

Risk factors of postoperative complications after curative surgery in gastric cancer

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Study aim. The aims of the study were: 1. Evaluation of factors increasing the risk of complications after total or subtotal gastric resection for gastric cancer; 2. Attempt to evaluate changes in perioperative management that should decrease the complication risk after curative surgical treatment in gastric cancer patients.

Patients and methods. The series includes 253 patients with gastric cancer who were prospectively followed up from 1988 to 2001. Detailed evaluation covered 132 patients in whom radical operations were performed. Analysed factors were: age, gender, nutritional status, stage, pathology of regional lymph nodes, operating time, type of surgery, stapler use, preoperative and postoperative nutritional support. Relations between each factor and general or surgical complications incidence were analyzed.

Results. Postoperative complications occurred in 63 patients (47.7%) – surgical complications in 33 (25%) and general complications in 51 (38.6%). Both types of complications occurred in 21 patients (15.9%). Oesophago-intestinal anastomosis leakage occurred in 9 patients (6.8%). Statistically significant differences in general complication number were seen between the N0 and the N1/N2 group ($p=0.02$). General complications were more frequent in the patients with subcardial tumor localisation ($p=0.01$). The higher frequency of surgical complications in the patients in whom total gastric resection was made comparing to the groups in whom other resections were made was statistically significant ($p=0.05$). In patients in whom splenectomy was additionally made (33 patients) the total complication number was clearly higher (26/33). Parenteral nutrition in the postoperative period significantly influenced the occurrence of general complications ($p=0.0057$). There was a statistically ($p=0.05$) difference between the mean age of patients with major general complications and the mean age of patients with minor general complications. Patients with major general complications were significantly older - by 8 years on average. Significant difference ($p=0.05$) was seen in mean BMI of patients with minor surgical complications and patients without surgical complications. There was also significant difference in surgical procedure duration in patients with major surgical complications and those without surgical complications ($p=0.01$), as well as a difference in the surgical procedure duration in patients with minor general complications and those without general complications ($p=0.05$).

Conclusion. As a result of prospective follow-up of patients with gastric cancer who underwent curative resection, the following conclusions were made: 1) Regional lymph node involvement (N1/N2), subcardial tumor location, high BMI, age, range and duration of surgical procedure significantly influenced the number of general and surgical complications 2) Stapler use caused improvement in surgical technique, but had no significant influence on the decrease in the number of surgical postoperative complications. 3) Parenteral nutrition in the postoperative period may increase the risk of general complications. 4) Comprehensive management aimed at minimising perioperative complications should include adequate preoperative and postoperative nutritional support, antibiotic and anticoagulant prophylactics, rationalisation of operation duration, good oncological justification for expanding the procedure to splenectomy and lymphadenectomy D3, which increase the number of complications and careful monitoring during the postoperative period, which requires knowledge of surgical characteristics.

Czynniki ryzyka powikłań pooperacyjnych po zabiegach z intencją wyleczenia w raku żołądka

Cell. Celem pracy były: ocena czynników zwiększających ryzyko powikłań po całkowitym lub prawie całkowitym wycięciu żołądka z powodu raka, próba oceny zmiany zasad postępowania okołoperacyjnego, zmniejszającego ryzyko powikłań po do-
szczętnym leczeniu chirurgicznym u chorych z rakiem żołądka.

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Materiał i metody. Materiał stanowiło 253 chorych z rakiem żołądka z lat 1988–2001, obserwowanych prospektywnie. Szczegółowej ocenie poddano 132 chorych, u których wykonano doszczętne zabiegi operacyjne. U chorych tych analizie poddano szereg parametrów: wiek, płeć, stan odżywienia, stopień klinicznego zaawansowania nowotworu wg klasyfikacji TNM, stan histologiczny regionalnych węzłów chłonnych, czas trwania zabiegu operacyjnego, rodzaj wykonanego zabiegu operacyjnego (całkowite lub prawie całkowite wycięcie żołądka, rodzaj zespolenia przełykowo-jelitowego), konieczność poszerzenia zabiegu operacyjnego o wycięcie innych narządów, użycie staplerów, stosowanie leczenia żywieniowego – przedoperacyjnego i pooperacyjnego. Poddano analizie statystycznej zależność pomiędzy poszczególnymi parametrami, a częstością występowania powikłań chirurgicznych i ogólnych.

