The POSSUM Scoring System and Complete Blood Count in the Prediction of Complications After Pancreato-Duodenal Area Resections

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The introduction of markers which help in the identification of patients prone to suffer from postoperative complications enables to recognize them more easily and thus, treat them more effectively.

The aim of the study was to evaluate complete blood count indicators, as well as preoperative results obtained on the basis of the POSSUM and P-POSSUM scoring systems, considering the prediction of complications after surgical resections in the pancreato-duodenal area.

Material and methods. A prospective 30-day non-interventional clinical study was conducted on a group of 65 patients who underwent scheduled surgery, due to pancreatic head cancer or chronic pancreatitis. Total pancreatoduodenectomy was performed in 24.1% of patients, while the remaining were subject to hemi-pancreatoduodenectomy. The authors evaluated the preoperative complete blood count parameters, as well as the risk of complications and mortality using the audit POSSUM and P-POSSUM scoring systems.

Results. Postoperative complications were observed in 32.4% of patients. The white blood cell count and platelet count in the preoperative period were statistically lower in the group of patients with postoperative complications, in comparison to patients without diagnosed complications. Higher severity scores obtained by means of the P-POSSUM scoring system, as well as higher mortality during the perioperative period can be ascribed to patients who suffered postoperative complications. However, no correlation was found between the occurrence of complications and gender, age, type of resection, preoperative hemoglobin level, absolute lymphocyte count, or numerical value representing the patient’s general condition (POSSUM) and predicted postoperative morbidity.

Conclusions. The absolute white blood cell count and total platelet count during the preoperative period may be considered as an indicator of the higher risk of complications during pancreato-duodenal area resections. The usefulness of the POSSUM and P-POSSUM scoring systems is limited. However, the surgical severity index and calculated mortality coefficient risk can facilitate the identification of patients threatened with postoperative complications.

Key words: complete blood count, surgical severity index, POSSUM and P-POSSUM scoring systems, pancreato-duodenal area, pancreatoduodenectomy

Anatomical conditions and complex pathophysiological processes are responsible for the difficulties connected with the surgical management of patients with pancreatic disorders. Pancreatic resections are considered as difficult operations connected with increased risk of postoperative complications (1).

Progress in pancreatic surgery, lead towards significant mortality reduction after resection procedures, especially in specialist centers. Postoperative complications continue to pose a significant problem concerning 25-40% of patients subject to pancreatoduodenectomies, influencing the final treatment result,
prolonged hospitalization, and increasing therapeutic costs (2). Smoking, alcoholism, jaundice, malnutrition, and postoperative hyperglycemia are considered as factors increasing the risk of postoperative complications (3, 8). Additional factors influencing the occurrence of postoperative complications include the experience of the center, operative technique, increased intraoperative blood loss, antibiotic therapy, use of somatostatin analogues, and perioperative nutrition (6, 9, 10).

Predictive indicators are being sought for. There use not requiring additional effort and costs. Thus, the need to perform routine complete blood count tests with an overview of the results on the basis of mathematical algorithms. Some expectations are associated with the POSSUM audit scoring system based on 12 variables, which are easy to use and do not require special skills (11). The analysed parameters were as follows: patient age, circulatory and respiratory system symptoms, systolic blood pressure, heart rate at rest, Glasgow coma scale, hemoglobin, urea, potassium, and sodium levels, leucocyte count, and ECG changes. The Portsmouth modified scoring system (P-POSSUM) enables to estimate the point value of the severity of the operation, based on six additional variables (12). The operating variables include the predictive range of the surgical procedure, number of surgical interventions, prognostic blood loss, presence and character of peritoneal cavity fluid, presence of neoplastic disease and its clinical stage, as well as type of performed operation.

The aim of the study was to evaluate complete blood count indicators, as well as preoperative results obtained on the basis of the POSSUM and P-POSSUM scoring systems, considering the prediction of complications after surgical resections in the pancreato-duodenal area.

