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Intraoperative Neurophysiological Monitoring in Thyroid Operations as a Method of Reducing Neurological Deficit

Śródoperacyjny monitoring neurofizjologiczny w operacjach tarczycy jako metoda ograniczania deficytów neurologicznych

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Abstract

Introduction. Intraoperative neuromonitoring consists in current stimulation of the laryngeal nerve located near the thyroid gland. The intensity is usually set in the range of 1–2 mA in order to give the desired effect, but also to give the selectivity of the controlled nerves. The charge is designed to stimulate the vocal cords and motor innervation within the larynx, especially in the area of tissues subjected to surgery.
Aim. The aim of the study was to present intraoperative monitoring of the recurrent laryngeal nerve as a method of reducing the incidence of side effects associated with damage to the laryngeal nerve and to compare the quality of life of patients who were neuromonitored during procedures with those who underwent surgery without the use of intraoperative neuromonitoring.
Material and Methods. The study was conducted in two research groups. The first group consisted of 100 patients from CentroMedica Sp. z o. o. from all over Poland, who underwent surgery to remove a thyroid tumor with the help of neuromonitoring. The second research group consisted of 100 patients of the same company. They also underwent thyroid tumor excision, but in their case without the use of neuromonitoring. In the study described in this paper, the diagnostic survey method was used using the HAQ health questionnaire and the analysis of medical records.
Results. In patients after procedures without the use of intraoperative monitoring, postoperative complications were observed more often than in patients with monitoring. Patients after procedures without neuromonitoring more often had hoarseness as a complication after the procedure.
Conclusions. Based on the conducted research, it can be concluded that intraoperative neuromonitoring during thyroid surgery has an impact on the better quality of life of patients after surgery. **(JNNN 2023;12(3):112–119)**
Key Words: intraoperative neuromonitoring, neurological deficits, neuromonitoring, neurophysiology, thyroid, thyroid diseases

Streszczenie

Wstęp. Neuromonitoring śródoperacyjny polega na stymulacji prądem nerwu krtaniowego zlokalizowanego w pobliżu tarczycy. Natężenie jest zwykle ustawiane w granicach 1–2 mA, aby mogło dać pożądany efekt, ale dać również selektywność kontrolowanych nerwów. Ładunek ma na celu stymulację strun głosowych i unerwienia ruchowego w obrębie krtani, szczególnie w rejonie tkanek poddanych operacji.
Cel. Celem pracy było przedstawienie śródoperacyjnego monitorowania nerwu krtaniowego wstecznego jako metody zmniejszania częstości występowania działań niepożądanych związanych z uszkodzeniem nerwu krtaniowego oraz porównanie jakości życia pacjentów, którzy podczas zabiegów byli neuromonitorowani do tych którzy mieli przeprowadzoną operację bez wykorzystania neuromonitoringu śródoperacyjnego.
Materiał i metody. Badanie zostało przeprowadzone w dwóch grupach badawczych. Pierwszą z grup stanowiło 100 pacjentów firmy CentroMedica Sp. z o.o. z terenu całej Polski, którzy zostali poddani operacji wycięcia guza tarczycy

przy asyście neuromonitoringu. Drugą grupę badawczą stanowiło 100 pacjentów tej samej firmy. Również zostali oni poddani zabiegowi wycięcia guzów w obrębie tarczycy, jednak w ich przypadku bez wykorzystania neuromonitoringu. W badaniu opisanym w niniejszej pracy zastosowano metodę sondażu diagnostycznego wykorzystując kwestionariusz stanu zdrowia HAQ i analizę opracowań dokumentacji medycznej.

Wyniki. U pacjentów po zabiegach bez użycia monitoringu śródoperacyjnego częściej zaobserwowano powikłania po operacji niż u pacjentów z monitoringiem. Pacjenci po zabiegach bez neuromonitoringu częściej miewali chrypkę jako powikłanie po zabiegu.

