Validation of a Risk Scoring System for Postoperative Pancreatic Fistula

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AIM: The aim of this study is to analyze the effects of pancreatic texture and pancreatic duct diameter on postoperative pancreatic fistula (POPF) formation and to define a risk scoring system for identifying high-risk patients for pancreatic surgery.
METHODS: The data of 100 consecutively operated patients who underwent pancreatic surgery between May 2017 and June 2018 from seven different centers were collected through a web-based data collection module that is accessible at the website of The Turkish Hepato Pancreatico Biliary Surgery Association and analyzed retrospectively. The patients' data were evaluated according to the International Study Group for Pancreatic Fistula (ISGPF) criteria. The risk scoring system is defined according to the texture of the pancreatic tissue and the diameter of the pancreatic duct. Risk coefficients were distributed as 3, 2, and 1 for soft, intermediate and firm pancreatic tissue, respectively. The risk coefficients for the pancreatic duct diameter were distributed as 3, 2, and 1 for the pancreatic duct diameter as smaller or equal to 3 mm, wider than 3 mm and smaller or equal to 5 mm, and wider than 5 mm, respectively. The total risk score was calculated by multiplying the distributed risk coefficients.
RESULTS: Thirteen out of 100 patients were excluded from the study due to missing or incomplete data. 17 of 87 (19.5%) patients had POPF. Six of 17 patients (35%) were in concordance with ISGPF-Grade A. Nine of 17 (53%) patients were in concordance with ISGPF-Grade B, and 2 of 17 (12%) patients were in concordance with ISGPF-Grade C. 22 of 87 (25.4%) patients were in the low-risk group, 18 (20.6%) patients were in the intermediate-risk group and 47 (54%) patients were in the high-risk group. There were no clinically relevant POPF in the low-risk group, while one patient developed an ISGPF-Grade A fistula. Two of 18 patients in the intermediate-risk group had POPF and both were clinically relevant. Fourteen of 47 patients in the high-risk group had POPF and 5 of 14 patients were clinically non-relevant, while 9 of 14 patients had clinically relevant POPF. The sensitivity and the specificity of the scoring system were 82.35% and 52.86% ($p = 0.012$), respectively. The area under the curve was 0.666 (95% CI: 0.54–0.77).
CONCLUSIONS: This study proposes and validates a simple intraoperative risk scoring system, based on pancreatic tissue and duct diameter, for predicting POPF. The scoring system demonstrated a high negative predictive value, allowing clinicians to identify patients less likely to develop POPF. This practical tool may assist in surgical decision-making and in tailoring postoperative management in pancreatic surgery.

Keywords: pancreatic surgery; pancreatic fistula; risk scoring system

Introduction

Despite current advances in surgical techniques, postoperative pancreatic fistula (POPF) formation is still considered to be one of the most challenging aspects of pancreatic resections. Prior to the 2005 meeting of the International Study Group of Pancreatic Fistula (ISGPF), a group of pancreatic surgeons convened with an aim of reaching an objective definition of pancreatic fistula; 26 different definitions existed for POPF [1]. Anatomically, a pancreatic fistula is defined as an abnormal pathway between the pancreatic ductal epithelium and another epithelial surface containing pancreatic enzyme-rich fluid. The ISGPF proposed a standardized definition of POPF as the drainage of any fluid

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volume from an intraoperatively placed drain, in which the amylase concentration exceeds three times the upper limit of normal serum amylase levels. Additionally, a clinical classification of three discrete grades of POPF (Grades A, B, and C—from mild to severe) was proposed based on the severity of related complications caused by the POPF formation [2]. In the 2016 update, Grade A is defined as a clinically non-relevant pancreatic fistula and referred to as biochemical leakage; Grade B and C classifications are defined more strictly in order to avoid the complexity [2].

