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Predictive nomogram of the risk of peritoneal relapse following radical gastric cancer surgery

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Background and objectives. Peritoneal relapse (PR) is the most common pattern of gastric cancer (GC) recurrence after radical treatment. Currently, a variety of adjuvant intraperitoneal chemotherapy methods are being tested for their efficacy in reducing the level of PR.

Methods. The radical treatment results of 226 patients with localized and locally-advanced GC have been analyzed. To select a group of patients with indications for adjuvant intraperitoneal therapy, a study of independent predictive factors and the development of a predictive PR nomogram for gastric cancer was completed.

Results. As a result of the analysis of about three dozen potential factors in mono- and multivariate analysis, the impact on PR risk was confirmed by 4 independent predictive factors, namely: serosal invasion and its size (HR 9.36, p <0.001), morphological type according to Lauren (HR 5.3, p <0.001), index of regional lymph node involvement (HR 2.23, p = 0.015) and localization of the tumor in the stomach (HR 3.98, p <0,001).

Conclusions. A predictive PR risk nomogram of gastric cancer after radical surgical treatment has been developed based on the identified independent factors, and it is of great clinical importance as a tool for segregating patients who require adjuvant intraperitoneal chemotherapy.

Keywords: gastric cancer, peritoneal relapse, peritoneal recurrence, predictive nomogram, peritoneal metastases, gastrectomy, intraperitoneal chemotherapy.

Предиктивна номограма ризику інтраперитонеального рецидиву після радикальної хірургії раку шлунка

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Обгрунтування. Інтраперитонеальний рецидив (IP) є найчастішим шляхом рецидивування раку шлунка (РШ) після радикального хірургічного лікування. Ефективність ряду методів ад'ювантної інтраперитонеальної терапії досліджується сьогодні з метою зниження рівня IP.

Матеріали і методи. Проведено аналіз результатів радикального хірургічного лікування 226 хворих на локалізований та місцево-розповсюджений РШ. З метою виділення групи пацієнтів з показами до ад'ювантної інтраперитонеальної терапії проведено дослідження незалежних предиктивних факторів та створення предиктивної номограми IP раку шлунка.

Результати. В результаті аналізу близько трьох десятків потенційних факторів в моноваріаційному та мультиваріаційному аналізі вплив на ризик IP підтвердили чотири незалежних предиктивних чинники: інвазія серозної оболонки та її площа (HR 9.36, p<0,001), морфологічний тип за Лоурен (HR 5.3, p<0,001), індекс ураження регіонарних лімфатичних вузлів (HR 2.23, p=0.015) та локалізація пухлини у шлунку (HR 3.98, p<0,001).

Висновки. На основі визначених незалежних факторів сформульовано предиктивну номограму ризику IP раку шлунка після радикального хірургічного лікування, що має важливе клінічне значення в якості інструменту для сегрегації групи хворих з необхідністю ад'ювантних методів інтраперитонеального впливу.

Ключові слова: рак шлунка, інтраперитонеальний рецидив, предиктивна номограма, перитонеальні метастази, гастректомія, внутрішньочеревна хіміотерапія.

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INTRODUCTION

Gastric cancer (GC) is currently the world's fifth most prevalent cancer, with nearly one million new cases (5.6% of all malignancies) diagnosed in 2020 [1]. Peritoneal relapse (PR) is the most common pattern of GC recurrence [2, 3], which develops in 44.8 % – 69% of patients with serosal invasion after radical surgery [4, 2]. PR development is most likely caused by the presence of a microscopic pool of tumor cells in the peritoneum prior to surgery [5] or intraoperative peritoneal dissemination [6].

The vast majority of locally advanced GC patients with a high risk of PR have subclinical peritoneal dissemination at the time of diagnosis, implying a rapidly fatal prognosis. In such patients, systemic chemotherapy does not provide effective eradication of subclinical peritoneal carcinomatosis. However, in recent years, the therapeutic paradigm for locally advanced GC has changed: a combination of surgery and adjuvant intraperitoneal chemotherapy is increasingly being examined as an alternative to the traditionally recognized surgical strategy.