Wyniki. Powikłania pooperacyjne wystąpiły u 63 chorych (47,7%) – chirurgiczne u 33 (25%), ogólne u 51 (38,6%). Oba rodzaje powikłań – chirurgiczne i ogólne jednocześnie – wystąpiły u 21 chorych (15,9%). Najgroźniejsze z pooperacyjnych powikłań chirurgicznych – nieszczelność zespolenia przełykowo-jelitowego – wystąpiło u 9 chorych po całkowitym wycięciu żołądka (6,8%). Istotnie statystycznie były różnice w ilości obserwowanych powikłań ogólnych pomiędzy grupą chorych N0, a grupą chorych N1/N2 ($p=0,02$). Powikłania ogólne występowały częściej w grupie chorych z podwypustową lokalizacją guza ($p=0,01$). Większa częstość występowania powikłań chirurgicznych w grupie chorych po całkowitym wycięciu żołądka, w porównaniu z grupami chorych po innych rodzajach wycięć żołądka, była istotna statystycznie ($p=0,05$). W grupie chorych, u których jako zabieg dodatkowy wykonano wycięcie śledziony (33 chorych), ogólna liczba powikłań była wyraźnie wyższa w porównaniu z grupą chorych, u których wykonano inne zabiegi dodatkowe (26/33). Żywienie pozajelitowe w okresie pooperacyjnym miało istotny wpływ na wystąpienie powikłań ogólnych ($p=0,0057$). Istotnie statystycznie ($p=0,05$) była różnica średniego wieku pomiędzy chorymi z „dużymi” powikłaniami ogólnymi i chorymi z „małymi” powikłaniami ogólnymi: chorzy, u których obserwowano „duże” powikłania ogólne byli starsi średnio o 8 lat. Istotnie statystycznie ($p=0,05$) była różnica pomiędzy średnimi wartościami BMI chorych z „małymi” powikłaniami chirurgicznymi i chorych bez powikłań chirurgicznych oraz różnica pomiędzy średnimi wartościami BMI chorych z „małymi” powikłaniami ogólnymi i chorych bez powikłań ogólnych. Istotnie statystycznie były różnice w długości trwania zabiegu operacyjnego, obserwowane pomiędzy grupą chorych z „dużymi” powikłaniami chirurgicznymi, a grupą chorych bez powikłań chirurgicznych ($p=0,01$) oraz różnice w długości trwania zabiegu operacyjnego, obserwowane pomiędzy grupą chorych z „małymi” powikłaniami ogólnymi, a grupą bez powikłań ogólnych ($p=0,05$).

Wnioski. Prospektywne obserwacje chorych z rakiem żołądka, poddanych zabiegom resekcyjnym z intencją wyleczenia, upoważniają do następujących wniosków: 1) Istotny wpływ na zwiększone ryzyko ogólnych i chirurgicznych powikłań pooperacyjnych ma stan histologiczny regionalnych węzłów chłonnych (N1/N2), podwypustowa lokalizacja guza nowotworowego, wysoka wartość BMI, wiek chorego, zakres i czas trwania zabiegu operacyjnego. 2) Wprowadzenie staplerów wpłynęło na usprawnienie techniki operacyjnej, ale nie miało istotnego wpływu na zmniejszenie chirurgicznych powikłań pooperacyjnych. 3) Żywienie pozajelitowe stosowane w okresie pooperacyjnym może zwiększać ryzyko powikłań ogólnych. 4) Kompleksowe działania zmniejszające ryzyko powikłań okołoperacyjnych powinny zawierać odpowiednią taktykę żywieniową przed i pooperacyjną, profilaktykę antybiotykową i przeciwzakrzepową, racjonalizację czasu operacji, onkologiczne uzasadnienie poszerzenia zabiegu o splenektomię i limfadenektomię D3, które zwiększają ryzyko powikłań oraz dokładny monitoring okresu pooperacyjnego, wymagający znajomości specyfiki zabiegu operacyjnego.

Key words: gastric cancer, surgery, postoperative complications, risk factors

Słowa kluczowe: rak żołądka, doszczętne leczenie chirurgiczne, powikłania pooperacyjne – czynniki ryzyka

Introduction

Despite a fall in the incidence of gastric cancer noted in the last few years it still remains one of the most common malignancies recognised in the Polish populace. Over 90% of cases recognised in Poland are advanced, which negatively affects treatment results. The standard oncological treatment performed with a curative intent is surgical excision of the stomach with regional lymph nodes (*gastrectomia fere totalis/totalis cum lymphadenectomia regionali*). In Poland some 50-70% of patients qualify for this procedure. Radical surgery performed for gastric cancer carries a high risk of postoperative complications, including perioperative mortality, which explains the need to search for treatment methods which would limit both the risk of complications and the mortality.

Study aim

The aims of the study were:

1. To evaluate the risk factors of complications after total or subtotal gastric resection for gastric cancer
2. To investigate, whether changes in perioperative management may decrease the complication risk after curative surgical treatment of gastric cancer patients.

Material and method

The series included 253 gastric cancer patients, prospectively followed-up from 1988 to 2001.

Detailed prospective evaluation was performed in 132 patients who had undergone radical operations.

During the premedication (30-45 min before surgery) patients received antibiotic prophylaxis (cephalosporin I generation & metronidazole i.v.) and antithrombotic prophylaxis (low molecular weight heparin s.c.). The peritoneum was opened

with the upper median incision usually extended below the umbilicus.

After careful assessment the following steps were performed: total or subtotal gastrectomy together with the major and minor omentum, lymphadenectomy of groups 1-12 and the restoration of the continuity of the digestive tract. In case of total gastrectomy the restoration of the continuity of digestive tract was obtained with the following methods:

- 1) „*omega*” – anastomosis of the oesophagus with the first intestinal loop „end-to-side”, pre-colonic, with a “side-to-side” enteroanastomosis of the afferent and efferent arms of the loop (the Braun enteroanastomosis);
- 2) „*un cut Roux*” – „*omega*”-type anastomosis with stapler suturation of the afferent intestinal loop;
- 3) „*Roux-en-Y*” anastomosis of the oesophagus with an isolated intestinal loop „end-to-side”, usually pre-colonic, covering the oesophago-jejunal anastomosis with the free end of the loop (hemiplication). The oesophageo-intestinal anastomosis was hand sutured with two layers of sutures (layer 1 – continuous suture, layer 2 – interrupted sutures) or – more often – with a circular stapler. The stapler anastomosis was reinforced with interrupted sutures all around and the oesophago-jejunal anastomosis was suspended with interrupted sutures to the peritoneal recess.