Although the mortality rate of pancreatic surgery has declined to below 5% over the past four decades, morbidity remains substantial, ranging from 30% to 40%, even in high-volume hepatopancreatobiliary centers [3–7]. While numerous studies in the current literature identified various risk factors for the POPF formation such as presence of pancreatitis and/or biliary stent at the time of surgery, body mass index (BMI), surgical technique (pylorus preserving pancreaticoduedonectomy (PD) versus classic PD), nature of the disease (benign versus malignant), operative time, estimated blood loss, and intraoperative blood transfusion; the texture of the pancreatic gland and the diameter of the pancreatic duct are accepted as the major risk factors on the occurrence of POPF formation [5,8–13].

The aim of the recent study is to analyze the effects of pancreatic texture and pancreatic duct diameter on POPF and to define and validate a risk scoring system for determining the low, intermediate and high-risk patients for pancreatic surgery. To our knowledge, this is the first multi-institutional study in the hepatopancreato-biliary field utilizing data collected through a web-based module in Turkey.

Methods and Patients

Data Collection

After the ethics approval was obtained from the Institutional Review Board of the Ethics and Research Committee of the Koc University Hospital (2017.003.IRB1.003), the data of the 100 consecutively operated patients who underwent pancreatic surgery between May 2017 and June 2018 were collected and analyzed retrospectively. Since this was a retrospective study based on anonymized data, informed consent from individual patients was not required. Seven experienced hepatopancreato-biliary surgeons from 7 hepatobiliary centers collaborated in this study by sharing the intraoperative, postoperative, and anonymized demographic data of the patients who underwent pancreatic surgery through a data collection module which is accessible at the website of The Turkish Hepato Pancreatico Biliary Surgery Association (https://hpb.org.tr/index.php). The diameter of the pancreatic duct and the texture of the pancreatic tissue were assessed intraoperatively by the operating surgeon. The diameter of the duct was registered as $\leq$3 mm, >3 mm and $\leq$5 mm, >5 mm. The texture of the pancreatic gland was assessed as firm, intermediate, or soft during surgery.

Surgical Techniques

A variety of surgical procedures were performed for a full spectrum of benign and malignant pancreatic pathology. The vast majority of the operations were carried out using the classical open technique (n = 97), while 2 patients underwent laparoscopic surgery, and 1 patient was operated on using a hybrid approach in which the resection phase was completed laparoscopically, but the anastomoses were performed via an open technique.

The most common surgical procedure was pylorus-preserving pancreaticoduodenectomy (62 patients). The other surgical procedures consisted of distal pancreatectomy (26 patients), classical pancreaticoduodenectomy (Whipple procedure, 9 patients), and tumor enucleation (3 patients). While the most common reconstruction technique for the right-sided pancreatectomies was Wirsungo-jejunostomy (46 patients), the most common technique for the left-sided pancreatectomies was classical sewing of the pancreatic stump (21 patients). The Dunking-pancreaticojejunostomy and Binding-pancreaticojejunostomy techniques were performed in 10 patients, for each procedure. Reinforcement of the suture or stapler line by using a medical device or omentum, and/or ligamentum Teres was performed in 4 patients. We could not reach the details of the reconstruction techniques in 8 patients. A linear stapler device was used for pancreatic stump closing in 1 patient who underwent distal pancreatectomy.

Postoperative Pancreatic Fistula Definition and Grading Criteria

The International Study Group for Pancreatic Fistula defined postoperative pancreatic fistula as ‘a drain output of any measurable volume of fluid with an amylase level 3 times higher than the upper limit of institutional normal serum amylase activity, associated with a clinically relevant development/condition related directly to the postoperative pancreatic fistula’ [2]. ISGPF classified the POPF according to the clinical severity and the management of the treatment. Clinically non-relevant POPFs were defined as Grade A, since the patients with Grade A POPF do not need any special medical or invasive treatment for this complication; hence these fistulas are called ‘biochemical leak’. Fistulas that require a specific therapeutic agent for the management, such as somatostatin analogues, blood product transfusion, or patients whose drains are either left in place more than three weeks or repositioned through endoscopic or percutaneous procedures are defined as Grade B. Postoperative pancreatic fistulas that require re-operation or cause a single or multiple organ failure or associated with mortality are defined as Grade C [2]. The patients’ data were evaluated and classified according to these criteria.

