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Research Article

The Effect of Preoperative Low Albumin Level on Postoperative Outcomes After Pancreaticoduodenectomy

Preoperatif Düşük Albüminin Pankreatikoduodenektomi Sonrası Postoperatif Sonuçlara Etkisi

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Abstract

The preoperative identification of patients who are at high risk for serious postoperative outcomes after pancreaticoduodenectomy is important for their management. Our aim was to investigate the factors affecting the serious complications after pancreaticoduodenectomy (PD). 92 patients who were operated for periampullar region tumor were retrospectively analyzed between November 2017 and July 2024. Patients were divided into two groups (patients without serious complication (woSC) and patients with serious complication (wSC)) and these groups were compared with demographic data, laboratory results, pathological findings, perioperative findings, and 30-day mortality rate. Risk factors affecting postoperative serious complications were determined. Logistic regression analyses were performed to identify the risk factors of postoperative serious complication. Twenty-four (26%) patients developed serious complications after PD. The albumin levels were significantly lower in the wSC group compared with the woSC group (p=0.035). The albumin was found to be an independent factor in multivariate analysis. Receiver operating characteristic (ROC) curve analysis showed that 37.8 g/L was the optimal cut-off value for postoperative serious complication in PD. So, lower albumin level (≤37.8 g/L) is associated with increased postoperative serious complications in PD for periampullar cancer.

Keywords: CALLY, Hypoalbuminemia, Inflammatory burden index, Systemic immune inflammation index, Whipple.

Özet

Pankreatikoduodenektomi (PD) sonrası ciddi postoperatif komplikasyon riski yüksek olan hastaların preoperatif olarak belirlenmesi, optimal yönetim için önemlidir. Bu çalışma, PD sonrası ciddi komplikasyonları etkileyen preoperatif faktörleri araştırmayı amaçlamaktadır. Periampüller bölge tümörü nedeniyle Kasım 2017 – Temmuz 2024 tarihleri arasında opere edilen 92 hasta retrospektif olarak incelendi. Hastalar ciddi komplikasyon yaşamayanlar (woSC) ve ciddi komplikasyon yaşayanlar (wSC) olmak üzere iki gruba ayrıldı. Gruplar demografik veriler, laboratuvar sonuçları, patolojik bulgular, perioperatif parametreler ve 30 günlük mortalite oranı açısından karşılaştırıldı. Postoperatif ciddi komplikasyonlar için risk faktörleri belirlendi. Postoperatif ciddi komplikasyonların risk faktörlerini belirlemek için lojistik regresyon analizi yapıldı. PD sonrası 24 hasta (%26) ciddi komplikasyon yaşadı. wSC grubunda albumin seviyeleri woSC grubuna göre anlamlı olarak daha düşüktü (p = 0.035) ve multivaryat analizde bağımsız bir risk faktörü olarak belirlendi. ROC analizi, ciddi postoperatif komplikasyonları öngörmede optimal kesme değerin 37.8 g/L olduğunu gösterdi. Sonuç olarak preoperatif düşük albumin seviyesi (≤37.8 g/L), periampuller kanser nedeniyle yapılan PD sonrası ciddi postoperatif komplikasyon riskinin artması ile ilişkilidir.

Anahtar Kelimeler: CALLY indeksi, Hipalbuminemi, İnflamatuvar yük indeksi, Sistemik immün-inflamasyon indeksi, Whipple.

Introduction

Pancreaticoduodenectomy (PD) remains the primary curative treatment for resectable periampullary tumors (1). Despite advances in surgical techniques and perioperative care, PD is still associated with a high rate of postoperative complications, reported to be as high as 40–50% (2). Serious postoperative complications (SPC) not only increase morbidity and healthcare costs but also negatively affect patients' quality of life (3). It was reported that patients with SPC can return to normal daily life activities 3–6 months after surgery (4). Early identification of patients at high risk for SPC is therefore essential for optimizing perioperative management, guiding prehabilitation strategies, and improving surgical outcomes (5). In recent years, considerable effort has been devoted to identifying reliable preoperative predictors, including clinical characteristics, comorbidities, and inflammatory markers such as body mass index (BMI), American Society of Anesthesiologists (ASA) score, and various hematological indices (6–9). However, despite extensive research, current predictive models remain insufficiently accurate and are not widely standardized in clinical practice. Most existing scoring systems are too complex for routine clinical use (7,10,11).