In case of sub-total gastrectomy the gastric stump was anastomosed to the first small intestine loop *modo* Billroth, pre-colon, with formation of the Braun enteroanastomosis. The anastomosis was hand sutured with two layers of sutures or – less commonly – with a stapler. The gastric stump was narrowed by hand or with a linear stapler. The duodenal stump was closed using one of the following techniques: 1) by hand, two layers of sutures, 2) with a linear stapler – one staple level, 3) with a linear staple – two staple levels 0.5 cm apart 4) with a linear staple secured with an additional level of hand sutures.

In case of total gastrectomy we either performed a nutritional jejunostomy or introduced a naso-jejunal feeding tube.

Peritoneal drainage was usually performed with two drains – one in the vicinity of the duodenal stump, and another near the oesophago-jejunal/gastro-jejunal anastomosis. In those cases when splenectomy was performed another drain was left at the splenectomy site.

Following factors were analyzed in the group of curative surgery patients:

- age and gender,
- nutritional state – basing on body mass index (BMI), weight loss, complete lymphocyte count (CLL), total protein and albumin plasma concentration,
- the duration of surgery,
- clinico-pathological advancement stage according to TNM classification (pTNM – basing on histopathological examination),
- regional lymph node status.

The analysis of suspected risk factors of perioperative complications and perioperative mortality included:

- the type of operation and, in case of total gastrectomy, the type of oesophago-jejunal anastomosis,
- the need for extending the procedure including resection of other organs (splenectomy, partial liver resection, partial pancreatic resection, partial colon resection, partial jejunal resection, cholecystectomy),
- stapler use,
- nutrition support: pre- and postoperative – enteral and parenteral.

The analysis of postoperative factors included:

Postoperative complications – with special respect to major surgical complications: (leakage of the oesophago-jejunal anastomosis, leakage of the duodenal stump),

- perioperative mortality
- overall 1-, 3-, 5-year mortality

All analysed complication risk factors were divided into two categories:

- qualitative features
- quantitative features

Qualitative features included:

- gender
- TNM status
- tumour localisation
- range and type of gastrectomy
- the oesophago-jejunal anastomosis technique (in total gastrectomy pts.),
- stapler use (for the oesophago-jejunal anastomosis),
- the need of performing additional surgical procedures,
- total parenteral nutrition (pre- and postoperative),
- enteral nutrition

Quantitative features included:

- age,
- body mass index (BMI),
- plasma protein concentration before surgery
- plasma albumin concentration before surgery
- duration of surgery

All observed complications were divided into 4 categories:

- major surgical complications
- minor surgical complications
- major general complications
- minor general complications

Subsequent statistical analysis of relationships of either qualitative or quantitative measures and incidence of complications was carried out and statistical analysis of the study results was performed.

The statistical analysis included the assessment of influence of qualitative or quantitative measures on the incidence of complications (surgical or general) in the group of the curative surgery patients.

To verify the hypothesis of the lack of relationship between qualitative measures and complications the *Chi*² test was used.

To verify the hypothesis of the lack of difference between mean values of quantitative measures in groups of different incidence of postoperative complications the one-way analysis of variance was used based on the F test.

In the case of significant differences to identify the pairs of means that differ significantly the multiple comparison test based on minimal significant differences was used.

Results

The prospective follow-up of 253 gastric cancer patients was performed from 1988 to 2001.

The detailed analysis was carried out in the group of 132 patients who had undergone curative surgery: resectability was 52.2%. The latter group included 40 women (30.3%) and 92 men (69.7%). The mean age of women was 58.8 yrs. (27–79), the mean age of men was 62.4 yrs. (44–78). The age groups of both genders are presented in Table I.

The grade of advance of malignancy according to TNM in the studied group is presented in Table II.

Complications were observed in 63 patients (47.7%).

Surgical complications were observed in 33 patients (25%) including:

Table I. Age distribution in the analyzed group of 132 patients according to gender

Age range (years)	Women	Men
< 30	1	
30 – 40	5	
41 – 50	3	10
51 – 60	12	29
61 – 70	10	38
> 70	9	15
Total	40	92

– major surgical complications in 16 patients (12.1%),
 – minor surgical complications in 17 patients (12.9%),
 General complications were observed in 51 patients (38.6%) including:

– major general complications in 13 patients (9.8%),
 – minor general complications in 38 patients (28.8%).
 The last group included 21 patients with concomitant surgical and general complications - (15.9%).

The detailed concomitant surgical and general complications analysis revealed the following “combinations”:

– major surgical complications + major general complications in 2 patients (9.5%),
 – major surgical complications + minor general complications in 7 patients (33.3%),

Table II. Gastric cancer stage in the analyzed group of 132 patients according to the TNM classification

Stage	TNM Classification	No. of patients
I A	T0N0M0	9
	T1N0M0	10
I B	T1N1M0	2
	T2N0M0	13
II	T2N1M0	1
	T3N0M0	18
III A	T2N2M0	1
	T3N1M0	28
III B	T4N0M0	2
	T3N2M0	17
	T4N1M0	7
IV	T4N2M0	8
	T3N1M1	3
	T4N1M1	1
	T3N2M1	4
	T4N2M1	8

– minor surgical complications + major general complications in 3 patients (14.3%),
 – minor surgical complications + minor general complications in 9 patients (42.9%),

A characteristic of the complications is presented in Table III.