Wnioski. Na podstawie przeprowadzonych badań można stwierdzić, że śródoperacyjny neuromonitoring podczas operacji tarczycy ma wpływ na lepszą jakość życia pacjentów po zabiegu. **(PNN 2023;12(3):112–119)**

Słowa kluczowe: śródoperacyjny neuromonitoring, deficyty neurologiczne, neuromonitoring, neurofizjologia, tarczyca, choroby tarczycy

Introduction

Intraoperative neurophysiological monitoring in thyroid surgeries is an effective and safe method that minimizes the risk of side effects during the procedure. It is an increasingly popular method in Europe and the rest of the world. Thanks to this procedure, the doctor has constant access to even 100% identification of the nerve, which is extremely important during surgical procedures in which nerve damage may occur. Neuromonitoring allows to assess the function of the nerve already during surgery and influences the strategy of surgical procedure [1].

Scientific studies that have been carried out so far indicate that thanks to electrical stimulation with an intensity of 1 to 2 mA, we can get a response from the muscles innervated by the laryngeal nerve. Failure to respond informs the surgeon of a problem with nerve function [2].

The aim of this paper is to present knowledge about intraoperative thyroid neuromonitoring as a method that reduces the occurrence of side effects of laryngeal nerve damage, and to compare the quality of life of patients who used it to those who underwent surgery without it.

Material and Methods

In the study described in this paper, the diagnostic survey method was used using the HAQ health questionnaire and analysis of documentation in video and audio versions, as well as characteristics and specialist conclusions related to the assessment of the use of intraoperative monitoring during the treatment of thyroid diseases in the human body, summaries and development of prognoses in relation to the use of the discussed method in the future development of medicine.

The study conducted in the period June 2021–September 2021 covered 200 patients of CentroMedica Sp. z o. o. Observations during this period were conducted on the basis of the HAQ questionnaire among patients from all over Poland. The study group was informed by the instructor about the purposes for which they were performed. After obtaining the appropriate amount of research material, its analysis and interpretation began. The knowledge gathered in the form of the results of own research, the collected theoretical and clinical material, the creation and development of hypotheses were used, on the basis of which the collected knowledge was used to confirm or refute them when creating the whole work.

The study was conducted in two research groups. The first group consisted of 100 patients from CentroMedica Sp. z o. o. from all over Poland who underwent surgery to remove a thyroid tumor. During the procedure, they underwent intraoperative neuromonitoring. The second research group consisted of 100 patients of the same company. They also underwent thyroid tumor excision, but neuromonitoring was not used in their case. The study was conducted to compare the incidence of side effects of the surgery performed in both study groups and to show whether intraoperative neuromonitoring helps to reduce the risk of postoperative complications (Table 1).

Table 1. Structure of the study groups by gender and age

Variable	Patient unmonitored	Monitoring patient	Total	%
Gender				
Female	40	47	87	44
Male	60	53	113	57
Age				
0–29 years	3	3	6	3
30–39 years	4	14	18	9
40–49 years	20	24	44	22
50–59 years	39	37	76	38
60–69 years	31	17	48	24
Over 70 years	3	5	8	4
Total	100	100	200	100

The research tool was the Karnofsky scale, which allowed the patient to be classified into one of 11 groups, depending on the quality of his life and general health:

— 1 group 0 — patient's death,
— 2 group 10 — a state of rapid increase in the threat to life,
— 3 group 20 — state of serious illness, absolute need for hospitalization and supportive treatment,
— 4 group 30 — state of severe disability, indication for hospitalization,
— 5 group 40 — state of incapacity and need for special care,
— 6 group 50 — condition requiring frequent care and frequent medical interventions,
— 7 group 60 — condition requiring periodic care, if maintained, the ability to independently meet most daily needs,
— 8 group 70 — state of inability to perform work or normal activity, while maintaining the ability to self-service,
— 9 group 80 — nearly active state (requires some effort), minor ailments and symptoms,
— 10 group 90 — state of normal activity, slight symptoms of disease,
— 11 group 100 — normal condition, no symptoms or symptoms [3].

Another study was the HAQ health assessment questionnaire, which allowed to assess how the disease affects the patient's functioning in everyday life. The study was conducted 1 month after the tumor resection within the thyroid gland. Before the start of the study, each patient was informed about its anonymous course, the possibility of refusing to participate and the right to discontinue participation at any time. At the beginning of the study, each respondent was assigned to one of the two research groups and defined their age group. The remaining questions concerned the patients' quality of life and their general health.

