

Surgical Injury and the Immune Inflammatory Response in Various Types of Strumectomy of Giant Goiter

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Abstract The aim of the study was to evaluate the impact of different types of strumectomy for giant nodular retrosternal goiter on the severity of the systemic inflammatory response based on a retrospective cross-sectional cohort clinical study. **Background.** Massive thyroid gland formations not only cause compression syndrome with impaired breathing, swallowing and phonation, but also require technically complex and invasive surgical procedures. The choice of surgical approach for a giant goiter is a key factor that determines not only the technical feasibility of radical removal of the formation, but also the severity of the postoperative inflammatory response. **Materials and Methods.** The study included 184 patients, divided into two comparable groups (1:1). In Group I (n=92), strumectomy was performed via the standard Kocher cervical approach; in Group II (n=92), it was performed via a longitudinal-transverse approach. The traumatic nature of the procedure was evaluated based on changes in markers of systemic inflammation (C-reactive protein, white blood cell count and erythrocyte sedimentation rate), as well as an analysis of the incidence of postoperative complications and the duration of the hospital stay. **Results.** It has been established that the use of a transverse-longitudinal approach was associated with a statistically significantly less pronounced systemic inflammatory response, as confirmed by a significantly lower level of C-reactive protein in the postoperative period (9.1 ± 4.8 mg/L versus 10.7 ± 5.3 mg/L in Group I; $p=0.030$). In group II, a statistically significantly lower incidence of postoperative complications was observed (10.9% vs. 25.0%; $p=0.018$), including a complete absence of cases of recurrent laryngeal nerve paresis and postoperative hematomas. A moderate positive correlation was found between C-reactive protein levels and length of hospital stay ($\rho = 0.42$; $p < 0.001$). **Conclusions.** The transverse-longitudinal approach in giant goiter strumectomy offers significant advantages, including reduced intraoperative injury, minimization of the systemic inflammatory response, a lower incidence of postoperative complications, and a shorter rehabilitation period, making it the preferred method for the surgical treatment of this pathology.

Keywords Giant nodular goiter, Strumectomy, Surgical approach, Systemic inflammatory response, C-reactive protein, Postoperative complications

1. Introduction

Surgical treatment of giant forms of nodular goiter, especially in the retrosternal region, remains one of the most challenging tasks of thyroid surgery [1]. Massive thyroid gland formations not only cause compression syndrome with impaired breathing, swallowing and phonation, but also require technically complex and invasive surgical procedures [2]. Traditionally, the outcomes of such procedures are evaluated based on criteria such as the extent of pathological tissue removal, the incidence of specific complications (injury of recurrent laryngeal nerves, hypoparathyroidism), and the normalization of hormonal status. However, recent surgical practice has increasingly focused on the evaluation of the systemic inflammatory response as a comprehensive marker of the injury caused by surgical intervention [3].

Any surgical procedure is accompanied by a natural response from the body, manifested by the activation of immune inflammatory processes, the severity of which depends directly on the extent and invasiveness of the surgery [4]. The most commonly used objective laboratory markers reflecting the severity of systemic inflammation are C-reactive protein (CRP) levels, peripheral blood white blood cell (WBC) count, and erythrocyte sedimentation rate (ESR) [5]. Their changes during the postoperative period allow to quantitatively estimate the degree of surgical stress and compare the invasiveness of various surgical approaches [6].

The choice of surgical approach in cases of giant goiter is a key factor that determines not only the technical feasibility of radical removal of the formation, but also the severity of the postoperative inflammatory response [7]. Although the classic Kocher cervical approach (also known as the Kocher collar incision) is the standard for most thyroid surgeries, in

cases of giant goiters—and especially retrosternal goiters—it may require excessive tissue traction, difficult visualization of anatomical structures, and, as a result, more significant injury [8]. An alternative is a combined approach with the use of a longitudinal-transverse sternotomy, which provides broader exposure of the surgical field and potentially less traumatic dissection of a voluminous formation [9].

