predictive value of neuromonitoring. The number of cases of postoperative paresis (transient and permanent) was assessed.
Material and methods: The prospective analysis included 101 thyroid operations with IONM (190 RLNs at risk of injury) in the period from January to April, 2012. Demographic data, rate of RLN identification, sensitivity, specificity and predictive value of the method, the duration of the procedurę and the percentage of RLN paresis were considered.
Results: The RLN was identified in 92% of the cases. Technical problems were observed in 12.98%, of which 61% were due to incorrect positioning of the endotracheal tube electrodes in relation to the vocal cords. The sensitivity, specificity, negative and positive predictive value and the accuracy of the method were respectively 71%, 98%, 62.5%, 98.9% and 97%. Early nerve injury occurred in 3.7% of the cases; 2.6% were temporary paresis and 1.1% permanent.
Conclusions: During the initial stages of implementing IONM we experienced technical problems that required correction in every tenth patient. The positive predictive value was relatively low; nevertheless, good results in terms of the rate of accurate identification of the RLN as well as the low rate of RLN paresis support the use of this method.

Key words: thyroid surgery, recurrent laryngeal nerve, intraoperative neuromonitoring, vocal cord paralysis.

Introduction

Thyroid operations entail a risk of injury to the recurrent laryngeal nerve (RLN), which results in temporary or permanent vocal cord paresis. This complication, especially if it is bilateral, is a severe handicap for the patient and significantly impairs the quality of life. At the beginning of the 19th century Lahey noted that precise identification and dissection of the RLN during thyroid surgery significantly reduces the risk of injury [1]. Wheeler presented similar opinions at the end of the 20th century, noting the necessity of identifying the RLN during every thyroid operation in order to avoid injury [2]. Any doubts regarding the need to identify the RLN during thyroidectomy were dispelled in a paper by Jatzko *et al.*, whose multicenter study involving 12 211 thyroid operations showed that without RLN identification the rates of temporary and permanent paresis are 7.9% and 5.2%, respectively, which are far higher than in operations with RLN identification, in which the rates are respectively 2.7% and 1.2% [3].

Currently, there is no doubt that identification of the RLN is the gold standard in thyroid surgery. Intraoperative neuromonitoring (IONM), first introduced by Sheed in 1966, not only facilitates the identification of the RLN, but also allows postoperative nerve function to be predicted intraoperatively. Additionally it allows us to understand the mechanisms of RLN injury [4–7].

The aim of the study was to assess the number of technical problems in the initial phase of IONM use and the specificity, sensitivity, positive predictive value and negative predictive value of neuromonitoring. Moreover, the number of cases of postoperative paresis (transient and permanent) was assessed.

Material and methods

The Department of General, Gastrointestinal and Endocrine Surgery of Wroclaw Medical University (Wroclaw, Poland) has considerable experience in thyroid surgery, performing about 500 such procedures a year. Prior to December 2012, RLN identification was done only by means of visualization; in January 2013 IONM was implemented in thyroid surgery for the first time.

The prospective analysis included 101 consecutive patients operated on due to various thyroid diseases in this department in the period from January 1st to April 30th, 2012. This group consisted of patients with nonmalignant disease and thyroid cancer, as well as patients with recurrent goiter. All the patients who underwent surgery during this period gave their informed consent to participate in the study. Procedures with IONM were performed by three surgeons, each with over 10 years of experience in the general surgery ward and with extensive experience in endocrine surgery, performing more than 100 thyroid procedures per year.

We evaluated patient demographics, the rate of identification of the RLN and the external branch of the superior laryngeal nerve, the percentage of early symptoms of RLN injury, detailing both transitional and permanent paresis, and the duration of surgery. The causes of intraoperative loss of signal, as well as the predictive value of neuromonitoring at this initial stage of its implementation, were also analyzed.

The study was approved by the Bioethics Committee of Wroclaw Medical University.

