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Analysis of Prognostic Factors Affecting Short-term and Long-term Outcomes of Gastric Cancer Resection

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Abstract. *Background: The aim of this study was the analysis of the influence of prognostic factors on short- and long-term outcomes of gastric cancer resection. Patients and Methods: A database of 709 patients who had gastric cancer resection between 2007 and 2015 was compiled. Results: Total gastrectomy (TG) and subtotal proximal gastrectomy (SPG) significantly increased the risk of overall complications (p=0.0015 and 0.0173, respectively) and surgical complications (p=0.0141 and 0.0035, respectively). Moreover the resection of an additional organ was an independent prognostic factor of overall complications (p<0.0001), systemic complications (p=0.0503), surgical complications (p<0.0001) and relaparotomy (p=0.0259). T stage (p<0.0001), N stage (p<0.0001), M stage (p<0.0001) and radical resection (p<0.0001) significantly affected 5-year survival rates. Conclusion: Early diagnosis and radical resection was crucial in 5-year survival rates. However, the type of gastrectomy and the resection of an additional organ were the most important factors in short-term outcomes of treatment for such patients.*

Gastric cancer is the second most common cancer of the gastrointestinal tract in the world. In 2020, the incidence of new cases of gastric cancer was estimated at 1,089,103, with a mortality rate of 768,793 people globally. Unlike East Asia, gastric cancer is a relatively rare neoplasm in North America and some highly developed countries in Western Europe. However, even there it is one of the most common causes of death from malignant neoplasms (1). In Poland, the number of deaths from gastric cancer reaches 5000 per year. In 2018, 3155 men and 1745 women died from this in our country (2).

Currently, the majority of publications concern aspects of multimodal therapy with pre- and perioperative chemotherapy, even in the presence of oligometastasis. Nevertheless, surgical resection is still the most effective treatment for such patients, and the principles of surgery of gastric cancer are usually well established (3-5).

Although data from a large number of articles reveals the impact of prognostic factors on the prognosis of patients with gastric cancer resection, survival is significantly improved by the effectiveness of surgical treatment measured by short-term outcomes. Most reports involving prognostic factors for patients after gastric cancer resection focus on the 5-year survival rate. There are no in detail articles on the influence of prognostic factors on short-term outcomes of treatment such as overall complications, systemic complications, surgical complications, relaparotomy and perioperative mortality (6-30). There are many prognostic factors that could affect the short-term outcomes of gastric cancer resection including gender, age, location, histologic type, tumour staging, type of gastrectomy, number of retrieved lymph nodes or resection of an additional organ.

In this study we carried out univariate and multivariate analysis of prognostic factors which, in addition to long-term outcomes (5-year survival), also affected the short-term outcomes of gastric cancer resection. Detailed analysis of prognostic factors made it possible to obtain interesting conclusions about gastric cancer resection, which may significantly influence the optimization of surgical treatment outcomes.

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Key Words: Gastric cancer resection, prognostic factor, treatment outcome.

Patients and Methods

Patient population. Between 2007 and 2015, 709 patients had gastric cancer resection at the First Department of General, Oncological, Gastrointestinal and Transplantation Surgery, Jagiellonian University Medical College in Krakow. Their database with clinicopathologic features and surgical characteristic was reviewed retrospectively (Table I).

Diagnosis and clinicopathological features. Routine preoperative diagnostics included gastroscopy during which samples were drawn for histopathological examination, chest X-ray, abdominal ultrasonography and, in selected cases, computed tomography. Gastric cancer was defined as a histologically verified primary adenocarcinoma located in the stomach. Patients with other gastric tumors such as gastric lymphoma, gastrointestinal stromal tumor or recurrence of gastric cancer were excluded. The site of the tumor was defined as the location of the main portion of the neoplasm in the upper, middle or lower third of the stomach. Sometimes at diagnosis, gastric cancer was so advanced that occupied two analyzed locations in the stomach (upper/middle/lower), in these cases the location was classified as 'other' (Table I); it was not possible to assume which location was primary. To correctly evaluate the influence of tumor location in the stomach on short- and long-term outcomes of gastric cancer resection in univariate analysis and the logistic regression model, location classified as other was not included. The Lauren classification was used for the histologic evaluation of the tumor (31). The gastric cancer staging system was evaluated by pathological examination of the surgical specimens in accordance with the eighth edition of the TNM staging system of the American Joint Committee on Cancer/Union for International Cancer Control (AJCC/UICC) (32).

