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Choosing the volume of resection for transverse colon cancer: preliminary results

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ABSTRACT

AIM: to justify the extent of resection for transverse colon cancer based on the lymphatic drainage.
PATIENTS AND METHODS: since October 2023, a prospective observational study has been initiated. As of January 2026, 42 patients with carcinoma of the transverse colon have been included. All patients underwent extended right hemicolectomy with omentectomy and D3 lymph node dissection. To evaluate the pathways of lymphatic drainage, intraoperative fluorescent lymphography (IFL) with peritumoral injection of indocyanine green (ICG) was performed. Lymph nodes of removed specimens were meticulously dissected from the mesentery in accordance with the Japanese Classification of Regional Lymph Nodes of the Colon. The study involved a correlative analysis of the fluorescent lymphography findings and the results of the morphological examination of the surgical specimen. The evaluated parameters included intraoperative metrics, postoperative complications, and the diagnostic accuracy of fluorescent lymphography.
RESULTS: postoperative complications occurred in 19 (45.2%) patients, with Grade I and II complications (according to the Clavien-Dindo classification) accounting for 16 (38.1%) cases. The rate of severe complications (Grade III-IV) was 7,1% (3/19). Successful IFL was performed in 34 (80.9%) patients. Multi-directional lymphatic drainage developed in 14 cases (41.2%): in two directions in 13 patients (38.2%) and in three directions in 1 (2.9%) case. In addition to lymph nodes along the middle colic artery, drainage was visualized towards lymph nodes in the mesentery of the right colon in 9 (26.5%) patients and towards the greater omentum in another 9 (26.5%) patients. Lymph node metastasis was detected in 14 patients (33.3%), including one case (2.4%) of metastasis in a 202 station lymph node (according to the Japanese classification).ICG-based fluorescent lymphography demonstrated high specificity of 0.95 (95% CI: 0.93–0.97) in identifying lymph nodes without metastases. However, the sensitivity of the method for detecting metastatic nodes was low at 0.15 (95% CI: 0.08–0.25). The positive predictive value (PPV) was 0.38 (95% CI: 0.24–0.54), while the negative predictive value (NPV) was high at 0.86 (95% CI: 0.83–0.89) regarding the absence of metastases in non-fluorescent lymph nodes.
CONCLUSION: the data obtained demonstrate significant variability in lymphatic drainage in transverse colon cancer, including pathways to the mesentery of the right colon and the greater omentum. Extended right hemicolectomy with omentectomy appears to be a justified extent of surgery, ensuring the removal of potential metastatic basins, and shows an acceptable safety profile. ICG-based fluorescent lymphography enables the intraoperative mapping of lymphatic drainage pathways. Further research is necessary to determine whether this technique can serve as a tool for personalizing the extent of resection.

KEYWORDS: *carcinoma of the transverse colon, extent of resection, intraoperative fluorescent lymphography, indocyanine green, lymph node dissection*

CONFLICT OF INTEREST: *the authors declare no conflict of interest*

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INTRODUCTION

Colorectal cancer occupies one of the leading places in the structure of cancer morbidity and mortality worldwide [1]. Tumors of the transverse colon (TC) account for up to 10% of all cases of colorectal cancer [2]. The main issue discussed in the treatment of this category of patients is the choice of the optimal volume of surgery: transverse colon resection (TCR) or extended right-sided hemicolectomy (ERHC) [3]. Proponents of TCR emphasize its lower injury rate, the possibility of preserving the ileocecal valve, which can reduce water and electrolyte losses and, as a result, improve the functional outcomes [4]. However, the data based on careful labeling of lymph nodes (LN) makes significant adjustments to this discussion. It has been demonstrated that in cancer of the middle third of the TC, metastases are detected not only along the middle colonic artery (MCA), but also with a high rate, up to 14%, in the lymph nodes along the right colonic artery, while cases of LN lesions along the iliac artery have not been described [5,6]. Another aspect complicating the choice of surgical approach is the risk of metastatic lesionin the 'extracolic' lymph nodes, in particular, in the area of the right a. gastro-epiploica [7]. The study by Wang X. (2021) revealed that the incidence of their lesions reaches 4%, while intestinal obstruction, ring-shaped cell carcinoma, and the level of cancer embryonic antigen ⩾ 17 ng/ml were established as independent predictors [8]. The latter can serve as a theoretical basis for developing recommendations for expanding the volume of lymphodissection and performing an omentectomy.