Some pathological factors are associated with metachronous peritoneal metastasis, namely: serosal invasion, diffuse infiltrative growth pattern, signet ring cell pathology, lymph node invasion, etc. [2]. The investigation of prospective predictors of metachronous peritoneal metastases enables us to develop a predictive nomogram of the peritoneal relapse risk of GC after radical surgery, which is crucial in surgical oncology today. Such a nomogram will allow clinicians to easily and quickly identify a group of patients who require adjuvant intraperitoneal chemotherapy.

METHODS

Patients and specimens

The study is based on an analysis of radical treatment efficacy in 226 patients with localized and locally advanced GC (pTis-4b, pN0-3b, M0) stages 0-III. The exceptions were three patients with cytologically positive peritoneal washes (but no macroscopic peritoneal metastases), who were classified as stage IV as per classification rules. The patients received treatment at the Department of Abdominal Surgery of Lviv Oncological Regional Treatment and Diagnostic Center in 2013–2018 (prospective clinical study). The age of patients ranged from 36 to 84 years, and the average age was 63.14 ± 10.78. The diagnosis of GC in all patients was verified morphologically before the onset of treatment. The GC study was conducted based on criteria from the TNM 7th edition classification (2009). Table 1 summarizes the patients' primary clinical and pathological characteristics.

18 (7.96%) of 226 patients received systemic adjuvant chemotherapy with an average number of cycles of 4.22 ± 1.66 (1 to 6 cycles) according to XELOX, CAF, and CF schemes.

Follow-up

Patients were regularly followed-up after the operation. We performed ultrasonography every 3 months and chest radiography every 6 months during the first two postoperative years and every 6 months thereafter. Patients with inconclusive ultrasonography results underwent computerized tomography. Peritoneal relapse-free survival (PRFS) was measured from the date of surgery to the date of peritoneal recurrence or the final follow-up exam. Overall survival (OS) was measured from the date of surgery to the date of death or the last follow-up exam. The study was approved by the University's Ethical Committee, which complied with the Declaration of Helsinki of 1975. Written informed consent was provided by all patients examined.

Statistical analysis

The statistical analysis of the primary data was performed using SPSS 22 and Statistica 6 software. The censored Kaplan-Meier method was used to study the cumulative survival of patients, whereas the reliability of the survival difference in certain groups was determined using a log-rank coefficient. A multivariate analysis was performed using the $\chi 2$ index and the Cox model. To test statistical correlations, Pearson's linear correlation coefficient was used.

RESULTS

Postoperative results

The median postoperative stay of patients in the hospital was 13.76 ± 3.5 days (ranging from 7 to 38 days) and was determined by the presence of postoperative complications. Postoperative complications (up to 30 days

Table 1.

Primary clinical and pathological characteristics of the patients

Criteria	Number of patients (n=226)
Sex	
male	159 (70.35%)
female	67 (29.65%)
Tumor localization according to the Japanese Gastric Cancer Association (JGCA)	
Upper third (U)	10 (4.42%)
Middle third (M)	30 (13.27%)
Lower third (L)	126 (55.75%)
Upper + Middle (UM)	10 (4.42%)
Middle + Lower (ML)	33 (14.6%)
Subtotal and total lesion (UML)	8 (3.54%)
Lower third with duodenum invasion (LD)	4 (1.77%)
Multicentric	5 (2.21%)
Borrmann's type	
Type I (exophytic tumor)	19 (8.41%)
Type II (crater-shaped)	83 (36.7%)
Type III (ulcerative-infiltrative tumor)	101 (44.69%)
Type IV (diffuse infiltrative tumor)	23 (10.18%)
Histological structure	
G1	23 (10.18%)
G2	56 (24.78%)
G3	45 (19.91%)
Poorly cohesive	77 (34.07%)
Poorly cohesive with signet-ring phenotype	22 (9.73%)
mucinous	2 (0.88%)
other	1 (0.44%)
Depth of tumor invasion (pT)	
Tis	2 (0.88%)
T1	18 (7.96%)
T2	41 (18.14%)
T3	23 (10.18%)
T4a	121 (53.54%)
T4b	21 (9.29%)
Area of serosal invasion (n=142)	
less than 5 cm^2	69 (48.6%)
5.1 - 10 cm^2	27 (19%)
10.1 - 20 cm^2	19 (13.38%)
20.1 - 60 cm^2	11 (7.75%)
more than 60 cm^2	16 (11.27%)
Regional lymph nodes status (pN)	
pN0	111 (49.12%)
pN1	47 (20.8.%)
pN2	35 (15.49%)
pN3a	25 (11.06%)
pN3b	8 (3.54%)
The level of lymph node dissection	
D0	46 (20.35%)
D1	65 (28.76%)
D1+	54 (23.89%)
D2	61 (26.99%)