The collected material was continuously entered into an Excel database specially developed for the purpose of the research. All calculations were performed using the SPSS Statistica 21.0 statistical package.

In the work, in the descriptive analysis of the results obtained, tables were used, which show the number and percentage.

To determine the interrelationships between the variables, the normalized Pearson correlation coefficient was used based on the Chi-square coefficient taking values in the range <–1;1>, where –1 means a negative correlation, 0 means a weak correlation and 1 means a strong correlation, and the Chi-square test (χ^2). The Chi-square test (χ^2) was used to test the relationship between two variables. It compares the values obtained during the tests with the expected values. A large difference (statistically significant) between the values obtained from the research and the expected ones suggests that there is a relationship between one variable and the other. At the beginning of this test, the null hypothesis, which tells us that the distribution of responses in both study groups is the same. In the next step, the level of significance of this test is examined based on the table of actual answers to selected questions and on the basis of the so-called table of theoretical values. As a result of comparing these tables, we obtain the value of the significance level for the Chi-square test [4].

Assuming a typical significance level of p=0.05, if the chi-squared value is greater than p (>0.05), there is no reason to reject the null hypothesis. However, if the obtained value is less than p (<0.05), there is a basis for rejecting the null hypothesis. The non-parametric Mann–Whitney U Test was used to assess differences in one trait between the two groups.

Results

After analyzing the study carried out according to the Karnofsky scale, it can be noticed that among the patients subjected to intraoperative neuromonitoring, the largest number — 32% of patients — was in the fitness level corresponding to point 80 (State of almost full activity, requiring some effort with minor symptoms of the disease and ailments). The second place turned out to be point 90 (state of normal activity, slight symptoms of the disease) with 25 (25%) respondents. It is very important that none of the patients died, and the lowest indicated value was point 30 (Severe disability, indications for hospitalization), in which there was 1 person subjected to the study.

In the second research group, 32% of respondents indicated the inability to work independently and activity, but retained the ability to self-service (item 70). Among the patients who were not subjected to neuromonitoring, point 80 was ranked second with 19% of the examined patients. It is also worth noting that none of the study group died after the procedure. The lowest values are points 20 (Serious illness, absolute need for hospitalization and supportive treatment) and 30. They were indicated by 1 (1%) patients each. In the case of both study groups, 4 (4%) respondents returned to full fitness without symptoms of the disease (Figure 1).

Among all the surveyed patients, the highest degree of pain in the VAS scale was defined as 6 — 33% from the 1st research group vs. 32% from the 2nd research group. The strongest possible pain was indicated by 1% of respondents from group I and 5% from group II. Pain on a scale of 1 and 0 was not indicated by any person from both study groups (Figure 2).

Pain around the postoperative wound was reported by 92% of patients without monitoring. In the group with monitoring 73%. No complications after the procedure were reported by 3% of the respondents from the first group and 20% of the respondents from the