The traditional intraoperative assessment of lymphatic collectors is subjective and inaccurate, and determining the direction of lymph outflow from a specific segment of the intestine is completely impossible. The introduction of fluorescent lymphography with ICG allows to visualize the lymphatic system [9]. With regard to TC cancer, using this technique in real time, it is possible to assess the individual features of the structure of the lymphatic system, identify regional collectors, as well as the presence of lymph outflow to extracolic lymph nodes, and thereby objectify the extent of the necessary lymphadenectomy [10]. So, we have planned a study to estimate lymphatic drainage in patients with cancer of the transverse colon.

AIM

AIM: to justify the transverse colon resection volume in cancer based on the features of lymph drainage.

PATIENTS AND METHODS

A prospective observational study was launched in October 2023. It included adult patients with malignant neoplasms of the transverse colon. Patients with primary multiple malignant neoplasms of the large intestine, inflammatory bowel diseases, polyposis syndromes, carcinomatosis, as well as with ASA III, according to the scale of the American Society of Anesthesiologists (ASA), were not included.

Patients who had revealed carcinomatosis according to the intraoperative revision were excluded from the study.

All patients included in the study underwent ERHC with omentectomy. For fluorescence lymphography, a 0.5 ml (1.25 mg) indocyanine green solution was injected subserously, 1–2 cm proximal and distal to the tumor. Lymph outflow was assessed after 60 minutes. Next, surgery was performed with D3 lymph dissection in the zones of the ileocolonic, right colonic and middle colonic arteries. The surgery ended with ileo-descendo or ileosigmoid anastomosis. Further, during the pathomorphological study of the removed specimens in accordance with the Japanese classification of regional lymph nodes of the colon and rectum (JSCCR), they were isolated from the mesentery of the colon, the LN were placed in containers and sent to the pathomorphological laboratory for examination. The data of fluorescent lymphography

and morphology of the removed specimen were compared.

The following data were evaluated: gender, age, body mass index, ASA class, Charlson's comorbidity index, type of surgical access, volume of intraoperative blood loss, operation time, type of anastomosis, time to the first gases and stools, incudence and nature of intraoperative and postoperative complications using Clavien-Dindo's scale [11], histological structure of the tumor, the depth of its growth into the intestinal wall, the number of removed and affected lymph nodes.

The data of intraoperative ICG — fluorescence lymphography were evaluated to match the results of pathomorphological studies; data on groups of lymph nodes were combined to calculate the diagnostic value.

Statistical Analysis

The patient data was entered into a spreadsheet Microsoft Excel 2019 for Windows. The data was analyzed using the Graph Pad Prism statistical software package, version 10 (Graph Pad Software, USA). Descriptive characteristics of variables are presented as absolute values for categorical data. For quantitative data, a preliminary assessment of the normality of the distribution was performed using D'Agostin-Pearson's method. In the case of a normal distribution, the variables are represented as an arithmetic mean with an indication of the standard deviation M (SD), and in the case of a non-normal distribution, as medians with an indication of the interquartile range Me (Q1; Q3). Sensitivity, specificity, predictive values of positive and negative results, and overall accuracy were calculated with 95% CI using Clopper-Pearson's method. For analysis, all available binary results of intraoperative ICG detection and confirmation of metastatic lesion by lymph nodes/zones were combined into a single set of cases.

RESULTS

In the period from October 2023 to January 2026, forty-three patients with TC cancer were included in the study. One of the patients was excluded from the analysis due to the detection of carcinomatosis according to the intraoperative revision. Thus, the results were analyzed in a group consisting of 42 patients.

Table 1. *Characteristics of patient group*

Indicators	Value (N = 42)
Gender, *n* (%)	
Male	17 (40.5)
Female	25 (59.5)
Age, years, Me (Q1; Q3)	67 (61.5; 73)
BMI, kg/m^2(M ± SD)	27 ± 4.9
Class as per ASA, *n* (%)	
I	1 (2.4)
II	29 (69.0)
III	12 (28.6)
Charlson's Comorbidity Index, score (M ± SD)	6.9 ± 2.5

The mean age of the patients was 67 (61.5; 73) years, the sample was dominated by women — 25 (59.5%).

The mean body mass index was 27.0 ± 4.9 kg/m^2. Most patients had ASA class II — 29 (69.0%).