Currently, there are not enough studies in the literature devoted to a comparative analysis of the various surgical approaches impact used in strumectomy for giant goiter on the severity of the systemic inflammatory response [10]. Filling this gap presents an important challenge, as minimizing surgical trauma is one of the key factors determining a favorable postoperative course, shorter hospital stays, and improved immediate treatment outcomes [11].

A comparative analysis of the injury rates associated with various surgical approaches in the strumectomy of a giant goiter is not only theoretically significant but also has important practical applications [12]. A comparative analysis of the injury rates associated with various surgical approaches in the strumectomy of a giant goiter is not only theoretically significant but also has important practical applications [13]. The severity of systemic inflammation is directly correlated with the duration of postoperative inpatient care, the rehabilitation period, and the risk of complications such as wound infection or thromboembolic episodes [14]. Consequently, choosing a surgical technique associated with a minimal immune-inflammatory response is one way of increasing the safety and efficiency of surgical treatment [15].

The objectives of the study were to determine baseline levels of inflammatory markers, to evaluate their changes during the early postoperative period, to conduct a comparative analysis of the severity of the inflammatory response between groups, and to analyze the relationship between markers levels (in particular, C-reactive protein) and the hospital stay duration [16]. The results of this study will allow an objective evaluation, based on laboratory criteria, to assess the advantages and disadvantages of each surgical approach in terms of intraoperative injury and may serve as an additional factor in selecting the optimal approach in a particular patient [17].

The aim of the study was to evaluate the impact of different types of strumectomy for giant nodular retrosternal goiter on the severity of the systemic inflammatory response based on a retrospective cross-sectional cohort clinical study.

2. Materials and Methods

This study was conducted at the Department of Lung and Mediastinal Surgery of the Republican Specialized Scientific and Practical Medical Center of Surgery named after V. Vakhidov. This retrospective-prospective analysis included 184 patients with a confirmed diagnosis of giant nodular goiter who were performed strumectomy between 2010 and 2023.

Depending on the surgical approach used, patients were divided into two groups that were comparable in terms of key demographic and clinical parameters:

Group I (n=92) included patients operated through the standard cervical approach according to Kocher;

Group II (n=92) consisted of patients who underwent a combined intervention using cervical access and longitudinal-transverse sternotomy.

The inclusion criteria for patients in the study were as follows:

Patients with a confirmed diagnosis of giant nodular goiter;

Indications for surgical treatment (strumectomy);

Conducting the surgery between 2010 and 2023 at the Republican Specialized Scientific and Practical Medical Center of Surgery named after acad. V. Vakhidov.

Performing a strumectomy using one of the two studied approaches (standard cervical access according to Kocher, combined approach with longitudinal-transverse sternotomy);

Availability of a full range of the following clinical and laboratory data before surgery and on the 1st–2nd day after surgery (measurement of C-reactive protein (CRP) levels; white blood cell count (WBC); erythrocyte sedimentation rate (ESR));

The ability to assess postoperative outcomes (complications and the duration of hospital stay).

The exclusion criteria for patients were:

Absence of a giant nodular goiter verified diagnosis;

Performing a surgical intervention other than the types of strumectomy being studied;

Absence of laboratory test results (CRP, WBC, ESR) during the preoperative period or on the 1st–2nd day after surgery;

Incomplete clinical data that did not allow for an assessment of postoperative complications or the duration of hospital stay;

Patients who did not undergo surgery at the study center or outside the period 2010–2023.

The main focus of the study was to evaluate the severity of the systemic inflammatory response as a marker of surgical injury. All patients were tested for laboratory markers of inflammation during the preoperative period and on 1–2 days after surgery: serum C-reactive protein (CRP) levels, white blood cell (WBC) count and erythrocyte sedimentation rate (ESR). The CRP level was determined with the use of turbidimetric method, and the WBC count was measured using a “Sysmex XN-550” hematology analyzer.