Surgical characteristics and treatment. The types of gastrectomy, total/subtotal distal/subtotal proximal and reconstruction options were determined by the location of the tumor, a histopathological examination, and the stage of the disease. However, all resections included in the study were carried out by conventional laparotomy. Lymphadenectomy with the removal of perigastric lymph nodes, lymph nodes around the left gastric artery, common hepatic artery, celiac trunk, splenic artery, hepatoduodenal ligament or additionally paraaortic lymph nodes (D2 or D2+) was standard in cases of radical stomach resections. In some cases, segmental pancreatectomy, spleen and/or bowel resections were performed to obtain potential oncological radicality. Cases with unresectable procedures (gastrojejunostomy, by-pass surgery or explorative laparotomy) without gastric cancer resection were excluded from the study. Some patients with advanced gastric cancer (stage II or higher according to TNM classification) received combined therapy using different chemotherapeutic regimens with fluorouracil, cisplatin with fluorouracil, irinotecan with fluorouracil or etoposide, doxorubicin and cisplatin.

Follow-up. Perioperative mortality was defined as any death during the hospital stay after surgery. After discharge, patients had a followed-up every 3-6 months or shorter intervals whenever justifiable. The dates of death were verified using data obtained from the census registry office. All relevant short-term outcomes of treatment, overall complications, systemic complications, surgical complications, relaparotomy as well perioperative mortality were collected and entered into an electronic database (Table II). In some cases, the same patient manifested both systemic and surgical complications. The 5-year survival was understood as long-term outcomes of treatment after gastric cancer resection (Table II). To each of the parameters of short- (overall complications, systemic complications, surgical complications, relaparotomy, perioperative mortality) and long-term (5-year survival) outcomes of treatment was carried out the univariate and multivariate analysis of affecting prognostic factors. These prognostic factors are presented in Table I as clinicopathologic features, and surgical characteristics.

Statistical methods. To determine the relationship between prognostic factors and the outcomes of treatment after gastric cancer resection, we applied the χ^2 test and a logistic regression model. The χ^2 test was used in the univariate analysis. In view of the available database of the presence of short-term outcomes of treatment and 5-year survival rates, logistic regression models were used in multivariate analysis, which allowed the generation of a dependency model for a binary dependent variable and one or more predictors (prognostic factors). $p<0.05$ was considered statistically significant in two-tailed analysis. The calculations were performed with the statistical package STATISTICA v. 13 and StatsDirect v. 3.3.4.

Results

Prognostic factors: clinicopathological features and surgical characteristics. The study involved 479 (67.6%) males and 230 (32.4%) females. The mean age±SD (min-max) was 63.9±12.0 (range=22-89) years, and the incidence of patients older than 70 years was 33.7%. Most tumors were located in the upper third part of the stomach (31.9%). The rates of intestinal and diffuse type of Lauren classification were comparable at 43.6% and 43%, respectively. The proportion of patients with T stage, N stage, M stage according to the eighth edition of TNM (AJCC/UICC) are presented in Table I. The most common type of gastrectomy was total gastrectomy (64.9%) and the most common resected additional organ was the spleen (12.7%). The incidence of patients who had >15 lymph nodes removed was 84.1%. The proportion of patients who underwent radical resection was 59.4% (Table I).

Outcomes of treatment. Postoperative complications are presented in Table II. The overall percentage of complications was 19.6%, while the rates of systemic and surgical complications were 11.6% and 11.3%, respectively. The proportion of relaparotomy was 4.8%. The incidence of perioperative mortality was 3.1%. The 5-year survival rate was 39.1%. Median follow-up was 58.6 (39.5-103.6) months.