Perioperative procedures

All the patients enrolled in the study were comprehensively diagnosed preoperatively and prepared for surgery by the department or by the outpatient Endocrinology Clinic. The study group included patients with multinodular goiter, toxic multinodular goiter, Graves' disease, Riedel's thyroiditis, thyroid cancer and primary hyperparathyroidism. All the patients with thyroid disorders were euthyroid. Patients with thyroid dysfunction upon admission were excluded from the study. A greatly enlarged thyroid gland in the course of a goiter, compression symptoms and suspicion or diagnosis of a malignant tumor of the thyroid were indications for surgical treatment of these patients. The results of a fine needle aspiration biopsy were the primary indication for treatment in cases of thyroid nodular lesions. Thyroid gland function of all the patients was re-assessed upon admission to hospital by determining TSH and FT4 levels; routine chest and neck X-rays were done to assess displacement, narrowing of the trachea and the presence of retrosternal goiters. Other tests in the preoperative period were typical for the standard preparation of patients for any operating procedure. In cases of suspicion of retrosternal goiters or huge goiters a single-photon emission computed tomography (SPECT-CT) scan was performed to evaluate the possibility of removing the goiter using cervical access only.

Before each operation the patients underwent ENT examination of the vocal cords (indirect examination or videolaryngoscopy). The same examination was also performed on the first or second postoperative day. In cases of abnormal vocal cord mobility, videostroboscopy was performed to confirm paresis or paralysis of the vocal cords and to assess the glottis width. The examination of vocal cords was repeated after 1, 3 and 6 months in cases of proven paralysis. Transient paralysis was defined as paralysis that resolved within 6 months after surgery; if the paralysis persisted for 6 months it was classified as permanent. In patients with suspected postoperative hypoparathyroidism or with clinical symptoms of tetany, levels of calcium, phosphorus and parathyroid hormone were determined, and in case of deficiencies they were given calcium and vitamin D_3 supplements.

Neuromonitoring and surgical technique

The RLN neuromonitoring was implemented and carried out in accordance with the guidelines of the International Study Group for Neuromonitoring (ISGN) [4]. Before beginning to use the new technique, both the surgical team and the anesthesiology team were trained on a two-day practical introductory course in neuromonitoring at the Department of Endocrine Surgery of Jagiellonian University Medical College in Krakow, Poland.

All thyroid procedures were performed with a Medtronic neuromonitoring device (NIM-3 Medtronic, Jacksonville, Florida, USA). Electromyographic signal acquisition (EMG) was performed using surface electrodes integrated into the endotracheal tube (Flex Medtronic). On female patients 7 mm endotracheal tubes were used; on males 7.5 mm or 8 mm tubes were used. The endotracheal tube was placed about 20–22 cm from the incisors, with particular emphasis on the precise positioning of the electrodes between the vocal folds. Esmeron (rocuronium bromide), a non-depolarizing muscle relaxant with an average duration of action of 30–40 min, was used for the induction of anesthesia. In cases of a lack of timely relaxation, Bridion (sugammadex sodium) was used. In a few cases we used succinylcholine chloride (suxamethonium). The correct endotracheal tube position was assessed by the anesthesiologist during intubation by direct laryngoscopy, and immediately after intubation by the surgeon, by means of the so-called “tap test” – direct percussion of the larynx and observation of the resulting EMG wave on the screen. A monopolar probe was used to stimulate the laryngeal nerves using the technique of intermittent stimulation with a current of 1 mA and a pulse duration of 100 ms at a frequency of 4 Hz. In cases of RLN mapping (a technique used to locate the RLN before visualization, which is particularly valuable in secondary thyroid operations), the current was set to 2 mA. The correct EMG wave was displayed on the monitor and then archived in a computer database. In accordance with ISGN guidelines, a lack of EMG wave or a value below 100 mV after stimulating the RLN with a current of less than 1–2 mA, in the absence of a palpable twitch of the larynx, was considered intraoperative signal loss. In every case of signal loss a widely accepted troubleshooting algorithm was used [4].

In all thyroid procedures a standardized study design – L1 + V1 + R1 + R2 + V2 + L2 – was adopted in accordance with the recommendations of the ISGN [4]. All the patients had preoperative thyroid ENT assessment performed to evaluate the mobility of the vocal cords (L1). Neuromonitoring was initiated by vagal stimulation (V1) on the operated side of the thyroid, before dissection. Before removing the thyroid lobe, the RLN was identified or mapping techniques were applied in order to find it (R1). Then, after the removal of the thyroid lobe, RLN conduction (R2) and the whole path of the reflex including vagal nerve conduction were confirmed (V2). After surgery each of the patients was examined up to two times by an ENT specialist (L2).

