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Risk factors and prognosis of voice disorders after surgical treatment of thyroid and parathyroid diseases

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Aim — to analyze risk factors and prognosis of voice disorders after surgical treatment of thyroid and parathyroid diseases.

Material and methods. There were 1272 patients who were operated in the endocrine surgery department for the period from January 1, 2016 to April 30, 2017. We studied the incidence of VF paresis, VF paralysis, and persistent dysphonia as clinical outcomes. Potential risk factors have to be analyzed were sex and age of patients, BMI, diagnosis, surgical technique, thyroid volume, experience of the surgeon and assistant, use of intraoperative neuromonitoring, etc.

Results. Significant relationships of risk factors with various complications of thyroid surgery were found. In logistic regression analysis, the independent predictors of complications were the following: 1) for VF paresis — extent of surgery and thyroid volume; 2) for VF paralysis — sex, extent of surgery and thyroid volume; 3) for persistent postoperative dysphonia — age and thyroid volume.

Conclusion. The correlation of various risk factors with development of VF paresis, VF paralysis and persistent dysphonia were identified in patients undergoing thyroid and parathyroid surgery.

Keywords: vocal fold paresis, vocal fold paralysis, dysphonia, thyroid surgery, parathyroid surgery, voice quality, recurrent laryngeal nerve injury, risk factors, logistic regression, multivariate analysis.

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There is impaired quality of voice in up to $^{2}/_{3}$ of patients after thyroid surgery [2, 25], that adversely affects quality of life of patients and professional activity. At the same time, normal voice quality is important not only for patients whose voice is a professional tool, but also for teachers, medical workers, guides, clergymen, service workers, etc. [4, 17]. Also, thyroid surgery followed byvoice disordersin some patients lead to financial costs for repeated specialized phoniatric examinations, phonopedic correction, subsequent surgical interventions to restore voice [1, 22]. These aspects of postoperative dysphonia can become a source of forensic actions and adversely affect the reputation of physicians and medical organizations [1, 10].

The most well-known cause of postoperative voice disturbances is injury of recurrent laryngeal nerve (RLN). Anatomical prerequisites for RLN damage include extralaryngeal branching, non-recurrent laryngeal nerve, sharp kinking of distal nerve segment covered by Berry ligament [22]. Variant anatomy results difficult visual detection of RLN while careful dissection of the nerve up to the «entry point» can cause its unintended injury. However, complete intersection of thenerve is rare. Surgical manipulations can lead to RLN dysfunction through traction, heating, compression by surrounding tissues during sutures tying, crush as a result of clamping, etc. [15].

In addition, voice impairment may be caused by invasive growth of the tumor and up to 40% of patients ignore dysphonia over several months [13]. In this regard, researchers emphasize that endocrine surgeons should initially assess patient's voice in order to suspect more serious stage of thyroid disease. Moreover, it is necessary to optimize examination, inform the patient about advanced risk of postoperative dysphonia and justify the use of additional measures to prevent RLN injury.

Incidence of RLN injuries during primary operations varies from 1.4 to 38.4% (mean 9.8%) and depends on diagnosis confirmation mode: considering complaints alone or otorhinolaryngologist's consultation; vocal cords (VC) assessment by using of indirect laryngoscopy or laryngostroboscopy; assessment of risk of complications according to the number of nerves more likely to be damaged or number of patients, etc. It is also noted that postoperative morbidity including RLN injury is higher in general sur-

Table 1. **Characteristics of patients**

	PTE	HTE	TE	TE+CLAE	TE+BLAE	In all
PHPT	63	6	0	0	0	69
FF	0	106	33	2	0	141
NCG/MCG	0	99	200	2	0	301
DTG/MTG	0	12	288	1	0	301
TC	0	20	303	93	44	460
In all	63	243	824	98	44	1272

Note: PTE — parathyroidectomy, HTE — hemithyroidectomy, TE — thyroidectomy, TE + CLAE — thyroidectomy with central lymphadenectomy of the neck level VI, TE + BLAE — thyroidectomy with bilateral lymphadenectomy of theneck levels II—V and VI.

gical departments compared with specialized endocrine surgery units [14]. In general, researchers have noted significant underestimation of the incidence of RLN injuries and VC paresis even in specialized departments of endocrine surgery [16].