The mean Charlson's comorbidity index was 6.9 ± 2.5 points (Table 1).

Laparoscopic access was performed in the vast majority of patients — 38 (90.5%) cases. The median intraoperative blood loss was 30 (30; 52.5) ml, and the median operation time was 197 (157; 235) minutes. A single (2.4%) intraoperative complication was the injury to the superior mesenteric vein (SMV). It required a vascular suture. Intestinal anastomosis was manual in 26 (61.9%) patients. The time median to the first discharge of gases was 1 (1; 2) days, and the mean time to the first stool was 2.7 ± 1.1 days. The median hospital stay after surgery was 10 (8; 12.2) days (Table 2).

Most tumors were represented by moderately differentiated adenocarcinomas — 32 (76.2%) cases. The depth of tumor germination was most often found to be T3 — 24 (57.1%) cases. Lymphovascular invasion was detected in 32 (76.2%) patients, venous invasion in 17 (40.5%) and perineural invasion in 3 (7.1%) cases. The median of removed lymph nodes in the specimen was 58.5 (45.5; 68). Metastatic lymph node lesion was detected in 14 (33.3%) patients (Table 3).

Postoperative complications developed in 19 (45.2%) patients. Moreover, grade I complications were noted in 3 (7.1%) patients: fever — in 2 (4.8%) cases and lymphorrhea — in 1 (2.4%) case. The most common grade II complication was gastrostasis, registered in 8 (30.9%) patients. Infection in the surgical site (SSI) was detected in 1 (4.8%) patient, as well as enteritis, antibiotic-associated diarrhea and anastomositis in 1 (2,4%), 2 (4,8%) and 1 (2.4%) patient, respectively. All these complications were treated conservatively. Grade III complications in the form of anastomosis failure were reported in 2 (4.8%) patients, which in both cases required relaparotomy. The scope of the repeated surgery consisted of dissociation of the anastomosis in one case and sanitation with drainage of the abdominal cavity in the other. Subsequently, the postoperative period in those patients proceeded smoothly, and they were discharged in satisfactory condition. One (2.4%) grade IV complication (cardiac arrhythmia) required treatment in the intensive care unit. There were no fatal outcomes (grade V) (Table 4).

Successful IFL with ICG was performed in 34 (80.9%) patients. In 4 (9.5%) cases, the system was depressurized when contrast was introduced. The absence of drug distribution into the lymphatic collectors was noted in 3 (7.1%) patients. In another 1 (2.4%) case, technical problems with the equipment caused the failure. According to the intraoperative mapping data, the most frequent lymph outflow direction was the nodes of group 223, visualized in 21 (61.8%) patients. The outflow was somewhat less frequent in the LN of group 222 — in 12 (35.3%) cases and towards the large omentum — in 9 (26.5%) cases. It should be emphasized that in addition to staining the lymph nodes along MCA, fluorescence of the mesentery lymph nodes of the right colon was detected in 9 (26.5%) patients. Moreover, in 2 (5.9%) cases, LN staining was noted in two groups. Fluorescence was detected along the right colon vessels (groups 211 and 213) in 4 (11.8%) patients, and along the ileo-colonic artery (groups 202 and 203) in 5 (14.7%) patients (Fig. 1).

Table 2. *Characteristics of surgeries and the postoperative period*

Indicators	Value (N = 42)
Type of surgical access, *n* (%) Laparoscopic Open	 38 (90.5) 4 (9.5)
Bloodloss, ml, Me (Q1; Q3)	30 (30; 52.5)
Operation time, minutes, Me (Q1; Q3)	197 (157; 235)
Intraoperative complications, *n* (%) Injury of the SMV	1 (2.4)
Type of anastomosis, *n* (%) Manual Stapler	 26 (61.9) 16 (38.1)
Discharge of the first gases, day, Me (Q1; Q3)	1 (1;2)
Discharge of the first stool, day, (M ± SD)	2.7 ± 1.1
Hospital stay after surgery, day, Me (Q1; Q3)	10 (8; 12.2)