Univariate and multivariate analyses. Univariate analysis by the χ^2 test revealed potential prognostic factors affecting the short-term outcomes of gastric cancer resection such as overall complications, systemic complications, surgical complications, relaparotomy and perioperative mortality (Table III). The same analysis was used to detect potential prognostic factors of 5-year survival for patients (Table IV). Subsequently, prognostic

Table I. *Potential prognostic factors: clinicopathological features and surgical characteristics.*

Prognostic factors	2007-2015 (n=709)
Clinicopathological features	n (%)
Gender	
Male	479 (67.6)
Female	230 (32.4)
Age, years	
≤70	470 (66.3)
>70	239 (33.7)
Location	
Upper	226 (31.9)
Middle	201 (28.3)
Lower	148 (20.9)
Other	134 (18.9)
Lauren type	
Diffuse	305 (43.0)
Intestinal	309 (43.6)
Mixed	95 (13.4)
T stage (eight edition AJCC/UICC)	
T1a	29 (4.1)
T1b	41 (5.8)
T2	124 (17.5)
T3	170 (24.0)
T4a	105 (14.8)
T4b	240 (33.8)
N stage (eight edition AJCC/UICC)	
N0	111 (15.7)
N1	104 (14.7)
N2	129 (18.2)
N3a	81 (11.4)
N3b	284 (40.1)
M stage (eight edition AJCC/UICC)	
M0	423 (59.7)
M1	286 (40.3)
Surgical characteristics	n (%)
Type of gastrectomy	
Total	526 (64.9)
Subtotal distal	140 (17.3)
Subtotal proximal	43 (15.3)
Resection type	
Radical	421 (59.4)
Palliative	288 (40.6)
Number of retrieved lymph nodes	
≤15	113 (15.9)
>15	596 (84.1)
Resection of an additional organ	
None	577 (81.4)
Spleen	90 (12.7)
Pancreas	2 (0.3)
Bowel	15 (2.1)
Spleen, pancreas	15 (2.1)
Spleen, bowel	4 (0.6)
Pancreas, bowel	2 (0.3)
Spleen, pancreas, bowel	3 (0.4)

Table II. *Outcomes of gastric cancer resection.*

	2007-2015 (n=709)
Short-term outcomes of treatment	n (%)
Overall complications	139 (19.6)
Systemic complications	82 (11.6)
Surgical complications	80 (11.3)
Relapalotomy	34 (4.8)
Perioperative mortality	22 (3.1)
Long-term outcomes of treatment	n (%)
5-year survival	277 (39.1)

factors statistically significantly affecting short-term outcomes and 5-year survival in the univariate analysis were assessed with the logistic regression model (Tables V, VI, VII, VIII and IX). Finally, multivariate analysis showed that total gastrectomy [odds ratio (OR)=1.12, 95% confidence interval (Cl)=0.93-1.36, p=0.0015], and subtotal proximal gastrectomy (OR=1.28, 95% Cl=1.04-1.58, p=0.0173) were independent risk factors of overall complications (Table V). The same types of gastrectomy significantly increased the incidence of surgical complications (total gastrectomy: OR=1.19, 95% Cl 0.94-1.49, p=0.0141; subtotal proximal gastrectomy: OR=1.16; 95% Cl=0.91-1.47, p=0.0035) (Table VII). Resection of an additional organ significantly increased rates of overall complications (OR=2.56, 95% Cl=1.79-3.65, p<0.0001), systemic complications (OR=1.52, 95% Cl=0.99-2.32, p=0.0503), surgical complications (OR=3.04; 95% Cl=2.07-4.46, p<0.0001), and relaparotomy (OR=1.9, 95% Cl=1.08-3.36, p=0.0259) (Tables V, VI, VII and VIII). The presence of distant metastases (M1 stage) was identified as an independent prognostic factor for a higher perioperative mortality proportion (OR=1.36; 95% Cl=0.39-4.66, p=0.0422) (Table VIII). The multivariate analysis showed that T stage (OR=0.52, 95% Cl=0.41-0.66, p<0.0001), N stage (OR=0.48, 95% Cl=0.39-0.6, p<0.0001), M stage (OR=0.01, 95% Cl=0.001-0.08, p<0.0001), location in the middle third part of the stomach (OR=1.57, 95% Cl=0.73-3.37, p=0,0239) and radical resection (OR=2.84, 95% Cl=2.01-10.95, p<0.0001) significantly affected 5-year survival (Table IX).