Significantly impaired quality of life due to complications after thyroid and parathyroid gland surgery is associated with adverse consequences for all participants of the treatment process. Therefore, prevention of RLN injury is still one of the most actual issues for national and foreign surgeons. Various surgical techniques implying minimal contact of the instruments with «vocal nerves» and maintaining safe distance to RLN with mandatory visual exposure and even partial mobilization of RLN were developed (in this regard Russian publications refer subfascial technique by O.V. Nikolaev and thyroid resection by A.V. Martynov, E.S. Drachinskaya; foreign reports — Dunhil procedure) [24]. These approaches for benign thyroid diseases reduced the incidence of unilateral VC paresis up to 2.0—4.5% and paralysis up to 1.4—2.3% [11, 14].

Certain hopes regarding prevention of RLN injuries were associated with development of intraoperative electrophysiological studies (EPS) of laryngeal nerves. However, current data of intraoperative neuromonitoring (IONM) of RLN are contradictory. Most authors note only insignificant decrease of the number of transient VC paresis and paralysis after IONM-assisted surgery [5, 18]. On the contrary, some authors report reduced number of VC paresis [12], while the others — VC paralysis [8].

It is still necessary to study risk factors and develop preventive measures because innovative technologies in thyroid and parathyroid glandsurgery have not eliminated the likelihood of postoperative VC paresis/paralysis and dysphoniain recent years.The role of some pre-and intraoperative variables including sex and age of patients, body mass index (BMI), diagnosis, surgical technique, thyroid volume, surgeon's experience, postoperative level of parathyroid hormone (PTH) and serum calcium is still unclear. These parameters can affect the function of laryngeal nerves.

Despite the significance of individual risk factors, complication is a result of interaction of several conditions as a rule. Multivariate analysis of these interactions and mathematical assessment of the likelihood of certain outcome are requirements of evidence-based medicine [3, 6]. There are almost no papers devoted to multivariate analysis and statistical models of the likelihood of such important complications after thyroid and parathyroid gland surgery as VC paresis/paralysis and dysphonia in Russian medical literature.

The purpose of the study is to identify risk factors of postoperative vocal disorders in patients withthyroid and parathyroid diseases. The objectives of the study included: 1) analysis of significant pre- and intraoperative predictors of postoperative VC paresis/paralysis and persistent dysphonia; 2) prognosis of the likelihood of these complications by using of logistic regression.

Material and methods

The study included 1272 patients who were operated at the specialized department of endocrine surgery of the Pirogov National Medical and Surgical Centerfor the period from January 1, 2016 to April 30, 2017 **(Table 1)**.

There were no patients with recurrent malignant and benign thyroid and parathyroid diseases. We have analyzed incidence of postoperative VC paresis/paralysis and persistent dysphonia.

Following risk factors of these complications were assessed: sex, age, BMI, diagnosis, surgical technique, thyroid volume, surgeon, use of IONM.

V_1R_1—R_2V_2scheme of IONM was applied: vagus nerve stimulation before thyroid lobe dissection (V_1); intermittent RLN stimulationin order to detect its placement during subsequent mobilization of thyroid lobe (R_1, R_2); vagus nerve stimulation after removal of each thyroid lobe (V_2) according to the International Standard for IONM of RLN [21, 26].

Ultrasound of the larynx and video-laryngoscopy (VLS) were useful to diagnose impaired mobility of vocal cords. Ultrasound of VC was performed in all patients before surgery and after 2—3 days postoperatively according to above-mentioned technique [2]. Patients with preoperative impaired mobility of vocal muscles and/or arytenoid cartilages were excluded from the study. VLS was performed to confirm postoperative muscle paresis if VC asymmetry was observed during ultrasound. VLS was also applied in case of dubious ultrasound picture or ultrasonic inaccessibility of VC. VC paralysis was confirmed by no VC mobility for more than 1 year.

Control survey in 1, 3, 6 and 12 months after surgery was performed in order to assess postoperative quality ofvoice (QoV). Persistent dysphonia was diagnosed on the basis of impaired phonation — hoarseness, decrease of voice loudness, etc. for more than 1 year after surgery.

Surgical interventions were performed by 5 surgeons. Three of them carry out over 200 procedures per year for thyroid disease, 2 surgeons — less than 50 operations per year. Surgeons with less experience performed surgical interventions under the supervision of senior colleagues who were the first assistants.