POPF Risk Scoring Model

Pancreatic duct diameter and the pancreatic gland texture are assumed as the major risk factors impacting on POPF

Table 1. The risk factors and coefficient value distribution.

Pancreatic duct diameter	Risk coefficient	Pancreatic gland texture		
		Firm	Intermediate	Soft
		1	2	3
X >5 mm	1	**1**	**2**	**3**
5 mm ≥ X > 3 mm	2	**2**	**4**	**6**
X ≤3 mm	3	**3**	**6**	**9**

The coefficient values from 1 to 3 were distributed according to the severity of the estimated risk for each variable. Bold characters show the results of the calculation obtained by multiplication of coefficients based on the pancreatic duct diameter and the texture of the pancreas. The green indicates a low risk score, yellow indicates intermediate risk, and red indicates a high risk score. X, Pancreatic duct diameter.

formation. It has been shown that the POPF risk increases as pancreatic duct diameter decreases and pancreatic tissue softens [5,8–11]. Based on this information, risk coefficients were distributed as 3, 2, and 1 for soft, intermediate and firm pancreatic tissue, respectively. The risk coefficients for the pancreatic duct diameter were distributed as 3, 2 and 1 for patients with a pancreatic duct diameter that is smaller or equal to 3 mm, wider than 3 mm and smaller or equal to 5 mm, and wider than 5 mm, respectively. The total risk score is calculated by multiplying the distributed risk coefficients. The patients whose estimated risk score was between 1 to 3 were assigned to the low-risk group, patients whose estimated risk score was 4 were assigned to the intermediate-risk group, and patients whose estimated risk score was 6 or 9 were assigned to the high-risk group (Table 1).

After the patients were grouped according to the risk classification, the number of patients with POPF and the clinical severity of the POPF among these groups were compared. Prediction of POPF using the scoring system served as the validation of the method.

Statistical Analysis

SPSS 26 (IBM Corp., Armonk, NY, USA) software was used to perform Fisher's exact test, chi-square. Categorical variables were expressed by using frequencies (n) and percentages (%). Statistical significance is defined as $p < 0.05$. Sensitivity, specificity, positive- and negative-predictive values expressed as percentages. Receiver Operating Characteristic (ROC) analysis was used in order to evaluate diagnostic performance for pancreatic fistula.

Results

In the data set, there were 100 patients who underwent pancreatic resection. Of the 100 patients initially enrolled, 13 were excluded from the final analysis due to incomplete intraoperative documentation, specifically the absence of recorded pancreatic duct diameter or gland texture, which were essential variables for applying the proposed risk scoring system. Thirty-four of 87 (39%) patients were female and 53 (61%) were male, with a median age of 61 years and 61.5 years, respectively. When patients with and without POPF were compared in terms of age and gender, male patients exhibited a higher incidence when compared to females (18.9% vs. 2.9%, $p = 0.044$). There were no statistically significant differences in terms of age. The demographic data of the patients and the relation with POPF formation are shown in Table 2.

The postoperative pathology reports revealed that 45 of 87 (51%) patients had pancreatic ductal adenocarcinoma. There were 11 (12%) patients with ampullary adenocarcinoma, 5 patients (6 %) with chronic pancreatitis, 5 patients (6%) with main duct intraductal papillary mucinous neoplasm (IPMN), 4 patients (5%) with pancreatic neuroendocrine tumor (PanNET), 4 patients (5%) with duodenal carcinoma, 3 patients (3.4%) with distal common bile duct carcinoma, 2 patients (2.3%) with a pancreatic metastasis of renal cell carcinoma, 2 patients (2.3%) with serous cystic adenoma, 2 patients (2.3%) with solid pseudopapillary tumor, 1 patient (1.1%) with mucinous cystic neoplasia, 1 patient (1.1%) with side-branch IPMN, 1 (1.1%) patient with hydatid cysts, and 1 patient with trauma. The patient who underwent surgery due to trauma was also 1 of 5 patients who underwent surgery due to chronic pancreatitis. A comparison of patients with and without clinically relevant postoperative pancreatic fistula (CR-POPF) in terms of postoperative benign and malignant pathologies revealed no statistically significant association with POPF development, as assessed by Fisher's exact test (Table 2).