Discussion

Clinicopathological features

Gender. Gastric cancer is twice as common in men as it is in women (33). Gender is reported as being not an independent prognostic factor of survival (6, 7). However, in a large database - which is presented in the study Li *et al*. - white

Table III. *Univariate analysis of clinicopathological features and their influence on the outcomes of gastric cancer resection.*

		Outcomes of treatment											
Clinicopathological features	n	Overall complications		Systemic complications		Surgical complications		Relaparotomy		Perioperative mortality		5-year survival	
Gender													
Male	479	106	p=0.015*	47	p=0.008*	59	p=0.209*	25	p=0.446*	18	p=0.147*	38%	p=0.398*
		22.1%		10%		12.3%		5.2%		3.8%			
Female	230	33		35		21		9		4		41.3%	
		14.4%		14.6%		9.1%		3.9%		1.7%			
Age													
≤70 lat	470	87	p=0.303*	53	p=0.068*	51	p=0.610*	24	p=0.587*	12	p=0.236*	36.6%	p=0.058*
		18.5%		9.9%		10.9%		5.1%		2.6%			
>70 lat	239	52		40		29		10		10		43.9%	
		21.8%		14.7%		12.1%		4.2%		4.2%			
Location													
Upper	226	49	p=0.593*	28	p=0.753*	31	p=0.140*	13	p=0.752*	9	p=0.821*	81	p=0.003*
		21.7%		12.4%		13.7%		5.8%		4.0%		35.8%	
Middle	201	38		20		24		9		5		87	
		18.9%		10.0%		11.9%		4.5%		2.5%		43.3%	
Lower	148	24		16		9		5		4		71	
		16.2%		10.8%		6.1%		3.4%		2.7%		48%	
Lauren type													
Diffuse	305	56	p=0.065*	40	p=0.194*	26	p=0.029*	12	p=0.645*	9	p=0.979*	117	p=0.509*
		18.4%		13.1%		8.5%		3.9%		3.0%		38.4%	
Intestinal	309	71		36		46		17		10		127	
		23%		11.7%		14.9%		5.5%		3.2%		41.1%	
Mixed	95	12		6		8		5		3		33	
		12.6%		6.3%		8.4%		5.3%		3.2%		34.7%	
T stage													
T1a	29	1	p<0.001*	1	p=0.003*	0	p=0.020*	0	-	0	-	28	p<0.001*
		3.5%		3.5%		0.0%		0%		0%		96.6%	
T1b	41	2		1		1		0		0		36	
		4.9%		2.4%		2.4%		0%		0%		87.8%	
T2	124	20		10		12		7	p=0.344*	1	p=0.210*	92	
		6.1%		8.1%		9.7%		5.7%		0.8%		74.2%	
T3	170	25		14		15		6		5		84	
		14.7%		8.2%		8.8%		3.5%		2.9%		49.4%	
T4a	105	26		13		17		6		5		21	
		24.8%		12.4%		16.2%		5.7%		4.8%		20.0%	
T4b	240	65		43		35		15		11		36	
		27.1%		17.9%		14.6%		6.3%		4.6%		87.8%	
N stage													
N0	111	8	p<0.001*	4	p<0.001*	5	p=0.029*	4	p=0.282*	1	p=0.242*	107	p<0.001*
		7.2%		3.6%		4.5%		3.6%		0.9%		96.4%	
N1	104	14		8		8		3		1		87	
		13.5%		7.7%		7.7%		2.9%		1.0%		83.7%	
N2	129	19		7		14		4		4		45	
		14.7%		5.4%		10.9%		3.1%		3.1%		34.9%	
N3a	81	16		10		10		7		4		15	
		19.8%		12.4%		12.4%		8.6%		4.9%		18,5%	
N3b	284	82		53		43		16		12		23	
		28.9%		18.7%		15.1%		5.6%		4.2%		8.1%	
M stage													
M0	423	60	p<0.001*	32	p<0.001*	36	p=0.005*	16	p=0.125*	8	p=0.024*	276	p<0.001*
		14.2%		7.6%		8.5%		3.8%		1.9%		65.3%	
M1	286	79		50		44		18		14		1	
		27.6%		17.5%		15.4%		6.3%		4.9%		0.4%	
		27.8%		17.4%		15.6%		6.6%		4.9%		0.4%	

*χ^2 test.