Statistical analysis. Mean, standard deviation and confidence interval (M±σ; CI) are used for continuous data (age, duration of operation, etc.) with normal distribution; median and interquartile range (Me, Q1—Q3) were used in case of abnormal distribution. Incidence of VC paresis/paralysis was calculated regarding the number of RLNs with advanced risk of trauma.

Student's t-test was used to compare quantitative variables with normal distribution, Mann—Whitney or Kruskal—Wallis tests for quantitative variables with abnormal distribution. Nominal variables were analyzed by using of Pearson χ^2 test. The results ofcomparison of binary variables by using of Pearson's χ^2 testare shown as odds ratios with 95% confidence interval (OR; 95% CI). Binary logistic regression was applied to determine prognostic role of various risk factors, sensitivity and specificity of threshold values were determined by ROC-analysis. Differences were significant at p-value <0.05.

Statistical analysis was performed by using of IBM SPSS Statistics 20.

Results

Analysis of VC paresis likelihood in early postoperative period

It was observed significant correlation of VC paresis likelihood with age (age 55.58±12.46 years in patients with VC paresis; CI 52.42—58.74 vs. 51.75±14.06 years in those without paresis; CI 50.74—52.75; p=0.024), surgical technique (the highest frequency of VC paresis after PTE and TE + BLAE (10.2 and 9.21%, respectively) and the smallest — after TE + CLAE, TE and HTE (2.14, 3.78 and 4.82%, respectively; p=0.003), thyroid volume (33.5; 15.0—68.0 ml vs. 22.6 ml; 14.0—48.2 ml; p=0.104) and duration of surgery (100.0 min; 80,0—142,5 min vs. 80.0 min; 60,0—100,0 min; p<0.001).

There was no significant correlation between VC paresis and sex (OR 1.45; 95% CI 0.60—3.51), BMI (p=0.509), diagnosis (p=0.322), experience of surgeon and assistant (p=0.100), use of IONM (p=0.879), level of parathyroid hormone after surgery (p=0.951).

Prognostic model of VC paresis. Initial analysis included 8 factors (sex, age, BMI, diagnosis, surgical technique, thyroid volume, surgeon's experience, IONM). Only three of them (surgical technique, diagnosis and thyroid volume) were significant for inclusion into logistic regression model.

Analysis of the likelihood of VC paralysis (1 year after surgery)

It was found significant relationships between VC paralysis and sex of patients (more probable men, OR 4.88; 95% CI 1.28—18.57), thyroid volume (it was higher in those with paralysis: 53.9 ml; 27.0—100.85 ml vs. 22.5 ml; 14.0—47.3 ml; p=0.046), time of surgery (prolonged intervention in patients with VC paralysis: 137,5 min; 90.0—215.0 min vs. 80.0 min; 60.0—100.0 min; p=0.001), impaired QoV in early postoperative period (these complaints were more frequent in patients with VC paralysis, OR 1.05; 95% CI 1.02—1.07) and early postoperative VC paresis (VC paralysis was more possible in patients with VC paresis, OR 1.6; 95% CI 1.22—2.09).

There was no significant correlation between incidence of VC paralysis and age (p=0.960), BMI (p=0.405), diagnosis (p=0.162), type of surgery (p=0.147), experience of surgeon and assistant (p=0.186 and p=0.213, respectively), IONM (p=0.900), parathyroid hormone after surgery (p=0.746).

Prognostic model of VC paralysis. Initial analysis included 8 factors (sex, age, BMI, diagnosis, type of surgery, thyroid volume, surgeon's experience, IONM).Three of them (sex, age and thyroid volume) were significant for inclusion into final logistic regression model.

Analysis of the risk of persistent postoperative dysphonia

It was significant correlation between the probability of persistent dysphoniaand age (patients with dysphonia were older, 56.2±12.2 years; 54.2—58.25 years vs. 51.6±13.6 years; 50.5—52.8 years; p<0.001), type of surgery (dysphonia was common after TE+BLAE (35.3%), rare — after PTE (14.8%; p=0.060), impaired QoVin early postoperative period (higher probability of persistent dysphonia was associated with these complaints, OR 2.26; 95% CI 1.56—3.26), VC paresis (probability of persistent dysphonia was higher in case of VC paresis: OR 2.81; 95% CI 1.53—5.14), VC paralysis (probability of persistent dysphonia was higher in case of VC paralysis: OR 6.18; 95% CI 1.72—22.24), thyroid volume (probability of persistent dysphonia was the highest in patients with thyroid volume over 60,0 ml (30.5%), and the smallest in patients with thyroid volume 36.0—59.9 ml (17.9%; p=0.027) and duration of surgery (prolonged intervention in patients with subsequent persistent dysphonia: 85,0 min; 70.0—110.0 min vs. 80.0 min; 60.0—100.0 min; p=0.034).

