TENSION-FREE THYROIDECTOMY — RESULTS OF THE INITIAL 77 OPERATIONS

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BACKGROUND: Surgeons from all over the world make considerable efforts to reduce thyroid intraoperative complications such as recurrent laryngeal nerves trauma and parathyroid vascular supply damage.
AIM: The aim of the study was improving thyroidectomy technique to reduce the rate of postoperative complications.
MATERIALS AND METHODS: Inclusion criteria were primary thyroid operation in cases of papillary or medullary cancer, follicular tumours (Bethesda IV) and Grave's disease. Thyroid volume ranged from 12–70 ml. Tension-free technique of thyroidectomy (TFT) was suggested by the authors of this study. Key points of TFT are the following: the first step is the complete dissection of Berry ligament fibers and terminal branches of lower thyroid arteries and vein. There is only lateral traction while medial traction is not applied at all. Mobilization of the upper parathyroid gland is performed at the medial thyroid surface. Thyroid lobe is extracted out of its bed beginning with the lower pole only after complete dissection of Berry's ligament, vessels and parathyroid glands. The last step of the operation is the dissection of the upper pole thyroid vessels. The mobilized lobe is easily withdrawn downwards, that leads to space increase between external branch of the superior laryngeal nerve and the upper pole of the lobe. Transient and continuous neuromonitoring as well as optical magnification and headlamps were used during operations. Vocal cords function was controlled before and after surgery (on the first day) by means of ultrasound or endoscopic laryngoscopy. Ionized calcium and parathyroid hormone levels were checked in cases of total thyroidectomy group on the day of surgery, on the 1st and 14th postoperative days.
RESULTS: 77 consecutive patients were included into the study (continuous sampling of patients). 33 hemithyroidectomies, 13 hemithyroidectomies with central ipsilateral neck dissection, 21 thyroidectomies, 8 thyroidectomies with central neck dissection, 2 thyroidectomies with central and lateral neck dissection were performed by the same surgeon. All the operations were performed by tension-free technique (TFT). There were no cases of loss of signal from the recurrent laryngeal nerves function during all the operations. One case of postoperative transient hypoparathyroidism finished with normalization of parathyroid hormone and calcium levels in 2 weeks after the operation.
CONCLUSION: initial experience in TFT allows to recommend this procedure for further practicing and examination.

KEYWORDS: tension-free thyroidectomy; TFT; thyroidectomy technique; thyroidectomy complications.

МЕДИАЛЬНАЯ ТИРЕОИДЭКТОМИЯ — РЕЗУЛЬТАТЫ ПЕРВЫХ 77 ОПЕРАЦИЙ

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ОБОСНОВАНИЕ. Хирургами во всем мире прикладываются значительные усилия для снижения вероятности развития осложнений при операциях на щитовидной железе (ЩЖ), таких как травматизация возвратных гортанных нервов, нарушение кровоснабжения околощитовидных желез.
ЦЕЛЬ. Совершенствование методики тиреоидэктомии для снижения риска послеоперационных осложнений.
МАТЕРИАЛЫ И МЕТОДЫ. Критерием включения в исследование явилась первичная операция на ЩЖ. Показаниями к операции явились папиллярный и медуллярный рак ЩЖ, фолликулярные опухоли (Bethesda IV), болезнь Грейвса. Объем ЩЖ у пациентов находился в пределах 12–70 мл. Нами была предложена методика медиальной тиреоидэктомии, отличающаяся от наиболее часто используемой методики операции рядом особенностей: проведением полной диссекции связки Берри и рассечением терминальных ветвей нижних щитовидных артерий и вены в качестве первого этапа операции; наличием только латеральной тракции доли ЩЖ при полном отсутствии тракции в медиальном направлении; мобилизацией верхней околощитовидной железы с медиальной поверхности доли ЩЖ; выведением в операционную рану доли ЩЖ, начиная от нижнего полюса, только после полной мобилизации доли от связки Берри, сосудов, околощитовидных желез; пересечением сосудов верхнего полюса доли в качестве последнего этапа операции, при этом полностью мобилизованная доля легко отводится вниз, что увеличивает расстояние между наружной ветвью верхнего гортанного нерва и верхним полюсом доли. При операциях применялись переменный и постоянный нейромониторинг, оптическое увеличение, налобный осветитель. Контроль функции гортани производился до операции и в 1-е послеоперационные сутки. После проведения тиреоидэктомии производился контроль уровня паратгормона и ионизированного кальция крови (в день операции, на 1-й послеоперационный день, через 14 дней после операции).

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РЕЗУЛЬТАТЫ. Методика была применена одним хирургом при проведении 77 последовательных операций на ЩЖ. В ходе исследования выполнено 33 лобэктомии, 13 лобэктомий с ипсилатеральной центральной шейной лимфодиссекцией, 21 тиреоидэктомия, 8 тиреоидэктомий с центральной шейной лимфодиссекцией, 2 тиреоидэктомии с центральной и боковой шейной лимфодиссекцией. Нарушения функции возвратного гортанного нерва не встречалось ни в одном случае. Транзиторный гипопаратиреоз отмечен у одного пациента, однако через 2 нед после операции уровни паратгормона и кальция крови нормализовались.