**MATERIAL AND METHODS**

Patients and study design

A prospective 30-day non-interventional study was initiated two days before planned surgery, being continued for a period of 28 days after the operation. During the period between 2002 and 2007, 87 patients were qualified for pancreateoduodenectomy. The operations were performed at the Department of Surgery, Regional Hospital in Lublin (Head of Department Prof. Piotr Paluszkiewicz). Patients with a history of abdominal operations, severe malnutrition, coagulopathies, or admitted due to emergency surgery were excluded from the study (fig. 1). The primary end-point was the occurrence of a complication, the secondary end-point the 28-th day after the operation. Consent was granted by The Ethical Committee.

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**Fig. 1. Qualification of patients subject to pancreato-duodenal area resections fulfilling study inclusion criteria**
Patient characteristics

The study group comprised 65 patients, aged between 32 and 83 years (mean age: 57.5 years), including 21 female and 44 male subjects. Six patients (4 male and 2 female) underwent preoperative biliary duct drainage: from the duodenal approach (3 male and 1 female patient) and percutaneous approach (1 man and 1 woman), 10-50 days before study inclusion. The risk of anesthesia according to the ASA scale was grade III in five, grade II in 56, and grade I in four patients.

Surgical methods and extent of the operation

The extent of the operation was determined on the basis of clinical and pathological indications, as well as imaging examination results (tab. 1). Surgery consisted in the excision of the head and isthmus of the pancreas, duodenum, and peripheral part of the stomach by means of Whipple-Kausch’s method, or complete pancreas, spleen, duodenum, and peripheral part of the body of the stomach resections. Alimentary tract reconstruction was performed by means of anastomosis of the stump of the common hepatic duct to the side of the intestinal loop, using interrupted, absorbable, multi-fiber 4-0 sutures. The gastric stump was anastomosed to the side of the intestinal loop, using continuous, absorbable, multi-fiber 3-0 sutures. The nasogastric tube was introduced during the postoperative period for enteral nutrition. In case of 49 patients subject to hemipancreate-duodenectomy the pancreatic stump was anastomosed to the side of the intestinal loop with pancreatic intussusception 1 cm into the intestinal lumen. In case of pancreateo-intestinal anastomosis, interrupted, absorbable, multi-fiber 4-0 sutures were used. The intestinal loop was visible in the rectocolic area.

In case of pancreatic cancer diagnosis surgery additionally consisted in the excision of extraperitoneal lymph nodes from the esophageal hiatus of the diaphragm and hepatic hilus to the level of the left renal vein. The surgical procedure was performed by one surgeon, although different teams were engaged.

Additional examinations and the POSSUM and P-POSSUM scoring systems

Complete blood count and ECG examinations were performed in all patients, preoperatively, as well as the evaluation of the circulatory and respiratory systems, according to the POSSUM and P-POSSUM scoring systems. Anthropometric measurements were performed on a routine basis including patient height, weight, and BMI.

Statistical analysis

Statistical analysis was performed by means of the StatDirect software (StatSoft, UK; 2010). The normal distribution was estimated by means of Kolmogorov-Smirnov’s method. In case of normal distribution the t-Student test was used for non-paired variables, and variance analysis. The U-test and \(^\chi^2\) independence test were used to estimate the correlation between variables. \(p<0.05\) was considered as statistically significant.

### Table 1. Types and number of resection procedures in the pancreateo-duodenal area considering 65 study group patients

<table>
<thead>
<tr>
<th>Hemipancreateoduodenectomy Whipple-Kausch method</th>
<th>Total pancreate-duodenectomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>n</td>
</tr>
<tr>
<td>Chronic pancreatitis with jaundice and development of pancreatic head tumor visible on imaging examinations (USG, CT)</td>
<td>2</td>
</tr>
<tr>
<td>Pancreatic head cancer diagnosed preoperatively on the basis of a transduodenal biopsy under endoscopic ultrasound control, or percutaneous fine-needle biopsy under USG or CT control</td>
<td>5</td>
</tr>
<tr>
<td>Pancreatic head cancer diagnosed during the intraoperative histopathological examination - oligobiopsy</td>
<td>42</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
</tr>
</tbody>
</table>
The PoSSUM score and CBC in the prediction of complications after pancreato-duodenal resections