after surgery) developed in 49 (21.68%) patients. Complications of grade III-IV, according to the Clavien-Dindo classification, were recorded in 9 (4%) of the patients. Postoperative mortality (grade V by Clavien-Dindo) happened in 4 patients (1.77%), 2 of whom died of pulmonary embolism and the other 2 of esophago-jejunal anastomosis leak and duodenal stump insufficiency.

Long-term outcomes

The median follow-up of patients in the study was 60 ± 2.08 (95% SI: 50-62) months. None of the living patients has left the study. There were 4 (1.77%) cases of postoperative 30-day mortality and 22 (9.74%) cases of deaths due to intercurrent pathology during the observation period (1.5 to 54 months) that were censored. The progression of the tumor process was recorded in 89 (39.38%) of 226 patients during the observation period. Most of the progression cases were patients with peritoneal recurrence, either alone or in combination with other metastases - 45 (50.56%) patients (Fig. 1).

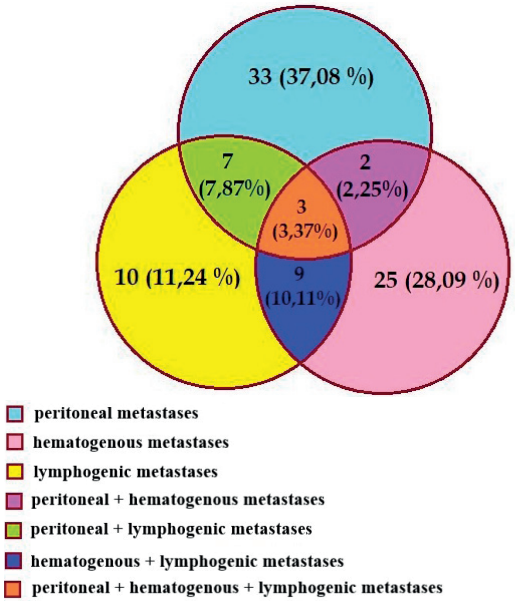

Figure 1. Structure of GC progression in 89 patients.

There was a statistically significant difference in disease progression after radical treatment of different types of GC according to the Lauren classification ($\chi^2 = 16,66$; $p = 0,011$). The most common way of progression for diffuse and mixed GC was peritoneal, which was detected in 39 (63.93%) of the patients, whereas hematogenous progression was commonly observed in patients with intestinal-type GC, specifically in 18 patients (64.29%). The frequency of lymphogenic progression was nearly the same in both morphological types of GC, occurring in 21 (34.43%) and 8 (28.57%) cases, in diffuse + mixed and intestinal GC, respectively.

The following prognostic factors are likely to have an impact on overall survival: the macroscopic form of the tumor according to Borrmann ($p<0.0001$), invasion of the serous membrane of the stomach ($p<0.0001$) (fig. 2), the area of tumor invasion in the serous membrane of the stomach ($p<0$, 0001), histological structure of the tumor ($p = 0.006$), the histological form of the tumor according to Lauren ($p = 0.0037$), the status of regional lymph nodes ($p <0.0001$) and stage of the disease ($p <0.0001$).