Therefore, the aim of this study was to investigate the effect of preoperative laboratory parameters on serious postoperative complications after pancreaticoduodenectomy and to determine a clinically applicable albumin threshold for risk stratification.

Material and Method

This study was designed as a single-center retrospective cohort study. Approval for this research was obtained from the Eskişehir Osmangazi University Ethics Board on 10.02.2025, with the ethical approval number 2024/06. A total of 115 patients were operated due to periampullar mass between November 2017 and July 2024. The study included participants who were at least 18 years of age and were diagnosed with periampullary adenocarcinoma. Patients with incomplete data and those undergoing surgery for benign conditions were excluded. Finally, 92 patients were evaluated. Participants were classified into two groups without serious complications (woSC) (n = 68) and with serious complications (wSC) (n = 24).

All patients were evaluated via blood hematological and biochemical parameters, tumor markers (carcinoembryonic antigen (CEA) and cancer antigen 19-9 (Ca19-9)), computed tomography (CT) of the thorax and abdomen (the abdominal CT was triple phase). The magnetic resonance imaging (MRI) of the pancreas and positron emission tomography with computed tomography imaging (PET/CT) were performed selectively. The treatment strategy was determined after a full evaluation by a multidisciplinary tumor board for all patients. Appropriate neoadjuvant chemotherapy and/or adjuvant chemotherapy/radiotherapy were applied when necessary. No special preoperative nutritional support was given to malnourished patients.

Hematological and biochemical parameters, as well as tumor markers analyzed in this study, were derived from blood samples collected one day prior to surgery. All patients provided written informed consent before the operation, and the procedures were performed by two senior surgeons with extensive experience. Open classical pancreaticoduodenectomy (with pylorus resection) with Blumgart-style pancreaticojejunostomy was performed for all patients. A routine abdominal drain was used to drain both hepaticojejunostomy and pancreaticojejunostomy anastomoses. Patients were discharged when adequate oral intake and mobilization were achieved, no complications were observed, and intravenous medication was not required. Any adverse events occurring during hospitalization or within 30 days post-surgery were considered postoperative complications and were categorized using the Clavien-Dindo classification (12). Complications classified as grade III or higher were defined as serious SPC.

Age, gender, The American Society of Anesthesiologists (ASA) classification, body mass index (BMI) (kg/m^2), comorbidities, tumor location, total bilirubin (mg/dL), albumin (g/L), C-reactive protein (CRP) (mg/L), CEA (ng/mL), Ca19-9 (U/ml) levels, lymphocyte count ($/mm^3$), platelet count ($/mm^3$), neutrophil count ($/mm^3$), the C-reactive protein-albumin-lymphocyte (CALLY) index (calculated by CRP, albumin, and lymphocyte as described in previous studies (13), Systemic Immune-Inflammation Index (SII) (calculated by platelet/lymphocyte count x neutrophil as described in previous studies (10), Inflammatory Burden Index (IBI) (calculated by CRP X neutrophils/lymphocytes as described in previous studies (11), the usage and type of preoperative biliary drainage, neoadjuvant

chemoradiotherapy status, operative data (combined resection, operation time (minutes), intraoperative blood loss (ml), intraoperative complications), pathological data (tumor size (cm), t stage, n stage, m stage, number of harvested and pathological lymph nodes, lymphovascular and perineural invasion), postoperative course (time to oral intake (days), length of hospital stay (days), the need for relaparotomy, and postoperative complications, time to adjuvant chemotherapy (days), and 30-day mortality) were analyzed and compared.