RESULTS

Most patients underwent pancreatoduodenal resections, due to pancreatic cancer (n=60), the remaining because of chronic pancreatitis. Complete pancreatoduodenectomy, splenectomy and distal gastrectomy were performed in 16 patients. Postoperative complications were observed in 21 (32.3%) patients. In case of five patients surgical re-intervention was required, consisting in the excision of necrotic liver tissues, interloop abscess drainage, ruptured gastric stump or abdominal integument closure (tab. 2). Patient age in case of postoperative complications was higher, as compared to non-complicated cases, although differences were statistically insignificant (tab. 3). No statistically significant differences were observed between complicated and non-complicated patient groups, considering gender, presence of pancreatic cancer and type of performed resection (tab. 3).

The BMI of study group patients ranged between 16.8 and 32.5 kg/m². BMI differences considering patients with or without postoperative complications were statistically insignificant (tab. 3). In most patients with diagnosed severe complications [class III–V, according to Dindo (13)], the BMI value exceeded 25.

Patients included in the study presented with preoperative hemoglobin values ranging

| Table 2. Postoperative complications in case of 65 patients subject to pancreato-duodenal area resections |
|---------------------------------|-----------|
| Type of complication            | Number of patients |
| Eventration                     | 2          |
| Left hepatic lobe necrosis      | 1          |
| Multiorgan failure              | 2          |
| Myocardial infarction           | 1          |
| Sepsis                          | 1          |
| Peptic ulcer rupture            | 1          |
| Intraabdominal abscess          | 1          |
| Postoperative wound infection   | 4          |
| Bacterial infection of the urinary tracts | 3          |
| Delayed stomach emptying        | 3          |
| Pneumonia                       | 2          |

Table 3. Characteristics of patients subject too analysis considering the occurrence of complications after pancreatoduodenal resections. Mean values (x̄), standard deviation (SD), and percentages (%) were presented. In case of bilirubin middle values were presented (â), minimum (min) and maximum (max). Statistical analysis was performed comparing results obtained in case of postoperative complications or in their absence. The statistical significance of (p) was determined

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>No complications</th>
<th>Complications</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>x̄ (SD)</td>
<td>x̄ (SD)</td>
<td>&gt;0.05*</td>
</tr>
<tr>
<td>Gender (male ratio)</td>
<td>67.7%</td>
<td>70.5%</td>
<td>&gt;0.05**</td>
</tr>
<tr>
<td>Rate of pts with pancreatic cancer</td>
<td>92.3%</td>
<td>88.6%</td>
<td>&gt;0.05**</td>
</tr>
<tr>
<td>Rate of pts subject to total pancreatectomy</td>
<td>24.6%</td>
<td>22.7%</td>
<td>&gt;0.05**</td>
</tr>
<tr>
<td>Rate of pts with biliary duct drainage before surgery</td>
<td>10.8%</td>
<td>11.3%</td>
<td>&gt;0.05**</td>
</tr>
<tr>
<td>ASA III ratio according to the preanesthetic evaluation</td>
<td>7.7%</td>
<td>6.8%</td>
<td>&gt;0.05**</td>
</tr>
<tr>
<td>Hemoglobin level (g/l)</td>
<td>24.70 (3,76)</td>
<td>24.49 (3,59)</td>
<td>&gt;0.05*</td>
</tr>
<tr>
<td>Leucocyte level (10³/µl)</td>
<td>9.22 (3,19)</td>
<td>9.22 (3,19)</td>
<td>&gt;0.05*</td>
</tr>
<tr>
<td>Lymphocyte level (10³/µl)</td>
<td>2.13 (0.91)</td>
<td>2.26 (1.01)</td>
<td>0.001*</td>
</tr>
<tr>
<td>Platelet level (10³/µl)</td>
<td>293.32 (121.33)</td>
<td>313.02 (128.43)</td>
<td>&gt;0.05*</td>
</tr>
<tr>
<td>Creatinine blood level (µmol/l)</td>
<td>93.7 (15.9)</td>
<td>93.7 (10.3)</td>
<td>&gt;0.05*</td>
</tr>
<tr>
<td>Bilirubin level (µmol/l) â; (min-max)</td>
<td>142.61 (5,64-314,64)</td>
<td>139.02 (5,64-314,64)</td>
<td>&gt;0.05*</td>
</tr>
</tbody>
</table>