ЗАКЛЮЧЕНИЕ. Первичные результаты исследования позволяют рекомендовать данную методику к дальнейшему использованию и изучению.

КЛЮЧЕВЫЕ СЛОВА: медиальная тиреоидэктомия; методика тиреоидэктомии; осложнения после тиреоидэктомии.

BACKGROUND

Thyroid gland surgery can result in several complications, including inferior laryngeal (recurrent) nerve palsy, hypoparathyroidism, superior laryngeal nerve palsy, and bleeding, which are most common and clinically significant [1, 5]. Significant efforts are made by surgeons worldwide to reduce the probability of occurrence of these complications. The main tendency to control the above-mentioned complications includes improvement of the technical means during the surgery, namely the using intraoperative neuromonitoring to control the condition of the laryngeal nerves [2], finding the parathyroid glands and controlling their perfusion [3], and ligating the vessels and separating the tissues (harmonic scalpel and electrocoagulation) [4]. Great importance is also attached to the accumulation by surgeons of experience in performing surgeries on the thyroid gland [5].

Thyroidectomy technique. Relatively, few scientific works focused on improving the basic technique of thyroidectomy. The technique of this surgery is rather standard. In the overwhelming majority of clinics, when performing both open and video-assisted surgeries, the surgery procedure consists of the following sequential stages:

- surgical approach to the thyroid gland;
- separation of the isthmus (not in all cases);
- separation of the upper pole vessels with or without superior laryngeal nerve visualization;
- transposition of the thyroid gland lobe into the surgical wound;
- division of the medial thyroid vein (Kocher's vein);
- visualization of the recurrent laryngeal nerve (RLN) (can be performed earlier, before the separation of the upper pole vessels);
- separation of the inferior thyroid veins and preservation of the inferior parathyroid gland;
- separation and preservation of the superior parathyroid gland;
- transection of the medial aspects of Berry's ligament, division of the inferior thyroid artery, and complete removal of the thyroid lobe.

The sequence of stages may vary to some extent (clinics lastly separate the upper pole vessels); however, the general principles of traditional thyroidectomy usually remain unchanged:

- the thyroid gland vessels and the inferior laryngeal nerve are isolated from the lateral side of the thyroid gland lobe;
- traction of the thyroid lobe is performed medially, toward the trachea;
- complete separation of the thyroid gland lobe from the trachea and transection of the inferior thyroid artery after mobilization of the parathyroid glands and visualization of the RLN.

Inferior laryngeal (recurrent) nerve palsy. A significant number of works demonstrated that traction mechanism is the main development of the RLN palsy [6, 7, 8]. The probability of a conduction disorder along this nerve due to its tension during surgery significantly exceeds the probability of direct damage. Complex high-tech techniques (continuous and intermittent neuromonitoring) have been proposed to control the degree of traction [8]. Concurrently, the very technology of the surgery did not significantly change even with the neuromonitoring introduction.

Superior laryngeal nerve palsy. The superior laryngeal nerve is often damaged through direct nerve action (ligation and coagulation) [9]. The nerve is especially affected often in patients with a significant thyroid volume and a short neck because in this case, the superior laryngeal nerve often passes between the branches of the superior thyroid vessels below the upper margin of the thyroid lobe (Fig. 1) [10]. Variable neuromonitoring is usually used, and in some cases, endoscopic imaging of the nerve, to reduce the risk of superior laryngeal nerve damage.

Hypoparathyroidism. The function of the parathyroid glands is preserved through their visualization and careful preservation of the feeding vessels. Techniques for controlling the perfusion of the parathyroid glands enable the assessment of blood supply to the glands after their separation from the thyroid gland [11]. The traction mechanism can also cause blood supply disorder to the parathyroid glands, as when the upper pole of the thyroid gland is displaced into the surgical wound, the vessels of the superior parathyroid gland are stretched, which can result in damage to the intima and intravascular thrombosis.

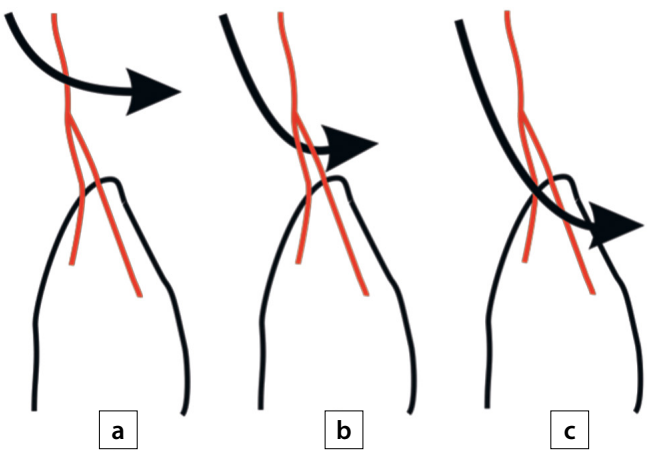

Fig. 1. Anatomical variations of the superior laryngeal nerve.