Table IV. *Univariate analysis of surgical characteristics on the outcomes of gastric cancer resection.*

Surgical characteristics	N	Outcomes of treatment											
		Overall complications		Systemic complications		Surgical complications		Relaparotomy		Perioperative mortality		5-year survival	
Type of gastrectomy													
Total	526	115	p=0.031*	68	p=0.146*	67	p=0.031*	27	p=0.421*	20	p=0.058*	186	p=0.001*
		21.9%		12.9%		12.7%		5.1%		3.8%		35.4%	
Subtotal distal	140	17		10		7		4		0		74	
		12.1%		7.1%		5%		2.9%		0.0%		52.9%	
Subtotal proximal	43	7		4		6		3		2		17	
		16.3%		9.3%		14.0%		7,0%		4,7%		39,5%	
Resection of an additional organ													
No	577	85	p<0.001*	56	p=0.002*	42	p<0.001*	22	p=0.008*	14	p=0.015*	246	p<0.001*
		14.7%		9.7%		7.3%		3.8%		2.4%		42.6%	
1	107	40		19		28		8		5		30	
		37.4%		17.8%		26.2%		7.5%		4.7%		28%	
>1	25	14		7		10		4		3		1	
		56.0%		28.0%		40.0%		16.0%		12.0%		4.0%	
Resection of an additional organ													
No	577	85	p<0.001*	56	p=0.020*	42	p<0.001*	22	p<0.001*	14	p=0.045*	246	p=0.001*
		14.7%		9.7%		7.3%		3,8%		2.4%		42.6%	
Spleen	90	35		16		26		8		4		28	
		38.9%		17.8%		28.9%		8.9%		4.4%		31.1%	
Bowel	15	3		2		1		0		1		2	
		20%		13.3%		6.7%		0%		6.7%		13.3%	
Pancreas	2	2		1		1		0		0		0	
		100%		50%		50%		0%		0%		0%	
Spleen, bowel	4	3		1		2		1		0		0	
		75%		25%		50%		25%		0%		0%	
Spleen, pancreas	15	6		5		5		1		2		1	
		40%		29.4%		29.4%		5.9%		11.8%		5.9%	
Pancreas, bowel	2	2		1		1		0		0		0	
		100%		50%		50%		0%		0%		0%	
Spleen, pancreas, bowel	4	3		1		3		2		1		0	
		75%		25%		75%		50%		25%		0%	
Number of retrieved lymph nodes													
>15	596	114	p=0.462*	66	p=0.347*	65	p=0.466*	28	p=0.780*	17	p=0.377*	247	p=0.003*
		19.1%		11.1%		10.9%		4.7%		2.9%		41.4%	
≤15	113	25		16		15		6		5		30	
		22.1%		14.2%		13.3%		5.3%		4.4%		26.6%	
Resection type													
Radical	421	61	p<0.001*	32	p<0.001*	38	p=0.022*	17	p=0.254*	9	p=0.073*	277	p<0.001*
		14.5%		7.6%		9.0%		4.0%		2.1%		65.8%	
Paliative	288	7		50		42		17		13		0	
		27.1%		17.4%		14.6%		5.9%		4.5%		0%	

*χ^2 test.

female patients as well as male Asian patients showed an independent prognostic factor for better survival in gastric cancer. According to the same database, the prognosis among black female patients between 1973 and 2003 was better than that of men, whereas sex-related survival was not significant in the black race between 2004 and 2013 (8). In Poland, epidemiological data on gastric cancer has stabilized in the last few years (5, 34, 35). Multivariate analysis in our study showed that gender was not a significant prognostic factor that affected overall complications, systemic complications, surgical complications, relaparotomy as well perioperative mortality and 5-year survival.

Table V. *The logistic regression model for overall complications.*

Prognostic factors	OR	95% CI	Coefficient	*p*-Value
(Intercept)	n/a		–2.8	<0.0001
Gender/male	1.57	0.99-2.5	0.45	0.0555
T stage	1.05	0.82-1.36	0.05	0.6733
N stage	1.15	0.8-1.65	0.14	0.4458
M stage	0.87	0.22-3.42	0.14	0.8394
Type of Gstrectomy				
Total	1.12	0.93-1.36	0.12	0.0015
Subtotal distal	0.34	0.18-0.66	1.06	0.2258
Subtotal proximal	1.28	1.04-1.58	0.25	0.0173
Resection of an additional organ	2.56	1.79-3.65	0.94	<0.0001
Resection type/radical	1.001	0.27-3.74	0.001	0.0989

OR: Odds ratio; CI: confidence interval.

