Cohort Study

Relieving the bile ducts prior to pancreatoduodenectomy – A retrospective cohort study

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ABSTRACT

Introduction: Obstructive jaundice is a common problem in pancreatic and periampullary tumors, but preoperative biliary drainage in patients with hyperbilirubinemia is still controversial. This study aimed to assess the risk of complications after preoperative drainage of biliary obstruction in patients who underwent pancreatoduodenectomy.

Method: A retrospective cohort study of all patients who underwent pancreatoduodenectomy from January 1st, 2015 to September 30th, 2021. Patients who had preoperative bile duct drainage were compared to patients without intervention. Type of interventions, complications, and outcomes after surgery were compared using univariate and multivariate analysis.

Results: Of 722 patients who underwent pancreatoduodenectomy, 389 patients had preoperative drainage of the bile ducts by ERC or PTC. There was an incidence of 27% drainage-related complications, all categorized as minor (Clavien-Dindo ≤ 3) and mainly related to PTC-aided drainage. After pancreatoduodenectomy, 23% of patients who had a preoperative biliary drain, had minor complications. Patients without biliary drainage had a higher risk of a complicated postoperative course (p = 0.001) and had a higher 30-day (p = 0.002) and 90-day mortality (p = 0.025).

Conclusion: Our study found preoperative bile duct drainage to be a safe procedure without severe complications. Patients undergoing preoperative bile duct drainage had fewer post-pancreatoduodenectomy complications and lower mortality.

1. Introduction

Obstructive jaundice is common in patients with malignancies in the pancreas [1]. Apart from the general discomfort with malaise, skin itching, and nausea, elevated bilirubin may lead to renal failure due to toxic necrosis of renal tubules, anemia, impaired coagulation, hepatic failure, and cholangitis [2–5]. Patients with severe obstructive jaundice (bilirubin ≥ 300 μmol/L), have an increased risk of morbidity and decreased long-term survival after pancreatoduodenectomy (PD) [6].

Internal drainage is primarily performed by endoscopic retrograde cholangiography (ERC) with placement of either a plastic stent, a self-expanding covered, or uncovered metallic stent (SEMS) in the common bile duct. Internal drainage can also be achieved by percutaneous transhepatic cholangiography (PTC) with placement of a percutaneous plastic catheter in the bile ducts [7]. A rather new technique is endoscopic ultrasound-guided transduodenal placement of stents mainly in patients where operation is not an option [8].

The incidence of complications from ERC-guided stent, pancreatitis, bleeding, iatrogenic lesions of the duodenum and bile duct, is around five percent in skilled hands but three times higher when performed in low volume centers [9,10]. PTC-guided placement has a ten percent risk of major complications including bleeding and bile peritonitis [11,12]. Cholangitis after stenting of the bile ducts occurs in five to ten percent of patients [11,12].

Whether obstructed bile ducts with hyperbilirubinemia should be treated with drainage before pancreatoduodenectomy is still a matter of debate. Some studies have reported an increased risk of complications after PD in patients who underwent preoperative bile duct drainage (PBD) [13,14]. The European Society of Gastrointestinal Endoscopy (ESGE) and the European Society of Medical Oncology (ESMO) do not recommend routine preoperative bile duct drainage for malignant obstruction, unless in case of cholangitis, and some cases with severe
hyperbilirubinemia \cite{9,15}. The American Society of Gastrointestinal Endoscopy (ASGE) share the same opinion unless the time to surgery is delayed substantially (more than one and a half week) \cite{16,17}.

This study aimed to examine the risks and complications associated with preoperative drainage of obstructed bile ducts in patients with hyperbilirubinemia and to assess the risk of postoperative complications following PD in patients with preoperative drainage of bile duct obstruction.

2. Method

2.1. Patient data

The present study included 722 patients who underwent PD at our institution from January 1st, 2015, to September 30th, 2021. All patients were included in the study regardless of surgical indication. Patient data were extracted from the electronic patient journal system EPIC and the department’s prospectively maintained database of pancreatic surgery.