Both the number of RLN identified by IONM and the number of nerve injuries were calculated in relation to the number of RLNs at risk of injury. Evaluation of IONM was carried out using the definitions presented by Chang and Lo [8]. Technical problems were calculated in relation to the number of thyroid procedures performed using neuromonitoring. The thyroid surgery technique with IONM consisted in performing a collar (Kocher’s) incision approximately 1 cm above the jugular notch of the sternum, then forming superior and inferior musculocutaneous flaps. In huge goiter cases the sternohyoid and sternothyroid muscles were transversely dissected. The thyroid gland dissection began with vagus nerve visualization in the area between jugular vessels on the operated side; then the RLN was identified before the beginning of goiter resection. Once the RLN was identified, the upper pole of the thyroid gland was exposed, the superior thyroid artery was ligated, then the thyroid gland was totally or subtotally removed with special emphasis on the localization of the parathyroid glands in order to save them. After removal of the thyroid lobe, the anatomical integrity and function of the RLN and vagus nerve were confirmed. The same procedure was carried out on the opposite side in cases of bilateral goiter. After obtaining hemostasis, a Redon drain was left in the site of the resected thyroid; it was removed on the second postoperative day.

Statistical analysis

The values of the averages, standard deviations (OS), minimum and maximum values and the percentage incidence (%) were calculated. Prism 5.0 statistical software (GraphPad, La Jolla, CA, US) was used to analyze the data. Student’s *t* test and Mann-Whitney U tests were used for the analysis of normally and non-normally distributed data, respectively, whereas Fisher’s exact test was used to compare non-parametric variables (%) between two groups. To compare more than two groups the Kruskal-Wallis test with post hoc analysis using Dunn’s multiple comparison was used. In all the analyses, results were considered statistically significant when $p < 0.05$.

Results

Out of 101 patients who were prospectively analyzed, 88 underwent total thyroidectomy and 14 lobectomy, giving a total of 190 RLNs at risk of injury. Primary operations were performed in 92 (91.1%) patients and secondary in 9 (8.9%). The average age of the patients was 55 ±13 years; there were 84 female and 17 male patients. The mean body mass index (BMI) of patients was 27.2 ±5.

The largest group was represented by patients with multinodular goiter: 66 (65.34%). There were 10 patients with thyroid cancer (9.91%), 42 with displacement or narrowing of the trachea (41.5%), and retrosternal goiter was present in 25 (24.75%) patients. The average goiter volume was 46 ml, and huge goiters, defined as a goiter with a volume exceeding 100 ml in ultrasound examination, were observed in 12 (11.88%). Detailed demographic and intraoperative data are shown in Table I.

Among 190 RLNs at risk of injury, we were able to identify the nerve by means of neuromonitoring in 175 (92.1%) cases. In other cases, where the RLN could not be identified with IONM, a correct signal from the vagus nerve after goiter removal proved to be helpful in assessing postoperative function. Intraoperative neuromonitoring revealed that the laryngeal nerve had the following courses: In 135 (71%) cases it ran below the inferior thyroid artery; in 55 (29%) it ran over the inferior thyroid artery; in 15 (7.97%) it branched; and a non-recurrent laryngeal nerve was observed in 1 (0.52%) patient. The external branch of the upper laryngeal nerve could be identified in only 17 (18%) of the patients.

During the study period technical problems with IONM occurred in 13 (12.87%) patients. The most common problem was rotation of the endotracheal tube, which occurred in 8 (7.92%) of the patients; 2 (1.98%) had the ground electrodes slide out, in 2 (1.98%) the endotracheal tube

Table I. Demographic and intraoperative characteristics of 101 patients included in the study (demographic data *n* = 101 patients/190 RLNs at risk)