Table III. Type and number of complications. M1 feature – metastases (confirmed by pathology report) in lymphatic nodes of the hepatoduodenal ligament, retropancreatic, mesenteric or periaortic lymph nodes and, in 1 case – a metastatic tumour in the small bowel wall

Character of complication	Type of complication	No of cases
"major" surgical	– duodenal stump leakage	4
	– subdiaphragmatic oesophago-jejunal anastomosis leakage	7
	– thoracic oesophago-jejunal anastomosis leakage	2
	– haemorrhage from upper gastrointestinal tract	2
	– perforation of duodenal ulcer	1
	total	
"minor" surgical	– suppuration of postoperative wound	4
	– post-drain suppuration	10
	– peritoneal effusion	1
	– reaction after venous puncture	6
total		21
Total: surgical complications		37
"major" general	– DIC	1
	– dysrhythmias + acute cardiac icaemia	5
	– myocardial infarct	1
	– cardiac arrest	1
	– stroke	1
	– ventilatory insufficiency	2
	– kidney failure	1
	– pancreatitis	1
	total	
"minor" general	– fever	29
	– atelectasis	5
	– pneumonia	6
	– acute bronchitis	1
	– “reactive” pleural effusion	12
	– diarrhoea	1
total		58
Total: general complications		71
Grand total		108

The most commonly observed complications (more than 50%) were minor general complications (53,7% of all complications), whereas the incidence of major surgical complications was 14.8%.

Desaturation of the oesophageo-jejunal anastomosis was observed in 9 patients (6.8%).

Postoperative mortality was 5.3%; 4 patients (76, 67, 74 and 78 years) died due to cardiac complications, 1 patient (69 years) – due to peritonitis resulting from ulcer perforation of the duodenal stump, 1 patient (49 years) – due to respiratory failure resulting from the desaturation of the oesophageo-jejunal anastomosis (within the thorax), 1 patient (61 years) – due to DIC in the course of desaturation of the oesophago-jejunal anastomosis (subdiaphragmatic).

All deaths were observed after total gastrectomy, mainly in patients in the 7th and 8th decade of life, with cardiac comorbidity. No death was observed after subtotal gastrectomy.

The analysis of overall 1-, 3-, 5-year survival according to histopathology revealed the following results: in early cancer 1- and 3-year survival was 100%, 5-year survival was 60%.

In advanced cancer 1-, 3-, 5-years survival was 79%, 47% and 30.5%, respectively.

In the whole group of patients the 1-, 3-, 5-year survival was 80.5%, 51% and 32%, respectively.

The values are presented on Figure 1.

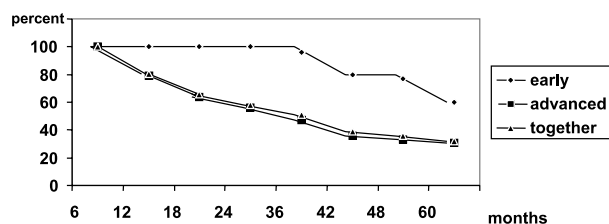


Figure 1. Overall 1-, 3-, and 5-year survival in gastric cancer patients undergoing curative resection according to histological type of tumour

The analysis of overall 1-, 3-, 5-years survival according to clinical advancement (TNM classification) is presented on Figure 2.

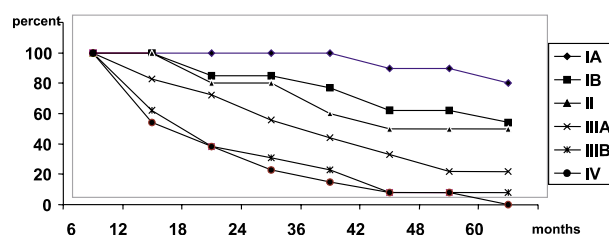


Figure 2. Overall 1-, 3-, and 5-year survival in gastric cancer patients undergoing curative resection according to the stage in TNM classification

Detailed analysis

Qualitative factors

1. Gender

The study group included 40 women (30.3%) and 92 men (69.7%). The influence of gender on the incidence of both surgical and general complications was statistically nonsignificant. P value was for 0.45 for surgical and 0.17 for general complications, respectively.

2. T status

The size of the tumor did not significantly influence the incidence of surgical complications ($p=0.62$).

The highest number of surgical complications was observed in patients from the T3 group (minor in 10 pts., major in 8 pts.) but this group was the largest one (70 pts.).

In T0 group – (9 pts.; 6.8% of the analyzed group) minor surgical complications were observed in 2 pts., and no major complication was observed.

In the T1 group (12 pts.) we observed 1 minor and 1 major complication; in the T2 group (15 pts.) – 2 minor and no major complications; in the T4 group (26 pts.) – 4 minor and 5 major complications.

Similar trends were observed for general complications. The relationship between the T feature and the incidence of complication is statistically non-significant ($p=0.28$).

3. N status

The incidence of surgical complication was higher in pts. with nodal involvement (N1 and N2) than in the N0 group. Minor and major surgical complications were observed in 9 cases from the N0 group, and in 24 cases from the N1+ N2 group. The difference was statistically non-significant ($p=0.32$).

Minor general complications were observed in 11 pts. from the N0 group and in 27 pts. from the N1/N2 group, and major general complications were observed in 5 pts. from the N0 group and in 8 pts. from the N1/N2 group. The incidence of general complications between the N0 and the N1/N2 groups reaches statistical significance ($p=0.02$) (Figure 3).