POSSUM and P-POSSUM scale parameters

* t-Student test; ** independency test χ²; # U test
between 97 and 160 g/L. Analysis of the preoperative hemoglobin level in case of patients with or without postoperative complications showed no statistically significant differences (tab. 3).

The preoperative absolute leucocyte and platelet count ranged between 4.8 – 18.9 K/µL and 114 – 889 K/µL, respectively. The white blood and platelet counts were significantly lower in case of patients with postoperative complications, as compared to those without complications (tab. 3).

The preoperative absolute lymphocyte count ranged between 800 and 6700. Patients that developed postoperative complications presented with lower preoperative lymphocyte count values (by 18%), as compared to those with the postoperative period uneventful. The differences were statistically insignificant.

The POSSUM scoring system enables to estimate the patients’ general condition, severity of the surgical procedure, and risk of postoperative complications and possible death. There is a statistically significant correlation between the occurrence of postoperative complications and severity of the surgical procedure, based on the POSSUM scoring system (tab. 3). The severity of the patients’ general condition before the surgical intervention, according to the POSSUM scoring system had no statistically significant correlation with the frequency of postoperative complications. Additionally, there was no association between the observed and estimated frequency of postoperative complications calculated using POSSUM scoring system. The estimated risk of death (according to the POSSUM scoring system) after pancreatoduodenectomy correlated with the occurrence of postoperative complications.

**DISCUSSION**

Considering our study material we evaluated the risk of postoperative complications in case of patients subject to pancreato-duodenal area resections. In case of the analysed group the rate of complications (32.4%) was similar to data (25-40%) obtained from reference centers (1, 3, 6). Surgical reintervention concerned 5 (7.7%) patients. Based on literature data the above-mentioned was observed in 0-12% (14), being a consequence of the extent of the operation and inflammatory response (8, 9).

The role of patient age as a risk factor of postoperative complications is not clearly defined. Patients that developed postoperative complications were older by an average of 5 years, as compared to those without postoperative complications (tab. 3). Patient age was considered as an independent prognostic factor of postoperative complications occurrence (15). The estimation of the patient’s age is burdened with a considerable error, due to their selection during qualification for resection procedures (16). One should point to the fact that a significant number of elderly patients with pancreatic pathologies qualified for resection procedures are disqualified from surgery because of many concomitant diseases increasing the risk of postoperative complications. There is a documented belief that age as an independent prognostic factor does not matter, and that the risk of complications is multifactorial (5, 17).

Considering the 65 patients we observed no correlation between the occurrence of postoperative complications and patient gender. Gender is not a risk factor of postoperative complications in case of patients subject to pancreato-duodenal resections (5, 17).

Analysis showed no statistically significant differences between BMI values, in case of postoperative complications and without (tab. 3). The correlation between obesity and risk of postoperative complications has been described repeatedly (5). In obese patients the amount of fat tissue can account for nearly 50% of the pancreas, affecting the texture of the organ and quality of pancreatoenterostomies (18). The presence of pancreatic fistulas in patients with high BMI values may be a decisive factor determining the success of surgical treatment (7). Considering our study group pancreatic fistulas were absent (tab. 2), which might have influenced the lack of connection between BMI values and risk of postoperative complications. The increased number of postoperative complications, other than pancreatic fistulas in patients with high BMI values might be connected with ventilation disturbances during the postoperative period, and growth of tissue insulin-resistance in patients with excessive amounts of adipose tissue (19).