According to the ISGPF criteria, 17 of 87 (19.5%) patients had pancreatic fistula formation in the postoperative period. 6 patients (35%) were in concordance with ISGPF-Grade A, referred to as biochemical leakage, and were clinically non-relevant patients. Nine (53%) patients were in concordance with ISGPF-Grade B fistula, and 2 (12%) patients were in concordance with ISGPF-Grade C fistula and those patients were clinically relevant.

The texture of the pancreatic tissue was evaluated as firm in 17 of 87 (19.5%) patients by the operating surgeons. One patient with a firm pancreas had ISGPF-Grade A POPF. 47 (54%) patients' tissue texture was considered intermediate and 10 of those patients had POPF. Three of 10 patients with POPF had ISGPF-Grade A fistula, 5 of 10 patients had

Table 2. The demographic data and postoperative pathology of the patients and their relation with clinically relevant POPF and clinically non-relevant biochemical leakage.

Parameter	n (%) of patients	CNR-BL n (%)	CR-POPF n (%)
Gender			
Male	53 (61%)	3 (5.7%)	10 (18.9%)
Female	34 (39%)	3 (8.8%)	1 (2.9%)
Total	87 (100%)	6 (6.9%)	11 (12.6%)
Statistical analysis			$p = 0.044$
Malignant pathology			
Pancreatic ductal adenocarcinoma	45 (51%)	1 (2.2%)	7 (15.5%)
Ampullary adenocarcinoma	11 (12%)	3 (27.3%)	1 (9.0%)
Main duct IPMN	5 (6%)	0	0
Side-branch IPMN	1 (1.1%)	0	0
Pancreatic neuroendocrine tumor (PanNET)	4 (5%)	0	1 (25%)
Duodenal carcinoma	4 (5%)	0	1 (25%)
Distal common bile duct carcinoma	3 (3.4%)	0	0
RCC metastasis to the pancreas	2 (2.3%)	0	0
Total malignant	75 (86%)	4 (5.3%)	10 (13.3%)
Benign pathology			
Chronic pancreatitis	5 (6%)	1 (20%)	0
Serous cystadenoma	2 (2.3%)	0	1
Solid pseudopapillary tumor	2 (2.3%)	0	0
Mucinous cystic neoplasia	1 (1.1%)	0	0
Side-branch IPMN	1 (1.1%)	0	0
Hydatid cyst	1 (1.1%)	0	0
Trauma	1 (1.1%)	1 (100%)	0
Total benign	12 (14%)	2 (16.7%)	1 (8.3%)
Statistical analysis			$p = 1.000$

n, number; POPF, postoperative pancreatic fistula; IPMN, intraductal papillary mucinous neoplasm; RCC, renal cell carcinoma; CNR-BL, clinically non-relevant biochemical leakage; CR-POPF, clinically relevant postoperative pancreatic fistula.

ISGPF-Grade B and 2 of 10 patients had ISGPF-Grade C fistula. 23 of 87 (26.5%) patients' pancreatic texture was considered as soft. Six of 23 patients with soft pancreatic tissue developed POPF. Two of 6 patients had ISGPF-Grade A fistula, while 4 of 6 patients had ISGPF-Grade B fistula formation.

The mean pancreatic duct diameter of the patients was 3.4 mm. The pancreatic duct diameter was above 5 mm in 8 of 87 (9.1 %) patients. Only one patient developed a biochemical leak (ISGPF Grade A) in this group. The pancreatic duct diameter was below or equal to 5 mm and above 3 mm in 26 of 87 patients (29.9%). Three of 26 patients developed POPF, where one of the three patients with fistula was in concordance with ISGPF-Grade A fistula, and two of the 3 patients were in concordance with ISGPF-Grade B. The pancreatic duct measured below or equal to 3 mm in 53 of 87 patients (61%). 13 of 53 patients developed POPF during their hospitalization period. 4 of 13 patients were in concordance with ISGFP-Grade A, 7 of 13 patients were in concordance with ISGFP-Grade B, and 2 of 13 patients were in concordance with ISGFP-Grade C. The results are summarized in Table 3.