2.2. Bile duct drainage

Our regional protocol recommends PBD to be performed when there are signs of bile duct obstruction. This is defined as dilation of the common bile duct found radiologically or jaundice. There is no fixed cut-off value for serum levels of bilirubin. Drainage of the bile ducts was primarily attempted by ERC at regional, high-volume endoscopic centers. In case of unsuccessful ERC, patients were referred to our center, which is a tertiary hospital and reference hospital for hepato-pancreato-biliary (HPB) surgery. After individual judgment, either ERC was attempted, or drainage of bile ducts was performed by PTC with placement of an external-internal drain. After drainage of the bile duct, bilirubin levels, renal function, and inflammatory markers were analyzed, and the clinical condition of patients was closely observed for the development of complications. At our center, the interventional radiologists perform on average 280 PTC-guided procedures annually, and our endoscopists do around 160 highly specialized ERCP procedures.

2.3. Surgery and postoperative care

All patients were discussed at the HPB multidisciplinary team meeting attended by radiologists, clinical physiologists, oncologists, and surgeons. All patients were operated on by four specialized HPB surgeons. PD was performed en-bloc with prepyloric amputation, and resection of the head of the pancreas, duodenum, and gall bladder. The division of the common hepatic duct was above the cystic duct just below the confluence. Reconstruction was performed by pancreateojunostomy, hepaticojejunostomy, and antecolic gastrojejunostomy with all anastomoses on the same segment of the small bowel. The pancreateojunostomy was either performed as an invaginated anastomosis \cite{18} or as a duct-to-mucosa procedure \cite{19}. The hepaticojejunostomy was performed end-to-side in a single-layer, either with running or single sutures.

A standard regime for postoperative care was followed and included mobilization and physiotherapy from postoperative day (POD) 1. Patients were allowed an intake of up to 1500 ml water on POD 1 and 2 and the preoperatively placed nasogastric tube was removed once oral intake was tolerated. Standard intravenous antibiotics, predominantly piperacillin/tazobactam or ceftazidime, and metronidazole were administered during the first three postoperative days. Preoperative epidural catheters were kept until POD 4. A single abdominal drain was placed intraoperatively behind the hepaticojejunostomy and pancreateojunostomy. The drain was removed on POD 5 except in the case of pancreatic fistula (POPF), biliary fistula (BF), or chylous ascites. If bile was observed in the abdominal drain, a PTC with internal/external biliary drainage was carried out to drain the bile duct and avoid a further intraabdominal accumulation of bile. Moreover, a CT scan of the abdomen was commonly performed to visualize any additional drainable fluid accumulations in case of which an ultrasonographically guided drainage was performed. Supportive measures were initiated once BF or POPF was confirmed, which included fluid therapy and antibiotics according to culture. In case of other complications, similar measures were initiated to diagnose and treat. Intensive Care Unit (ICU) admission or reoperation was only undertaken in case of clinical deterioration and onset of organ failure.

2.4. Endpoints

Baseline characteristics for each patient included patient age, gender, body mass index (BMI), American Society of Anesthesiologists (ASA) Physical Status Classification \cite{20}, 30-day and 90-day mortality.

Primary endpoints included data on preoperative drainage of bile ducts, the occurrence of postoperative complications (Clavien-Dindo) \cite{21}, mortality, length of hospital stay, and 30-day readmission rate. Clavien-Dindo was categorized for the primary admission. Definitions of BF and POPF were per the International Study Group of Liver Surgery (ISGLS) \cite{22} and the International Study Group for Pancreatic Fistulas (ISGPP) \cite{23}.

Secondary endpoints included the type of bile duct drainage, complications related to bile duct decompression, time from bile duct decompression to surgery, and histological diagnosis of the resection specimens.

This study is set up in accordance with the STROCSS guidelines for the presentation of cohort studies \cite{24}.

2.5. Statistical analysis

SPSS version 26 (SPSS Inc., Chicago, Illinois, USA) for Windows (Microsoft Corporation, Redmond, Washington, USA) was used for statistical analysis. Continuous variables were expressed as mean ± SD or median with range when appropriate and were compared using the independent samples t-test. Categorical variables were expressed as percentages and were compared using Pearson’s chi-square test with Yates’ correction. Univariate and multivariate analysis using a binary logistic regression model was used to identify independent risk factors.