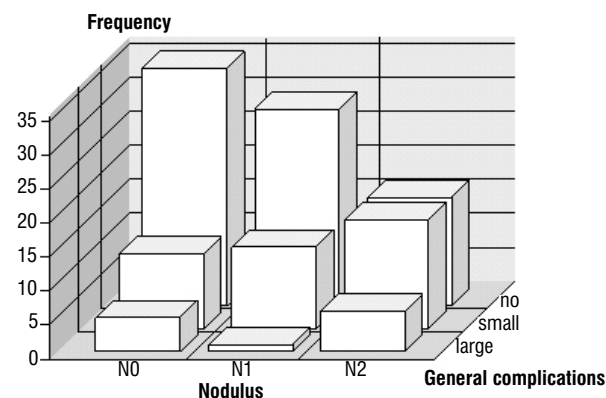


Figure 3. Distribution ranges illustrating the relations between lymph node involvement and the incidence of general complications

4. M status

Among the 132 pts. who had undergone curative surgery in 16 cases distant metastases were diagnosed (group M1). In 6 of these pts. surgical complications were observed – major in 3 cases and minor in 3 cases. In the group without distant metastases (M0 group) major surgical complications occurred in 14 patients, and minor – in 13 pts. The influence of the M feature on the incidence of surgical complications was statistically insignificant ($p=0.47$).

We observed similar trends regarding general complications, especially minor complications: in the M0 group complications were observed in 31 pts. (27%), and in the M1 group in 7 pts. (as high as 43.8%). However, the influence of the M feature on the incidence of general complications was statistically insignificant ($p=0.19$).

5. Tumour localization

The following tumour locations were distinguished: the cardia (the vicinity of the oesophago-gastric junction), the corpus, the pylorus, the entire stomach and gastric stump after prior resection.

The tumour localization had no significant influence on the incidence of surgical complications. ($p=0.17$).

However in case of general complications the highest incidence was noted in pts. with tumours localized in the upper corpus of the stomach – 7 pts. with major complications (53.8%) and 18 pts. with minor complication (48.6%). General complications were more prevalent in pts. with subcardial tumour location ($p=0.01$) (Figure 4).

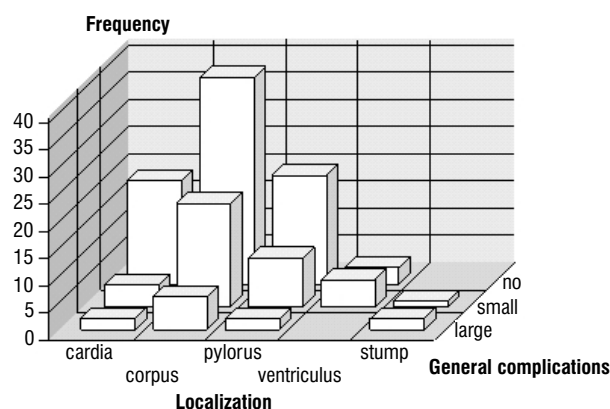


Figure 4. Distribution ranges illustrating the relations between tumour localization and the incidence of general complications

6. Range and type of gastrectomy

In the analysed group of 132 patients who had undergone curative surgery the following techniques were applied: total gastrectomy in 77 cases, subtotal gastrectomy in 44 cases, resection of the cardia (i.e. resection of the upper part of stomach and 1/3 lower part of oesophagus with gastro-oesophageal anastomosis within the thorax cavity) in 6 cases and total gastrectomy combined with resection of 1/3 lower part of oesophagus with oesophago-jejunal anastomosis within the thorax cavity in 5 cases. Surgical

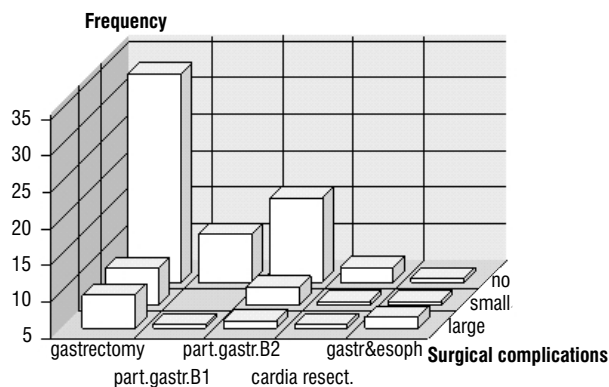


Figure 5. Distribution ranges illustrating the relations between the range of gastric resection and the incidence of surgical complications

complications, both major (9pts, 52.9%) and minor (10 pts. 62.5%) were more prevalent in the total gastrectomy group as compared to the cardia excision and subtotal gastrectomy.

The difference of surgical complication incidence between the total gastrectomy group and the other groups is statistically significant ($p=0.05$) (Figure 5).

The general complication incidence rate did not relate to the type of surgery ($p=0.83$).

7. The type of oesophago-jejunal anastomosis

In case of total gastrectomy the continuity of the digestive tract was restored with the following methods: *Roux-en-Y* (46 pts.), *"omega"* method (31 pts.) and *"un cut Roux"* method (5 pts.).

No significant relationship was found between type of oesophago-jejunal anastomosis and surgical or general complications incidence ($p=0.84$ and $p=0.59$, respectively).

8. Oesophago-jejunal anastomosis: manual anastomosis versus circular stapler:

Both types of anastomosis carry the risks of all surgical anastomotic complications, especially the major ones (desaturation of the anastomosis).

The difference between the incidence of complications (manual anastomosis: 15 pts. – 7 major, 8 minor; stapler anastomosis: 18 pts. – 8 major and 10 minor) was not statistically significant ($p=0.066$).