Bleeding. The inferior thyroid artery is well known to provide approximately 80% of the blood supply to the thyroid gland. Concurrently, the transection of this vessel is usually performed at the last stage of the surgery, later than the medial and inferior thyroid vein transection. Blocking the venous outflow from the thyroid gland while maintaining arterial supply increases the blood pressure in the thyroid tissue, which increases tissue bleeding and the risk of intraoperative hemorrhage. The intersection of the upper pole vessels in the early stages of surgery reduces arterial blood supply but does not eliminate it since the superior thyroid artery provides only approximately 20% of blood to the thyroid gland.

AIM

This study aimed to develop a thyroidectomy technique with reduced the risk of traction injury of the RLN and reduced risk of postoperative hypoparathyroidism.

MATERIALS AND METHODS

Location and period of the study

Location. The study was conducted at the St. Petersburg State University, at the N.I. Pirogov Clinic of High Medical Technologies of federal subordination (St. Petersburg).

Study period. The study was prospectively conducted from August to October 2021.

Study populations (one or more)

Inclusion criteria. The criterion for enrollment in the study was primary thyroid surgery.

There were no *exclusion criteria*.

Indications for thyroid gland surgery include follicular tumor (Bethesda IV), thyroid carcinomas (Bethesda VI), Graves' disease, diffuse toxic goiter, multinodular toxic goiter, and diffuse multinodular non-toxic goiter.

Method of sampling from the studied population (or several samples from several populations under the study)

The sampling was performed by continuous inclusion of cases.

Study design

Study design description:

- one-center,
- interventional,
- one-time (patients are monitored once),
- prospective,
- patient follow-up period was up to 2 weeks after surgery.

The laryngeal function in patients was examined before surgery and on postoperative day 1.

The parathyroid hormone and blood calcium levels were evaluated only in patients who underwent total thyroidectomy (31 patients). The level of parathyroid hormone was assessed 1 h after the surgery and on postoperative day 1. The ionized calcium level was assessed on postoperative day 1. In the case of a decreased level of parathyroid hormone after the surgery, its level was redetermined after 14 days.

- one-sample,
- uncontrollable,
- non-randomized

Description of the medical intervention (for interventional studies)

Principles of tension-free thyroidectomy technique (TFT)

The authors proposed a method of medial thyroidectomy, which mainly differ from traditional thyroidectomy in the following:

- complete mobilization of the thyroid gland lobe from the trachea after transection of the isthmus by dissecting Berry's ligament as stage 1 of the surgery (Fig. 2);
- the intersection of small branches of the inferior thyroid artery and vein that extend toward the thyroid tissue, as stage 2 of the surgery (Fig. 3) with complete mobilization of the thyroid lobe from the trachea and related vessels. The main trunk of the inferior thyroid artery and vein is preserved along with the branches that extend toward the parathyroid glands. The veins of the thyroid gland (medial, inferior, and superior) are not intersected at this stage;
- stage 3 (Fig. 4) with a lateral elevation of the mobilized lobe of the thyroid gland in the complete absence of the lobe traction in the medial and upper direction during the entire surgery period;
- stage 4 (Fig. 5) with complete isolation of the RLN from the medial side of the thyroid lobe only after the lobe is completely separated from the trachea and inferior thyroid vessels;
- stage 5 (Fig. 6) with isolation of the vessels of the superior and inferior parathyroid glands from the medial side of the thyroid lobe;
- stage 6 (Fig. 7) with transposition of the lower pole of the lobe into the surgical wound only after complete parathyroid gland mobilization;
- stage 7 (Fig. 8) with the intersection of the upper pole vessels (always the last stage of the surgery, whereas the fully mobilized lobe of the thyroid gland is easily retracted downward, which increases the distance between the *m.cricothyroideus* and the upper pole of the lobe and reduces the risk of outer branch damage of the superior laryngeal nerve).

Methods

Methods for determining inclusion criteria included analysis of preoperative examination data, namely thyroid gland ultrasound, neck and upper mediastinum computed tomography, thyroid nodule fine-needle aspiration biopsy (FNAB), thyroid scintigraphy, blood tests for thyroid-stimulating hormone (TSH), free T3, free T4, antibodies to the TSH receptor, and calcitonin.

The thyroid gland ultrasound was performed using expert class devices.

The thyroid nodule FNAB was performed under ultrasound control in the presence of nodules with 1 cm or larger size. The cytological material was assessed according to the Bethesda classification.

Ultrasound laryngoscopy was performed when clear ultrasound imaging of the vocal folds was possible and in patients with calcified laryngeal cartilage.

The level of ionized calcium in the blood was assessed using an EasyLight Calcium analyzer, and the level of parathyroid hormone was evaluated using a DiaSorin Liaison XL analyzer.