Statistical Analysis

IBM SPSS Statistics for Windows, version 25.0 (IBM Corp., Armonk, N.Y., USA) was used for analyses. The normality of the distribution of continuous data was analyzed via the Kolmogorov-Smirnov test. Normally distributed continuous data were given as mean ± standard deviation (SD) and were compared via the Student's t-test. Non-normally distributed continuous data were expressed as median (interquartile range) and were compared via the Mann-Whitney U test. Categorical data were expressed as frequency (percentages) and the Chi-square test or Fisher's exact test was used for comparisons, appropriately. Univariate binary logistic regression analyses were performed for variables that may predict SPC. After, a multiple variate binary logistic regression analysis was performed containing variables that had a p-value ≤ 0.1 in univariate analyses. The results were given as Odds ratio (OR), 95% confidence interval (CI), and p-value. Receiver operating characteristic (ROC) curve analyses were performed for continuous data that were found as independent predictors for SPC in multiple variate binary logistic regression analysis. The results were expressed as area under curve (AUC), 95% CI, cut-off value, sensitivity, specificity, and p-value. The cut-off value was determined as the maximum value of the Youden index (sensitivity + specificity - 1). A two-tailed p-value < 0.05 was considered significant.

Results

Demographics, clinical, laboratory, pathological data, and perioperative findings of the study group and subgroups are summarized in Table 1. The study group included 92 patients. In the woSC group, there were 68 (73.9%) patients, while in the wSC group there were 24 (26.1%). The mean age of the study group was 64.35 ± 8.91 years and the rate of males was 55.4% (n=51). Patients in the wSC group were older than those in the woSC group (67.04 ± 7.48 vs. 63.4 ± 9.22 years); however, this difference did not reach statistical significance (p = 0.060). Similarly, subgroup analyses revealed no significant differences in demographic or clinical characteristics. For laboratory data, there was no statistically significant difference except for serum albumin level. The mean serum albumin level was significantly lower in the wSC group compared to the woSC group (36.32 ± 4.63 (g/L) vs. 38.67 ± 4.63 (g/L), p=0.035). Lymphovascular invasion was found in 63 (68.5%) patients with a statistically significantly higher rate in woSC group (n=51, 75% vs. n=12, 50%, p=0.023). Other pathological data showed no notable differences. In perioperative findings, patients in the wSC group had statistically significantly longer hospital stays than those in the woSC group, as expected. (30.5 (16.25-36.75) days vs. 19.5 (14.25-23.75) days, p=0.014). Eight (8.7%) patients underwent relaparotomy. All patients with relaparotomy were in the wSC group (33.3%), while there were none in the woSC group (p<0.001). The reasons for relaparotomy were the evisceration in three patients (all were treated with emergent reclosure), intraabdominal bleeding in two patients (no focus was found in laparotomy and the removal of hematoma was performed for both, one of them died after surgery), bleeding from gastroenterostomy anastomosis site in two patients (bleeding was controlled by suturing the bleeding site in both patients), and bleeding from gastroduodenal artery in one patient (bleeding was controlled by suturing the gastroduodenal artery stump). Two patients (2.2%) had intraoperative complications. Consistent with the pattern seen for relaparotomy, all occurrences were in the wSC group (8.3%), though the intergroup difference was not statistically significant (p = 0.066). Postoperative complications occurred in 26 (18.5%) patients. The rate of postoperative complications was 2.9% (n=2) in the woSC group and 100% (n=24) in the wSC group (p<0.001). Postoperative complications (other than relaparotomy and 30-day mortality reasons) were three intra-abdominal abscesses (all were treated by percutaneous drainage), two postoperative pancreatic fistulas (percutaneous drainage was performed for both), two gastroenterostomy anastomosis bleeding (treated by endoscopic intervention).

Table 1. Baseline characteristics of patients with and without serious complications.