9. Concomitant additional procedures

Concomitant surgery was performed in 50 pts. In 36 pts 1 additional procedure was carried out, in 12 pts. – 2 additional procedures, and in 2 other patients – 3 additional procedures. The additional procedure was splenectomy in 33 cases (in 12 cases together with other additional procedures, usually partial pancreatectomy), cholecystectomy in 18 cases, partial pancreatectomy (resection of body/tail of the pancreas) in 6 cases, 2 cases of partial liver resection (left lobe), 2 cases of jejunal resection, 2 cases of colonic resection, 1 case of partial diaphragm resection, 1 case of ovariectomy, 1 case of femoral hernioplasty.

No significant difference was observed the incidence of surgical (15/50 *versus* 18/82; $p=0.15$) or general (23/50 *versus* 28/82; $p=0.39$) complications between the patients with concomitant additional procedures and the remaining patients.

The general complication incidence in the splenectomy group was higher (26/33) as compared to the rest of the patients undergoing additional procedures.

10. Preoperative parenteral nutrition

Preoperative Total Parenteral Nutrition (TPN) was administered to 21 pts. The inclusion criteria for preoperative TPN were: marked weight loss (10% and more of the ideal body weight; in the studied group mean weight loss was 13%, range 3-45%), plasma protein concentration below 6.0 g%, plasma albumin concentration below 2.8 g% and total lymphocyte count below 1.5 G/L. Preoperative TPN was mainly administered in the years 1988-1995. In the later period preoperative parenteral nutrition was replaced (whenever possible) with natural nutrition enhanced with ready-made industrial preparations.

The number of surgical complications among patients who had not received preoperative TPN was higher than in patients, who did receive it (27/111 *versus* 6/21), however this difference does not achieve statistical significance ($p=0.12$). We observed a similar situation in the case of general postoperative complications (42/111 *versus* 9/21), where the difference also failed to reach statistical significance ($p=0.75$).

11. Postoperative TPN

Postoperative TPN was administered to 92 patients. – mainly those, who had undergone total gastrectomy or who had developed postoperative complications necessitating nutritional treatment (leakage of the duodenal stump or of the oesophago-jejunal anastomosis).

Thus, in this group the incidence of surgical complications is higher in this group than in the group of patients who did not receive postoperative TPN (28/92 *versus* 5/40), however, this difference fails to reach statistical significance ($p=0.08$).

As for the incidence of general complications among patients who did not receive TPN – they were observed in 10 cases – 6 pts. with "major" complications and 4 patients with "minor" complications. Among patients who had received TPN we observed complications in 41 cases: 34 "minor" complications, and 7 "major" complications.

Statistical analysis has shown, that postoperative parenteral nutrition significantly influences the incidence of general complications ($p=0.0057$).

12. Enteral nutrition

Postoperative enteral nutrition (EN) was administered to 40 pts. (30.3%) with either a nutritional jejunostomy or with a naso-jejunal feeding tube.

Surgical complications occurred in 13 of these patients (32.5%): in 8 cases "major" and in 5 pts. "minor".

General complications occurred in 23 pts. on enteral nutrition (57.5%), in 5 cases "major" and in 18 cases "minor".

The statistical analysis has shown, that EN administered during the postoperative period significantly influences the incidence of general complications ($p=0.01$).

Quantitative factors

1. Age

The mean age of the patients who had undergone curative gastric surgery was 61.3 yrs.

The mean age of patients with surgical complications was: 62.8 yrs. in case of the "minor" complications group and 60.8 yrs. for the "major" complications group – the difference was non-significant.

The mean age of the patients with general complications was: 59.1 yrs. in the "minor" complications group and 67.0 yrs. in the "major" complications group – the difference was statistically significant ($p=0.05$), in contrast to the groups mentioned above.

2. Body Mass Index (BMI)

Mean value of Body Mass Index in all patients undergoing curative surgery was 24.8 kg/m².

The mean BMI of the patients with surgical complications was: 27.7 kg/m² in the "minor" complications group and 24.4 kg/m² in the "major" complications group. In patients free of surgical complications BMI was 24.4 kg/m². The difference of BMI between the "minor" surgical complications group and the free of surgical complications group was statistically significant ($p=0.05$).

The mean BMI of the patients with general complications was: 26.1 kg/m² in the "minor" complications group and 24.3 kg/m² in the "major" complications group. In patients free of general complications BMI was 23.9 kg/m². The difference of BMI between the "minor" general complications group and the free of general complications group was statistically significant ($p=0.05$), as in the case of surgical complications.

3. Plasma protein concentration before surgery

Plasma protein concentration before surgery in all the patients undergoing curative surgery was 6.59 g% (4.6-8.4).

The mean plasma protein concentration in the patients with surgical complications was: 6.49 g% (5.6-7.8) in the "minor" complications group, 6.47 g% (5.0-7.8) in the "major" complications group and 6.63 g% (5.2-7.7) in the free of surgical complications group.

The mean plasma protein concentration in patients with general complications was: 6.46 g% (4.6-8.3) in the "minor" complications group, 6.73 g% (5.8-8.4) in the "major" complications group and 6.67 g% (5.2-7.7) in the free of general complications group.

The difference of plasma protein concentration before surgery in both the surgical complications group and general complications group was non-significant.

4. Plasma albumin concentration before surgery

Plasma albumin concentration before surgery in all the patients undergoing curative surgery was 3.68 g% (2.3-5.2).