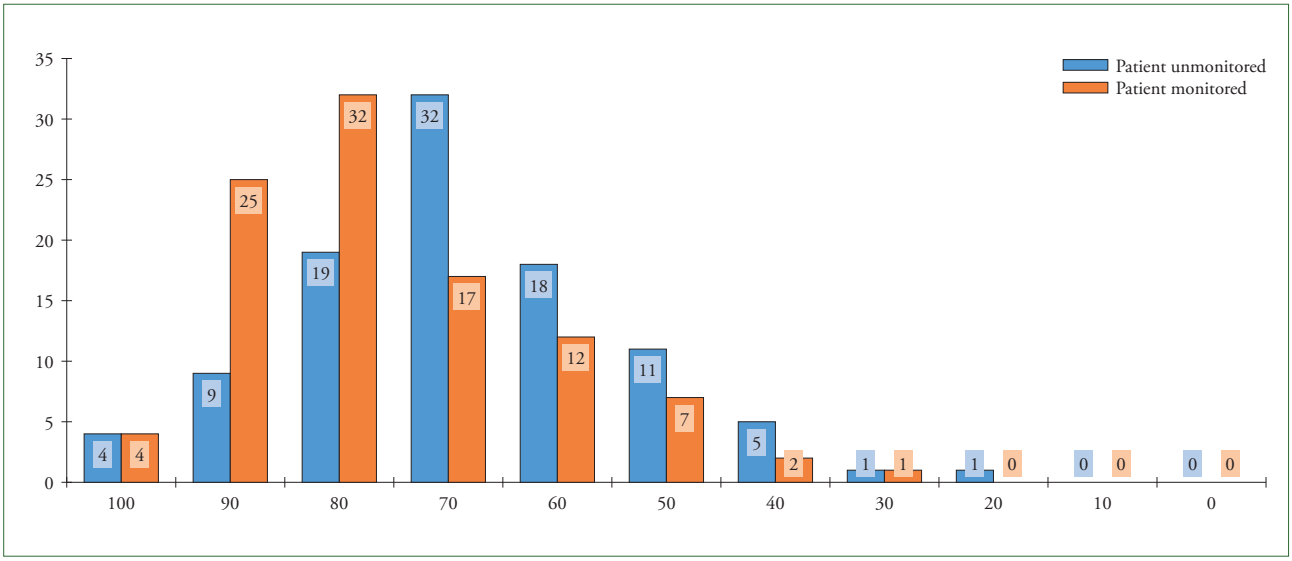

Figure 1. Test result according to the Karnofsky scale

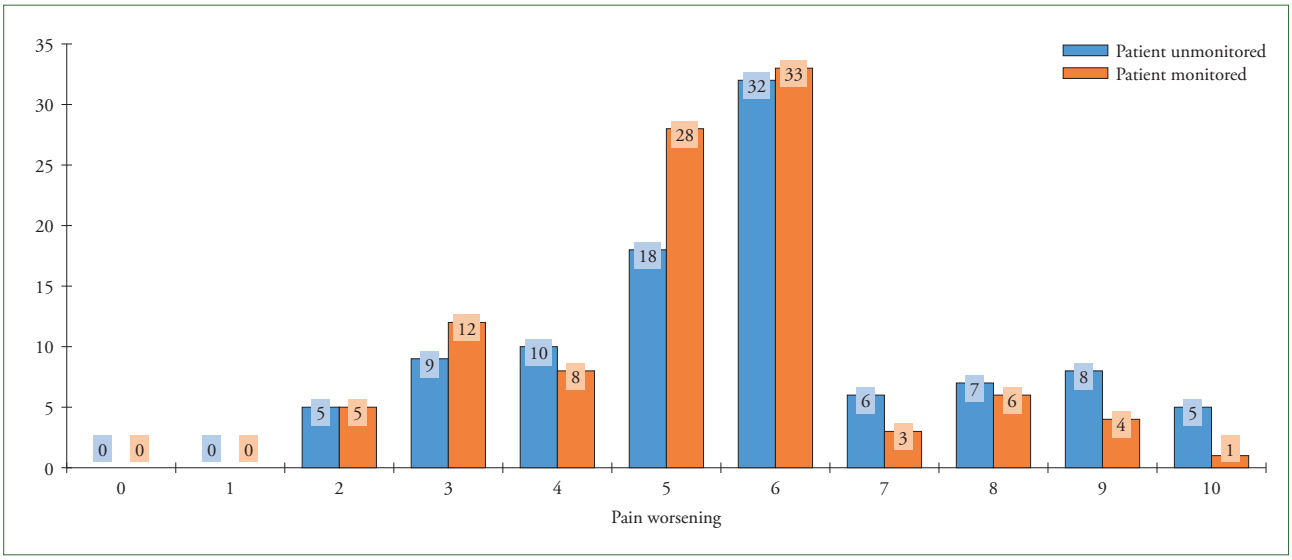

Figure 2. Increased pain due to illness in the past week

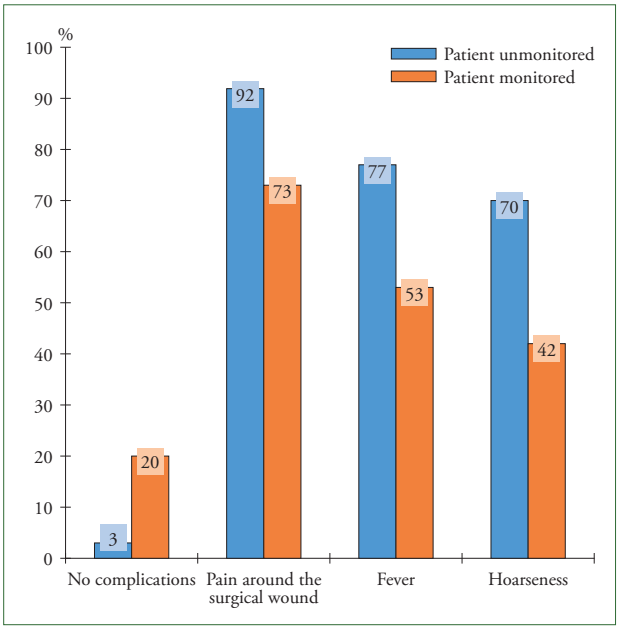

Figure 3. Complications after the procedure

second research group. Fever occurred in 77% of patients without monitoring and in 53% of patients with monitoring. Hoarseness as a complication after the procedure was indicated by as many as 70% of respondents from the first research group and 45% of respondents from the second research group (Figure 3 and Table 2).

The result of the significance level of the chi-square test is lower than the assumed one ($p<0.05$), which would indicate that there are grounds for rejecting the null hypothesis in favor of the alternative hypothesis that subjecting the patient to intraoperative monitoring influenced his postoperative complications. Patients without neuromonitoring more often had hoarseness as a postoperative complication (Table 3).

The level of significance performed with the Mann–Whitney U test is higher than assumed ($p>0.05$), which means that there was no statistically significant difference between the independent variables (group of patients

Table 2. Subjecting the patient to intraoperative neuromonitoring resulted in hoarseness as a complication after the procedure

Have you been subjected to intraoperative neuromonitoring?	Complication after the procedure: Hoarseness		N	df	χ^2	p
	No	Yes				
Patient unmonitored	30	70	100	1	12.79	0.00
Total %	15.00	35.00	50.00			
Monitoring patient	55	45	100			
Total %	27.50	22.50	50.00			
Sum	85	115	200			
	42.50%	57.50%	100.00%			

N — number of observations; df — degrees of freedom; χ^2 — chi-square test; p — test probability

Table 3. Subjecting the patient to intraoperative neuromonitoring influenced his assessment of his health condition according to the HAQ questionnaire

Variable	Mann-Whitney U test against the variable: Assessment of health status								