Parameter	Result	
Age, mean ± SD [years]	55 ±13	
Gender, females (*n*) : males (*n*)	84 : 17	
BMI, mean ± SD [kg/m^2]	27.2 ± 5	
Displacement/narrowing of trachea, *n* (%)	42 (41.5)	
Retrosternal goiter, *n* (%)	25 (24.75)	
Goiter volume, mean/median [ml]	46/33	
Huge goiter > 100 ml, *n* (%)	12 (11.88)	
	Primary procedures	**Secondary procedures**
Preoperative diagnosis, *n* (%)	92 (91.1)	9 (8.9)
Multinodular goiter, *n* (%)	53 (52.47)	2 (1.98)
Toxic multinodular goiter, *n* (%)	17 (16.83)	2 (1.98)
Graves' disease, *n* (%)	4 (3.96)	–
Thyroid cancer, *n* (%)	6 (5.95)	4 (3.96)
Riedel's thyroiditis n, (%)	–	1 (0.99)
Primary hyperparathyroidism, *n* (%)	12 (11.88)	–
Surgical procedure:		
Thyroidectomy, *n* (%):	55 (54.45)	
With lymphadenectomy VI (ATA)	3 (2.97)	
With lymphadenectomy II, III, IV (ATA)	1 (0.99)	
Near total thyroidectomy, *n* (%)	12 (11.88)	
Dunhill procedure, *n* (%)	5 (4.95)	
Subtotal bilateral thyroidectomy, *n* (%)	3 (2.97)	
Lobectomy, *n* (%)	14 (13.87)	
Parathyroid gland resection, *n* (%)	12 (11.88)	

was too deeply inserted, and in 1 case (0.99%) an inappropriate endotracheal tube was chosen. Table II shows the most common technical problems during IONM and the rate of their effective correction.

Intraoperative signal loss was observed in 8 cases; in 5 it was a real loss and was associated with paralysis of the vocal cord, while in 3 cases it was a false positive signal. In 2 cases a false negative signal was registered, but RLN paresis was found in the postoperative laryngological examination. A true negative signal was recorded for 180 nerves at risk of injury. In total, out of 190 RLNs at risk of injury, in early laryngological examinations the number of RLN injuries was 7 (3.7%), of which 5 (2.6%) were transient paralysis, and 2 (1.1%) were permanent. The sensitivity of the method was 71%, specificity 98%, positive predictive value 62%, negative predictive value 98%, while the accuracy of the method was 98.9%. An analysis of the IONM predictive value is shown in Table III, and the number of cases of postoperative paralysis of the vocal cords is presented in Table IV.

The mean duration of the procedure with IONM was 105 min (minimum: 40 min, maximum: 230 min, median: 100 min). In cases of multinodular goiter the mean duration was 104 min, while in toxic goiters (toxic multinodular goiter, Graves' disease, adenoma toxicum) it was 105 min, in thyroid cancer it was 139 min, and in recurrent goiter it was 109 min.

Table II. Technical problems during IONM

Technical problem, *n* (%)	**Effective correction, *n* (%)**
Endotracheal tube rotation, 8 (7.92)	3 (37.5)
Slippage of the ground electrode, 2 (1.98)	2 (100)
Inadequate endotracheal tube, 1 (0.99)	–
Endotracheal tube inserted too deep, 2 (1.98)	2 (100)
Total, 13 (12.9)	6 (46.15)

Discussion

Neuromonitoring as a complementary technique to visual RLN identification is increasingly employed in thyroid surgery. In Germany, more than 90% of thyroid procedures are performed using IONM; in France the rate is about 15% of operations, while in the United States it is used in nearly 40% of operations [9–12]. In Italy, the number of thyroid operations performed with IONM increased from 253 in 2007 to 5100 in 2013, reflecting the rapid popularization of this method [13]. Neuromonitoring technology for the RLN and the external branch of the superior laryngeal nerve (EBSLN) has now been standardized by the International Study Group for Neuromonitoring, making it much easier to work with IONM, espe-

Table III. Intraoperative loss of signal and its predictive value – intraoperative RLN loss of signal with IONM (*n* = 190)

True positive (TP) *N* = 5	**False positive (FP) *N* = 3**	**True negative (TN) *N* = 180**	**False negative (FN) *N* = 2**	
Sensitivity TP/(TP + FN) 71%	Specificity TN/(FP + TN) 98%	Positive predictive value TP/(TP + FP) 62.5%	Negative predictive value TN/(FN + TN) 98.9%	Accuracy (TP + TN)/*n* 97%

Table IV. Number of cases of recurrent laryngeal nerve paresis after thyroid and parathyroid operations