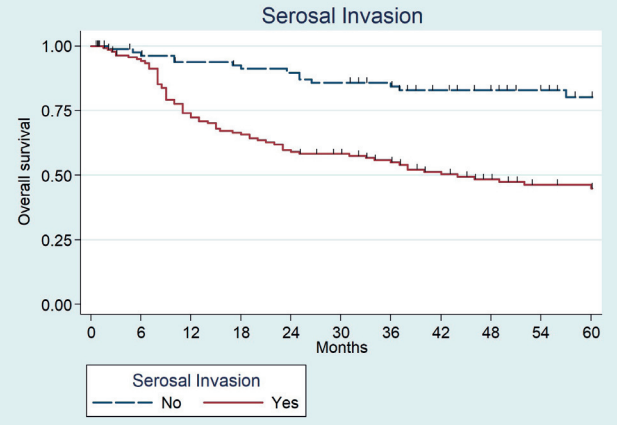

Figure 2. Overall survival depending on the presence of serous invasion.

Study of clinical and morphological risk factors of peritoneal recurrence

To determine reliable predictors of peritoneal recurrence after radical surgery for gastric cancer, peritoneal relapse-free survival was studied in the framework of a univariate analysis (Table 2).

As shown in Table 2, among potential demographic, laboratory, tumor-associated, morphological, lymphogenic, and therapeutically-associated factors of peritoneal relapse, statistically significant effects were confirmed by: female sex, tumor location (JGCA), Borrmann's type, depth of tumor invasion (pT),

Table 2

Univariate analysis of potential factors of peritoneal recurrence

Factors	Patients (n=226)	Patients with peritoneal relapse (n=45)	2-year PRFS, (%)	PRFS (HR: 95 % CI)	*p*
1	2	3	4	5	6
Sex					0.047
male	159	26	83.3%	1	
female	67	19	72.9%	1.85 (1.02–3.34)	
Age					0.47
<60	80	15	82.4%	1	
≥60	146	30	78.9%	1.25 (0.67–2.33)	
Serum protein (gm/l)	(n=221)				0.072
≤75	116	26	78.1%	1	
>75	105	14	86.4%	0.56 (0.29–1.07)	
Fibrinogen (gm/l)	(n=221)				0.26
≤4	108	16	82.4%	1	
>4	113	24	78.9%	1.43 (0.76–2.69)	
Coagulogram	(n=221)				0.12
normal	95	34	82.7%	1	
hypocoagulation	118	6	70.1%	1,32 (0,77 – 2,33)	
hypercoagulation	8	0	100%	0,46 (0,23 – 1,01)	
Serum biochemistry	(n=221)				0,32
normal	202	35	83.2%	1	
abnormal	19	5	69.3%	1.43 (0.65 – 4.22)	
Urinalisis	(n=221)				0,063
normal	134	16	89.0%	1	
abnormal	87	24	71.4%	2.55 (1.35 – 4.80)	
Course of disease					0,55
uncomplicated	121	22	81.2%	1	
complicated	105	23	78.9%	1.19 (0.66 – 2.14)	
Tumor localization (JGCA)					<0,0001
U	10	3	59.3%	0.86 (0.53–1.1)	
M	30	5	88.9%	0.61 (0.38–0.78)	
L	126	16	88.6%	0.65 (0.42–0.89)	
UM	10	4	47.6%	1	
ML	33	9	68.7%	0.73 (0.5–0.96)	
UML	8	8	12.5%	1.54 (1.1–1.81)	
LD	4	0	100%	0.58 (0.32–0.91)	
multicentric	5	0	100%	0.51 (0.31–0.86)	
Borrmann's type					<0.0001
type I	19	1	94.1%	1	
type II	83	12	84.3%	2.96 (0.38–22.7)	
type III	101	15	85.7%	2.95 (0.39–22.3)	
type IV	23	17	28.8%	25.4 (3.4–191.6)	
Serosal invasion					<0.0001
no	84	4	95.8%	1	
yes	142	41	70.8%	7.31 (2.61–20.4)	
pT (TNM7)					<0.0001
pTis	2	0	100%		
pT1	18	0	100%	1	
pT2	41	3	94.3%	1.1 (0.32–4.6)	
pT3	23	1	94.4%	1.2 (0.38–4.2)	
pT4a	121	31	75.4%	8.2 (5.4–38.9)	
pT4b	21	10	33.5%	18.2 (4.2–65.2)	
Area of serosal invasion					<0.00001
0 cm^2	84	4	95.8%	1	
less than 2 cm^2	41	6	84.5%	3.11 (0.8–26.4)	
2.1–5 cm^2	28	4	82.8%	3.64 (0.74–27.6)	