	Study group (n=92)	**Patients without serious complication (n=68)**	**Patients with serious complication (n=24)**	***P value***
Age, years	64.35 ±8.91	63.4 ±9.22	67.04 ±7.48	0.060
Gender, male, n (%)	51 (55.4)	37 (54.4)	14 (58.3)	0.740
ASA class, n (%)				0.295
≤2	58 (63)	45 (66.2)	13 (54.2)	
>2	34 (37)	23 (33.8)	11 (45.8)	
Comorbidity, n (%)	67 (72.8)	49 (72.1)	18 (75)	0.781
BMI (kg/m^2)	25.99 ±3.91	26.19 ±3.8	25.42 ±4.23	0.414
Tumor location, n (%)				0.896
Pancreas	60 (65.2)	45 (66.2)	15 (62.5)	
Distal choledochus	6 (6.5)	4 (5.9)	2 (8.3)	
Duodenum	1 (1.1)	1 (1.5)	-	
Ampulla of Vater	25 (27.2)	18 (26.5)	7 (29.2)	
CEA (ng/mL)	3.27 (2.13-5.83)	3.27 (1.95-5.6)	3.25 (2.3-7.68)	0.619
Total bilirubin (mg/dL)	2.22 (0.91-7.03)	1.76 (0.89-7)	3.15 (1.08-8.09)	0.429
Albumin (g/L)	38.06 ±4.72	38.67 ±4.63	36.32 ±4.63	**0.035**
CRP (mg/L)	4.75 (1.2-8.9)	4.5 (1.2-9.35)	5.8 (1.58-8.7)	0.471
Lymphocyte count (/mm^3)	1790 (1485-2220)	1820 (1510-2365)	1720 (1370-2155)	0.439
Neutrophil count (/mm^3)	4470 (3342.5-5735)	4525 (3372.5-5855)	4240 (3275-5682.5)	0.762
Platelets count (/mm^3)	281.26 ± 96.16	274.66 ± 96.52	299.96 ± 94.61	0.270
CA19-9 (U/mL)	109.75 (13.1-451.13)	91.29 (10.65-431.5)	207.25 (44.25-583.5)	0.124
CALLY	1.56 (0.68-5.65)	1.68 (0.72-5.65)	1.16 (0.65-5.19)	0.307
SII	59.71 (42.5-91.05)	56.97 (42.5-86.89)	72.83 (42.94-97.45)	0.341
IBI	12.52 (2.38-23.8)	10.31 (2.54-18.78)	16.09 (2.15-39.54)	0.298
Preoperative biliary drainage, n (%)	48 (52.2)	37 (54.4)	11 (45.8)	0.469
PTC	4 (4.3)	2 (2.9)	2 (8.3)	
ERCP	43 (46.7)	34 (50)	9 (37.5)	
Both	1 (1.1)	1 (1.5)	-	
Additional resection, n (%)	28 (30.4)	20 (29.4)	8 (33.3)	0.720
Operation time (min)	442.17 ±67.62	437.21 ±64.05	456.25 ±76.55	0.238
Intraoperative blood loss (ml)	350 (250-450)	350 (250-450)	325 (250-450)	0.751
Tumor size (cm)	2.75 (2-3.5)	2.75 (2.03-3.5)	2.75 (1.85-3)	0.548
T stage, n (%)				0.410
T1-T2	60 (65.2)	46 (67.6)	14 (58.3)	
T3-T4	32 (34.8)	22 (32.4)	10 (41.7)	
Harvested lymph nodes count	28 (21-35)	28 (21.25-35)	27.5 (18.5-35.5)	0.563
Pathological lymph nodes count	2 (0-3)	2 (0-3)	1 (0-3.75)	0.817
N stage, n (%)				0.618
0	27 (29.3)	19 (27.9)	8 (33.3)	
1-2	65 (70.7)	49 (72.1)	16 (66.7)	
M stage, n (%)				0.109
0	87 (94.6)	66 (97.1)	21 (87.5)	
1	5 (5.4)	2 (2.9)	3 (12.5)	
Lymphovascular invasion, n (%)	63 (68.5)	51 (75)	12 (50)	**0.023**
Perineural invasion, n (%)	66 (71.7)	50 (73.5)	16 (66.7)	0.521
Time to oral intake (day)	5 (5-6)	5 (5-6)	6 (5-7)	0.289
Length of hospital stay (day)	20 (15-28.75)	19.5 (14.25-23.75)	30.5 (16.25-36.75)	**0.014**
Relaparotomy, n (%)	8 (8.7)	-	8 (33.3)	**<0.001**
Intraoperative complication, n (%)	2 (2.2)	-	2 (8.3)	0.066
Postoperative complication, n (%)	17 (18.5)	2 (2.9)	24 (100)	**<0.001**
Neoadjuvant chemotherapy, n (%)	3 (3.3)	2 (2.9)	1 (4.2)	1
Time to postoperative chemotherapy, n (%)	47.5 (36.25-69)	45 (36-58)	77 (44-100)	0.056
30-day mortality, n (%)	11 (12)	-	11 (45.8)	**<0.001**