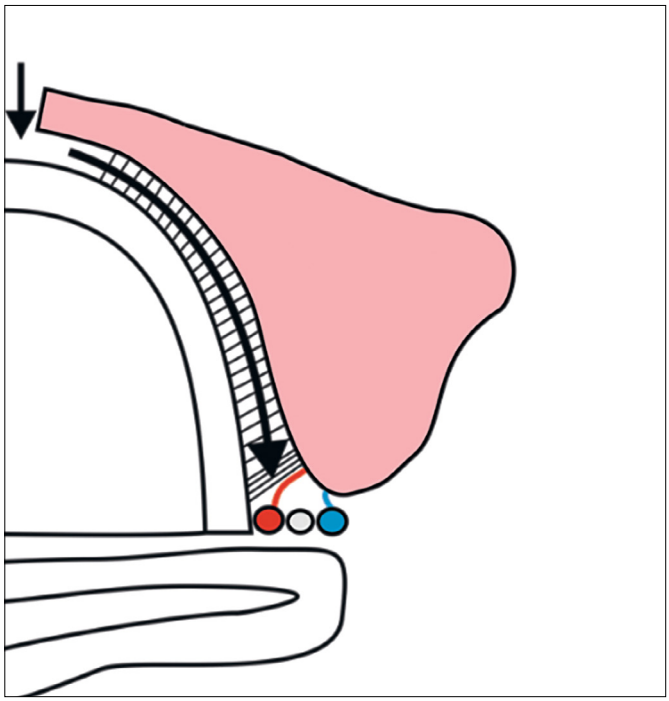

Fig. 2. Stage 1 of the surgery, dissection of Berry's ligament.

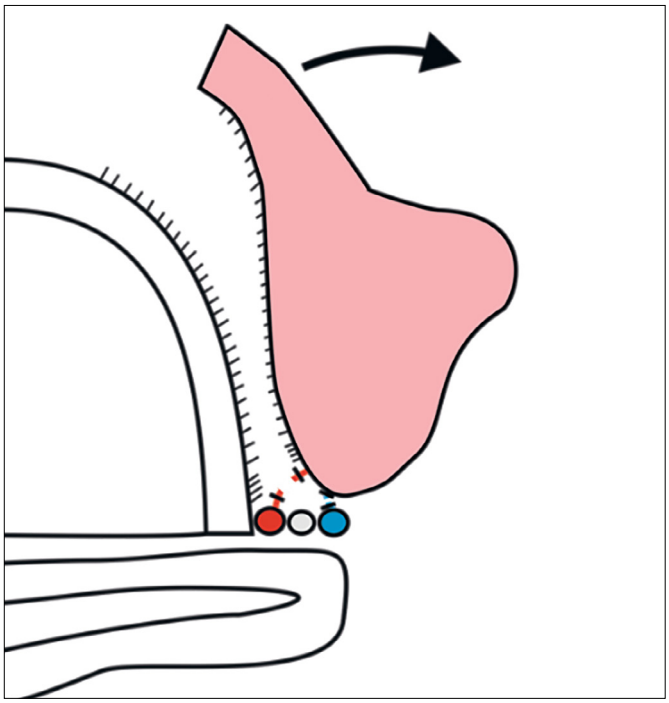

Fig. 3. Stage 2 of the surgery, the intersection of the major branches of the inferior thyroid artery and vein.

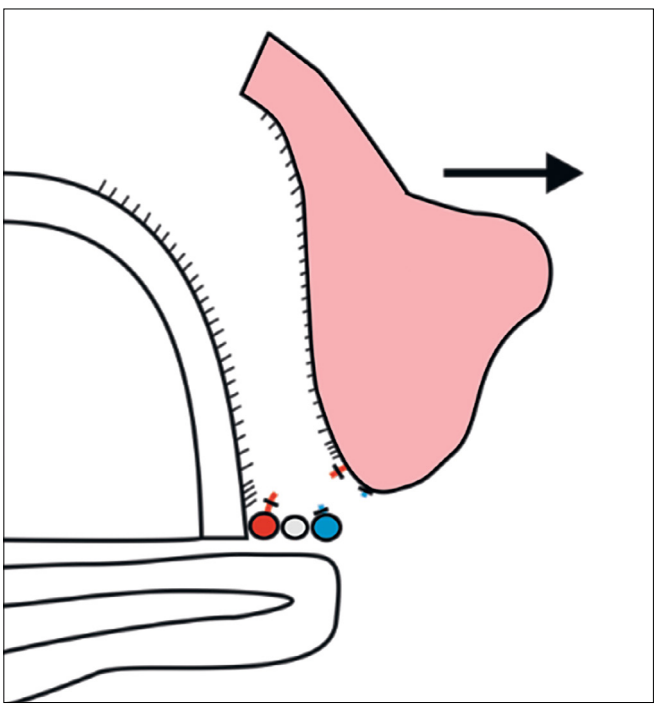

Fig. 4. Lateral elevation of the mobilized lobe of the thyroid gland in the complete absence of the lobe traction in the medial direction during the entire surgery duration.