3. Results

3.1. Preoperative bile duct drainage

Of 722 patients undergoing PD, 389 patients (53.9%) underwent preoperative drainage of the bile ducts. Of these, 351 patients (90.2%) had bile stents inserted by ERC, the remaining by PTC. Most patients had plastic stents (86.1%), 14 (3.6%) patients covered SEMS, and two patients uncovered SEMS (Table 1). In 38 patients, PTC was the first method of drainage, mainly after failed ERC or due to obstruction in the duodenum. In nine other cases, PTC was used to replace previously inserted endoscopic stents. Overall, drain replacement occurred in 23% of the cases, the majority being PTC (45%).

The median time from drainage to PD was 32 days, and patients with pancreatic ductal adenocarcinoma (PDAC), periampullary adenocarcinomas, and cholangiocarcinomas were most often in need of preoperative biliary drainage (Table 2).

3.2. Complications related to preoperative bile duct decompression procedures

A total of 27% of patients in the PBD-group had adverse effects after preoperative drainage (Table 2). Of the 351 patients who had ERC, 56 (16%) patients developed cholangitis, and 27 (8%) patients suffered from post-ERC pancreatitis. Twelve patients (32%), who underwent...
μ-drainage, were 204 μmol/L (3-660), SD ± 123.9 and 78 μmol/L (3-660), SD ± 65.3 in patients who underwent PBD and in patients who did not undergo PBD, serum bilirubin was at all times under 25 μmol/L, which, at our institute, is the highest normal serum concentration. Average levels of serum bilirubin after PBD, but before PD, were 39 μmol/L (3–428), SD ± 67. Multivariate analysis using binary logistic regression revealed that increasing levels of bilirubin were associated with an increased risk of complications (p = 0.047).

Most preoperative bile duct drainage complications were managed with hospital admission, intravenous fluids, and antibiotics (Clavien-Dindo 2). In five cases of cholangitis, three after ERCP and two after PTC, and in one case with post-ERCP pancreatitis, pancreatic operations were postponed. The highest Clavien-Dindo score after PBD was 3b (endoscopic procedure in general anesthesia).

There were no significant differences in overall post-drainage complications when ERC was compared with PTC. However, ERC reduced the risk of cholangitis (p = 0.016) and reduced the need for stent replacement (p = 0.001) when compared to PTC-aided drainage (Table 2). ERC with the insertion of plastic stents reduced the overall risk of complications (p = 0.022) and the risk of post-ERC pancreatitis (p = 0.008) compared to SEMS (covered and uncovered).

Patients with non-malignant etiologies had more complications (p = 0.002), and this also included replacement of drain (p = 0.048).

### 3.3. Postoperative course after PD with and without preoperative bile duct decompression

Around 42% of the patients who underwent a PD had an uncomplicated postoperative course (Clavien-Dindo 0 and 1). Approximately 23% had mild complications that required pharmacological treatment other than analgetics, electrolytes, and antiemetics (Clavien-Dindo 2), and 29% had complications that required intervention under local and general anesthesia (Clavien-Dindo 3a and 3b). Interventions requiring local anesthesia included superficial revision of the surgical wound and ultrasound-guided drainage of intraabdominal fluid collections.

Patients in the non-PBD group had a higher overall risk of a complicated postoperative course (p = 0.001), but there were no significant differences in the subgroup analysis. However, the non-PBD group had a higher risk of complications with interventions under local anesthesia (Clavien-Dindo 3a) and a higher 30-day (PBD = 1 vs. non-PBD = 5, p = 0.002), and 90-day mortality (PBD = 5 vs. non-PBD = 9, p = 0.025).

ERC-guided drainage had significantly fewer complications compared to PTC-guided drainage (p = 0.020). When plastic stents were compared with SEMS, the insertion of plastic stents reduced the overall risk of complications (p = 0.001).

Patients with malignant tumors who did not have preoperative drainage had a greater risk of postoperative complications (Clavien-Dindo 3b) (p = 0.010), while patients with benign tumors had a lower risk of complications if they did not have preoperative drainage (p = 0.012).

