Original Research Article

SAGE Open Medicine

SAGE Open Medicine
Volume 9: 1–9
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DOI: 10.1177/20503121211039667
journals.sagepub.com/home/smo

Association of the rate of bilirubin decrease with major morbidity in patients undergoing preoperative biliary drainage before pancreaticoduodenectomy

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Abstract

Objective: The objective of this study was to examine the relationship between the rate of bilirubin decrease following preoperative biliary drainage before pancreaticoduodenectomy and postoperative morbidity.

Methods: Records of patients who underwent pancreaticoduodenectomy at the Department of Surgery in Ramathibodi Hospital between January 2008 and December 2019 were retrospectively reviewed. The patients were classified into either an adequate or inadequate drainage rate groups according to the bilirubin decrease rate. Major morbidity was defined as higher than grade II in the Clavien-Dindo classification. Risk factors for major morbidity were analyzed by logistic regression analysis.

Results: In total, 166 patients were included in the study. Major morbidity was observed in 36 patients (21.6%). Adequate biliary drainage rate was observed in 39 patients (23.4%). Patients who had major morbidity were less likely to have come from the adequate biliary drainage rate group than the inadequate group (38.9% vs. 61.1%). However, through multivariate logistic analysis, only body mass index, operative time, and pancreatic duct diameter were independent factors associated with major morbidity, whereas the bilirubin decrease rate was not.

Conclusions: Bilirubin decrease rate following preoperative biliary drainage has no significant association with major postoperative morbidity after pancreaticoduodenectomy.

Keywords

Pancreaticoduodenectomy, drainage, bilirubin, operative time, postoperative complications, morbidity

Date received: 18 March 2021; accepted: 27 July 2021

Introduction

Obstructive jaundice is a common presentation of patients with a periampullary tumor.[1] The standard treatment for periampullary tumor is pancreaticoduodenectomy (PD), which is a complex surgery with high morbidity.[2] Recently, there have been a number of studies reporting the poor outcomes of patients with severe jaundice who had underwent PD.[3,4] The pathophysiology of a poor surgical outcome in obstructive jaundice includes the following: blockage of bile salts in the intestinal tract induces the proliferation of the normal microbial flora, dysfunction of the intestinal mucosal barrier, bacterial translocation, increasing endotoxin concentrations in the portal circulation, altered Kupffer cell function affecting the liver's reticuloendothelial system, decreased cellular immunity, and prolonged wound healing.[5] Thus, preoperative biliary drainage (PBD) prior to PD is indicated in patients with severe jaundice.[4] However, there are contradicting studies which do not recommend routine PBD in patients undergoing PD due to the increased rate of infectious complications[6,7] and the poorer oncologic outcomes when compared with patients who received upfront surgery.[8]

There has been a small number of studies that investigated the factors associated with the outcomes following

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PBD before PD, such as, the drainage method[9–12] and the drainage duration.[13] When considering the drainage method, contradicting results can be found between the endoscopic approach and the percutaneous approach. A recent systematic review reported that a percutaneous approach is preferred to an endoscopic approach due to fewer procedure-related complications and postoperative complications.[9] However, there is also an argument for the endoscopic approach since the percutaneous approach can cause catheter-related complications and increased incidence of seeding metastasis.[10,11] Some even suggest that endoscopic drainage should be the first-line treatment for malignant biliary tract obstructions.[12] Despite the different approaches, ultimately, biliary decompression is important in severely jaundiced patients. PBD provides both a prognostic and therapeutic benefit since it can provide tissue for pathological investigation and helps restore hepatocyte function.[3,14] The usual timing required for the restoration of hepatocyte functions after PBD is approximately 2 weeks.[14] However, the restoration time may be delayed in some patients. The restoration of hepatocyte function can be delayed by prolonged biliary obstruction prior to drainage, infection, and any background of liver disease.[14,15] Regarding any association between the restoration of the patient's liver and hemodynamic function from the prolonged biliary obstruction with the outcome following PD, there are only a few studies investigating the association between the rate of bilirubin decrease and the outcome of PD.[16,17] Thus, the aim of this study is to investigate the rate of bilirubin decrease after PBD in periampullary tumor patients, and whether the rate of the bilirubin decrease affects the outcome following PD.