The importance of various peripheral blood morphological factors evaluated during the preoperative period as a prediction of postoperative complications has been the subject of numerous investigations (3, 11, 12).

The role of anemia during the preoperative period remains unclear. Studies performed on
Jehovah's witnesses showed that decreased hemoglobin values before non-cardiosurgical operations significantly increased the risk of postoperative complications and mortality (20). The preoperative hemoglobin level < 100 g/L and intraoperative blood loss of 500 ml increases two-fold the risk of postoperative complications (21). In case of patients without religious or organizational limitations as to blood supplementation the postoperative course did not depend on the preoperative hemoglobin level (10). The possibility of adaptation to lower hemoglobin values, characteristic of younger people, consisting in increased stroke volume, reduced peripheral resistance, and increased tissue oxygenation may be limited in elderly patients, thus, leading towards circulatory system complications. One can assume that in the analysed group of patients subject to pancreatoduodenal area resections the relatively low average age and absence of laboratory signs of anemia (tab. 3) were factors influencing the lack of correlation between preoperative hemoglobin levels and risk of postoperative complications.

The complete leucocyte count is an important indicator of the cellular response. The low leucocyte level is responsible for the susceptibility to infections and may be connected with the increased incidence of septic complications (22). Considering the analysed group of 65 patients the lowest leucocyte count levels were observed in subjects who developed postoperative wound, urinary tract, or respiratory tract septic complications. The complete leucocyte count was presented as a risk factor of septic complications in patients subject to different surgical interventions. Significant benefits of preoperative therapy with granulocyte colony stimulating factor (G-CSF) were observed in patients with increased perioperative risk demonstrating a reduced number of postoperative septic complications (22). During the past years the subpopulation of leucocytes seems to have greater clinical significance, and the performed studies exhibit greater sensitivity. The reduced number of complications observed in our study confirmed the participation of leucocytes in the complex response to injury, influencing the occurrence of septic complications. An open issue is the participation of leucocytes in response to surgical trauma considering patients with malignant neoplasms. In such cases leucocyte stimulation is more pronounced, as compared to patients without neoplastic pathologies, in addition to platelet count and coagulation system stimulation (23). In the analysed group of 65 patients there were no differences in the leucocyte count of subjects with pancreatic cancer, as compared to those with diagnosed chronic pancreatitis.

The estimation of the preoperative platelet count serves as a risk factor of the occurrence of intraoperative hemorrhagic complications. The average platelet count in case of patients with diagnosed postoperative complications was significantly lower, as compared to patients without the above-mentioned (tab. 2). Literature data showed that the platelet count is an important element of the generalized response of the organism to trauma and inflammation. Considering patients with pancreatic head, duodenal, or distal biliary tract cancer a longer survival rate and disease-free interval were observed in case the preoperative platelet count exceeded 300 K/µL (24). Additionally, an increased preoperative platelet count was connected with shorter hospitalization and fewer postoperative complications (25). Probably, the antibacterial properties of platelets and their role in the cellular response are also significant (26). The preoperative platelet count estimation may be an important prognostic factor determining the risk of postoperative complications. However, further studies concerning the problem are required.

The role of lymphocytes in the cellular and humoral response to surgical trauma is disputed. The reduced lymphocyte count is connected with an increased number of septic complications during the postoperative period (7, 8, 27). Considering the 65 patients subject to pancreatoduodenal area resections the average lymphocyte count was 2.13 K/µL. The introduction of preoperative enteral nutrition serves to effectively restore the normal number of lymphocytes by reducing the risk of postoperative complications (8). Fifty-eight of the study group patients received preoperative enteral or parenteral nutrition, in order to supplement malnutrition disturbances. Cancer and other pancreatic pathologies are often responsible for malnutrition, due to limited acceptance of food and avoidance of diets rich in fat responsible for pain and diarrhea (7). Preoperative nutrition demonstrated that differences in the occurrence of postoperative complications were statistically insignificant (tab.
3), which was easily proven by other authors considering patients with malnutrition (27).