No. of RLN at risk	**RLN paresis/injury**		
	Overall (transient + permanent), *n* (%)	**Transient *n* (%)**	**Permanent *n* (%)**
All (190 RLNs)	7 (3.7)	5 (2.6)	2 (1.1)
Retrosternal goiter (50 RLNs)	2 (4)	1 (2)	1 (2)
Non-retrosternal goiter (140 RLNs)	5 (3.57) $p = 1.0$*	4 (2.85)	1 (0.71)
Huge goiter > 100 ml (24 RLNs)	1 (4.16) $p = 1.0$*	1 (4.16)	0
Goiter size < 100 ml (166 RLNs)	6 (3.61)	4 (2.41)	2 (1.2)
Benign pathology (170 RLNs)	6 (3.52) $p = 0.5470$*	4 (2.35)	2 (1.18)
Thyroid cancer (20 RLNs)	1 (5)	1 (5)	0

**Fisher's test.*

cially at the initial stage of its implementation [4, 5]. In recent years there has also been increasing interest in IONM in Poland. On April 16, 2011, a conference of the Polish Study Group for Neuromonitoring took place in Krakow, and its members considered it appropriate to equip endocrine surgery centers with the devices used in this method. The necessity of using IONM in selected thyroid diseases was also stated [14]. Since then, a number of centers in Poland have introduced neuromonitoring, including the Wroclaw Medical University Department and Clinic of General, Gastroenterological and Endocrine Surgery, which began to use neuromonitoring during thyroid procedures in 2012.

The authors of this study assessed the initial implementation phase of intraoperative neuromonitoring in 101 consecutive patients (190 laryngeal nerves at risk of injury). Before carrying out thyroid surgery using IONM both the surgical team and the anesthesiology team underwent a two-day training course at the Department of Endocrine Surgery, Jagiellonian University Medical College in Krakow. Although the surgeons participating in the study carry out about 100 thyroid operations annually, we did not have extensive experience in the identification of the RLN. Despite the IONM training and good cooperation among the surgeons and anesthesiologists, we encountered some technical problems in the initial period of introducing the new method. These problems affected 13 (12.87%) out of 101 thyroid operations performed. The most frequent problem, which arose in 8 (61%) cases, was endotracheal tube rotation immediately after intubation or during the operation. We successfully repositioned the endotracheal tube in only 2 patients. In 1 case an inappropriate endotracheal tube was selected – the tube size (7 mm) was too small for a male patient, which resulted in a lack of a valid signal during thyroid surgery. It was much easier to eliminate such errors as slippage of the skin surface of ground electrodes in 2 (1.98%) cases or inserting the endotracheal tube too deep in 2 (1.98%) cases; here the percentage of improvement was 100%. Pragacz and Barczyński described similar technical problems during the initial implementation phase of IONM at a general surgery department in Staszow, Poland [15]. In their report, among the first 50 thyroid operations using IONM, technical problems occurred in close to 25% of the procedures. The most common technical problems were improper positioning of the surface electrodes in relation to the vocal folds, endotracheal tube rotation and incorrect endotracheal tube placement, which required correction [15]. These technical problems seem to be typical in the initial period of implementing IONM, since after performing 50 more thyroid procedures Pragacz *et al.* reported a statistically significant decline in the number of such problems (p = 0.029) [16]. On the basis of the first 152 thyroid procedures performed in his surgical center, Dionigi described the learning curve for the intraoperative neuromonitoring method, noting that most of the technical problems occurred in the first 50 operations performed with IONM [17]. The number then decreased in each successive group of 50 thyroid operations (p < 0.05). In his report, technical problems were noted in 10% of the first 50 operations with neuromonitoring; 93% of these problems were related to sub-optimal endotracheal tube contact with the vocal folds, frequently in connection with intraoperative rotation of the endotracheal tube [17]. Jonas *et al.* described a somewhat longer period of learning IONM, noting that improvement in the treatment results comes after several years of using this method, especially in terms of reducing the number of permanent injuries to the nerve [18]. These experiences indicate the need for good cooperation between the surgeon and the anesthesiologist during the initial stage of operations using neuromonitoring, and for good technical problem-solving skills. They also point to the need for good preparation before introducing new technology, in the form of courses and training in referral centers [15, 16, 19].