Продовження таблиці 2

1	2	3	4	5	6
more than 5 cm^2	73	31	58.2%	12.2 (2.8–48.7)	
Perigastric tumor in-filtration of omentums					<0.0001
absent	156	21	87.0%	1	
present	70	24	64.7%	3.2 (1.79 – 5.80)	
Lauren's type					<0.0001
diffuse/mixed	122	38	69.9%	1	
intestinal	101	6	92.9%	0.16 (0.07 – 0.38)	
Histological structure					0.003
G1	23	0	100%	1	
G2	56	7	85.3%	1.2 (0.5–2.9)	
G3	45	6	87.1%	1.1 (0.39–3.2)	
Poorly cohesive	77	23	69.7%	7.2 (4.4–28.9)	
Signet-ring	22	9	67.2%	78.1 (3.8–31.2)	
mucinous	2	0	100%		
other	1	0	100%		
Peritoneal cytology					
Mesothelial cells	105	18	82.8%	1	<0.0001
Lot of lymphocytes	55	8	86.0%	0.81 (0.35–1.86)	
Cancer cells	3	2	50.0%	9.04 (2.09–39.1)	
Regional lymph nodes status					0.0042
pN0	111	15	87.2%	1	
pN+	115	30	73.1%	2.40 (1.29–4.48)	
Number of affected lymph nodes					<0.0001
0	111	15	87.2%	1	
1 - 3	64	11	84.5%	1.2 (0.65–2.68)	
4+	51	19	56.8%	5.1 (3.57–9.4)	
Index of lesions of regional lymph nodes					<0.0001
0	111	15	87.2%	1	
≤0.1	41	6	86.8%	1.15 (0.32–3.4)	
0.11–0.2	28	4	87.0%	1.22 (0.41–4.1)	
≥0.21	46	20	50.5%	5.22 (3.88–9.24)	
Intervention duration					0,019
≤ 225 min	118	17	85.2%	1	
> 225 min	108	28	74.2%	2.0 (1.11–3.71)	
Intraoperative blood loss					0,076
≤ 120 ml	120	19	85.0%	1	
>120 ml	106	26	74.5%	1.69 (0.94–3.06)	
Blood transfusions					0,13
no	194	36	82.1%	1	
yes	32	9	68.2%	1.80 (0.87–3.75)	
Plasma transfusions					0,011
no	162	25	85.5%	1	
yes	64	20	67.0%	1.80 (0.87–3.75)	
Lymph nodes dissection					0,31
D0	46	6	85.5%	1	
D1	65	17	71.5%	2.2 (0.87–5.64)	
D1+	54	11	83.5%	1.60 (0.59–4.34)	
D2	61	11	81.9%	1.36 (0.50–3.68)	
Prolonged postoperative lymphorrhea					0,44
yes	26	3	86,2 %	1	
no	200	42	78,8%	1.46 (0.62–3.78)	
Adjuvant chemotherapy					0,28
yes	18	7	54%	1	
no	208	38	79,4%	1.67 (0.88–5.37)	

Table 3.