ASA: American Society of Anesthesiologists, BMI: Body mass index, CEA: Carcinoembryonic antigen, CRP: C-reactive protein, CA19-9: Carbohydrate antigen 19-9, CALLY: C-reactive protein-albumin-lymphocyte, SII: Systemic immune-inflammation index, IBI: inflammatory burden index, PTC: Percutaneous transhepatic cholangiography, ERCP: Endoscopic retrograde cholangiopancreatography.

Eleven patients (12%) died within 30 days after surgery, all of whom were in the wSC group (45.8%). A statistically significant difference was observed between the groups ($p < 0.001$). The reasons for 30-day mortality were acute respiratory failure in seven patients (two patients with pneumonia, one patient with pulmonary embolism, two patients with pulmonary edema, and two patients with acute respiratory distress syndrome), multiorgan dysfunction syndrome in

two patients, massive gastrointestinal bleeding in one patient, and intraabdominal bleeding in one patient (mentioned above). Postoperative chemotherapy was initiated later in the wSC group than in the woSC group, but the difference was not statistically significant (77 [44–100] days vs. 45 [36–58] days, p = 0.056). Venous resection was performed in 17 (18.5%) patients, four (16.7%) patients were in the wSC group, and 13 (19.1%) patients were in the woSC group.

Table 2. Logistic regression analysis of factors associated with serious postoperative complications

	Univariate analysis				**Multivariate analysis**			
		95% CI				95% CI		
	OR	Lower	Upper	*P*	OR	Lower	Upper	*P*
Age	1.051	0.993	1.113	0.088	1.043	0.979	1.110	0.192
BMI	0.950	0.840	1.074	0.410	-	-	-	-
Gender, male	1.173	0.458	3.007	0.740	-	-	-	-
ASA >2	1.656	0.642	4.269	0.297	-	-	-	-
Comorbidity	1.163	0.401	3.374	0.781	-	-	-	-
Tumor location, n (%)					-	-	-	-
Pancreas	1	-	-	-				
Distal choledochus	1.5	0.249	9.031	0.658				
Duodenum	-	-	-	1				
Ampulla of Vater	1.167	0.408	3.336	0.774				
CEA	1.056	0.991	1.125	0.093	1.058	0.972	1.152	0.190
Total bilirubin	1.024	0.930	1.128	0.626	-	-	-	-
Albumin	0.896	0.808	0.995	**0.040**	0.867	0.761	0.989	**0.034**
CRP	0.997	0.970	1.025	0.833	-	-	-	-
CALLY	0.961	0.891	1.035	0.291	-	-	-	-
SII	1.004	0.998	1.011	0.210	-	-	-	-
Preoperative biliary drainage	0.709	0.279	1.804	0.470	-	-	-	-
Additional organ resection	1.200	0.443	3.250	0.720	-	-	-	-
Operation time	1.004	0.997	1.011	0.237	-	-	-	-
Intraoperative blood loss	0.999	0.996	1.003	0.691	-	-	-	-
T stage					-	-	-	-
1-2	1	-	-	-				
3-4	1.494	0.573	3.891	0.412				
Tumor size	0.826	0.522	1.307	0.414	-	-	-	-
Pathological lymph nodes	1.020	0.894	1.165	0.765	-	-	-	-
Lymphovascular invasion	0.333	0.126	0.880	**0.026**	0.222	0.069	0.712	**0.011**
Perineural invasion	0.720	0.263	1.967	0.522	-	-	-	-
Harvested lymph nodes	0.982	0.943	1.023	0.392	-	-	-	-
N stage	0.776	0.285	2.109	0.618	-	-	-	-
M stage	4.714	0.737	30.143	0.101	-	-	-	-
Time to oral intake	1.367	0.870	2.147	0.175	-	-	-	-
Intraoperative complication	>100	-	-	0.999	-	-	-	-
Neoadjuvant chemotherapy	1.435	0.124	16.576	0.772	-	-	-	-