It was not observed significant correlation between persistent postoperative dysphonia and sex of patients (OR 0.78; 95% CI 0.41—1.50), BMI (p=0.231), diagnosis (p=0.171), experience of surgeon and assistant (p=0.268 and p=0.063, respectively), IONM (p=0.622), level of PTH after surgery (p=0.787).

According to logistic regression model, only age of patients and thyroid volume were significant independent predictors of persistent postoperative dysphonia.

Discussion

Influence of patient's sex. Female gender is considered to be a significant factor of reduced frequency of the voice after surgery. This is explained by higher incidence of RLN bifurcation, more common hypocalcemic symptoms, features of laryngeal anatomy (thyroid cartilage plates are joined under sharper angle in men) and higher prevalence of thyroid diseases among women.

In our study, VC paralysis was significantly more common in men than in women (OR 4.88, 95% CI 1.28—18.57). However, there were no differences among men or women regarding incidence of VC paresis and persistent dysphonia in postoperative period.

Influence of age

In our study, we found a significant direct relationship between age and VC paresis/persistent dysphonia that is consistent with the results of other authors. No significant influence of the age on the incidence of VC paralysis was revealed.

Despite the fact that researchers often find a direct correlation between advanced age and incidence of complications, prerequisites and mechanism of this relationship are still unclear. Probably,prognostic significance of age for complications is caused by correlation of advanced age with more severe forms of cancer, less elasticity of laryngeal structures and concomitant diseases. Age is an unmodifiable risk factor, so age-related approach to predicting complications and selecting preventive measures can reduce the risk of vocal nerve injury.

Influence of BMI

We found no significant impact of BMI on the clinical outcomes although increased BMI is associated with additional technical difficulties (short neck, increased depth of wounds and greater time of surgery) and requires advanced experience of the assistants.

Influence of diagnosis

Tumor and adhesive processes near the nerve, as well as intraoperative bleeding are recognized as risk factors for intraoperative trauma of laryngeal nerves [25, 26].

In our study, increased thyroid volume (in patients with NCG and MCG), adhesive process (in patients with autoimmune thyroiditis), advanced bleeding (in patients with thyrotoxic goiter), cancer were not significantly associated with VC paresis/paralysis and persistent postoperative dysphonia.

In our opinion, no significant correlation of the diagnosis and complications is caused by several reasons: 1) interrelation of vocal nerve injury with surgical manipulations within «risk areas», i.e. type of surgical intervention. This correlation is not always observed between the diagnosis and surgical technique because the same diagnosis can require different surgical approaches (for example, HTE and TE may be advisable for both NCG and FF, etc.); 2) according to multivariate analysis, other variables are more important predictors of VC paresis/paralysis and persistent dysphonia than the diagnosis.

***Table 2*. Incidence of VC paresis and paralysis depending on surgical technique**

	Incidence of complications, %	
	VC paresis	VC paralysis
PTE	5,20	1,04
HTE	4,82	1,24
TE	3,78	0,66
TE+CLAE	2,14	0,0
TE+BLAE	9,21	2,94
Inall	4,20	0,82

Influence of surgical technique

Most researchers find a correlation between surgical technique (and, accordingly, manipulations within «risk areas» near laryngeal nerves) and incidence of VC paresis [12, 14].

In our study, incidence of VC paralysis was 4.20%, VC paralysis — 0.82%. Surgical technique was significantly related to the incidence of VC paralysis (p=0.023). Moreover, this variable was slightly correlated with the incidence of VC paralysis (p=0.147) and persistent postoperative dysphonia (p=0.067), that is consistent with the results of other researchers.