The risk scoring system was applied to all patients. According to the results derived from this system, 22 of 87 (25.2%) patients had scores ranging from 1 to 3 and were classified as low risk for POPF formation. 18 of 87 (20.8%) patients had 4 points and were classified as intermediate risk for POPF formation. 47 of 87 (54%) patients had 6 or 9 points and were classified as high risk for POPF formation. One of 22 patients in the low-risk group developed a biochemical leak, so there were no clinically relevant POPF as predicted. Two of 18 patients in the intermediate-risk group had POPF and both were clinically relevant. 14 of 47 patients in the high-risk group developed POPF and 9 of 14 patients were clinically relevant (Fig. 1).

The statistical analysis shows that the sensitivity and the specificity of the scoring system were 82.35% (95% CI: 56.6–96.2) and 52.86% (95% CI: 40.6–64.9) ($p = 0.0287$), respectively, while the cut-off value for the risk score was 6. A chi-square test revealed a statistically significant association between the risk group and POPF occurrence ($\chi^2 = 7.099, p = 0.0287$). The positive predictive value (PPV) and the negative predictive value (NPV) of the scoring system were 29.8% and 92.5% respectively. If the threshold was

Table 3. Patients' distribution according to the texture and the pancreatic duct diameter.

Pancreatic duct diameter	Number of patients	Pancreatic gland texture		
		Firm	Intermediate	Soft
		17	47	23
X >5 mm	8	3	5	0
5 mm ≥ X > 3 mm	26	4	18	4
X ≤3 mm	53	10	24	19

X, Pancreatic duct diameter.