	Sum of ranks Patient without monitoring	Sum of ranks Patient with monitoring	U	Z	p	Z corrected	p	N valid patient not monitored	N valid monitoring patient
Have you been subjected to intraoperative neuromonitoring?	10 583.50	9 516.50	4 466.50	1.30	0.19	1.30	0.19	100	100

Z — Mann–Whitney U test; p — test probability

Table 4. Subjecting the patient to intraoperative neuromonitoring resulted in the occurrence of pain in the area of the postoperative wound as a complication after the procedure

Have you been subjected to intraoperative neuromonitoring?	Complications after surgery: Pain in the area of the postoperative wound		N	df	χ^2	p
	No	Yes				
Patient unmonitored	8	92	100	1	12.5	0.00
Total %	4.00	46.00	50.00			
Monitoring patient	27	73	100			
Total %	13.50	36.50	50.00			
Sum	35	165	200			
	17.50%	82.50%	100.00%			

N — number of observations; df — degrees of freedom; χ^2 — chi-square test; p — test probability

subjected to intraoperative neuromonitoring and the group of patients not subjected to intraoperative neuromonitoring) and the dependent variable (health assessment according to the HAQ questionnaire) (Table 4).

The result of the significance level of the chi-square test is lower than the assumed one ($p<0.05$), which would indicate that there are grounds for rejecting the null hypothesis in favor of the alternative hypothesis that subjecting the patient to intraoperative monitoring influenced his postoperative complications.

Patients without monitoring more often felt pain in the area of the postoperative wound as a postoperative complication (Table 5).

The result of the significance level of the chi-square test is lower than the assumed one ($p<0.05$), which would indicate that there are grounds for rejecting the null hypothesis in favor of the alternative hypothesis that subjecting the patient to intraoperative monitoring influenced his postoperative complications.

Complications after the procedure were observed more often in patients without monitoring than in patients with monitoring.