Of mild complications (Clavien-Dindo 2), the main cause in both groups, was chylous ascites and delayed gastric emptying (DGE), which resulted in the need for total parenteral nutrition (Overall 9%, PBD 9% vs. non-PBD 11%). This was followed by infections other than the surgical site infections (Overall 5%, PBD 4%, non-PBD 9%), complications needing general anesthesia (Clavien-Dindo 3b), dehiscence of the fascia (9%, PBD 9% vs. non-PBD 4%), surgical site infections (6%, PBD 7% vs. non-PBD 5%), POPF (10%, PBD 9% vs. non-PBD 12%) and BF (8%, PBD 3% vs. non-PBD 14%). More patients had BF (p = 0.001) in the non-PBD group (46 patients vs. 11 patients; p = 0.008), and the risk of post-ERC pancreatitis (endoscopic procedure in general anesthesia).

The median length of hospital stay after PD was 13 days (range 5–390 days) without a significant difference between the PBD and non-PBD group (11 days vs. 14 days). Readmission after discharge was 34% and there were significantly more incidents of readmission in the non-PBD group (PBD 30% vs. non-PBD 38%, p = 0.034). The main causes of readmissions were infections (27%) followed by nutrition and electrolyte deficiencies (18%), diarrhea/vomiting (11%), subcutaneous and intraabdominal hematomas (10%), and abdominal discomfort (8%). The remaining causes for readmission included intraabdominal infection, dysfunctional PTC catheters, and dysregulated diabetes, however, the occurrences of each of these causes were below five percent.

### Table 1

|                      | Preoperative Bile Duct Drainage | P-value |
|----------------------|--------------------------------|---------|
|                      | Total | Yes | No |         |
| Pancreatoduodenectomy, n (%) | 722   | 389 | 333 | 0.001  |
|                      | 100%  | 53.9% | 46.1% |         |
| - Male               | 374   | 213 | 161 | NS |
|                      | 51.8% | 54.7% | 48.3% |         |
| - Female             | 348   | 176 | 172 | NS |
|                      | 48.2% | 45.3% | 51.7% |         |
| Age, median (range)  | 69    | 69  | 69  | NS |
|                      | (16–87) | (32–87) | (16–87) |         |
| BMI, median (range)  | 24.5  | 24.3 | 24.7 | NS |
|                      | (12–49) | (15–48) | (12–45) |         |
| ASA-score, n (%)     | 142   | 76  | 66  | NS |
|                      | (19.7%) | (19.5%) | (19.8%) |         |
|                      | (19.7%) | (19.5%) | (19.8%) |         |
| -1                   | 473   | 264 | 209 | NS |
|                      | (65.5%) | (67.9%) | (62.8%) |         |
| -2                   | 31    | 15  | 16  | NS |
|                      | (4.9%) | (4.9%) | (4.8%) |         |
| -3                   | 177   | 82  | 95  | 0.025 |
|                      | (24.5%) | (21.1%) | (28.5%) |         |
| -4                   | 28    | 12  | 16  | NS |
|                      | (3.9%) | (3.1%) | (4.8%) |         |
| Length of admission, median (range) | 13 | 11 | 14 | NS |
|                      | (5–390 days) | (5–390 days) | (5–273 days) |         |
| Clavien-Dindo Score  |       |     |     |         |
| -Uncomplicated       | 232   | 147 | 85  | 0.001 |
|                      | (32.1%) | (37.8%) | (25.3%) |         |
|                      | (32.1%) | (37.8%) | (25.3%) |         |
| -1                   | 68    | 34  | 34  | NS |
|                      | (9.4%) | (8.7%) | (10.2%) |         |
| -2                   | 170   | 92  | 78  | NS |
|                      | (23.5%) | (23.7%) | (23.4%) |         |
| -3a                  | 31    | 15  | 16  | NS |
|                      | (4.3%) | (3.9%) | (4.8%) |         |
| -3b                  | 177   | 82  | 95  | 0.025 |
|                      | (24.5%) | (21.1%) | (28.5%) |         |
| -4                   | 28    | 12  | 16  | NS |
|                      | (3.9%) | (3.1%) | (4.8%) |         |
| -5                   | 13    | 10  | 9   | 0.043 |
|                      | (1.8%) | (1.0%) | (2.7%) |         |
| 30-day readmission, n (%) | 244 | 118 | 126 | 0.034 |
|                      | (33.8%) | (30.3%) | (37.8%) |         |
| 30-day mortality, n (%) | 8 (1.1%) | 1 (0.3%) | 7 (2.1%) | 0.002 |
|                      | (3.6%) | (3.6%) | (3.6%) |         |
| 90-day mortality, n (%) | 14 | 5 | 9 | 0.025 |
|                      | (1.9%) | (1.3%) | (2.7%) |         |
| Type of bile duct drainage, n (%) |           |     |     |         |
| -Plastic             | 335   | 86.1% | 14 | (86.1%) | |
|                      |       | (3.6%) | 14 | (3.6%) | |
| -Metallic, coated    | 2     | 2 (0.5%) | 2 (0.5%) | |
|                      |       |       | 2 (0.5%) | |
| -Metallic, uncoated  | 2     | 2 (0.5%) | 2 (0.5%) | |
|                      |       |       | 2 (0.5%) | |
| -PTC-aided stent     | 38    | 38 | 38 | NS |
|                      |       | (9.8%) | (9.8%) |         |
| Time from drainage to operation, median (range) | 32 | 32 | 32 | |
|                      | (1–534 days) | (1–534 days) | (1–534 days) |         |