Table 3. *Results of the pathomorphological examination of surgical specimens*

Indicators	Value (N = 42)
The grade of tumor differentiation, *n* (%) Grade I Grade II Grade III	 2 (4.8) 32 (76.2) 8 (19)
Depth of invasion, *n* (%) T1 T2 T3 T4a T4b	 2 (4.8) 4 (9.5) 24 (57.1) 11 (26.2) 1 (2.4)
Total number of lymph nodes, Me (Q1; Q3)	58.5 (45.5; 68)
pN+, *n* (%)	14 (33.3)
Perineural invasion, *n* (%)	3 (7.1)
Lymphovascular invasion, *n* (%)	32 (76.2)
Venous invasion, *n* (%)	17 (40.5)

Table 4. *Frequency and structure of postoperative complications according to Clavien-Dindo's scale*

Indicators	Value (N = 42), *n* (%)
Grade I Fever Lymphorrhea	3 (7.1) 2 (4.8) 1 (2.4)
GradeII Gastrostasis BSSI Enteritis Antibiotic-associated diarrhea Anastomositis	13 (30.9) 8 (19) 1 (2.4) 1 (2.4) 2 (4.8) 1 (2.4)
GradeIII Anastomosis failure	2 (4.8) 2 (4.8)
Grade IV Cardiac arrhythmia	1 (2.4) 1 (2.4)
Grade V	0

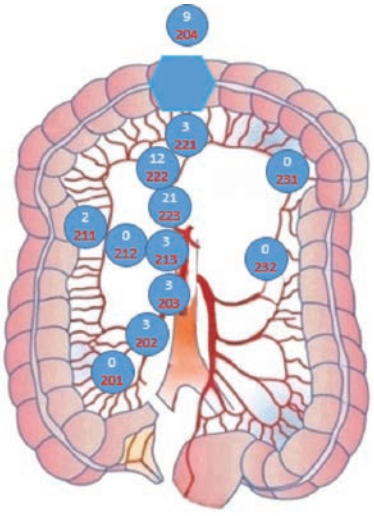

Figure 1. *Mapping of lymph node groups*

The analysis of IFL data showed that in 14/34 (41.2%) cases, lymph outflow was carried out in more than one direction. Thus, lymphatic drainage in two different directions was detected in 13 (38.2%) patients (Fig. 2), in three directions (MCA, mesentery of the right colon and into the large omentum) — in 1 (2.9%) patient. Lymph outflow in exactly one direction was recorded in 20 (58.8%) cases. It should be noted that in 1 case it was a lymph node of group 204, which indicated the direction of lymph outflow to the large omentum, and in another patient — to the lymph nodes of group 211. That is, the contrast spread into the mesentery of the right colon only (Fig. 3).