The mean plasma albumin concentration in patients with surgical complications was: 3.88 g% (3.4-4.6) in the “minor” complications group, 3.73 g% (2.6-4.8) in the “major” complications group and 3.63 g% (2.3-5.2) in the free of surgical complications group.

The mean plasma albumin concentration in patients with general complications was: 3.56 g% (2.3-4.6) in the “minor” complications group, 3.84 g% (2.7-5.2) in the “major” complications group and 3.75 g% (2.7-4.8) in the free of general complications group.

The difference of plasma albumin concentration between pts with and without complications in both the surgical and general complication groups were non-significant.

5. Duration of surgery

The mean duration of surgery in the studied group was 248 min.

The mean duration of surgery in the patients with surgical complications was: 263 min in the “minor” complications group and 288 min in the “major” complications group. The mean duration of surgery in the patients without surgical complications was 238 min.

The difference of the mean duration of surgery between the “major” surgical complications group and the free of surgical complications group was statistically significant ($p=0.01$).

The mean duration of surgery in the patients with general complications was: 265 min in the “minor” complications group and 251 min in the “major” complications group. The mean duration of surgery in the patients without general complications was 234 min.

The difference of the mean duration of surgery between the “major” general complications group and the free of general complications group was also statistically significant ($p=0.05$).

Discussion

Despite the development of diagnostic methods, especially visualisation techniques and endoscopy, initial diagnosis still remains the basic problem in gastric cancer. Early diagnosis directly influences the curability – which may be as high as 90%. In Poland early gastric cancer (limited to the mucous and submucous membranes) is diagnosed only in a few percent of patients undergoing surgical procedures with a curative intent. In Western European Countries and in the US this ratio reaches some 15%, while in Japan – as much as 50-65% [1-3].

In our material – 132 patients with gastric cancer in whom we performed radical operations with curative intent – early gastric cancer was found in 9 pts. (i.e. 6.8%). The remaining patients (93.2%) had more advanced stages of the disease, usually III0 (55 pts. – 41.7%) and IV0 (24 pts. – 18.2%).

The ratio of patients undergoing radical resection (resectable) reaches 50-60% in Polish material [4, 5]. We observed this also in our group with 52.2% of radical resections (as in the 1988-2001 time lapse).

Patients with gastric cancer radical surgery (especially in the form of total gastrectomy) present with a relatively high risk of postoperative complications and postoperative mortality [6-16].

In Western European countries in the late seventies postoperative mortality in cases of total gastrectomy reached, approximately, 30%. In the eighties it fell to 10% and recently it is seldom reported to exceed 5%. In Poland recently it is reported not to exceed 10% [17, 18]. In our group of patients the postoperative mortality rate was 5.3% (i.e. 7/132).

According to literature data the ratio of postoperative complications after total gastrectomy may be as high as 50-60%, especially in patients in the 7th and 8th decade of life. The ratio of the one complication which is the main cause of postoperative mortality – desaturation of anastomosis – reaches 20% [9, 14, 16, 19]. We observed postoperative complications in 63 patients (47.7%), with anastomosis leakage in 9 patients (6.8%).

Total or subtotal gastrectomy with accompanying lymphadenectomy remains the method of choice in the treatment of both early and advanced gastric cancer. It is therefore all the more important to attempt to improve the results of these procedures – especially to decide upon the factors and treatment methods which would allow to limit the risk of postoperative complications [9, 20]. In this paper we have presented such an analysis of a number of factors and techniques which appear at different moments throughout treatment – before, during and after surgery. Our analysis covered both characteristic features on the part of the patients and the applied methods themselves.

The patient characteristics which, according to our material, seem to influence directly the ratio of postoperative complications are age and BMI.

Age had significant influence ($p=0.05$) as a factor which increased the risk of general complications during the postoperative period, which we refer to as “major”, as compared to the complications referred to as “minor”, in the case of which age did not have such a significant impact. Patients in whom we had observed “major” general complications were older (on average by 8 years – mean age in this group of patients being 67 years) than patients with “minor” general complications. This correlates with literature reports [12, 14]. In these papers the authors present patients in the 7th and 8th decade of life who had undergone radical surgery for gastric cancer and stress the significant impact of patient age upon ventilatory and circulatory complications. This is undoubtedly caused by the postoperative state of the patients’ cardiovascular and pulmonary health [12]. In our study group the greater part of major complications did also arise from cardiovascular and pulmonary problems (myocardial ischaemia, myocardial infarct, dysrhythmias, ventilatory insufficiency).

The BMI was an independent risk factor of both surgical and general complications, which we have referred to as “minor”. The mean BMI value in patients with “minor” surgical complications was 27.7, while in patients with “minor” general complications this value was 26.1. Mean BMI value of patients in whom no complications were observed was 24, and was significantly lower ($p=0.05$). One may therefore expect, that if a patient with gastric cancer scheduled for radical surgery has BMI value >27 the postoperative risk ratio is significantly higher (e.g. problems with wound healing).