Patients and methods

A total of 307 patients underwent PD at the Department of Surgery, Ramathibodi Hospital, Mahidol University, Bangkok, Thailand from January 2008 to December 2019 and their data were retrospectively reviewed. Patients who underwent PBD were included in the study.

Ramathibodi Hospital has a routine practice for patients who are due to undergo PD. All patients undergoing PD are examined by preoperative cross-sectional dynamic imaging using either triple-phase computed tomography or magnetic resonance imaging. The indications for PBD prior to PD are severe jaundice (serum total bilirubin ⩾ 5 mg/dL), malnutrition, or an operation waiting time longer than 2 weeks. In terms of the PBD method, endoscopic retrograde cholangiopancratography (ERCP) is the first-line approach. ERCP is performed by an experienced endoscopist. Stent type selection is dependent on the surgeon's preference. If a stent cannot be placed via an endoscopic approach, a percutaneous transhepatic biliary drainage (PTBD) is performed. PTBD is performed by an interventionist under standard procedures.

Patient data were retrospectively reviewed, including age, gender, body mass index (BMI), comorbidity, American Society of Anesthesiologists (ASA) classification, smoking history, cholangitis history, serum albumin level, serum total bilirubin level, pre-operative diagnosis, and waiting time. Waiting time is defined as the duration between PBD and surgery. Perioperative data including operative time, blood loss, pancreatic texture, and pancreatic diameter were collected.

Regarding the serum total bilirubin level, patients' blood was taken to determine the bilirubin level prior to PBD and at multiple intervals until the patient undergo PD. The solution of non-parametric of the rate of the bilirubin using the Random-effects generalized least squares (GLS) regression model adjusted by time, presence of cholangitis, age, and serum albumin level was done to determine bilirubin level for the days the blood was not collected. The equation used is as follows

$$Y_{TotalBilinubin} = 5.488e^{1.507(time)+0.526(cholangis)(time)-0.003(Age)(time)-0.113(Albu\min)(time)}$$

The study protocol was approved by the Institutional Ethical Committee at the Faculty of Medicine, Ramathibodi Hospital (protocol number, MURA 2018/844).

Operative procedure

PD was performed by experienced hepatopancreatobiliary surgeons. Routine prophylactic antibiotic was administered 30 min before the skin incision was made. The decision to perform classical PD or pylorus-preserving PD was dependent on the surgeon's preference. Reconstruction after resection was performed using Child's technique, starting with the pancreaticojejunostomy, then hepaticojejunostomy and gastrojejunostomy consecutively. A trans-anastomotic pancreatic duct stent, either internal or external, was placed into selected patients depending on the surgeon's preference. Pancreatic texture was classified as hard, firm, or soft consistency, based on palpation by the surgeon. Intra-operative blood loss was documented. Patients were transferred to a critical care unit or intermediate ward after the operation. Routine biochemical analyses of patients' blood were performed. An oral diet was started as soon as the gastric content output was less than 400 mL/day, along with the presence of a bowel movement.

Perioperative morbidity

Postoperative morbidity were classified according to the Clavien-Dindo classification.[18] Only procedure-related complications were consider. Major morbidity were defined as higher than grade II in the Clavien-Dindo classification. Postoperative pancreatic fistula (POPF) was diagnosed according to the International Study Group of Pancreatic Fistula (ISGPF) guidelines.[19] POPF was classified into three categories: biochemical leakage (transient pancreatic fistula with no clinical impact), grade B (a fistula requiring a change