Table VI. *The logistic regression model for systemic complications.*

Prognostic factors	OR	95% CI	Coefficient	*p*-Value
(Intercept)	n/a		–3.7	<0.0001
Gender/male	1.98	1.09-3.6	0.68	0.2548
T stage	1.027	1.005-1.05	0.03	0.1527
N stage	0.25	0.092-0.68	1.38	0.6815
M stage	0.82	0.17-3.99	0.2	0.8045
Resection of an additional organ	1.52	0.99-2.32	0.42	0.0503
Resection type/radical	0.76	1.17-3.38	0.28	0.7156

OR: Odds ratio; CI: confidence interval.

Age. The incidence of gastric cancer increases with age and most often occurs in the 7th decade of life (33). It is usually acknowledged that in gastric cancer surgery older patients demonstrate increased risk of complications and a poorer prognosis (6, 7, 9-13). Although most articles on the impact of age on prognosis of patients with gastric cancer recognize old age as more than 60 years, the 7th decade of life is usually a period of relatively good health nowadays, therefore, in our study, the border age affecting the outcomes of treatment was fixed at 70 years (6, 7, 10, 11). In the present study, the logistic regression model revealed that even at an age >70, this was not an independent prognostic factor influencing the short- and long-term outcomes of treatment for patients with gastric cancer resections. Similarly, Kulig *et al*. did not find differences in complications and perioperative mortality rates, except for a higher incidence of cardiopulmonary complications in older patients undergoing gastric cancer resection (6.6% *vs*. 12.3%). The median survival of patients was not significantly longer in younger (30.8 months) *vs*. older (24.1 months) patients (p=0.056) (14). Another report from Poland stratified patients into four groups according to their age: 29-50 years (group I), 51-65 years (group II), 66-75 years (group III) and 76-92 years (group IV). The middle-aged patients (group II) had significantly better 3-year survival than either the youngest (group I) or the oldest patients (group IV) (15). Nakamura *et al*. reported that youth is a prognostic factor of better survival for early gastric cancer, however for advanced gastric cancer, younger patients are prone to more advanced stages of TNM and a poorer prognosis (36). Saito *et al*. concluded that elderly patients undergo less aggressive surgical resections such as extended lymph node excision or multi-organ resections and present a poorer prognosis (37).

Tumor location. Incidence of gastric cancer situated in the lower or middle third part of the stomach have been steadily going down. Incidence in the upper third part is stable or higher, which could be caused by an inappropriate diet, or obesity and reflux disease in patients with gastric cancer (17-21). However, the occurrence of this prognostic factor depends on geographical location and race, for example, in

Table VII. *The logistic regression model for surgical complications*.

Prognostic factors	OR	95% CI	Coefficient	*p*-Value
(Intercept)	n/a		–2.76	0.0003
Type of gastrectomy				
Total	1.19	0.94-1.49	0.17	0.0141
Subtotal distal	0.28	0.12-0.66	1.26	0.2391
Subtotal proximal	1.16	0.91-1.47	0.14	0.0035
Lauren type				
Diffuse	0.29	0.16-0.57	1.21	0.2972
Intestinal	0.67	0.36-1.24	0.4	0.2016
Mixed	0.31	0.15-0.67	1.15	0.2914
T stage	1.13	0.89-1.44	0.12	0.3044
N stage	1.13	0.8-1.45	0.12	0.3584
M stage	1.73	0.31-9.67	0.55	0.5314
Resection of				
an additional organ	3.04	2.07-4.46	1.11	<0.0001
Resection type/radical	1.16	0.92-1.47	0.15	0.1947

OR: Odds ratio; CI: confidence interval.

Table VIII. *The logistic regression model for relaparotomy and perioperative mortality*.

Prognostic factors	OR	95% CI	Coefficient	*p*-Value
(Intercept)	n/a		–2.17	0.0296
Resection of an additional organ	1.9	1.08-3.36	0.64	0.0259
Prognostic factors	The logistic regression model for perioperative moratlity			
	OR	95% CI	Coefficient	*p*-Value
(intercept)	n/a		–2.17	0.0066
M stage	1.36	0.39-4.66	0.31	0.0422
Resection of an additional organ	4.37	0.62-31.06	1.48	0.1399

OR: Odds ratio; CI: confidence interval.

Table IX. *The logistic regression model for 5-year survival*.