We would like to emphasize the fact that in our patients preoperative parenteral nutrition decreased the risk of postoperative complications although the negative effects of hyperalimentation are becoming a common subject of investigations and literature reports [21-23]. Gastric cancer manifests itself through a number of features, among them impaired nutritional status. In the course of clinical observations it has been estimated that some 50-60% of patients qualified for surgical treatment of malignancies of the upper alimentary tract are in need of preoperative nutritional treatment. Metabolic disorders arising from the development of the oncological diseases aggravate due to the surgical trauma, which significantly increases the patient's catabolism, thus using up energy sources and increasing the risk of grave postoperative complications [24-28]. In our group of patients the mean preoperative loss of body mass reached 13% (3-45%), i.e. a mean value of 8 kg (2-25 kg) and was observed in 33% of the patients. The loss of 10% of ideal body mass is an indication for nutritional treatment [21-23, 25-28]. One may presume that in the examined group of patients the administration of preoperative parenteral nutrition equaled the chances of malnourished patients without causing any complications arising from intravenous nutritional treatment.

In our group of patients the most important factors increasing the risk of postoperative complications were: the regional lymph node status ($p=0.02$); tumour localization ($p=0.01$) the range and type of gastric resection ($p=0.05$), the method of performing the oesophago-jejunal anastomosis ($p=0.01$) and the duration of the surgical procedure ($p=0.05$).

In the examined group the characteristics of the malignant tumour (size, rate of infiltration) did not affect the risk of postoperative complications, as has also been reported by other authors [20]. The depth of infiltration and the expression of some substances within the malignant tissue (protein p53, oncogene c-erbB2, E-cadherin, β -catenin etc) pose as risk factors connected to the risk of local nodal metastases, dissemination and survival [29-37].

The N feature significantly influenced the ratio of general complications, which were more common ($p=0.02$) in N1/N2 patients, as compared to N0 patients. This is probably related to the range of regional lymph node dissection and, thus, to the duration of the surgical procedure. The range of lymph node dissection and its

impact on postoperative mortality and morbidity is still being widely discussed in literature [6-8, 10, 38-46].

We have also observed a significant influence of the localization of the tumour on the increase of the risk of general complications. The risk was higher ($p=0.01$) in the case of tumours localized in the upper part of the body of the stomach. This phenomenon probably arises from the possibility of infiltration of neighbouring organs – the tail of the pancreas, the spleen, the left hepatic lobe), more common in this case of tumour localization. Therefore, in such cases, the range of resection and the duration of the procedure have to be increased [11, 47, 48].

The range and type of gastric resection also influences the postoperative risk ratio. In our group of patients total gastrectomy significantly ($p=0.05$) increased the risk of both “major” and “minor” surgical complications. Similar data may be found in literature [19, 49-52]. We observed no differences arising from the technique of anastomosis (sutured by hand or mechanically) although some authors report mechanical suturation to be safer [19, 53].

Simultaneous additional procedures were performed in 50 patients (38%), of these splenectomy accounted for 33 cases. A majority of complications observed in this group of patients (both surgical and general) were reported in the splenectomy patients (26/33 i.e. 79%). Literature reports present similar results – splenectomy is reported to be an independent risk factor of postoperative complications in patients undergoing total gastrectomy for gastric cancer [54]. In our material splenectomy was such an important factor not only due to the excision of “the largest lymph node”, but also because in 12 cases splenectomy was accompanied by yet another additional procedure – usually with partial resection of the pancreas (6 patients).

An important factor affecting the risk of postoperative complications was the duration of surgery. The differences in procedure duration between patients with “major” surgical complications and “minor” general complications reached statistical significance when compared to procedure duration in patients in whom no such complications were reported ($p=0.05$). Similar data may be found in literature [12].

Parenteral nutrition may have a significant impact on the course of the postoperative period, including the complications ratio. In our material we observed the influence of parenteral nutrition on the increased risk of general complications. The difference in the frequency of these complications in the group of patients receiving parenteral nutrition in the preoperative period and in the group of patients without parenteral nutrition is statistically significant ($p=0.0057$); similar observations may be made when analyzing patients on postoperative enteral nutrition ($p=0.01$). This latter feature may arise from the fact that the latter group of patients includes those with complications necessitating intensive nutritional treatment (e.g. anastomosis dehiscence) who are in need of lengthy treatment and long hospitalization.

Basing upon these results we may conclude, that some of the factors increasing the risk of postoperative complications are found on the part of the patient – obesity, age, advance of disease (N-stage) and tumour localization. The character of the malignancy also determines the range and type of surgery – one cannot discuss the indications for radical gastrectomy or for increasing the range of excision to include other infiltrated organs if such is the intraoperative necessity and there exists a possibility of performing a radical operation.

On the other hand the factors on which the surgeon does have some influence when undertaking surgical treatment with a curative intent in the case of a patient with gastric cancer include improving the nutritional status of the patient in the preoperative period, correct qualification for nutritional treatment, perfecting surgical techniques (incl. the correct choice of operation) and, during the postoperative period, close scrutiny and care of the patient with adequately chosen pharmacological and nutritional treatment.

Conclusions

The prospective observation of gastric cancer patients undergoing resection with a curative intent has brought us to the following conclusions:

1. The factors which significantly influence the risk of both general and surgical postoperative complications include the histopathological status of the regional lymph nodes (N1/N2), subcardial localization of the tumour, high BMI, advanced age and the range and duration of surgery.
2. The introduction of staplers has improved the surgical technique, but it has not decreased the ratio of postoperative complications.
3. Postoperative parenteral nutrition may increase the risk of general complications.
4. In order to decrease the ratio of complications a complex approach is necessary – including a correct approach to pre-and postoperative nutritional treatment, prophylaxis with antibiotics and anticoagulants, rational choice of time for surgery, oncological indications for splenectomy and D3 lymphadenectomy (which significantly increase the risk ratio) and careful postoperative monitoring which demands a good understanding of the surgical specificities.

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