When performing the surgery, the following were used:

- binocular magnifiers (×2.5), Univet;
- electrocoagulator, Erbe Vio;
- harmonic scalpel, Ethicon Harmonic;
- for Graves' disease, Erbe Bi-Clamp;
- neuromonitor, Inomed C2 (variable stimulation at 5 mV, constant stimulation at 2 mV);
- headlamp, Dr. Kim DKH-50 with a video camera;
- titanium clips 3 mm.

The laryngeal nerve function was monitored using an Inomed C2 neuromonitor (stimulation at 5 mV). The vagal nerve function before (V1) and after surgery (V2) was compared, as well as the RLN function before (R1) and after surgery (R2). The superior laryngeal nerve function was assessed at the beginning and the end of surgery by direct stimulation and assessment of the muscle and electrical responses.

Statistical analysis

No statistical methods were used.

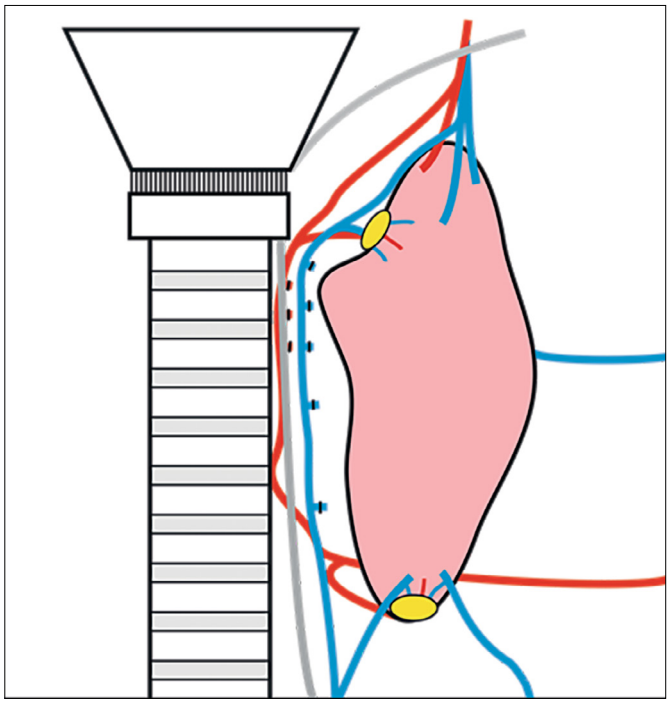

Fig. 5. Complete isolation of the recurrent laryngeal nerve from the medial side of the thyroid lobe after complete separation of the lobe from the trachea and inferior thyroid vessels

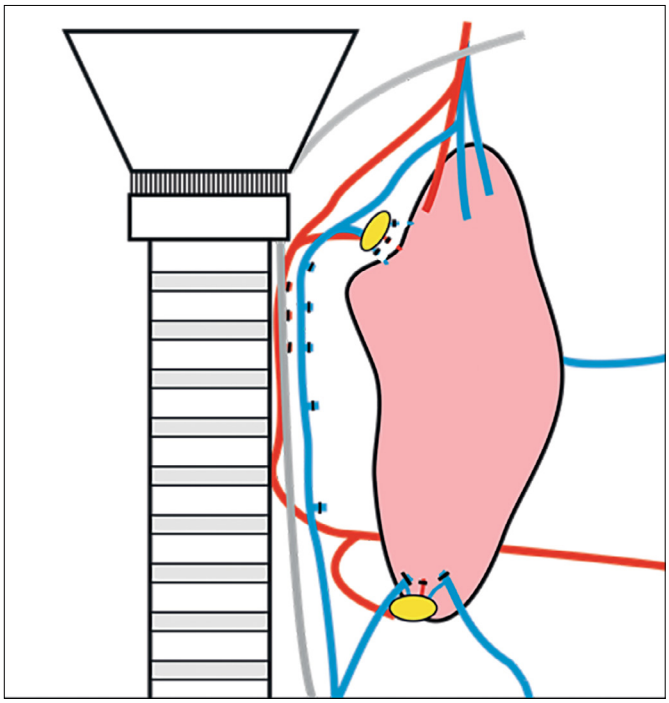

Fig. 6. Isolation of the vessels of the superior and inferior parathyroid glands from the medial side of the thyroid lobe.