Multivariate analysis of peritoneal recurrence factors

Factors	Univariate analysis PRFS (HR: 95 % CI)	p	Multivariate analysis PRFS (HR)	p	Points for nomogram
Sex		0.047		0.28	
male	1				
female	1.85 (1.02–3.34)		1.47		
Tumor localization "U" (JGCA)		<0.0001		<0.001	
no	1				0
yes	5.76 (3.1–10.8)		3.98		1
Borrmann's type		<0.0001		0.82	
type I, II, III	1				
type IV	9.20 (5.0–17.0)		1.12		
Histological type		<0.0001		0.99	
other	1				
Poorly cohesive, signet-ring	3.60 (1.89–6.86)		0.99		
Perigastric omental infiltration		<0.0001		0.59	
absent	1				
present	3.2 (1.79–5.80)		1.22		
Intervention duration		0.019		0.46	
≤ 225 min	1				
> 225 min	2.0 (1.11–3.71)		1.34		
Plasma transfusion		0.011		0.52	
no	1				
yes	1.80 (0.87–3.75)		1.25		
Lauren's type		<0.0001		<0.001	
intestinal	1				0
diffuse / mixed	6.20 (2.6–14.7)		5.3		1
Serosal invasion		<0.0001		<0.001	
absent	1				0
≤5 sm^2	3.30 (1.0–.10.5)		4.25		1
>5 sm^2	12.18 (4.3–34.5)		9.36		2
Lesion index of regional lymph nodes		<0.0001		0.015	
≤0.2	1				0
>0.2	4.90 (2.7–8.9)		2.23		1

area of serosal invasion (fig. 3) (not confirmed for an intestinal subgroup, p = 0.65), perigastric tumor infiltration of omentums (not confirmed for the intestinal subgroup, p = 0.84), histological structure, Lauren's type, peritoneal cytology, regional lymph node status, metastatic lesions of 4 or more regional lymph nodes, lesion index of regional lymph nodes (fig. 4), intervention duration, and plasma transfusion. Identified predictive factors require confirmation in multivariate analysis.

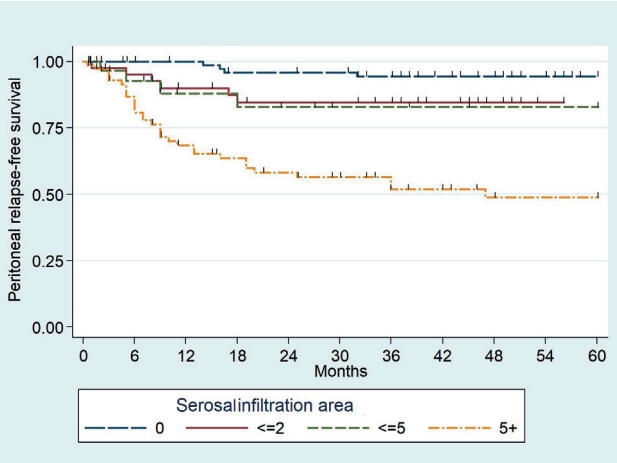

Figure 3. Peritoneal relapse-free survival depending on the size of serosal invasion

Regional lymph node metastases, as demonstrated above, are likely to increase the risk of peritoneal recurrence. However, the greater extent of regional lymph node involvement correlates with higher stages of the disease and is potentially associated with a greater

area of the serosal lesion. As a result, the influence of the lesion index of regional lymph nodes on the risk of peritoneal recurrence was studied in a homogeneous (relative to the area of tumor infiltration of the serous membrane of the stomach) group of patients, and statistical significance was confirmed (p=0,046, HR 2.39, 95 % CI 1.01-5.7).

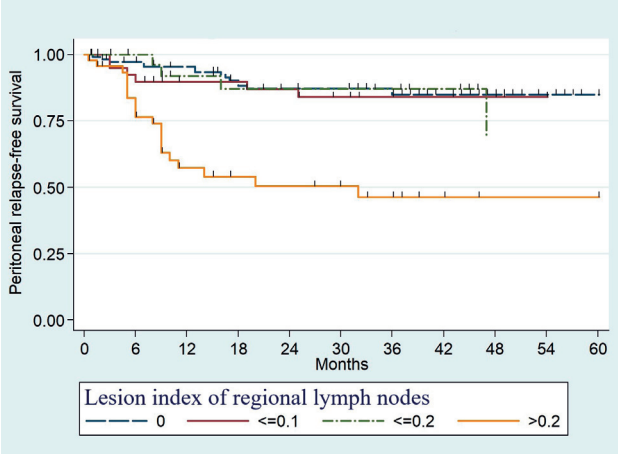

Figure 4. Peritoneal relapse-free survival depending on the lesion index of regional lymph nodes

Peritoneal recurrence factors that demonstrated statistical probability in a monofactorial analysis (Table 3) were further examined in a multivariate analysis and ranked by the scores of independent predictive factors. Based on this, a nomogram was developed to assess the risk of peritoneal recurrence in gastric cancer patients after radical surgery (Fig. 5, 6), and prognostic groups of gastric cancer patients were formed based on the risk of peritoneal recurrence (Fig. 7).