At the same time, data on the duration of hospital stay were analyzed, and intraoperative and postoperative complications (bleeding, recurrent laryngeal nerve paresis, hypoparathyroidism) were recorded, as well as the extent of the procedure performed (total, subtotal, hemistrumectomy).

The statistical analysis was performed using StatTech v. 4.1.5 (developed by StatTech LLC, Russia). We used the Shapiro-Wilk test to check whether the distribution of the quantitative variables was normal. Normally distributed

quantitative data were described as mean and standard deviation ($M \pm SD$), with 95% confidence interval (95% CI). Data with a non-normal distribution were described as median and interquartile range ($Me [Q_1-Q_3]$). Categorical variables were described by absolute values and percentages.

To compare the quantitative measures of two independent groups, the Student's t-test (for a normal distribution) or the Mann-Whitney U test (for a non-normal distribution) was used. The proportions in the contingency tables were compared using Pearson's chi-square test or Fisher's exact test. Spearman's correlation coefficient (ρ) was used to evaluate the relationship between quantitative variables. Differences were considered statistically significant at $p < 0.05$.

3. Results

The conducted analysis revealed systematic and statistically significant differences in the severity of the systemic inflammatory response between the two groups of patients who underwent strumectomy due to giant nodular goiter using different surgical approaches.

Initially, there were no statistically significant differences in the levels of laboratory markers of inflammation between the groups. However, a clear pattern was observed during the postoperative period.

C-reactive protein (CRP) levels decreased significantly after surgery in both groups ($p < 0.001$); however, this decrease was more pronounced in Group II (transverso-longitudinal sternotomy). While in Group I (Kohler access), the mean C-RB concentration decreased from 25.9 ± 13.7 mg/L to 10.7 ± 5.3 mg/L, in Group II it decreased from 28.4 ± 12.9 mg/L to 9.1 ± 4.8 mg/L. At the same time, during the postoperative period, the mean C-reactive protein level in Group II was statistically significantly lower than in Group I ($p=0.030$) (Tab. 1).

Table 1. Analysis of the CRP values dynamics depending on the studied group of patients

Indicator	Group I (mg/l)	Group II (mg/l)	p
CRP (before)	25.9	28.4	<0.001
CRP (after)	10.7	9.1	<0.001

ESR also decreased significantly after surgery in both groups ($p < 0.001$). In Group I, the mean values decreased from 40.4 ± 11.3 mm/h to 20.8 ± 9.3 mm/h, and in Group II they decreased from 38.0 ± 10.9 mm/h to 22.2 ± 8.4 mm/h. No intergroup differences were found in postoperative ESR values ($p=0.298$) (Tab. 2).

Table 2. Analysis of the of ESR values dynamics depending on the studied group of patients

Indicator	Group I (mm/h)	Group II (mm/h)	p
ESR (before surgery)	40.4	38.0	<0.001
ESR (after surgery)	20.8	22.2	<0.001

The WBC count showed comparable trends in both groups, decreasing significantly after surgery ($p < 0.001$) from $6.9 \pm 1.7 \times 10^9/L$ to $5.8 \pm 1.0 \times 10^9/L$ in Group I and from $7.0 \pm 1.8 \times 10^9/L$ to $5.8 \pm 1.0 \times 10^9/L$ in Group II, with no significant differences between the groups ($p = 0.826$) (Tab. 3).

Table 3. Analysis of the WBC values dynamics depending on the subgroup of studied patients

Indicator	Subgroup I ($10^9/L$)	Subgroup II ($10^9/L$)	Subgroup III ($10^9/L$)	p
WBC (before surgery)	7.1	6.8	6.9	<0.001
WBC (after surgery)	5.8	5.8	5.7	0.005

To assess the clinical significance of the identified differences, an analysis of the relationship between the duration of hospital stay and the dynamics of the main inflammatory markers was conducted. It was found that patients in Group II, who had a more favorable postoperative inflammatory response profile, in particular with significantly lower C-reactive protein (CRP) levels (Table 1) demonstrated a statistically significant reduction in the duration of hospital stay. At the same time, the dynamics of other markers of inflammation—ESR (Table 2) and WBC (Table 3)—which showed no intergroup differences, did not correlate with the duration of hospital stay.