BMI: Body Mass Index, ASA-score: American Society of Anesthesiology, PTC: Percutaneous Transhepatic Cholangiogram.
and complications

BMI: Body Mass Index, ASA: American Society of Anesthesiology, PBD: Preoperative biliary drainage, ERC: Endoscopic Retrograde Cholangiography, PTC: Percutaneous Transhepatic Cholangiogram, SEMS: Self-expandable metallic stent.

### Table 2
Histological diagnoses, preoperative bile duct drainage and post-drainage complication incidence.

| Type of bile duct drainage (%) | Total | Yes | No | Preoperative bile duct drainage | Total | Thrombus/ Bleeding | Cholangitis | Pancreatitis | Perforation | Drain replacement |
|-------------------------------|-------|-----|----|-----------------|-------|-------------------|------------|--------------|------------|----------------|
| N                             | 351   | 90  | 6  | (96.1%)         | 82    | 6 (ns)            | 56 (0.016) | 27 (ns)     | 1 (0.001)  | 74 (0.001)    |
| Plastic                       | 335   | 82  | 6  | (0.005)         | 52    | 23 (ns)           | 6 (ns)     | 4 (0.001)   | 0 (ns)     | 1 (ns)        |
| Metallic, coated              | 14 (3.6%) | 6 | 0  | (ns)           | 2     | 0 (ns)            | 2 (0.002)  | 0 (ns)      | 0 (ns)     | 1 (ns)        |
| Metallic, uncoated            | 2 (0.5%) | 2 | 0  | (ns)           | 12 (0.016) | 0 (0.076) | 2 (0.001)  | 17 (0.001)  |
| PTC-aided stent               | 38 (9.8%) | 15 | 1  | (ns)           | 12 (0.016) | 0 (0.076) | 2 (0.001)  | 17 (0.001)  |
| Histology, n (%)              |       |     |    |                | 48    | 6 (ns)            | 66 (ns)    | 22 (ns)     | 2 (0.022)  | 83 (0.048)    |
| Ductal adenocarcinoma         | 286   | 54  | 3  | (95.1%)         | 205   | 2 (ns)            | 35 (ns)    | 10 (ns)     | 1 (ns)     |               |
| Peripapillary adenocarcinoma  | 111   | 19  | 3  | (10.5%)         | 11    | 3 (ns)            | 12 (ns)    | 3 (ns)      | 1 (ns)     |               |
| Duodenal adenocarcinoma       | 46    | 10  | 2  | (9.6%)          | 36    | 0 (ns)            | 1 (ns)     | 1 (ns)      | 0 (ns)     |               |
| Other malignancies            | 64    | 14  | 1  | (28.4%)         | 28    | 1 (ns)            | 7 (ns)     | 6 (0.016)   | 0 (ns)     |               |
| Neuroendocrine tumor          | 37    | 14  | 0  | (28.1%)         | 1     | 0 (ns)            | 1 (ns)     | 0 (ns)      | 0 (ns)     |               |
| Choledochocarcinoma           | 33    | 9   | 0  | (9.9%)          | 21    | 0 (ns)            | 7 (ns)     | 2 (ns)      | 0 (ns)     |               |
| Metastasis                    | 10    | 1   | 0  | (0.8%)          | 9     | 0 (ns)            | 1 (ns)     | 0 (ns)      | 0 (ns)     |               |
| IMN                           | 48    | 19  | 11 | (49.4%)         | 11    | 1 (ns)            | 4 (ns)     | 5 (0.001)   | 1 (0.022)  | 8 (0.048)    |
| Other pathology               | 77    | 15  | 2  | (10.7%)         | 62    | 8 (0.019) | 1 (ns)     | 2 (ns)      | 1 (ns)     |