Advanced surgery including TE with radical bilateral cervical lymphadenectomy (TE+BLAE) was accompanied by the highest incidence of complications. Depending on surgical technique and, accordingly, the risk of RLN trauma, we could also expect various incidence of vocal disorders after «minor» (HTE) and advanced operation (TE+CLAE). However, there was gradual increase of the incidence of these complications in the series «TE+CLAE» — «TE» — «HTE» **(Table 2)**.Therefore, patients after HTE were analyzed separately **(Table 3)**.

In our opinion, higher incidence of complications after HTE was caused by significant enlargement of dominant thyroid lobe and intraoperative changesof primary surgical plan. Higher volume of excised dominant thyroid lobe is associated with advanced risk of complications. Moreover, TE was intraoperatively replaced with HTEin 3 patients due to IONM data of impaired function of inferior laryngeal nerve after removal of the first thyroid lobe.If IONMhad not been, these patients would have been included into TE group (incidence of VC paresis in THE group would be 3.06% in this case).

Special attention should be paid to the analysis of the incidence of VC paresis after PTE (5.2% in early postoperative period). There was nosignificant correlation between this complication and sex, BMI, volume of excised parathyroid gland, use of IONM and surgeon's experience. In our opinion, the following circumstances were significant for increased incidence of this complication:

Table 3. **Incidence of complications after HTE depending on the diagnosis**

	Diagnoses required HTE					
	PHPT	FF	NCG/MCG	DTG/MTG	TC	In all
VC paresis	0	1,4	7,69	0	16,67	4,82
VC paralysis	0	0	1,59	0	9,09	1,24

small dimensions of the wound and limited examination of surgical field during selective PTE as a rule; close placement of parathyroid gland and RLN and therefore surgical manipulations are performed near the branches of RLN; high sensitivity of RLN to various mechanisms of trauma (traction, heating, compression) in advanced age patients; obligatory ultrasound of VC (laryngoscopy if it was necessary) in all patients in early postoperative period followed by diagnosis of impaired VC mobility even if there was no deterioration of QoV. VC paresis was transient as a rule. Complete recovery of VC function was observed within 6 months after surgery in 80% of patients, 1-year incidence of VC paralysis after PTE was 1.04%.

Influence of thyroid volume

Thyroid hyperplasia (in particular, with retrosternal and retrotracheal spread) is associated with high risk of surgical complications, including laryngeal muscle paresis. Advanced traction of the nerve is the leading mechanism of RLN dysfunction in this case [12, 13].

In our study, we found that complications are directly related to thyroid gland enlargement that is consistent with the results of other researchers. Multivariate analysis confirmed that the highest frequency of complications is typical for patients with thyroid volume over 36.0 ml that was noted in case of NCG/MCG and DTG/MTG. In our opinion, the necessity of advanced traction during hypertrophied thyroid mobilization resulted increased incidence of VC paresis/paralysis and persistent dysphonia in these patients.

Influence of experience of surgeon and assistant

The risk of complications including nerve injury is also associated with the experience and qualification of surgeon [21]. The problem of training of young endocrine surgeons and their participation in the operation as assistant or surgeon is under separate discussion in medical literature. Specialized departments found no significant differences in the number of complications after surgery performed by experienced surgeon or young surgeons under supervision of certified staff surgeon [9].

Similar results were obtained in our study. No significant differences were observed in the incidence of VC paresis/paralysis and persistent dysphonia in relation to surgeon's experience. So, it may supposed that understanding «Surgeon» variable solely as a measure of «experience» or «professionalism» regarding volume of previously performed operations does not fully reflect the impact of this variable on the results of interventions. Some factors including surgical style, assistant's experience, overall experience of surgical team, turn of surgery, fatigue of surgeon, etc. should also be considered in such trials rather absolute number of interventions alone («surgeon's experience» is not synonymous with «number of operations» per unit of time).

Influence of IONM

Researchers note that IONM do not provide significant advantages in most clinical situations (primary surgery, non-toxic goiter, small thyroid volume, no invasive growth of tumor, etc.) regarding prevention of RLN injury compared with visual detection of the nerves [12]. As a possible explanation, it is noted that surgeons usually use both visual finding of the nerves and neuromonitoring. So, it is difficult to calculate individual contribution of these methods into reduction of VC paresis rate [20].