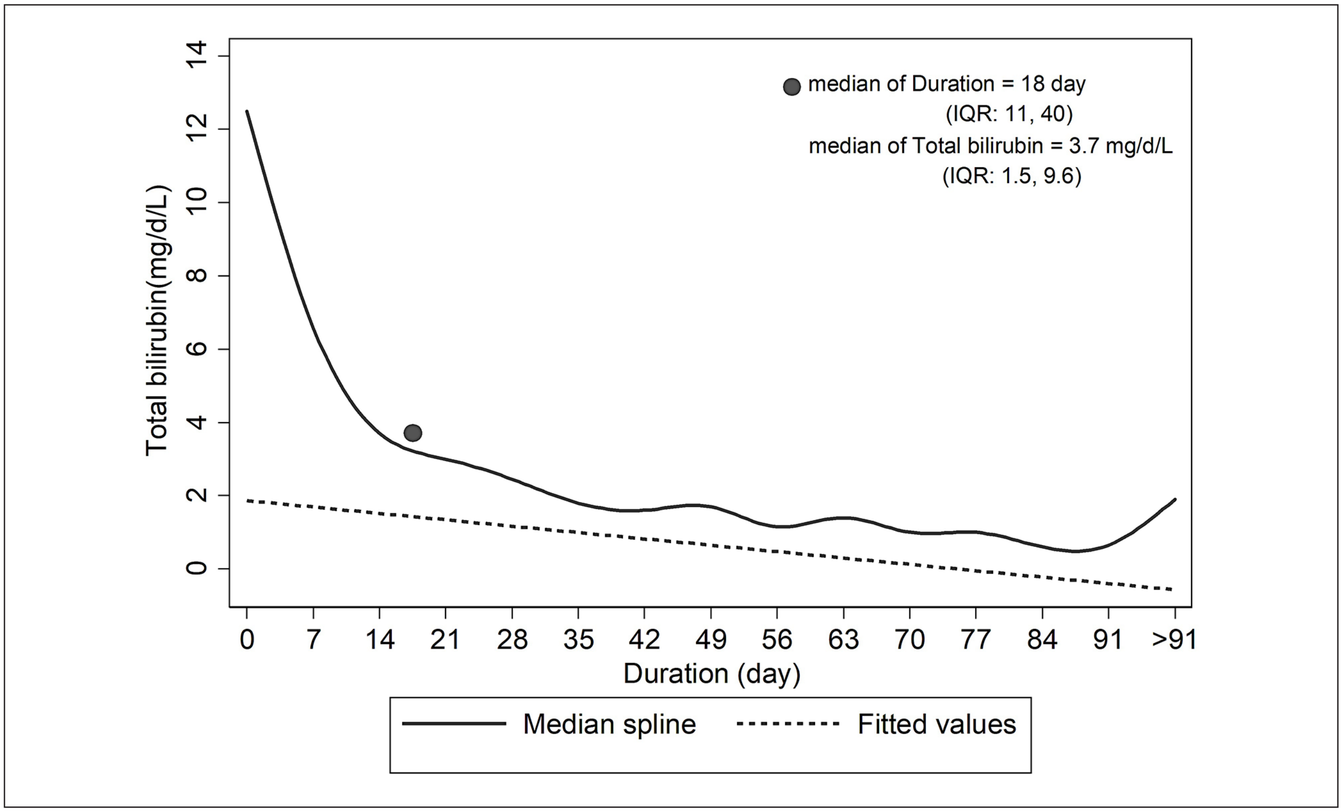

Figure 1. The overall rate of bilirubin decrease.

in management or adjustment of the clinical course) and grade C (a fistula requiring a major change in clinical management or deviation from the normal clinical course). Postoperative mortality included mortality within 90 days of the operation and in-hospital mortality.

Statistical analysis

The analysis of the patient characteristics was done using student's t test for continuous variables and χ^2 test or Fisher's exact test for categorical variables. A p value of <0.05 was considered statistically significant. The potential risk factors were analyzed by univariate and multivariate methods using a logistics regression model. Independent risk factors were expressed as odd ratios (ORs) with 95% confidence intervals (CIs).

Results

Post-drainage bilirubin decrease rate

The rates of bilirubin decrease at post-drainage week 1, 2, 3, and 4 (compared with pre-drainage bilirubin level) were 12.0%, 23.1%, 27.9%, and 32.5%, respectively, as shown in Figure 1. According to the European Society of Gastrointestinal Endoscopy's clinical guidelines, a decrease in total bilirubin of <20% from baseline on the seventh day post stent insertion should be considered inadequate drainage.[20] Thus, a cutoff of 20% was used to distinguish between the adequate and inadequate drainage group in this study.

Patient characteristics and perioperative data comparing between adequate and inadequate rate groups

A total of 307 patients underwent PD from January 2008 to December 2019, of whom 166 underwent PBD. The epidemiology of the adequate drainage and inadequate drainage groups is displayed in Table 1. The percentage of patients who exhibited an adequate rate of bilirubin decrease was 23.4% (39/166). The inadequate group's bilirubin decreased at a significantly lower rate (0.8 vs. 1.9, $p < 0.001$). The waiting time for PD between the two groups was not statistically different (39 days for the adequate group vs 47 days for the inadequate group, $p = 0.129$).