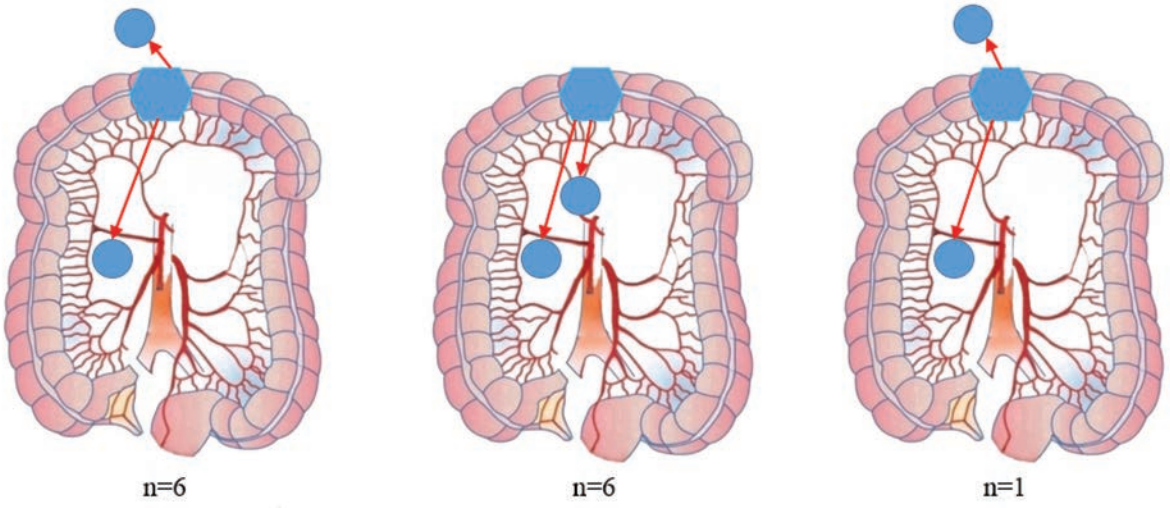

Figure 2. *Lymphatic drainage in two directions*

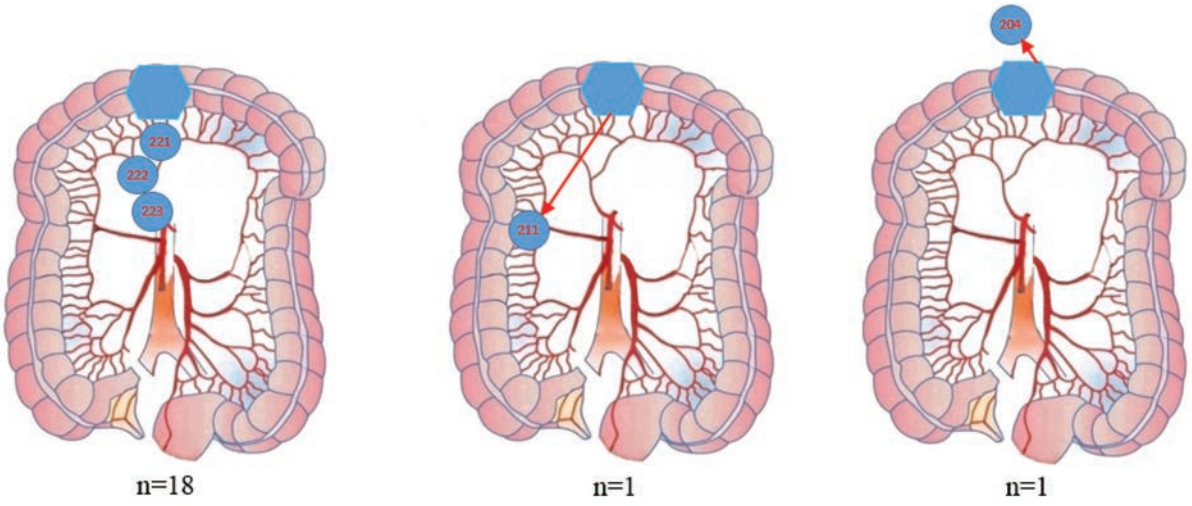

Figure 3. *Lymphatic drainage in one direction*

The analysis of the results of the pathomorphology of the removed specimens showed that the largest amount of LN was isolated along the middle colon artery. The median of this indicator in group 221 was 13 (7; 16), in group 222 — 4 (2; 6) and in group 223 — 4 (2; 7). Lymph nodes in the basin of the ileo-colonic artery were more often detected in the right parts of the colon: group 201 — 8 (5; 13), group 202 — 5 (4; 8) and group 203 — 4 (3; 6). As expected, the fewest lymph nodes were found in the area of the right colon artery (groups 211, 212, 213) — 8 (5; 13), 2 (0; 3), 1 (0; 4), respectively, the median isolated LN in the mesentery of the left colon in groups 231 and 232 was equal to 3 (1; 5) and 1 (0; 2), respectively. The median of lymph nodes in the large omentum was 5 (1; 9) (Table 5).

The most common metastases were found along MCA, in the lymph nodes of groups 221 — in 11 (26.2%), 222 — in 6 (14.3%) and 223 — in 2 (4.8%) cases. Attention is drawn to the fact that 1 patient had metastasis to the LN of group 202 along with metastasis to the lymph node of group 221. No metastatic lesions of the nodes along the right and left colon arteries and the large omentum were detected in any case (Table 5).

An assessment of the consistency of intraoperative ICGfluorescence with the results of pathomorphologywas performed in 34 patients who underwent both ICG and morphology, but generalized by group (Table 6).

The sensitivity of the method was 0.15 (95% CI: 0.08–0.25), specificity — 0.95 (95% CI: 0.93–0.97), positive prognostic value — 0.38 (95% CI: 0.24–0.54), negative prognostic value — 0.86 (95% CI: 0.83–0.89), overall accuracy — 0.88 (95% CI: 0.85–0.91). Thus, the affected lymph nodes during pathomorphologywere found only in the collectors, which were contrasted with lymphography. If intraoperative lymph outflow to the lymph nodes was not detected, no metastatic lesions of these groups of lymph nodes were detected.