Prognostic factors	OR	95% CI	Coefficient	*p*-Value
(intercept)	n/a		–0.15	0.1084
Resection type/radical	2.84	2.01-10.95	6.55	<0.0001
Type of gastrectomy				
Total	0.76	0.61-0.96	0.27	0.1891
Subtotal distal	0.28	0.08-1.046	1.26	0.5842
Subtotal proximal	0.855	0.53-1.37	0.15	0.5198
Resection of an additional organ	0.47	0.32-0.69	0.19	0.5373
>15 retrieved lymph nodes	0.83	0.34-2.05	0.18	0.691
Location				
Upper	0.97	0.47-2.02	0.02	0.945
Middle	1.57	0.73-3.37	0.46	0.0239
Lower	1.22	0.52-2.84	0.2	0.0541
T stage	0.52	0.41-0.66	0.64	<0.0001
N stage	0.48	0.39-0.6	0.71	<0.0001
M stage	0.01	0.001-0.08	4.42	<0.0001

OR: Odds ratio; CI: confidence interval.

Asia the proportion of tumors in the lower third part of the stomach exceeds 50% (6).

Tan *et al*., Zhao *et al*., and Lee at al. indicated that the location in the upper third part of the stomach was not an independent prognostic factor of poor survival (6, 25, 26). In this study, the most common location was the upper third part of the stomach (31.9%). In multivariate analysis, location was not a prognostic factor that affected overall complications, systemic and surgical complications, relaparotomy as well perioperative mortality, but the location in the middle third part of the stomach had influence on improved 5-year survival rates (p=0.0239). Conclusions from most reports are consistent with the results of our study. Petrelli *et al*. reviewed 50 studies including 128,268 patients with gastric cancer, they indicated that a location in the upper third part of the stomach entailed increased risk of tumor-related death and was an important prognostic factor of poorer prognosis (22). Matsuda *et al*. and Yu *et al*. Also found the same, *i.e*. that patients who underwent resection for gastric cancer with proximal cancer had a poorer 5-year survival (23, 24).

Lauren types and tumor staging. In line with the results of our study, the proportion of intestinal type gastric cancers has decreased, while the incidence of diffuse type has recently increased (38-42). Tan *et al*. noticed that the histological type in gastric cancer patients does not effect prognosis (6). However, most reports have shown that patients with intestinal type gastric cancer demonstrate significantly better survival than diffuse type and mixed type (27-29). In our study, the Lauren type was not an independent prognostic factor that affected the short-term outcomes of treatment and the 5-year survival rates.

As we all know, early stages (according to TNM classification) have an influence on better prognosis after gastric cancer resection (6, 7, 10, 25, 26, 30). Although in studies from the Netherlands and France where stage IV remained stable over the last few years, the staging of TNM of gastric cancer at diagnosis significantly decreased over the last decades (38, 43-47). In the present study, early gastric cancer occurred in 9.9% of cases, while the proportion of patients with stage IV cancer compromised 40.3%. In multivariate analysis, T stage (p<0.0001), N stage (p<0.0001) and M stage (p<0.0001) influenced the 5-year survival and the presence of distant metastases (M1 stage) influenced perioperative mortality (p=0.0422). Nevertheless, TNM stages was not independent prognostic factors affecting short-term outcomes of treatment such as overall complications, systemic complications, surgical complications and relaparotomy.

Surgical characteristics

Type of resection. Some articles reported that the 5-year survival rates for patients with gastric cancer reveal no significant changes depend on type of gastrectomy at the same stage of the disease (48-50). Studies carried out by the Polish Gastric Cancer Study Group have shown that total gastrectomy improves the 5-year survival in patients with stage IIIA according to the TNM classification (51). In multivariate analysis from the present study, the type of gastrectomy (total, subtotal, proximal or subtotal distal) statistically significantly influenced the overall and surgical complications, but not the systemic complications, relaparotomy as well perioperative mortality and 5-year survival rate.

In Asia, the proportion of patients with gastric cancer who undergo radical resection exceeds 90% (6, 52). In this study, this type of resection occurred in 59.4% of cases. The fact is that opposite to palliative, radical resection is an independent prognostic factor of better survival which is documented in patients in our study (52, 53-55). An interesting conclusion from the present study was that, the type of resection (radical, palliative) was not an independent risk factor in the logistic regression model influencing the short-term outcomes of treatment such as overall complications, systemic complications, surgical complications, relaparotomy and perioperative mortality.