NS: Not significant, IPMN: Intraductal Papillary Mucinous Neoplasm, PTC: Percutaneous Transhepatic Cholangiogram.

### 3.4. Risk factors associated with preoperative bile duct decompression and complications

Univariate and multivariate analysis identified age as a risk factor for developing complications after PD (Table 3).

Univariate analysis identified using ERC as the method of PBD, and placing a plastic stent, as factors, which reduced the risk of complications after PD. However, these were not significant in the multivariate analysis.

### Discussion

The risk of complications after drainage of the bile ducts has deterred many centers from preoperative ERC or PTC-guided intervention in patients with obstructive jaundice. Especially severe pancreatitis, which may take months to resolve and exclude the patient from a later pancreatectomy is a worst-case scenario. The overall risk of post-ERC pancreatitis is reported to be between two and ten percent [25] and the occurrence of cholangitis is around 24% [26]. In most cases, post-ERC pancreatitis is uncomplicated, and severe cases of cholangitis under proper antibiotic treatment are rare. Most drain-related complications were mild and mainly related to PTC-aided drainage. However, PTC-aided drainage, was a rescue procedure only performed in complicated cases, where ERC was not possible. This supports previous observations and could explain the high complication rate [27].

In our study, drainage of the bile ducts had an overall complication rate of around 27%, but most of them ran an uncomplicated course. Seven percent of the patients undergoing ERC developed pancreatitis.

### Table 3
Risk factors associated with preoperative bile duct drainage and postoperative complications.

| Patient characteristics | Univariate | Multivariate |
|-------------------------|------------|--------------|
|                         | Odds Ratio | 95% CI       | P-value | Odds Ratio | 95% CI       | P-value |
| Age                     | 1.020      | 1.005-1.036  | 0.010   | 1.019      | 1.003-1.035  | 0.019   |
| Gender                  | 0.812      | 0.594-1.110  | 0.191   |            |              |         |
| BMI                     | 0.983      | 0.949-1.019  | 0.350   |            |              |         |
| ASA-score               |            |              |         |            |              |         |
| PBD characteristics     |            |              |         |            |              |         |
| ERC                     | 0.498      | 0.363-0.684  | 0.001   | 0.979      | 0.306-3.125  | 0.971   |
| PTC                     | 1.850      | 0.835-4.102  | 0.130   | 0.502      | 0.158-1.599  | 0.244   |
| Plastic stent           | 0.483      | 0.352-0.664  | 0.001   |            |              |         |
| SEMS                    | 1.203      | 0.373-3.876  | 0.797   |            |              |         |
| Drain replacement        | 0.868      | 0.547-1.377  | 0.548   |            |              |         |
| Post-PBD complications   | 0.862      | 0.558-1.331  | 0.503   |            |              |         |
| serum-bilirubin          | 1.000      | 0.998-1.001  | 0.618   |            |              |         |
| serum-creatinine         | 0.997      | 0.992-1.003  | 0.303   |            |              |         |
| PD characteristics       |            |              |         |            |              |         |
| Time from PBD to surgery | 1.001      | 0.998-1.004  | 0.455   |            |              |         |
but only one patient had the surgery postponed. And 17% of patients with PBD developed cholangitis (ERC 16% vs. PTC 32%), but surgery was only delayed in five patients. On this ground, we found PBD before PD to be mostly a safe procedure with a small risk of severe complications. Our results on drainage-related complications are in line with previous reports from other high-volume centers [28,29]. The incidence may be high, but also include minor complications, which rarely have implications on the post-procedural course. But this does raise a concern regarding the experience level of the radiologists and endoscopists performing the procedures, as the risk of adverse effects is correlated to the level of experience [29]. At our center, PTC-guided drainage is performed only by a few radiologists to maintain high volume and procedural experience.