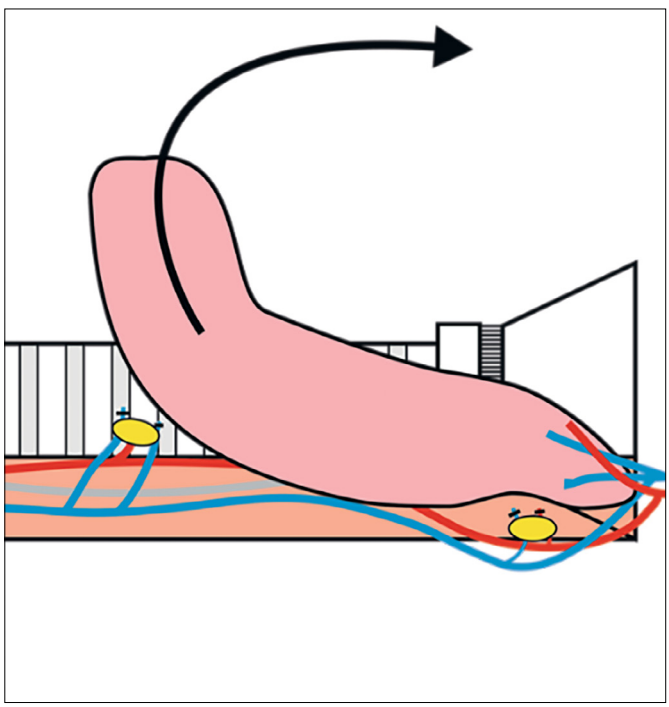

Fig. 7. Transposition of the lower pole of the lobe into the surgical wound after a complete parathyroid gland mobilization.

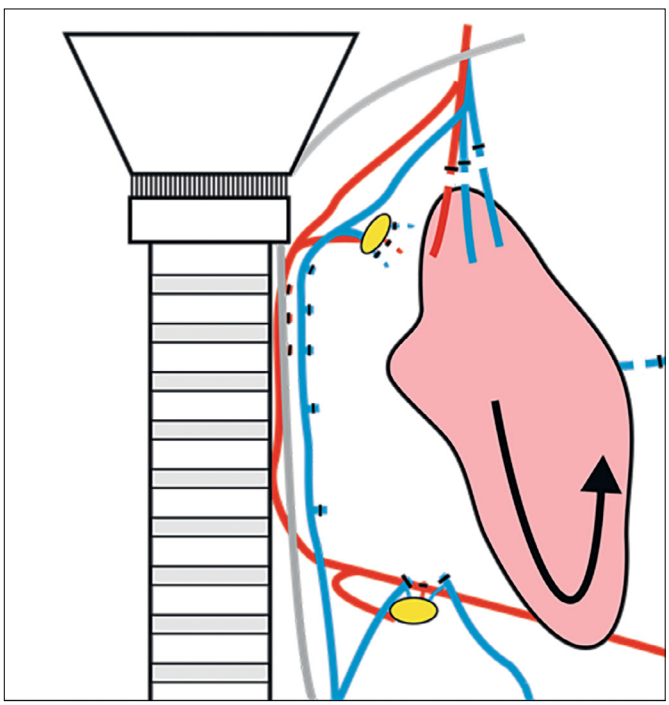

Fig. 8. The intersection of the upper pole vessels as the final stage of surgery.

Ethical considerations

Biomedical Ethics Committee of the N.I. Pirogov Clinic of High Medical Technologies (polyclinic, hospital) of St. Petersburg State University approved the single-center clinical study "Improvement of the thyroidectomy technique," protocol number 07-1/21 of 07/20/2021.

RESULTS

During this period, the same surgeon (I.V. Sleptsov) performed 77 surgeries on the thyroid gland. The structure of surgeries is presented in Table 1. The age and gender composition of patients are presented in Table 2. Indications for surgery are presented in Table 3.

Surgery duration. The average duration of the surgery was 54 min for hemithyroidectomy, 100 min for thyroidectomy, 60 min for hemithyroidectomy with central cervical lymphadenectomy, and 117 min for thyroidectomy with central cervical lymphadenectomy.

RLN function. RLN dysfunction was not registered in any case. In all cases, the nerve function remained completely

stable during the entire time of the intervention. The amplitude of the RLN signal at the beginning of the surgery was equal to or greater than the signal amplitude at the end of the surgery in all cases. No decreased amplitude or loss of signal (LOS) was determined during the entire duration of the surgery (monitoring of the RLN function was performed every 2 min).

The function of the superior laryngeal nerve. The superior laryngeal nerve function was preserved in all cases.

Laryngeal function. Impaired mobility of the vocal folds before and after surgery was not noted in any case.

The function of the parathyroid glands. After thyroidectomy (31 patients), a decreased blood level of the parathyroid hormone 1 h after the surgery was noted in one patient, whose histological specimen comprised an accidentally removed parathyroid gland. On postoperative day 1, the level of blood parathyroid hormone was within the normal range in all but one patient. In this patient, the levels of parathyroid hormone and ionized calcium in the blood were studied 2 weeks after the surgery, and the normalization of these parameters was noted.

Postoperative bleeding. No postoperative hematomas or bleeding during the study were registered.

DISCUSSION

Representativeness of samples

The total number of surgeries performed using the medial thyroidectomy technique reveals the possibility of its use for any volume of thyroid surgery.

Comparison with other techniques

During surgical interventions using neuromonitoring, the authors noted the development of conduction disorders of the inferior laryngeal (recurrent) nerve only in cases when the traction of the thyroid lobe was performed in the direction "toward the trachea" (medially) or "medially and upward." In the case of lateral thyroid lobe traction, the electrical function of the nerve remained completely stable, without any deviations from the primary parameters recorded at the beginning of the surgery.