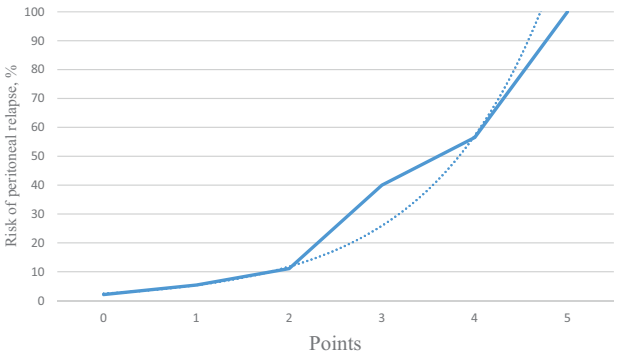

Figure 5. Nomogram of the dependence function of peritoneal recurrence risk on prospective factors of multivariate analysis (and exponential trend line)

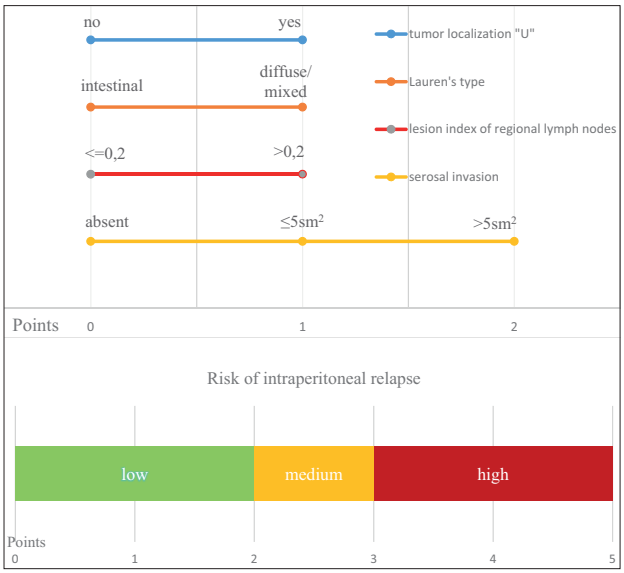

Figure 6. Algorithm for calculating the risk score of peritoneal recurrence in gastric cancer

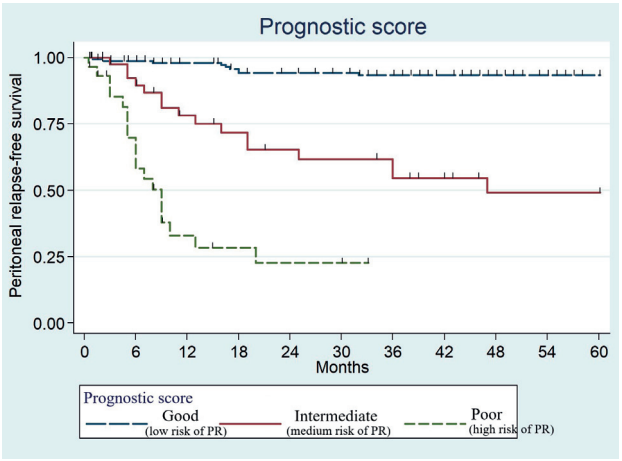

Figure 7. The prognostic groups of patients with gastric cancer in relation to the risk of peritoneal recurrence.