Thus, the use of a transverse-longitudinal approach for strumectomy of a giant goiter was associated with a less pronounced systemic inflammatory response, as evidenced by a significantly lower C-reactive protein level in the postoperative period (Table 1), as well as a more favorable profile of postoperative complications. The positive correlation found between C-reactive protein (CRP) levels and duration of inpatient care suggests that reducing the intensity of the inflammatory response may help shorten the duration of patient rehabilitation.

4. Discussion

The study demonstrates that the choice of surgical approach during strumectomy for giant nodular goiter has a significant impact on the nature of the postoperative systemic inflammatory response and the incidence of complications.

A key finding of the study was the identification of a statistically significant, less pronounced increase of CRP level in the group of patients who underwent surgery using a transverse-longitudinal approach. As CRP is a highly sensitive marker of tissue injury and systemic inflammation, its lower level in the postoperative period in Group II objectively indicated less surgical aggression and a less traumatic nature of the procedure. This fact can be logically explained by the technical characteristics of the approach: a wider and more anatomical exposure of the surgical field allows avoiding excessive tissue traction, minimizing manipulation in critical areas, and performing the resection

with less injury to surrounding structures.

An important clinical confirmation of the transverse-longitudinal approach advantages was the statistically significant reduction in the incidence of postoperative complications. The complete absence of such serious complications in this group as recurrent laryngeal nerve paresis and postoperative bleeding/hematoma correlated directly with the observed reduction in the inflammatory response. Less tissue trauma naturally leads to a reduced risk of injury to major blood vessels and impaired microcirculation in the area of anatomically important structures, such as the recurrent laryngeal nerves.

The moderate positive correlation found between C-reactive protein levels and length of hospital stay underscores not only the pathophysiological but also the practical importance of controlling the inflammatory response. Higher level of systemic inflammation is associated with a longer recovery period, which is probably due to the need to control inflammatory processes, slower tissue repair and a higher incidence of complications. Thus, the reduction in the duration of hospital stays in Group II is a natural consequence of both the less invasive nature of the procedure and the more favorable profile of postoperative complications.

The absence of statistically significant differences between groups in the dynamics of markers such as ESR and WBC does not contradict the main conclusion of the study. These markers, being less specific than C-reactive protein (CRP), may reflect general components of the stress response that are equally present during any invasive procedure. At the same time, CRP is considered the most accurate laboratory indicator of the degree of tissue injury, which is confirmed by the results of our study.

5. Conclusions

This study convincingly demonstrates that the choice of surgical approach is a determining factor in the development of a systemic inflammatory response during strumectomy for giant nodular goiter.

The study found that the transverse-longitudinal approach (sternotomy) results in a statistically significant reduction in postoperative C-reactive protein levels compared with the standard Kocher cervical approach, which objectively indicates that this technique causes less intraoperative trauma.

The clinical significance of this advantage is confirmed by a statistically significant reduction in the incidence of postoperative complications, including serious ones such as recurrent laryngeal nerve paresis and postoperative hematomas.

An important practical aspect is the identified positive correlation between C-reactive protein (CRP) level and hospital stay days, demonstrating a direct association between the intensity of the inflammatory response and the duration of patient rehabilitation.

Thus, the transverse-longitudinal approach may be recommended as the preferred surgical strategy for the

treatment of giant nodular goiter, as its use helps to minimize the systemic inflammatory response, reduce the risk of postoperative complications and shorten the duration of stay in the hospital. It ultimately improves immediate treatment outcomes and enhances the safety of the surgical procedure.

Ethical Approval and Consent to Participate

Our institution's research ethics board does not require review or approval of case reports.

Our investigation is conducted in accordance with the World Medical Association's Code of Ethics (Declaration of Helsinki).

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Conflict of Interests

The authors declare no conflict of interest.

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