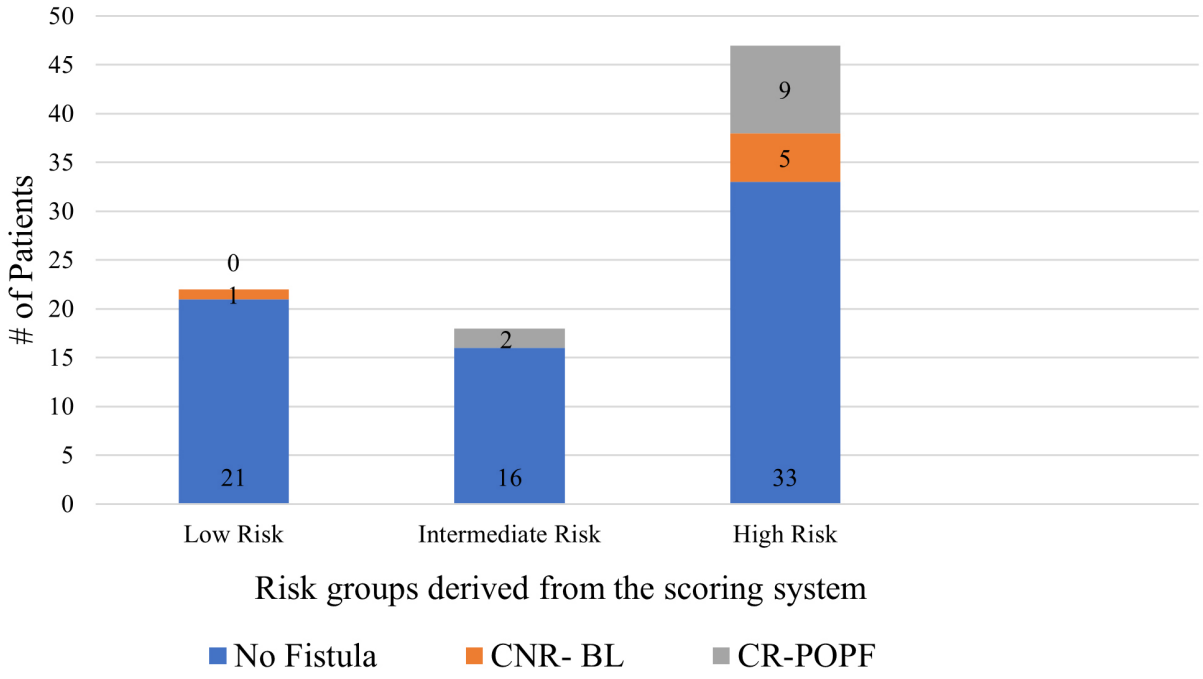

Fig. 1. Distribution of patients according to the risk groups. Patients were distrubuted according to risk groups derived from the proposed scoring system. The number of patients with clinically relevant or non-relevant postoperativ pancreatic fistula is also shown. CNR-BL: clinically non-relevant biochemical leakage; CR-POPF: clinically relevant postoperative pancreatic fistula. #, number.

set to clinically relevant POPF, then the NPV was 100%. The accuracy was calculated as 58.6%. The area under the curve was 0.666 (95% CI: 0.54–0.77). The ROC curve is shown in Fig. 2.

Discussion

Postoperative pancreatic fistula continues to be one of the leading causes of morbidity and mortality after pancreatic surgery. Fistula formation is considered the key factor that opens Pandora's box, leading to complications such as delayed gastric emptying, sepsis, life-threatening hemorrhage, multi-organ failure, and mortality [14]. Risk factors, including BMI [15–17], texture of the pancreatic parenchyma [18–20], gender [21,22], diameter of the main pancreatic duct [23–27], pathologic sub-type of the disease [28] have been studied to understand the pathophysiology of the fistula development. In order to improve the surgical outcome, several studies aimed to identify a risk scoring system for detecting high-risk patients for pancreatectomy [29–33]. The current study evaluates the dataset of the Turkish Hepato Pancreatico Biliary Association and tries to set up a scoring system to predict the risk of POPF.

The association between demographic features, such as age and gender, and POPF has been studied before. Yoshioka *et al.* [33] claimed that patients younger than 65 years old have a 3 times greater risk of developing POPF compared to patients older than 65 years. In two different centers, Matsusue *et al.* [34] reported that patient age greater than 70 was an independent risk factor for POPF, while Choe *et al.* [35] assigned age greater than 60 as a risk factor. Gender has been evaluated as an independent risk factor and male sex has been attributed as a high-risk factor for the POPF. Hu *et al.* [21] studied 539 patients who underwent pancreatic surgery and found a statistically significant difference between male and female patients in terms of POPF ($p < 0.008$). Consistent with these findings, our study also demonstrated a significantly higher rate of POPF among male patients compared to female patients (18.9% vs. 2.9%, $p = 0.044$). This reinforces the notion that male gender may contribute to increased susceptibility to fistula formation, potentially due to anatomical or physiological differences.

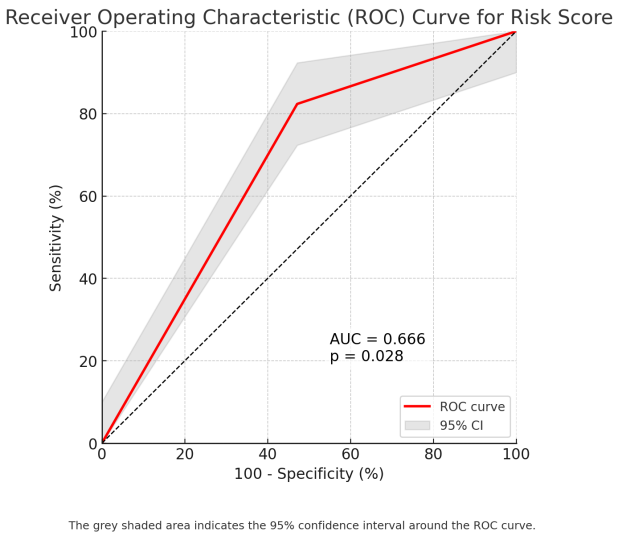

Fig. 2. The statistical analysis of the risk scoring system. The grey lines represent the 95% confidence interval around the ROC curve. AUC, area under curve.