Number of retrieved lymph nodes. In the study of Tan *et al*., the percentage of patients with gastric cancer with the removal of >15 lymph nodes was raised from 38.6% to 81.7% over a 30-year period (6). Although some reports indicated higher rates of postoperative complications after extended lymphadenectomy (D2, D2+ or D3) compared to D1, it is a routine procedure for patients with potentially radical gastric cancer resection, as it raises the oncological radicality and results in better survival for such patients (56-58). Marubini *et al*. did not observe any differences in perioperative mortality depending on the extent of lymphadenectomy (58). In the present study, dissection of >15 lymph nodes was a significant prognostic factor of 5-year survival in univariate (p=0.003) but not in multivariate analysis (p=0.691). Interestingly, this was not an independent prognostic factor influencing overall, systemic and surgical complications, relaparotomy and perioperative mortality in the logistic regression model.

Resection of an additional organ. Combined resection of the neoplasm-related affected organs such as the spleen, pancreas or bowel, like an extended lymphadenectomy, may cause increased oncological radicality and better survival in patients of gastric cancer resection (52, 53, 55, 59). However, multiple organ resection is associated with relatively high rates of complications and perioperative mortality (53, 59, 60). Furthermore, Mita *et al*. indicated that extended multi-organ resection could be beneficial only if radical surgery is carried out in such patients (54). Wang *et al*. reported that patients with locally advanced gastric cancer (T4-TNM) extending to the bowel might benefit from radical resection with

acceptable rates of postoperative complications (52). Opposite to Wang *et al*., in multivariate analysis from our study, the resection of an additional organ was an independent risk factor of overall complications ($p<0.0001$), systemic ($p=0.0503$) and surgical complications ($p<0.0001$) as well relaparotomy ($p=0.0259$), and did not significantly influence 5-year survival rates ($p=0.5373$).

Study limitations. A limitation was that this was a retrospective, single-centre research project. The prognostic factors which were chosen for the analysis, for which data in the patient database of the patients was the most complete. Nevertheless, an analysis of all prognostic factors affecting overall complications, systemic and surgical complications, relaparotomy, as well perioperative mortality and 5-year survival of gastric cancer resection exceeds the size of a discussion for a single scientific article.

In fact, conclusions concerning 5-year survival did not differ from the previous papers, regarding the effect of prognostic factors on outcomes of gastric cancer resection. That said, early diagnosis followed by a radical resection is crucial in gastric cancer patients. However, the study database was from recent years (the final follow-up date was December 18, 2020). Moreover, analysis of prognostic factors after gastric cancer resection apart from the 5-year survival details their influence in the short-term treatment outcomes, such as overall complications, systemic and surgical complications, relaparotomy as well as perioperative mortality, which is an added benefit of our study.

Conclusion

When possible, a subtotal distal gastrectomy should be the preferred type of gastric cancer resection, as it causes significantly less incidence of overall and surgical complications compared to total and subtotal proximal gastrectomy. Resection of an additional organ such as the spleen, pancreas and/or the bowel is not recommended, because of the significantly increased rates of overall complications, systemic and surgical, as well as relaparotomy. In patients with resection of an additional organ, gastric cancer was too advanced in order for this to make a difference in the 5-year survival. Furthermore, the presence of distant metastases significantly increased the proportion of periopertive mortality. A location in the middle third part of the stomach was demonstrated as an independent prognostic factor of improved 5-year survival. However, early recognition with radical resection is still crucial for 5-year survival of patients after gastric cancer resection.

Conflicts of Interest

The Authors declare that they have no conflicts of interest.

Authors' Contributions

Piotr Kulig: concept of the study, collection and analysis of patients database, statistical analysis, database results analysis, preparing articles for discussion, writing the manuscript. Przemysław Nowakowski: collection and analysis of patients database, statistical analysis, database results analysis, preparing articles for the discussion. Marek Sierzęga: concept of the study, collection and analysis of patients database, database results analysis, critical review. Radosław Pach: collection and analysis of patients database, statistical analysis, database results analysis. Oliwia Majewska: collection and analysis of patients database, preparing articles for the discussion. Anna Markiewicz: collection and analysis of patients database, statistical analysis, database results analysis. Piotr Kołodziejczyk: concept of the study, database results analysis. Jan Kulig: concept of the study, database results analysis, critical review. Piotr Richter: concept of the study, database results analysis, critical review.

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