This phenomenon is anatomically explained, as the branches of the inferior thyroid artery and veins often extend from different sides of the RLN, therefore, their tension in the medial direction and pressing against the dense tissue of the trachea causes local compression of the recurrent nerve trunk and impaired conduction along with it (Fig. 9). The use of intraoperative neuromonitoring clearly showed the relationship between the degree of traction and its direction and the degree of signal amplitude decrease and the risk of complete LOS, even while maintaining the macroscopic nerve integrity.

Clinical significance of results

When implementing the TFT method proposed by the authors, five basic principles are observed:

1. The surgery is performed with the obligatory use of intermittent neuromonitoring (5 mV). The use of continuous neuromonitoring is possible but is not mandatory since the RLN conduction is not decreased when the surgery is correctly performed in the study. Neuromonitoring in TFT is used to monitor the location of the nerves and not their function.

Table 1. Structure of thyroid surgeries performed within the study.

Surgery	Number of patients	Nerves at risk
hemithyroidectomy	33	33
hemithyroidectomy with central cervical lymphadenectomy	13	13
thyroidectomy	21	42
thyroidectomy with central cervical lymphadenectomy	8	16
thyroidectomy with central and lateral cervical lymphadenectomy	2	4
Total	77	108

Table 2. Age and gender composition of patients.

Gender	Number of patients	Age
male	16	49±32
female	61	45±29

Table 3. Indications for thyroid surgery.

Diagnosis	Number of patients
a follicular tumor (Bethesda IV)	32
thyroid cancer (Bethesda VI)	32
Graves' disease	9
multinodular toxic goiter (Bethesda II)	3
multinodular non-toxic goiter (Bethesda II)	1
Total	77

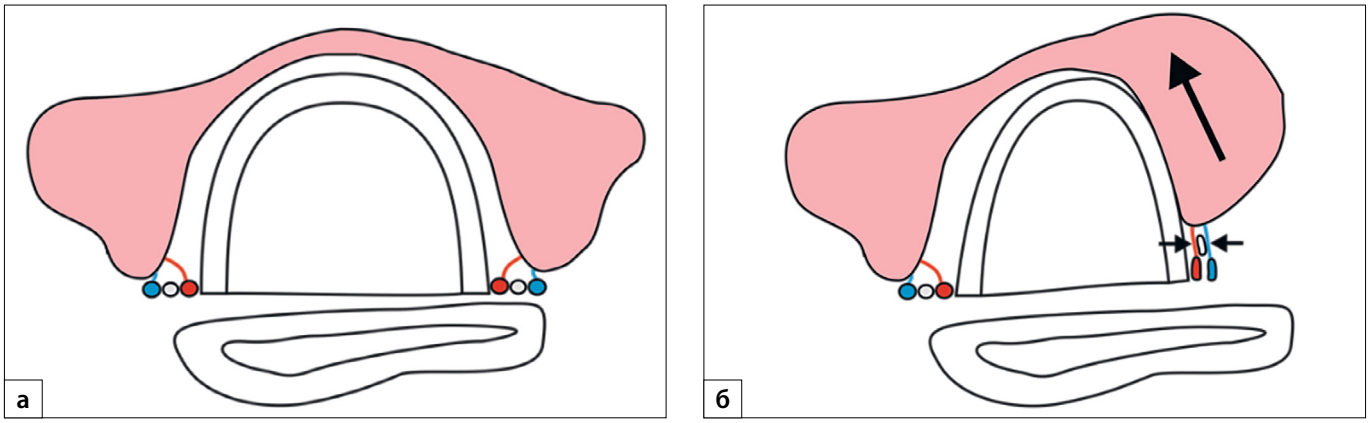

Fig. 9. The relationship of the inferior thyroid vessels and the recurrent laryngeal nerve: normal (a) and with the traction of the thyroid lobe in the medial direction (b).

2. During the thyroid lobe mobilization until the lobe is completely separated from the trachea, traction is performed only in the lateral direction. This principle is most significant and cannot be violated.
3. The thyroid gland lobe must be completely separated from the trachea and branches of the inferior thyroid arteries and veins before any thyroid displacement. The branches of the inferior thyroid artery are coagulated, ligated, or clipped during the mobilization of Berry's ligament. The use of titanium clips greatly facilitates the surgery.
4. Only the terminal branches of the inferior thyroid artery are divided; the artery trunk is preserved along its entire length. In most cases, the trunk of the artery is preserved up to the superior parathyroid gland. In the presence of connecting branches with the superior thyroid artery (found in most patients), connecting branches are also preserved.
5. The parathyroid glands should not be subjected to traction. Translocation of the thyroid gland lobe into the wound is possible only after complete separation from the lobe of the RLN and parathyroid glands.