Due to the risk of post-ERC complications ESGE [9], ASGE [16], and ESMO [15] do not recommend routine PBD in jaundiced patients before PD, except in severe symptomatic cases or if the operation is delayed. The magnitude of delay, however, was not specified, nor was the risk of renal failure addressed [3,13,14]. There is some controversy to this, as other studies including meta-analyses did not find an increased risk [3,5,30]. This controversy is one of the few reasons why we, at our institute, opt to perform PBD to a greater extent. Besides cases of cholangitis, our regional protocol recommends that PBD be performed already when jaundice is present. There is no fixed cut-off value for serum levels of bilirubin. Another reason for our high volume of PBD is the time to surgery, which on average is 32 days. A time which recommends PDB according to international guidelines.

Overall, there were fewer post-PD complications in the PBD-group (61% vs. 75%), which is interesting as this to a greater extent, is a comparison of patients with obstructive jaundice undergoing drainage, compared to patients without obstructive jaundice not undergoing drainage. Likewise, patients with malignancies were at greater risk of getting complications after PD if they did not undergo PBD. This is interestingly also the conclusion of an extensive meta-analysis conducted by Moole et al. [31]. Other systematic reviews and meta-analyses comparing PBD in liver surgery have shown PDB in selected patient groups, including jaundiced patients to reduce morbidity and mortality [32,33]. As mentioned earlier, jaundice has systemic effects, and combined with the systemic effects of malignancies, this could explain why PBD could be beneficial in select patients.

Although overall 30-day and 90-day mortality were low, there were significantly more cases in the non-PBD group. There were no differences in age (median 69 years) between the groups, and most patients were ASA 2, but there were few cases where the patients were ASA 1. The causes of 30-mortality were not related to PBD, but surgery-related complications including postoperative bleeding, bowel ischemia, and sepsis caused by surgical site infections. However, for 90-day mortality, there were more patients in the non-PBD group with leakage from the HJS and more patients in the PBD-group with POPF, however, these differences were not significant. A possible reason for the cases of leakage from the HJS in the non-PBD group could be that these patients had high-risk bile ducts (non-dilated, small diameter).

A major strength of our study is the large sample size from a high-volume HPB center, representing our current clinical practice, and adherence to strict guidelines in postoperative care and the case of complications. Furthermore, we applied standard and strict registration and documentation of postoperative complications. This allows for a solid comparison of PBD to non-PBD. Also, the time from diagnosis to surgery is somewhat equal in both groups, which was a major flaw in a large RCT performed on this topic used as a reference in current guidelines [17].

The study also has its limitations. Most of the patients were referred from other hospitals after the insertion of ERC-guided stents and some patients had replacement of their stents after referral, which may influence the interpretation of data. Another limitation is the retrospective design of the study although data were entered prospectively, they were analyzed retrospectively.

5. Conclusion

It is still controversial whether to perform preoperative biliary drainage on obstructive jaundice patients before surgery. The results of the present study from a high-volume HPB center showed that preoperative drainage of bile ducts before PD in jaundiced patients can be performed with a low risk of severe procedure-related complications. Furthermore, postoperative morbidity and mortality were lower in the group that underwent preoperative drainage before PD. The indication of PBD depends on the bilirubin level and must be evaluated individually.

Provenance and review

Not commissioned, externally peer-reviewed.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available due to a restriction agreement with the Danish Data Protection Agency but are available from the corresponding author on reasonable request. This study has been registered on Clinical Trials (www.clinicaltrials.gov) with the identification number NCT05434520.

Conflicts of interest

None to declare.

Author contribution

WF: Designed study, wrote the paper, analyzed data, approved the final version, LP: Designed study, analyzed data, revised paper, approved the final version, SKB: Designed study, analyzed data, revised paper, approved the final version, PSK: Analyzed data, revised paper, approved the final version, JHS: Designed study, revised paper, approved the final version, CPH: Designed study, revised paper, approved the final version.

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Research Registration Unique Identifying Number (UIN)

1. Name of the registry: Clinical Trials
2. Unique Identifying number or registration ID: NCT05434520
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): https://clinicaltrials.gov/ct2/show/NC T05434520

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Not applicable.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ansu.2022.104894.
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