Table 5. *Characteristics of lymph node groups*

Groups of lymph nodes	Total number of lymph nodes, Me (Q1; Q3)	Affected groups of lymph nodes, *n* (%)
201	8 (5;13)	0
202	5 (4;8)	1 (2.4)
203	4 (3;6)	0
211	4 (2;6)	0
212	2 (0;3)	0
213	1 (0;4)	0
221	13 (7;16)	11 (26.2)
222	4 (2;6)	6 (14.3)
223	4 (2;7)	2 (4.8)
231	3 (1;5)	0
232	1 (0;2)	0
204	5 (1;9)	0

Table 6. *Classification table*

	pathomorphology+	pathomorphology–
ICG+	3	53
ICG–	17	516

DISCUSSION

The prospective study is aimed at studying the features of lymph outflow in TC cancer using IFL to justify the volume of resection. The results of IFL with ICG have demonstrated that lymph outflow from TC cancer has significant variability. Thus, in 9 (26.5%) patients, it was performed in the LN groups located in the mesentery of the right colon (201, 202, 203, 211, 212, 213). These data may indicate the risk of metastasis beyond the 'classical' regional zones. Moreover, one (2.4%) patient had a metastatic lesion of the lymph node of group 202, which is a direct pathomorphological confirmation of the clinical significance of this pathway of lymph drainage. Taking into account this clinical case, it can be argued that in a number of patients, when performing TC resection, there is a risk of performing non-radical surgery with the abandonment of affected nodes. The second significant direction of lymph outflow identified during the study was drainage into the lymphatic system of the large omentum, registered in 9 (26.5%) patients. Despite the fact that our study did not reveal metastatic lesions of the omentum lymph nodes, the very frequency of visualization of this pathway indicates its potential role in the

progression of the tumor process. This may serve as an argument in favor of performing an omentectomy during radical surgeries for TC cancer.

In this study, all patients underwent extended right-sided hemicolectomy with omentectomy and D3 lymphodissection, mainly by laparoscopic access, in 38 (90.5%) patients. The extended volume of the surgery demonstrated an acceptable safety profile: the median intraoperative blood loss was 30 ml, and the operation time was 197 minutes. Postoperative recovery was satisfactory, with a median time to the first discharge of gases on day 1 and a median postoperative hospital stay of 10 days. However, the overall incidence of postoperative complications was relatively high (45.2%), with the majority of them being reversible functional disorders, including gastrostasis in 8 (19.0%) patients (grade II according to Clavien-Dindo). Theoretically, the high incidence of gastrostasis may be associated with the omentectomy, but it was transient and stopped, on average, within 3 days. Severe complications (grades III-IV) were rare (7.1%). These data indicate that the chosen volume of resection, although associated with a certain risk of functional impairment, is technically feasible and safe, and can potentially improve oncological outcomes. It is worth noting that the benefits of ICG- navigation in the form of reduced intraoperative blood loss and the frequency of postoperative complications were previously demonstrated in a meta-analysis in relation to lateral pelvic lymph node dissection, which is consistent with our observations [12].

Intraoperative fluorescent lymphography with ICG demonstrated a high specificity of 0.95 (95% CI: 0.93–0.97) and a significant negative prognostic value of 0.86 (95% CI: 0.83–0.89), which indicates the high accuracy of the method with respect to the assumption of a low risk of metastatic lesion of non-contrastable groups of lymph nodes. Low sensitivity values of 0.15 (95% CI: 0.08–0.25) and a positive prognostic value of 0.38 (95% CI: 0.24–0.54) indicate the limited ability of the technique to detect all affected LN. An important practical conclusion is that metastases were found exclusively in the contrasted lymphatic collectors. Thus, a negative result of ICG — lymphography can serve as an intraoperative criterion for excluding metastatic lesions in the relevant areas, which potentially allows individualizing the volume of lymph dissection. The data obtained are consistent with the results of the study by Panagiotti L.L., who also noted the high reproducibility and safety of the technique of paratumoral administration of indocyanine green for mapping individual lymphatic drainage pathways in colon cancer [13].

The limitations of this study are its relatively small sample size, as well as technical failures in performing IFL in 8 (19%) cases. To form final clinical recommendations, it is necessary to continue the study with a long-term assessment of oncological outcomes.

CONCLUSION

The results obtained show that extended right-sided hemicolectomy with omentectomy can be considered as the most justified volume of surgery for patients with TC cancer, ensuring the removal of all potential areas of lymphogenic metastasis and demonstrating acceptable safety.

AUTHORS CONTRIBUTION

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