Comparison between major and non-major morbidity

Of the 166 patients included in the study, 36 patients had major postoperative morbidity (21.68%) and the remaining 130 patients had minor morbidity or no morbidity. The

Table 1. Total bilirubin value and rate of bilirubin decrease comparing adequate and inadequate rate groups.

Data	Total (n = 166)	Adequate rate (n = 39)	Inadequate rate (n = 127)	p value
TB (mg/d/L), median (IQR)				
Pre-drainage	12.5 (6.1, 19.5)	11.9 (7.3, 20.0)	12.9 (4.6, 19.3)	0.849
Within 7 day	6.6 (3.2, 10.7)	6.6 (3.7, 9.6)	9.7 (0.8, 15.2)	0.725
Rate of bilirubin decrease	1.1 (0.3, 1.8)	1.9 (1.3, 2.4)	0.8 (0.2, 1.6)	<0.001
Age (years), mean ± SD	60.72 ± 11.28	60.28 ± 10.46	60.85 ± 11.56	0.781
Gender, n (%)				
Male	92 (55.42)	17 (43.59)	75 (59.06)	0.089
Female	74 (44.58)	22 (56.41)	52 (40.94)	
BMI (kg/m^2), mean ± SD	22.84 ± 3.70	22.49 ± 2.92	22.95 ± 3.91	0.438
DM, n (%)				
No	134 (80.72)	33 (84.62)	101 (79.53)	0.481
Yes	32 (19.28)	6 (15.38)	26 (20.47)	
ASA class, n (%)				
I	19 (11.45)	5 (12.82)	14 (11.02)	0.832
II	58 (34.94)	15 (38.46)	43 (33.86)	
III	83 (50.00)	17 (43.59)	66 (51.97)	
IV	4 (2.41)	1 (2.56)	3 (2.36)	
V	2 (1.20)	1 (2.56)	1 (0.79)	
Smoking, n(%)				
No	118 (71.08)	29 (74.36)	89 (70.08)	0.606
Yes	48 (28.92)	10 (25.64)	38 (29.92)	
WBC (cell/, median (IQR)	7375 (6100, 8750)	7300 (6070, 8640)	7400 (6100, 8810)	0.739
Hb (g/dL), median (IQR) n = 164	12.0 (11.0, 13.0)	12.4 (11.3, 13.3)	12.0 (11.0, 12.9)	0.259
Albumin (g/L), mean ± SD	34.13 ± 4.94	33.67 ± 4.24	34.27 ± 5.15	0.513
Biliary intervention, n (%)				
PTBD	6 (3.61)	0	6(4.72)	0.337
ERCP	160 (93.39)	39(100)	121(95.28)	
Type Material, n (%) n = 157				
Plastic	155 (98.73)	36(97.30)	119(99.17)	0.417
Metallic	2 (1.27)	1(2.70)	1(0.83)	
Waiting time (day)	45 (27, 69)	39 (21, 55)	47 (28, 78)	0.129
⩽30 day	49 (30.25)	13 (34.21)	36 (29.03)	0.543
>30 day	113 (69.75)	25 (65.79)	88 (70.97)	

TB: total bilirubin (normal range 0.2–1.2 mg/dL); IQR: interquartile range; WBC: white blood cell count; BMI: body mass index; DM: diabetes; ASA: American Society of Anesthesiologists; PTBD: percutaneous transhepatic biliary drainage; ERCP: endoscopic retrograde cholangiopancreatography.

clinicopathological characteristics of the patients stratified by morbidity is shown in Table 2. Those with major morbidity had greater body mass index (BMI; 24.2 vs. 22.4 kg/m^2, p = 0.009), and longer operative time (8.8 vs. 7.9 h, p = 0.018) compared with those with minor/no morbidity. Pancreatic duct diameter was significantly smaller in patients who had major morbidity (3 vs. 4 mm, p = 0.011). Patients who had major morbidity were less likely to have come from the adequate biliary drainage rate group than the inadequate group (38.9% vs. 61.1%, p = 0.014).