According to the authors, TFT has shown its clear advantages over traditional surgery as follows:

1. Separation of the thyroid gland lobe from the trachea and the lobe traction only in the lateral direction almost exclude a decreased conduction of the RLN. The signal amplitude did not change during the surgery in any patient. No cases of LOS were found. The RLN function was remarkably stable throughout the surgery without any changes. The experience of surgeries according to the traditional technique indicates the presence of fluctuations in the nerve function in most surgeries. Such changes in function are far from significant and lead to laryngeal dysfunction; however, nerve function fluctuations are almost always registered, and almost always the final signal amplitude after surgery is lower than the initial amplitude recorded before surgery. During TFT, signal changes were completely absent in all cases, without any exceptions. In the study, patients with rather complicated cases (Graves' disease with a thyroid gland volume of 70 ml and 50 ml; patients with papillary cancer with Hashimoto thyroiditis; patients with thyroid follicular tumors of 50–95 mm in size) received surgical treatment. Despite this, no changes in the conduction of the RLN were registered in any case.
2. Intersection of branches of the inferior thyroid artery at an early stage of the surgery reduces the blood supply to the thyroid tissue and eliminates hypertension in the tissue, which reduces bleeding during the surgery. No cases of bleeding were recorded during the surgery, as well as hematomas in the postoperative period.
3. The inferior thyroid artery dissection from the medial surface of the thyroid lobe preserved its trunk and branches to the parathyroid glands. No cases of persistent hypoparathyroidism were observed after the surgery in the study.
4. Transection of the upper pole vessels as the final stage of the surgery increased the distance between the superior laryngeal nerve and the thyroid tissue, which ensured the preservation of the superior laryngeal nerve function in all patients (confirmed by intraoperative neuromonitoring).
5. In the absence of thyroid gland lobe traction in the medial direction and the absence of attempts to dislocate the lobe of the thyroid gland into the surgical wound at the beginning of the surgery, the trunk of the RLN does not approach the thyroid gland tissue. During all surgeries, the minimum distance between the nerve and the gland tissue is approximately 5 mm. The proximity of the nerve to the gland tissue, often described in the literature, is a direct consequence of traction behind the lobe in the medial direction. Such traction creates the illusion of close contact between the nerve and the gland tissue.
6. When isolating Berry's ligament, no branches of the RLN located between the ligamentous leaves, in any case, were observed. During the study, patients had an accessory motor branch of the recurrent nerve; however, in all cases, this branch passed behind Berry's ligament and was not connected with it in any way.
7. The complexity of TFT was equal for males and females.
8. Result analyses revealed that TFT makes the thyroidectomy technique anatomically and functionally logical as follows:
   - the main source of blood supply to the thyroid gland is divided at the very beginning of the surgery;
   - functionally important anatomical structures (RLN and parathyroid glands) are completely separated from the thyroid tissue until the lobe is removed above the skin level, which ensures the preservation of their function;

- the preservation of the superior laryngeal nerve is ensured by the traction of the thyroid lobe downwards, followed by the separation of the branches of the superior thyroid vessels close to the thyroid tissue. Such traction does not damage the laryngeal nerve since no tight connections are made between the nerve and the vessels.

9. When performing a TFT surgery, the surgeon primarily concentrates his efforts on fundamentally solving important issues, namely RLN and parathyroid gland mobilization while preserving the blood vessels that supply them. During stage 1 of the surgery, the thyroid gland is in its original position, which prevents the development of complications. Lateral displacement of the thyroid lobe does not affect the function of the RLN, which allows the surgeon to freely manipulate the surgical wound.

Study limitations

The technique has several disadvantages as follows:

1. At this stage of technique development, TFT has a longer duration compared with traditional thyroidectomy. The time to complete the surgery progressively decreased during the study, which indicates the accumulation of the experience of surgeons in performing TFT.
2. TFT requires intraoperative neuromonitoring since monitoring is necessary to control the direction of the nerve under conditions of limited visibility.
3. TFT requires the use of a binocular magnifier to improve the anatomical visualization of structures. The surgery can be performed without optical magnification; however, with its presence, the precision of the surgeon's actions is significantly increased. Using a headlamp during the surgery is also recommended since the surgeon has to perform manipulations in a narrow operating space.
4. TFT cannot be endoscopically performed since the precision of vascular coagulating devices is still insufficient and their use on the medial surface of the thyroid lobe is difficult.
5. TFT is complicated if it is impossible to dissect the isthmus of the thyroid gland (Graves' disease in the presence of a thick isthmus and malignant nodes in the isthmus). During the study, not a single case was impossible in the transection of the isthmus.
6. TFT can be difficult in case of a significant volume of the thyroid gland, as well as with increased bleeding since manipulation in the narrow space between the surface of the trachea and the medial surface of the thyroid lobe is difficult. Concurrently, surgeries were performed on patients with Graves' disease with a thyroid gland volume of >70 ml and in cases of thyroid nodules with a diameter of >7 cm; in all cases, TFT was successfully performed, albeit with additional time costs.

Directions for further research

Continuing this work with studies to assess the parathyroid gland perfusion during a thyroid gland surgery is recommended.

CONCLUSION

TFT is a safe procedure to reduce the risk of complications during thyroidectomy. The obvious advantages of TFT in comparison with the traditional thyroidectomy include the elimination of conduction disorders of the inferior laryngeal nerve, bleeding reduction of the thyroid tissue, and vascular supply preservation of the parathyroid glands. Thus, this technique is recommended for further practice and study.

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