According to our data, IONM was not significantly associated with reduced number of VC paresis in early postoperative period compared with isolated visual identification of RLN (4.19 and 4.32%, respectively; OR 0.98, 95% CI 0.60—1.64). The same is true for VC paralysis (0.85 and 0.82%, respectively; OR 1.012, 95% CI 0.61—1.68). These findings are consistent with the results of other authors [5, 18]. We did not find significant advantages of IONM in reducing the incidence of VC paresis, as well as causal relationship between frequency of successful RLN identifications and decrease of the number of VC paresis. Moreover, these was similar number of patients with long-standing dysphonia in both groups (21.9% without IONM and 20.6% with IONM).

These data are not unusual because IONM does not fundamentally prevent any injury. On the one hand, introduction of IONM into thyroid surgery was a stage of endocrine surgeons community work aimed at the problem of intraoperative trauma of RLN. On the other hand, IONM is advisable for only identification of RLN in surgical wound and assessment of its bioelectric function (amplitude of action potential and latent period). These properties explain the advantages of IONM in certain clinical situations. Firstly, IONM can give some advantage in addition to standard visual detection of RLN in case of anatomical features (non-recurrent nerve, RLN bifurcation, atypical course of the nerve in recurrent goiter) despite the need for visual identification of RLN during thyroid surgery. Clear nerve topography and its precise detection (whether certain structure in the wound is indeed a nerve) are essential to prevent VC paresis. Secondly, no electrical conductivity of anatomically intact nerve may be valuable to refuse contralateral thyroid procedure in order to eliminate the risk of bilateral injury of RLN and postoperative bilateral laryngeal paralysis.

Potential feasibility of bilateral RLN injury prevention by using of IONM has become the motive to rethink the approach to TE. Summarizing overall experience, it is possible to formulate some principles of this surgery: initial manipulations with dominant thyroid lobe followed by obligatory IONM of n. vagus — n. recurrens - m. vocalis after removal of the dominant thyroid lobe. Dominant lobe can have either the largest dimension or tumor or thyrotoxic node. One of the possible decisions should be considered if electrophysiological signal was lost on the dominant side: completion of surgery after dominant thyroid lobe excision (including primary suture of the nerve in case of thermal injury or intersection of RLN if it is possible), or continuing the operation with maximum caution, involvement of more experienced surgeon, permanent IONM, etc. Admission to specialized hospital to complete thyroidectomy (for example, thyroid cancer) or for radioiodine therapy (toxic goiter) may be advisable as a final stage of treatment.

In our work, IONM data justified change of surgical strategy in 3 patients (2 with NCG (0.66% from all patients with NCG) and 1 with thyroid cancer (0.22% from all patients with thyroid cancer). HTE was finally carried out. Other useful features of IONM are identification of non-recurrent laryngeal nerve; reduced time of RLN detection during redo surgery; improved quality of resection due to precise identifying RLN within entry point to the larynx and comprehensive excision of thyroid tissue in this area; intraoperative stimulating to observe branches of cranial nerve (n. accessorius, ansa cervicalis, n. phrenicus) and continuous mode of neuromonitoring (with stimulation of n. vagus).

Influence of time of surgery

Duration of surgery is associated with surgical technique and technical difficulties including those caused by manipulations near RLN. However, according to the literature data, duration of thyroidectomy is not a risk factor for paresis of vocal muscles [9]. The same data were confirmed in our study.

Influence of early postoperative hypoparathyroidism

Impaired blood supply of parathyroid glands and subsequent intra- and postoperative hypocalcemia can result dysfunction of vocal muscles. At the same time, we did not find literature data regarding the effect of hypoparathyroidism on the function of laryngeal nerves, vocal muscles and postoperative QoV.

Comparison of patients with and without hypoparathyroidism (PTH less than 15.0 and over 15.0 pg/ml, respectively) in early postoperative period did not reveal significant correlation with any clinical outcomes: incidence of VC paresis 8.70 and 7.74%, respectively, OR 1.14, 95% CI 0.66-1.96; VC paralysis — 1.24 and 1.61%, respectively, OR 0.77, 95% CI 0.20—2.91; persistent dysphonia — 23.36 and 20.40%, respectively, OR 1.14, 95% CI 0.66—1.96. Thus, we did not confirm effect of postoperative hypocalcemia on the incidence of early and late complications.