Analysis of the risk factors associated with major morbidity

The results of the univariate and multivariate analyses of potential risk factors for major postoperative morbidity are shown in Table 3. The univariate analysis identified the following variables as being significantly associated with major morbidity: BMI (OR = 1.1; 95% CI = 1.0–1.2; p = 0.012), operative time (OR = 1.2; 95% CI = 1.0–1.4; p = 0.021), and pancreatic duct diameter (OR = 0.7; 95% CI = 0.6–0.9; p = 0.021). Multivariate analysis revealed that BMI (OR = 1.1; 95% CI = 1.0–1.2; p = 0.040), operative time (OR = 1.2; 95% CI = 1.0–1.5; p = 0.027), and pancreatic duct diameter (OR = 0.7; 95% CI = 0.6–0.9; p = 0.033) were significantly associated with major morbidity. From the univariate and multivariate analysis, bilirubin decrease rate did not associate with major morbidity.

Discussion

PD is a complex abdominal surgery associated with high morbidity.[2] Preoperative optimization of patients undergoing

Table 2. Patients' perioperative characteristics comparing major and non-major mobidity.

Data	Total (n = 166)	Non-major morbidity (n = 130)	Major morbidity (n = 36)	p value
Age (years), mean ± SD	60.72 ± 11.28	60.56 ± 11.66	61.27 ± 9.93	0.739
Gender, n (%)				
Male	92 (55.42)	74 (56.92)	18 (50.00)	0.460
Female	74 (44.58)	56 (43.08)	18 (50.00)	
BMI (kg/m^2), mean ± SD	22.84 ± 3.70	22.45 ± 3.69	24.25 ± 3.45	0.009
DM, n (%)				
No	134 (80.72)	102 (78.46)	32 (88.89)	0.160
Yes	32 (19.28)	28 (21.54)	4 (11.11)	
ASA class, n (%)				
I	19 (11.45)	15 (11.54)	4 (11.11)	0.111
II	58 (34.94)	47 (36.15)	11 (30.56)	
III	83 (50.00)	65 (50.00)	18 (50.00)	
IV	4 (2.41)	3 (2.31)	1 (2.78)	
V	2 (1.20)	0	2 (5.56)	
Preoperative cholangitis, n (%)	21 (12.65)	16 (12.31)	5 (13.89)	0.801
Smoking, n (%)				
No	118 (71.08)	90 (69.23)	28 (77.78)	0.317
Yes	48 (28.92)	40 (30.77)	8 (22.22)	
WBC (cell/mm^3), median (IQR)	7375 (6100, 8750)	7400 (6270, 8750)	7230 (5520, 8690)	0.331
Hb (g/dL), median (IQR) n = 164	12.0 (11.0, 13.0)	12.0 (11.0, 12.9)	12.0 (11.3, 13.1)	0.475
Biliary intervention, n (%)				
PTBD	6 (3.61)	4 (3.08)	2 (5.56)	0.611
ERCP	160 (96.39)	126 (96.92)	34 (94.44)	
Type of stent, n (%)				
Plastic	155(98.3)	123 (98.4)	32 (100)	0.999
Metallic	2 (1.27)	2 (1.60)	0	
Albumin (g/L), mean ± SD	34.13 ± 4.94	34.50 ± 5.01	32.78 ± 4.53	0.065
⩾35	90 (54.22)	66 (50.77)	24 (66.67)	0.090
<35	76 (45.78)	64 (49.23)	12 (33.33)	
Preoperative diagnosis, n (%)				
Benign	23 (13.86)	17 (13.08)	6 (16.67)	0.581
Malignant	143 (86.14)	113 (86.92)	30 (83.33)	
Diagnosis, n (%)				
Ampulla cancer	63 (37.95)	48 (36.92)	15 (41.67)	0.231
Pancreatic cancer	39 (23.49)	35 (26.92)	4 (11.11)	
Duodenal cancer	9 (5.42)	8 (6.15)	1 (2.78)	
Cholangiocarcinoma	16 (9.64)	11 (8.46)	5 (13.89)	
Other	39 (23.49)	28 (21.54)	11 (30.56)	
Operative time (hr), mean ± SD	8.13 ± 2.16	7.92 ± 2.15	8.87 ± 2.10	0.018
Blood loss (ml), median (IQR)	800 (500, 1400)	700 (500, 1500)	800 (500, 1250)	0.336
Pancreatic texture, n (%) n = 160				
Hard/Firm	73 (45.63)	61 (49.19)	12 (33.33)	0.093
Soft	87 (54.37)	63 (50.81)	24 (66.67)	
Pancreatic diameter (mm), median (rang), n = 160	3 (2, 5)	4 (3, 5)	3 (2, 4)	0.011
Rate of bilirubin decrease, n (%)				
Adequate rate	39 (23.49)	25 (19.23)	14 (38.89)	0.014
Inadequate rate	127 (76.51)	105 (80.77)	22 (61.11)	

Major morbidity defined as higher than grade II in the Clavien-Dindo classification. SD: standard deviation; BMI: body mass index; DM: diabetes; ASA: American Society of Anesthesiologists; PTBD: percutaneous transhepatic biliary drainage; ERCP: endoscopic retrograde cholangiopancreatography; WBC: white blood cell count; IQR: interquartile range.