The use of prognostic scoring systems serves the evaluation of the patient’s condition by means of numerous parameters, in order to predict the course of the disease or efficacy of therapy. Complete blood count parameters, basic macroelement levels, and the efficiency of the circulatory, respiratory and renal systems were required to elaborate a mathematical algorithm estimating the possibility of postoperative complications. POSSUM scoring system results were only presented in few reports, where the assessment of the clinical usefulness of the above-mentioned was unclear (3, 11, 12, 28, 29, 30). The point values stratify the feature describing the general condition of the patient before surgery and the severity of the surgical procedure. The obtained results describe the possible risk of postoperative complications and mortality. The above-mentioned is important when determining therapy, and qualifying patients for surgical intervention (11, 28, 29, 30).

A statistically significant correlation was observed between the P-POSSUM scoring system determining the severity of the surgical procedure and risk of postoperative complications (tab. 3). Algorithm data considering the extent of the operation, predicted blood loss, presence of cancer and tumor stage, as well as type of operation are known surgical perioperative risk factors. Each of the above-mentioned factors were considered independently showing the prognostic value in patients subject to pancreatoduodenal area resections (1, 3, 4, 5, 7, 9, 10, 18, 20, 25, 27). A comparable range of surgery in all patients is burdened with significant risk of complications, and resections of the pancreas and duodenum are considered as the most extensive and difficult operations of the alimentary tract (1, 4, 5, 30). The severity of the procedure was also connected with the duration of the operation. The time of the surgical procedure cannot be considered as a preoperative parameter, and thus, was excluded from analysis. The preoperative general condition of patients may be of great significance considering the postoperative course, especially during clinical situations that prevent the preoperative correction of metabolic disorders and improve the functioning of major systems. The obtained results determining the patient’s general condition have not shown sufficient predictive value in predicting the occurrence of postoperative complications. The study analysis showed no statistically significant correlation between preoperative physiological condition indices and occurrence of postoperative complications (tab. 3).

The numerical values concerning postoperative complications were estimated as the risk percentage of perioperative death and occurrence of postoperative complications. Statistical analysis showed that the occurrence of postoperative complications was significantly dependent of the estimated risk of death after surgery, while postoperative morbidity was at the border of statistical significance. The rate of postoperative complications in the analysed group amounted to 64.34% (tab. 3), and was twice the actual value of the above-mentioned (32.3%). Despite the significant overestimation it is worth mentioning the correlation between the estimated risk and actual number of postoperative complications. Thus, the POSSUM scoring system enables to accurately estimate the risk of postoperative complications after pancreatoduodenal resections. The overestimation of postoperative complications was underlined by other authors, and most likely results from the meticulous and careful qualification of patients for extensive surgical operations, and proper preoperative therapy, which reduce the number of metabolic and functional disturbances possibly influencing the postoperative course (28, 30). The correlation between postoperative complications and estimated risk of postoperative death seems interesting. There was no statistically significant correlation between the occurrence of postoperative complications and risk of perioperative mortality. The mortality values are overestimated in relation to patients subject to pancreatoduodenal resections (28, 30). Based on obtained data one can come to the conclusion that the type of operation presented in the study was characterized by a high degree of difficulty, being only performed in selected surgical centers which qualify and treat patients with pancreatoduodenal area pathologies. The general scoring system for different types of abdominal operations can be characterized by a certain margin of inaccuracy, which reduces its clinical value. The number of factors influencing the postoperative course considering patients after extensive pancreatoduodenal resections certainly does
not exhaust the parameters determined by the POSSUM scoring system. Therefore, the obtained results should be only considered indicatively.

CONCLUSIONS

The reduced complete leucocyte or platelet count during the preoperative period is characteristic of increased risk of postoperative complications in patients qualified for pancreatoduodenal resections.

The clinical usefulness of the POSSUM and P-POSSUM scoring systems is limited. However, the surgical severity index and estimated risk of death can be helpful in identifying patients threatened with postoperative complications.

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