The high rate of RLN identification from the very beginning of IONM use is noteworthy. In our study the rate was 92.1%. From its initial introduction, the specificity, negative predictive value and accuracy of IONM are also at a high level; and in our center the rates were 98%, 98.5% and 97% respectively. In contrast, the relatively low sensitivity (71%) and positive predictive value (62.5%) did not prompt the authors to perform a so-called two-stage thyroidectomy in case of signal loss during the initial thyroid gland lobe resection. At the initial stage of IONM implementation Pragacz and Barczyński identified a similar number of nerves (89.9%) [14], while Dionigi *et al.* reported 100% identification [17]. Other centers have also reported 100% RLN identification with IONM [4, 9]. Pragacz and Barczyński also noted a relatively low positive predictive value at the initial stage of implementation (55.6%); therefore those authors also decided not to discontinue thyroid surgery after signal loss [14]. It must be taken into account that with the development of neuromonitoring skills, the predictive value increases to 90%; only after attaining this rate of positive prediction do we have grounds for discontinuing the operation in case of intraoperative signal loss [16, 20, 21].

Intraoperative neuromonitoring is a tool that facilitates identification of the RLN, even without previous extensive experience in RLN visualization or with little experience in the field of thyroid surgery [15, 16]. However, Duclos *et al.* pointed out that the learning curve is influenced primarily by previous experience in thyroid surgery and that it requires some modification of prior surgical technique [22]. The introduction of neuromonitoring in our center also had an impact on surgical technique. Using IONM, the surgeons begin the operation with vagus nerve identification and then visualize the laryngeal nerve on the operated side, and only then is the superior pole of the thyroid exposed and the goiter dissected. Before the introduction of IONM, surgeons typically began the procedure by dissecting the superior pole, then dissected along the capsule, and then the thyroid lobe was resected. The use of neuromonitoring necessitated great attention to hemostasis in the operating field, which could be significant in parathyroid preservation.

The overall rate of RLN injuries following thyroid surgery, with or without IONM, varies over a fairly wide range of 0–20% for transient paralysis and from 0.3% to 3% for permanent paralysis [20, 23, 24]. The fairly good results in terms of RLN paralysis even in the initial stage of IONM utilization are worth noting. In our center early paralysis affected 3.7% of the patients, transient paralysis affected 2.6%, and in 1.1% the paralysis was permanent. These results are quite similar to those published by Dionigi *et al.* [17], who in the initial period of IONM application reported transient injuries in 2.6% of the patients, while among the first 50 operations there was no permanent paralysis. A slightly higher percentage of complications was described by Pragacz *et al.*, who reported a rate of 7.5% for transient injuries and 6.5% for permanent injuries, which might have been affected by those authors' relatively low previous experience in thyroid surgery [14]. Much better results in terms of vocal cord paralysis are reported by centers that have performed a much larger number of operations with IONM. In 2009 Barczyński *et al.* published the results of thyroid surgery with IONM, reporting a total rate of paralysis of 2.7% in 1000 RLNs exposed to the risk of injury; transient paralysis affected 2.0% in a group of high-risk patients and 1.8% of the low-risk patients; the rates of permanent injuries in these two groups were 1.0% and 0.6% respectively, and were better than those obtained in operations without IONM [25].

It seems that IONM is a good tool for learning to identify the RLN, which is reflected by the decrease in the number of complications. This is confirmed by the research carried out by Alesina *et al.*, whose study analyzed 4343 thyroid operations performed by 18 residents; they compared the results of operations performed by a resident and an experienced surgeon with the results of operations performed by two residents using IONM [26]. The study revealed that in the first group the rate of temporary paralysis was 2.6%, and in the second group 2.7%. Of course, these results should not be interpreted as meaning that IONM can replace experienced assistance during thyroid surgery, but clearly indicate the educational value of this method in nerve identification, which is reflected by the avoidance of potential injury during thyroid surgery.

After appropriate theoretical and practical preparation, introducing intraoperative RLN neuromonitoring is a simple process, and the benefits resulting from its implementation in terms of minimizing RLN paralysis support its frequent use in thyroid surgery.

In conclusion, the most common difficulties in the initial phase of implementing intraoperative neuromonitoring involved technical problems in proper electrode contact with the vocal cords, which significantly reduced the predictive value of the method. At the initial stage of IONM use it is a very effective tool for nerve identification, allowing for a low rate of nerve injury.

Conflict of interest

The authors declare no conflict of interest.

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