PD is very important.[21] One of the problems encountered in such patients is obstructive jaundice and malnutrition. Obstructive jaundice alters the function of intestinal microbial flora, Kupffer cell function, and cellular immunity.[5] Thus, PBD is indicated for the patient with severe preoperative jaundice and malnutrition.[22] However, some studies

Table 3. Univariate and multivariate analysis of predictors of major morbidity.

Data	Univariate		Multivariate	
	OR (95%CI)	p value	OR(95%CI)	p value
Waiting time (day) n = 162				
≤30 day	1			
>30 day	0.9 (0.4–2.0)	0.864		
Preoperative cholangitis	1.1 (0.3–3.3)	0.801		
Age (years)	1.0 (0.9–1.0)	0.738		
Gender				
Male	1			
Female	1.3 (0.6–2.7)	0.460		
BMI (kg/m^2)	1.1 (1.0–1.2)	0.012	1.1(1.0–1.2)	0.040
DM				
No	1			
Yes	0.4 (0.1–1.3)	0.169		
ASA class				
I	1			
II	0.8 (0.2–3.1)	0.842		
III	1.0 (0.3–3.5)	0.952		
IV	1.2 (0.1–15.4)	0.862		
V	–	–		
Smoking				
No	1			
Yes	0.6 (0.2–1.5)	0.319		
Biliary intervention				
PTBD	1			
ERCP	0.5 (0.0–3.0)	0.487		
Albumin(g/L)	0.9 (0.8–1.0)	0.068		
>35	1			
<35	0.5 (0.2–1.1)	0.093		
WBC (cells/mm3)	0.9 (0.8–1.1)	0.647		
Hb (g/dL)	0.9 (0.9–1.0)	0.661		
Diagnosis				
Pancreatic cancer	1			
Ampullary cancer	2.7 (0.8–8.9)	0.096		
Duodenal cancer	1.0 (0.1–11.1)	0.940		
Cholangiocarcinoma	3.9 (0.9–17.4)	0.067		
Other	3.4 (0.9–11.9)	0.052		
Operative time (h)	1.2 (1.0–1.4)	0.021	1.2 (1.0–1.5)	0.027
Blood loss(ml)	1.0 (0.9–1.0)	0.060		
Pancreatic texture				
Hard/ Firm	1			
Soft	1.9 (0.8–4.2)	0.096		
Pancreatic duct diameter (mm)	0.7 (0.6–0.9)	0.021	0.7 (0.6–0.9)	0.033
Rate of bilirubin decrease	1.1 (0.8–1.5)	0.342		

OR: odds ratio; CI: confidence interval; BMI: body mass index; DM: diabetes; ASA: American Society of Anesthesiologists; PTBD: percutaneous transhepatic biliary drainage; ERCP: endoscopic retrograde cholangiopancreatography; WBC: white blood cell count.

reported an increase in infectious complication in patients who received PBD prior to undergoing PD.[23] At Ramathibodi Hospital, the presenting symptom of obstructive jaundice is very prevalent, with most patients having a mean total bilirubin level of 12.5 mg/dL at the time of diagnosis. This value is relatively greater than other previously reported studies.[13,24] Thus, the PBD rate in our hospital is greater than other reports. The overall rate of bilirubin decrease in our center is 12% within 1 week, which is comparable with other studies.[9] The association between the rate of bilirubin decrease and short-term outcome following PD was rarely reported.[16,25] An ideal rate of bilirubin decrease after PBD is more than 50% within 1 week.[26] However, most patients did not reach this rate in real clinical practice.[9,13,24] Thus, a cutoff point of more than 20% bilirubin decrease within 7 days suggested by the European Society of Gastrointestinal Endoscopy (ESGE) guideline was adopted in this study as an adequate bilirubin drainage.[20] The current study's result showed that patients who had major morbidity were less likely to have come from the adequate biliary drainage rate group than the inadequate group. However, through logistic regression analysis, the bilirubin decrease rate was not associated with severe short-term outcome following PD. The possible explanation for the contradicting results is that the number of patients who had adequate drainage was not large enough to detect a significant association.