Influence of postoperative complaints

Postoperative complaints is the easiest method to diagnose RLN injury. According to our data, 35.0% of patients complained of impaired QoV in early postoperative period. However, in most patients, these complaints were not associated with vocal nerves injury, i.e. this method has very low specificity (69.8%) regarding diagnosis of VC paresis. Our data coincide with the opinion of other authors who note that impaired phonation may be caused by postoperative edema and inflammation of laryngeal mucosa, VC trauma during endotracheal intubation, hematoma and infection of postoperative wound. These disorders are usually transient and become subclinical within a few weeks or several months after surgery [13, 20].

Another problem with evaluation of complaints is that in some patients postoperative VC paresis may be asymptomatic or with minimal symptoms. In this regard, sensitivity of vocal symptoms in detecting VC paresis from 33 to 68% is reported in the literature [13, 20]. According to our results, sensitivity of complaints in diagnosis of VC paresis was 99.7% (VC paresis was diagnosed by laryngoscopy in 2 patients with preserved QoV).

Influence of VC paresis in early postoperative period

VC paresis occupies an ambiguous position in the structure of causal relationships of postoperative complications in thyroid surgery: on the one hand, it is a consequence of intraoperative events; on the other hand — causative factor determining QoV recovery rate, risk of VC paralysis and persistent dysphonia.

We revealed direct significant relationship between VC paresis and likelihood of VC paralysis (OR 1.6, 95% CI 1.22—2.09) and persistent postoperative dysphonia (OR 6.18, 95% CI 1.72—22.24) that is consistent with the results of other authors.

Considering clinical significance of VC paresis and its consequences, we performed ultrasound of the larynx in all patients in postoperative period and video-assisted laryngoscopy in those with dysphonia (in combination with impossibility of ultrasound examination). As a result, VC paresis was diagnosed in some patients without impairment of QoV. In our opinion, routine assessment of VC mobility is useful to estimate true number of unsatisfactory postoperative results and to correct surgical habits and manipulations within «risk areas» in order to avoid certain mistakes in the future.

Prediction of VC paresis, paralysis and persistent dysphonia in postoperative period

Prediction of VC paresis. According to the literature, age (over 50—55 years), partial intrathoracic thyroid, DTG, thyroid cancer, surgery for recurrent goiter, surgical technique, operation outside the specialized hospital, absence of IONM, little surgeon's experience are the most common predictors of VC paresis [13, 21].

In our trial, logistic regression confirmed the volume of surgical intervention and thyroid volume as independent predictors of VC paresis. TE + BLAE, PTE and thyroid gland

volume over 36.0 ml had a direct correlation with VC paresis while TE, HPE and thyroid volume less than 36.0 ml — inverse relationship with the likelihood of VC paresis.

Prediction of VC paralysis. Considering regression coefficients, male gender, thyroid volume over 36.0 ml and TE + BLAE were directly related to the likelihood of VC paralysis while thyroid volume less than 36.0 ml, surgical technique including TE, HTE and TE + CLAE reduced the likelihood of VC paralysis.

Prediction of persistent postoperative dysphonia. There was direct correlation of age and thyroid volume over 60.0 ml with postoperative dysphonia. Inverse relationship was noted for thyroid volume 36.0—60.0 ml.

Conclusion

We found following significant predictors of VC paresis: age, volume of surgery, thyroid volume and time of operation. Volume of operation and thyroid volume were also independent preoperative prognostic factors.

It was observed significant relationship of VC paralysis with sex, volume of operation, thyroid volume, duration of surgery and VC paresis. Sex, volume of operation and thyroid volume were also independent preoperative prognostic factors.

The following factors had significant relationship with persistent postoperative dysphonia: sex, volume of surgery, thyroid volume, duration of operation, impaired QoV and VC paresis. Age and thyroid volume were also independent preoperative prognostic factors.

BMI, experience of surgeon and assistant and postoperative hypoparathyroidism were not associated with clinical outcomes.

Several principles of surgical treatment of thyroid and parathyroid diseases may be proposed, justified and tested in view of our data: 1) consideration of some preoperative factors such as gender and age of patients, diagnosis, volume of surgery, thyroid volume, use of IONM to reduce the risk of complications; 2) surgery onset from the dominant thyroid lobe; 3) making a decision to continue operation only after electrophysiological study of n. vagus — n. recurrens — m. vocalis immediately after dominant thyroid lobe removal; 4) obligatory postoperative laryngoscopy or ultrasound of VC to objectively establish the incidence of VC paresis and to determine the duration and extent of further curative measures.

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