DISCUSSION

Peritoneal relapse is the most common pattern of GC recurrence after radical surgery [5]. The efficacy of various adjuvant peritoneal chemotherapy methods, such as hyperthermic intraperitoneal chemotherapy (HIPEC) [9], pressurized intraperitoneal aerosol chemotherapy (PIPAC) [10], early postoperative intraperitoneal chemotherapy (EPIC), extensive intraoperative peritoneal lavage (EIPL) [5, 12], intraperitoneal immunotherapy [13], etc., is being studied today to reduce the rate of peritoneal relapse. Thus, in clinical practice, the study of independent predictors and the development of a predictive nomogram for the peritoneal recurrence of GC may

serve as a powerful tool for forming a cohort of patients with indications for adjuvant intraperitoneal chemotherapy. There are only a few reports on this subject in the literature [14]. Based on the results of monovarietal analysis of about three dozen potential factors and multivariate analysis, we identified four independent predictive factors of peritoneal recurrence of GC based on which we built a nomogram: invasion of the serosal membrane, area of serosal invasion, morphological type according to Lauren, index of regional lymph node involvement, and tumor localization in the upper third of the stomach.

The depth of tumor invasion in the gastric wall, and particularly the invasion of the stomach's serous membrane, are significant predictors of GC peritoneal recurrence [2, 4, 15]. As expected, our study confirmed the likely impact of primary tumor invasion depth on the risk of peritoneal relapse, with a drastic increase when reaching the level of the serous membrane (pT4a) and a subsequent increase when growing into adjacent structures (pT4b). The presence of serosal invasion determines the likelihood of malignant cell desquamation into the free abdominal cavity, resulting in implantation metastasis. In our study, the rate of peritoneal recurrence was 28.87% in the presence of serosal invasion, compared to only 4.76% in its absence.

Naturally, the likelihood of peritoneal relapse increases as the extent of serosal invasion grows. As a result, we observed a likely progressive decline in the level of 2-year PRFS to 84.4% with an invasion area greater than 5 cm^2, to 62.6% with an area greater than 10 cm^2, and to 18.8% with an area greater than 60 cm^2. The prognostic significance of invasion extent in the stomach's serous membrane has previously been reported [16]. According to Lauren, this tendency has only been statistically confirmed in patients with diffuse and mixed types of gastric cancer. The extent of tumor invasion into the serous membrane had no effect on the risk of PR in patients with intestinal cancer.

Hence, the potential for implantation metastasis development is strongly dependent on the biology of the tumor rather than the mechanistic factors of dissemination (depth and size of invasion). Thus, high affinity for peritoneal metastases has previously been demonstrated for the diffuse type, as well as undifferentiated and signet ring cell cancer [2, 3]. In this study, PR developed in 31.15% of patients with diffuse and mixed types by Lauren, while in patients with intestinal GC, only in 5.94%.

The possibility of implantation metastasis development in the absence of serous membrane invasion is an intriguing issue in clinical oncology. In our study, we found that 4.76% of such patients had PR. Possibly, their occurrence could have been triggered by malignant cell translocation through an intact serous membrane or by a lymphogenic factor [17]. Admittedly, the presence of the "pN+" factor in this study increased the risk of metachronous implantation metastasis. Also, the findings of this study regarding the number of affected lymph nodes and the predictive significance of the lymphogenic lesion index were innovative. Thus, as the number of affected regional lymph nodes increased to a level ≥ 4, the risk of peritoneal recurrence increased dramatically, whereas patients with 1–3 lymph node invasion had a risk of peritoneal recurrence compared to patients with pN0. The risk of PR dramatically increases when reaching a lymphogenic lesion index ≥ 0,21.

As a result, this fundamental scientific finding confirms the possibility of the lymphogenic factor being of significance in the implementation of peritoneal recurrence mechanisms. Desquamation in the area of perinodal tumor invasion and dissemination caused by surgical trauma, as well as lymphorrhea in the abdominal cavity, are possibilities for implementing the lymphogenic mechanism. However, the effect of expanded lymph dissection on the risk of PR is still debatable [18].

The mechanism of influence on the risk of peritoneal recurrence in the case of tumor localization in the upper third of the stomach remains uncertain. Potential justification for that could be different molecular profiles of tumors located in different anatomical thirds of the stomach with different potential for implantation metastasis [19].

In conclusion, based on the identified independent prospective factors, a predictive nomogram of peritoneal gastric cancer recurrence after radical surgical treatment has been developed, with a clear practical direction and major clinical significance as a tool for segregating patients for receiving adjuvant intraperitoneal therapy.

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