Table 5. Subjecting the patient to intraoperative neuromonitoring contributed to the occurrence of complications after the procedure

Have you been subjected to intraoperative neuromonitoring?	Complications after the procedure		N	df	χ^2	p
	Yes	No				
Patient unmonitored	97	3	100	1	14.2	0.00
Total %	48.50	1.50	50.00			
Monitoring patient	80	20	100			
Total %	40.00	10.00	50.00			
Sum	177	23	200			
	88.50%	11.50%	100.00%			

N — number of observations; df — degrees of freedom; χ^2 — chi-square test; p — test probability

Discussion

There is no doubt that the number of cases of various types of thyroid diseases is increasing every year. As a result, the number of thyroid surgeries performed is also increasing. Thyroid diseases are an important clinical problem. As many as 3–7% of the population can palpate a thyroid tumor, while during USG examination focal lesions are found in 50% of people over 50 years of age. It should be mentioned that about 5% of these changes are malignant. Ultrasound examinations and biopsies contributed to the development of the diagnosis of thyroid diseases and the increase in the number of operations performed. Surgical treatment of thyroid diseases is associated with possible complications (postoperative bleeding, vocal cord paralysis, hypoparathyroidism). Vocal cord paralysis occurs when the external branch of the laryngeal nerve or the recurrent laryngeal nerve is damaged. The voice is an important tool in creating interpersonal relationships, which is why attention to it during surgery is very high.

Neuromonitoring is intended to reduce complications during thyroid surgery. Although recurrent laryngeal nerve palsy (RLN) is rare, it is one of the most serious complications of thyroid surgery. This can affect patients' quality of life, increase hospitalization costs and lead to lawsuits. Of course, devices that minimize the risk of nerve damage have long been sought. One of them is intraoperative neuromonitoring (IONM). Although neuromonitoring during thyroid surgery has been used for decades, there is still debate about its effectiveness. The different results of the meta-analysis result from the lack of standardization and the incorrect use of the method. The undeniable advantages of IONM have been demonstrated in high-risk operations such as cancer, malignant, hyperactive, recurrent or sternal goiter.

In 2011, a meta-analysis was published comparing the incidence of vocal fold paralysis after thyroid surgery with and without neuromonitoring. Forty-three studies (20 prospective and 23 retrospective) were performed and a total of 64 699 RLN at risk of injury were analysed. The overall rate of vocal cord paralysis was 3.52% in the IONM group and 3.12% in the unmonitored group. The frequency of transient paralysis was 2.74%, respectively. and 2.49%, and permanent 0.75% and 0.58% [5].

In 2013, the results of a meta-analysis including six studies using randomness were presented. 1602 patients were included in the analysis. It was assessed whether the use of IONM in thyroid surgery reduces the incidence of recurrent laryngeal and superior laryngeal nerve palsy. The results were obtained from the operations of 1513 patients (2912 nerves at risk) according to the frequency of VLU palsy. The frequency of transient paralysis was 2.2% in the group with neuromonitoring and 3.9% in the group without neuromonitoring, and the frequency of permanent paralysis was 0.5% and 0.8%, respectively. These differences were not statistically significant. However, the investigators concluded that the statistical power of the study was insufficient, especially in the permanently paralyzed VLU group, despite the inclusion of a large patient population in the meta-analysis. It was stressed that such analyzes should include surgical outcomes for 4,500 patients or 9,000 patients at risk of nerve damage. The authors of the meta-analysis found that the use of IONM did not significantly affect the incidence of VLU paralysis during thyroid surgery. Research methodology should be based on neuromonitoring standards. It should also be emphasized that in most cases the paralysis was transient [6].