In contrast, no statistically significant association was observed between patient age and POPF development in our cohort (mean age: 57.5 vs. 60.8 years, $p = 0.309$), suggesting that age alone may not be a predictive factor for fistula formation in this population.

The overall rate of POPF in our study was 19.5%, which is in concordance with the current literature. The rate of CR-POPF was 12.6% which is also consistent with the current data obtained from similar studies [2,36]. Despite the data being collected from seven different hepatobiliary centers, the consistency of the results with previous studies may be related to the surgeons' experience and their high commitment to the principles of pancreatic surgery.

Vallance *et al.* [29] published a review article with the aim of evaluating the recent risk scoring systems for POPF and classified the studies into three groups according to the time at which the scoring was applied, as preoperative, perioperative and postoperative. Out of the six studies that are included in the review, only Callery *et al.*'s study [31] used intraoperative data while determining the risk groups. They based their study on four risk factors, which were the texture of the pancreas, the type of pathology, the amount of intraoperative blood loss and the width of the pancreatic duct. According to the methodology of their study, a 10-point risk prediction system was defined. They prospectively validated their scoring system on 212 patients and found that patients with scores of 0 points did not develop a CR-POPF, while all patients with CR-POPF were patients with scores of 9 or 10. Their results show a positive predictive value of 87.5% and a negative predictive value of 89.7% for high-risk patients. They also performed statistical analysis for the low-risk group patients and found the positive and negative predictive values as 23.6% and 96.2%, respectively. In our study, one patient from the low-risk group developed a biochemical leakage and was clinically non-relevant. Two of 18 patients in the intermediate-risk group developed CR-POPF. Fourteen of 47 patients developed POPF in the high-risk group and 9 of them were clinically relevant. The positive predictive value and the negative predictive value of the recent scoring system were 29.8% and 92.5%, respectively. If the threshold was set to CR-POPF, then the NPV would have been 100%.

Chen *et al.* [37] aimed to develop a risk scoring system that uses the intraoperatively obtained data for the prediction of the POPF. They retrospectively evaluated the data of the 921 patients who underwent pancreatic head resection and stated that a 6-point scoring system can accurately predict the CR-POPF. They used BMI, the texture of the pancreas, the width of the pancreatic duct, and the amount of intraoperative blood loss while setting the scoring system. Their statistical analysis shows that the sensitivity and specificity rates were 75% and 85% in the low-risk group, respectively, while the same parameters were 77% and 63% in the high-risk group, respectively. The sensitivity and specificity rates of the current study were 82.35% and 52.86%, respectively. Both studies showed a decline in terms of specificity.

There are over a hundred risk scoring systems existing in the current medical literature that aim to predict the risk of POPF. Having preliminary information about more risky patients should bring different advantages and may change surgical or medical strategies such as performing pancreatic duct stents [38,39] as a prophylactic surgical strategy or using octreotide analogs [40,41] in the postoperative period or performing total pancreatectomy in high risk patients, especially if concomitant vascular resections are being performed.

Verdeyen *et al.* [42] compared four POPF scoring systems in their study. They also developed an additional scoring system by removing the blood loss parameter from the parameters used in these four scoring systems. As a result of their evaluation, they claimed that the scoring systems calculated the POPF risk correctly to a large extent and that effective results could be obtained without the blood loss parameter. In our study, the POPF risk was also estimated correctly; no fistula patients were detected in the low-risk group, while 11 patients in the high-risk group developed clinically relevant pancreatic fistulas.

Yu *et al.* [43] developed a scoring system using the pancreatic duct index and computed tomography (CT) values taken two weeks before surgery. The cut section of the pancreas was measured tomographically on the CT plain scan image and accepted as the CT value. After the calculations they made, they claimed that they could detect the POPF risk with high accuracy in the preoperative period. Ingwersen *et al.* [44] developed a scoring system for POPF by using radiomics features of tomography images. They concluded the study by claiming that they found a new and promising system with high accuracy for determining the POPF risk preoperatively. Since our study has an intraoperative evaluation, it cannot provide information about the

postoperative period in the preoperative term. In this respect, it differs from the study of Yu *et al*. [43] and Ingwersen *et al*. [44].