CI: Confidence interval, OR: Odds ratio, ASA: American Society of Anesthesiologists, BMI: Body mass index, CEA: Carcinoembryonic antigen, CRP: C-reactive protein, CA19-9: Carbohydrate antigen 19-9, CALLY: C-reactive protein-albumin-lymphocyte, SII: Systemic immune-inflammation index, PTC: Percutaneous transhepatic cholangiography, ERCP: Endoscopic retrograde cholangiopancreatography.

Table 2 shows the univariate and multiple variate logistic regression analyses of independent predictors for PSC in patients with periampullary tumor. In univariate logistic regression analyses, serum albumin level (OR:0.896, 95% CI:0.808-0.995, p=0.040) and lymphovascular invasion (OR:0.333, 95% CI:0.126-0.880, p=0.026) were found to be statistically significant variables. In multiple variate logistic regression analysis, both were found as independent predictors for PSC after PD (serum albumin level: OR:0.867, 95% CI:0.761-0.989, p=0.034, lymphovascular invasion: OR:0.222, 95% CI:0.069-0.712, p=0.011). ROC curve analysis revealed that serum albumin level was able to predict PSC after PD with 71% sensitivity and 63% specificity at the cut-off value of 37.8 g/L (p=0.033) (Table 3 and Fig 1).

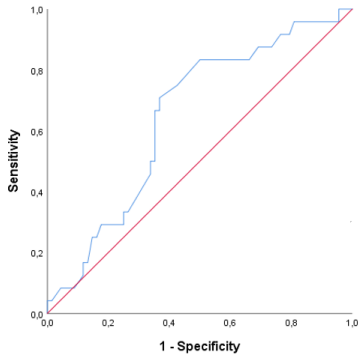

Figure 1. ROC curves of albumin to predict postoperative serious complication in patients with periampullary tumor.

Table 3. ROC curve analysis results of albumin to predict postoperative serious complication in patients with periampullary tumor.

	AUC	95% CI Lower	Upper	P	Cut-off	Sensitivity	Specificity
Albumin	0.647	0.525	0.769	**0.033**	≤37.8	0.708	0.632

ROC: Receiver operating characteristic, AUC: Area under curve, CI: Confidence interval

Discussion

In this study, we demonstrated that a lower preoperative serum albumin level is an independent predictor of serious postoperative complications following pancreaticoduodenectomy. Specifically, an albumin threshold of ≤37.8 g/L was associated with an increased risk of SPC. The identification of such a cut-off value may have important clinical implications, as it could facilitate the early identification of high-risk patients who may benefit from closer perioperative monitoring and targeted prehabilitation strategies.