Barczyński et al. showed that the use of IONM significantly reduces the incidence of transient RLN paralysis in this type of surgery [7]. Identification of recurrent laryngeal nerves during thyroid surgery is sometimes very difficult. Alesina et al. evaluated the effectiveness of neuromonitoring in thyroid surgery. They analyzed the results of 250 surgical procedures performed on 246 patients with goitre recurrence (203

cases), hyperthyroidism (26 cases) and thyroid cancer recurrence (17 cases). IONM was used in 89 patients (NM group) and 131 patients underwent surgery without IONM (NV group). Patients who had undergone adjuvant thyroidectomy for thyroid cancer, patients who had previously undergone contralateral surgery, and patients with regrowth of thyroid tissue in the pyramidal lobe were excluded from the study. 128 patients in the NM group and 161 patients in the NV group were at risk for VLU damage. The incidence of transient VLU palsy was 6.2% in the NM group and 2.5% in the NV group. Overall, the researchers concluded that the surgeon's experience was the most important factor in the success of thyroid surgery. To minimize the risk of VLN paralysis, the authors proposed starting the incision on the dorsal side of the gland, which was theoretically least abundant in scar tissue.

They also pointed out that keeping small pieces of thyroid tissue around Berry's ligaments is an appropriate way to protect the nerves. Finally, they emphasized that the use of neuromonitoring cannot replace routine visualization and careful dissection of the recurrent laryngeal nerves in the surgical field [8].

In the study by Sopiński et al., the frequency of RLN palsy was lower in the IONM group compared to the non-IONM group. The relatively high incidence of paralysis is attributed to the presence of other risk factors. RLN damage was often detected during surgery. In addition, all cases of postoperative paralysis (diagnosed on the 1st postoperative day) were included in the analysis. In most of the cited reports, the researchers assessed the incidence of both temporary and permanent paralysis (in this case, the incidence of complications was much lower). In the literature, there are two definitions of temporary and permanent RLN paralysis. Some authors argue that permanent paralysis lasts longer than 6 months after surgery, while other researchers believe that such complications can be diagnosed within 12 months after surgery. Thyroid surgery is associated with an increased risk of damage to the laryngeal nerve. Visualization of the nerve pathways before resection of the gland is a standard in this type of surgery. The use of intraoperative neuromonitoring of the recurrent laryngeal nerves does not significantly reduce the risk of such nerve damage. Researchers believe that further studies are needed to assess the effectiveness of this procedure in a large patient population [9].

Although the research conducted so far does not confirm the key benefits of neuromonitoring, it can be considered a groundbreaking way to protect nerves from damage in real time and alert surgeons to dangerous movements. Neuromonitoring is safe and has no side effects. Its use increases the cost of surgery and hospitalization, but improves the quality of the procedure and ensures patient safety. The HAQ health assessment questionnaire was used in the study. It allowed to assess how the disease affects the functioning of the patient in everyday life. After analyzing the results, patients with neuromonitoring experience a better quality of life than patients without neuromonitoring. The quality of life does not have a single definition and consists of many factors, including physical and mental health, emotional state, professional and financial situation and interpersonal relationships. So important is human speech and attention to it during surgery, because it is associated with every aspect of the quality of life. It can be said that speech is one of the most important abilities needed to communicate with the world around us.

In the paper, the hypotheses were verified with the chi-square test and the Mann–Whitney U test. It has been shown that the use of neuromonitoring in thyroid surgeries significantly improved the comfort of life of patients after the procedure. It should be noted that the use of neuromonitoring reduced postoperative complications such as hoarseness, fever or wound pain after surgery compared to the group without the use of IONM. It has been shown that comorbidities do not affect the use of neuromonitoring during procedures.

Conclusions

After analyzing all the results of the research, it can be concluded that intraoperative neuromonitoring reduces the incidence of side effects among patients who have undergone it and significantly improves their quality of life.

To sum up, operations with the use of neuromonitoring reduce the risk of complications during thyroid tumor surgery, but do not exclude them completely. Certainly, the use of IONM improves the quality of life of patients.

Implications for Nursing Practice

This paper was aimed at analyzing and discussing intraoperative neurophysiological monitoring in thyroid surgeries as a method of reducing neurological deficits. A number of diseases in which such a procedure is used were analyzed, and possible effects in the form of reducing the side effects of surgical procedures were given. The quality of life of patients who benefited from intraoperative neuromonitoring and those who did not undergo it was also analyzed. The work showed that it has a positive effect on patients and reduces the occurrence of side effects after thyroid surgery.

Therefore, appropriate actions should be taken to increase public awareness and appropriate training of medical staff on intraoperative neuromonitoring. Nursing

staff should promote methods that reduce complications in patients after thyroid surgery.

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