Another advantage of this scoring system may be using the obtained data for deciding whether the surgery should be performed by experienced surgeons or by residents or fellows. Sheikh *et al*. [45] performed a study about the perception of hepato-pancreato-biliary training among general surgery residents and found that residents who have completed their surgical training do not feel adequately experienced in performing complex hepato-pancreato-biliary procedures such as pancreatectomy. Patients with low risk, according to the data obtained from risk prediction models, may be good candidates for the training of residents or hepato-pancreato-biliary fellows. Since our risk scoring model depends on intraoperative findings and has a negative predictive value of 92.5% for all types of POPF and 100% for CR-POPF, it may be a good alternative for the prediction of patients with better surgical prognosis intraoperatively.

Kawahara *et al*. [46] sent a questionnaire to 71 institutions and studied the results of 1134 patients who underwent pancreas surgery with the aim of evaluating the effect of experience in hepato-pancreato-biliary surgery. They grouped the surgeons who performed pancreatectomies according to their post-graduate years. Group 1 consisted of surgeons who were working for less than 10 years, called younger surgeons, while the second group consisted of surgeons who had been working as surgeons for more than 10 years. According to their study, the incidence of CR-POPF rate was significantly higher for the operations performed by younger surgeons. But in the methods section, it is stated that the risk scoring systems were not taken into account during the case selection. In our opinion, the results of the current study could have been different if the case selection and patient match were based on a risk prediction model, which identifies the low-risk patients for pancreatic surgery. In that way, maybe, the younger surgeons and the residents might have the opportunity of performing pancreatectomy in less risky patients to obtain better surgical results and avoid risks. We believe that our risk scoring model is a simple and feasible alternative for selecting patients with a good prognosis and, therefore, a useful tool for deciding the eligible patients for the education of health professionals in the field of hepatopancreatobiliary surgery.

This study has some limitations. First of all, this study is a retrospective study with a limited number of patients. Besides, due to the multicentric nature of the study, variations in technical skills and postoperative management strategies may affect the results. On the other hand, all centers included in the study mainly follow similar protocols accepted by the Turkish Hepato Pancreatico Biliary Surgery Association and all the centers have acceptable mortality and morbidity rates consistent with the current literature; we do not expect these limitations to lead to a statistically significant difference. The fact that left and right-sided pancreatectomies and the sewing techniques were not evaluated separately may be another limitation of the study. Since we primarily aimed to focus on pancreatic tissue and pancreatic duct diameter, we considered the side and the type of surgery and the type of sewing technique of the pancreatic stump as negligible. Although only the pancreatic duct diameter and the hardness of the pancreatic tissue were examined in our study may be seen as a limitation, we consider this a feature of the study rather than a limitation, since our aim was to create a simple and easily applicable scoring system with as few parameters as possible.

Conclusions

As a conclusion, when this easy and feasible scoring system is applied to the patients, individuals who are less likely to develop POPF can be estimated intraoperatively and this estimation might help identify patients who are less prone to complications. That information may be important while deciding the eligible patients for the education of the hepatopancreatobiliary surgery.

Availability of Data and Materials

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request.

Author Contributions

KKartal and ME conceptualized the study and drafted the manuscript. AB, AC, BA, KKarayalcin, MKerem, MKapan, OA, SK, TU, YT, and ME contributed to patient enrollment, surgical data acquisition, and critical review of the manuscript. ME and AC supervised the statistical analysis. All authors contributed to the interpretation of the results, revised the manuscript critically for important intellectual content, and approved the final version of the manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

Ethics Approval and Consent to Participate

Ethics approval was obtained from the Institutional Review Board of the Ethics and Research Committee of the Koc University Hospital (2017.003.IRB1.003). Since this was a retrospective study based on anonymized data, informed consent from individual patients was not required. The study conformed to the provisions of the Declaration of Helsinki.

Acknowledgment

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Conflict of Interest

The authors declare no conflict of interest.

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