Pancreaticoduodenectomy is a highly complex and technically demanding procedure requiring multiple gastrointestinal anastomoses which causes postoperative morbidity (14). Morbidity and mortality after PD are influenced by both patient-related and procedure-related factors (15). In the early postoperative period, mortality is most commonly associated with multi-organ dysfunction secondary to postoperative complications, whereas in the later phase it is more often related to prolonged malnutrition (16). Serum albumin, a well-recognized marker of nutritional and inflammatory status, plays a key role in tissue repair and immune response. Hypoalbuminemia has been shown to impair wound healing, reduce collagen synthesis, and promote inflammatory activity (2). These mechanisms may contribute to the increased risk of postoperative complications observed in patients with low albumin levels (7). In addition to its biological role, serum albumin has been increasingly incorporated into composite risk prediction models such as frailty-based scores and nutritional indices, where it consistently emerges as an independent determinant of postoperative outcomes in high-risk abdominal surgery (8,9).

Although postoperative declines in albumin may occur as part of the physiological response to surgery, patients with lower preoperative albumin levels are more susceptible to this decrease (16). Therefore, identifying high-risk patients prior to surgery may enhance the effectiveness of prehabilitation programs and contribute to improved postoperative outcomes (1,16). Notably, a prospective randomized study reported that perioperative albumin replacement did not reduce the incidence of Clavien–Dindo grade ≥2 complications following pancreatectomy (17). However, that study included patients with normal baseline albumin levels and a heterogeneous group of surgical procedures, which may limit the comparability of its findings.

Inflammatory indices have also been investigated as potential predictors of oncological outcomes. A large study involving 6359 patients suggested that the IBI may serve as a prognostic marker in cancer (11). Similarly, previous studies have reported associations between IBI and survival or postoperative outcomes in various malignancies, including gastric cancer, hepatocellular carcinoma (HCC), esophageal cancer, colorectal cancer, and non-small cell lung cancer (18–22). However, in our cohort, IBI was not significantly associated with SPC after PD. The systemic immune-inflammation index (SII), derived from lymphocyte, neutrophil, and platelet counts, has been linked to recurrence and survival in patients with HCC (10). A meta-analysis including 4875 patients with solid tumors also demonstrated that elevated SII is associated with poorer survival (22). In contrast, we did not observe a significant relationship between SII and SPC in our study population. However, the CALLY index has been proposed as a prognostic biomarker in HCC and has subsequently been investigated in other malignancies, including colorectal cancer, distal cholangiocarcinoma, and gastric cancer (23–25), our findings did not demonstrate a significant relationship between the CALLY index and SPC following PD. The lack of association between inflammatory indices and SPC in our cohort may indicate that early postoperative complications after PD are more strongly driven by surgical stress and baseline physiological reserve rather than systemic inflammatory status alone, which is more relevant for long-term oncologic outcomes.

Postoperative hemorrhage after pancreaticoduodenectomy has been consistently identified as one of the most clinically relevant complications, often associated with pancreatic fistula, vascular erosion, or technical anastomotic issues, and it remains a leading cause of reintervention and mortality (26). A multinational

study including 1348 patients reported a major morbidity rate of 17% after PD (1). In our study, the rate was higher (26.1%), with postoperative hemorrhage being the most common complication. These findings underscore the importance of meticulous surgical technique and careful perioperative hemostatic management.

This study has several limitations. First, its retrospective design introduces the potential for selection bias. Second, the relatively small sample size and limited number of events may affect the robustness of the statistical analyses. Third, the heterogeneity of tumor types may limit the generalizability of the findings. Finally, detailed nutritional assessment parameters beyond serum albumin were not available, which may have provided a more comprehensive evaluation of patients' nutritional status.

Conclusion

Preoperative serum albumin level is an independent predictor of serious postoperative complications following pancreaticoduodenectomy. An albumin level ≤37.8 g/L may serve as a clinically useful threshold for identifying high-risk patients. Incorporating albumin into preoperative risk assessment may help guide perioperative management and improve patient outcomes.

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Conflict of interest statement

There is no conflict of interest.

Ethics Committee Approval

Approval for this research was obtained from the Eskişehir Osmangazi University Ethics Board on 10.02.2025, with the ethical approval number 2024/06.

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