To the best of our knowledge, there is currently no study that explored the relationship between bilirubin decrease rate and postoperative morbidity exclusively in patients who underwent PD. Sano et al. conducted a study in patients who received major hepatobiliary or pancreatic surgery and found that patients with a slower bilirubin decline after PBD had a higher rate of morbidity.[16] Moreover, factors associated with a slow rate of bilirubin decrease were age and a prolonged period of undrained jaundice. However, Sano's study included patients who underwent hepatectomy as well as pancreatic resection, and there is already strong evidence from previously reported studies that performing liver resection in jaundice patients is associated with poor short-term outcomes.[27] Thus, the association seen in Sano's study could have been the effect from the liver resection population.

Based on the study's results, the factors associated with major morbidity after PD were operative time, pancreatic duct diameter, and BMI. Each factor is discussed in turn. First, with respect to duration of surgery, a prolonged operative time is associated with major morbidity and mortality, as previously reported.[28,29] In earlier study, we reported the factors associated with infectious complications in patients who underwent major hepatectomy were reported. It was found that patients who have intraabdominal infection have significantly longer operative time than those in a non-intraabdominal infection group.[28] This is consistent with Chacon et al., who studied the effect of operative duration and infectious complications and mortality in a large population of patients who underwent hepatectomy.[30] It was found that an operative time greater than 3 h significantly increased mortality, with a considerable peak at 8 h. Furthermore, as the 30-day mortality rate increased in accordance with the operative time, it was concluded that operative time is associated with a linear increase of risk of mortality and infectious complications following hepatectomy. Recently, Coimbra et al. reported the predicting factors for major postoperative morbidity in a large population cohort study.[31] They found that the independent factors associated with morbidity consisted of the following: age, chronic obstructive pulmonary disease, coronary heart disease, chronic liver disease, pancreatic resection, and operative time. Usually, PD is a complex operation, with a prolonged operative time. Surgical team communication and proper usage of the surgical safety checklist are effective means of reducing operative time.[32]

Second, with regard to BMI as a factor, multiple previous studies have proven that BMI is associated with complications following PD.[33,34] A possible mechanism is that BMI is a predictor of the percentage of pancreatic fat which, in turn, is a risk factor for POPF.[35] Finally, with regard to small pancreatic duct as a factor, such finding was anticipated. A small pancreatic duct diameter is a well-known significant factor for severe complications, including intraabdominal infection and post-pancreatectomy hemorrhage.[36,37]

This study had a few limitations. First, some selection bias may be present due to the retrospective nature of the study. Second, the study population was relatively small. Third, the waiting time between PBD and PD in the current study is longer than other previous studies.[13,38] A prolonged waiting time might be from the congestion of the patient in the high volume center in our country, severe jaundice, and nutritional status of the patient.[39] Fourth, there was the variation of the rate of bilirubin decrease in each patient; for example, a patient displayed a good rate of bilirubin decrease in the first week, but a slower rate in the second week. The variation in the drainage rate may or may not affect patients' outcome and is a potential for further study. Fifth, only two subjects in the study population received metallic stent placement. The population was heavily skewed toward those with plastic stents; thus, the study's applicability to those with metallic stents would need further investigation in order to be determined. Finally, there is lack of biliary bacteriology data of the study population.

Conclusion

The preoperative optimization of the patient undergoing PD is crucial. PBD is one of the most common interventions for patients with severe jaundice who are scheduled for PD. From our study, only BMI, operative time, and pancreatic duct diameter were the factors associated with major morbidity. Although patients with inadequate bilirubin drainage had higher major morbidity, an association between bilirubin decrease rate and major morbidity could not be established from a multivariate analysis. Thus, a future study with larger population is warranted to confirm or deny this hypothesis.

Acknowledgements

The authors thank Associate Professor Panuwat Lertsithichai and Dr. Napaphat Poprom, PhD, for their data analysis work, and Mr. William Farquharson for his contribution as a language consultant. The authors also express their heartfelt thanks to their data collectors and friends who supported them in this research work.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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