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Natural history and therapeutic strategies of post-pancreatoduodenectomy abdominal fluid collections

Ten-year experience in a single institution

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Abstract

Trial Design: The aim of this study was to identify independent risk factors for post-pancreatoduodenectomy (post-PD) abdominal fluid collections (AFCs) and evaluate our management protocol on it.

Methods: A retrospective analysis of consecutive 2064 cases who underwent PD over the past decade in 1 single center was conducted. The patients were divided into AFCs and non-AFCs group. Univariable and multivariate logistic regression analysis was performed to identify independent risk factors of AFCs. The AFCs group was compared with the non-AFCs group with respect to the incidence of postoperative outcomes. The characteristics of AFCs were further analyzed in terms of clinical manifestations.

Results: Two thousand sixty-four cases with pancreaticoduodenectomy were recruited and 15% of them were found AFCs. Diameter of main pancreatic duct ≤3 mm was found to be an independent predictor of AFCs ($P<.001$), along with soft pancreatic texture ($P=.002$), mesenterico-portal vein resection ($P<.001$), and estimated intraoperative blood loss >800 mL ($P<.001$). The incidence of mild complications was significantly higher in AFCs group than in non-AFCs group (34% vs 20%, $P<.001$), whereas no significant differences were noted in the rate of severe complications between these 2 groups (15% vs 15%, $P=.939$).

Conclusion: Enhanced drainage is recommended as an effective measure to decrease the incidence of severe complications caused by post-PD AFCs.

Abbreviations: CT = computed tomography, GDA = gastroduodenal artery, post-PD AFCs = post-pancreatoduodenectomy abdominal fluid collections, PPPD = pylorus-preserving pancreaticoduodenectomy.

Keywords: abdominal fluid collections, management strategy, pancreatoduodenectomy

1. Introduction

Pancreaticoduodenectomy (PD) or pylorus-preserving pancreaticoduodenectomy (PPPD) is the standard surgical method of pancreatic head region tumors.[1] Over the past 3 decades, operative mortality rates after PD have decreased dramatically.[2–4] An increase in experience and continuous improvements in surgical techniques, anesthesia, and perioperative care have led to this decline, and in many high-volume centers, the mortality rate is lower than 4%.[5–9] However, the postoperative morbidity rate is still ranging from 30% to 50%.[10–13]

Abdominal fluid collections (AFCs), as one of the most common complications of post-PD, is a critical trigger of life-threatening complications such as digestive tract fistula, intra-abdominal abscess, and hemorrhage.[14] It leads to prolonged hospitalization, severe morbidity, or even surgical mortality.[15] The incidence of AFCs is reported to be 0% to 17% based on a variety of definitions.[16–18] However, little is known about AFCs, which is partly related to the complexity of operation, difficult detectability, and lack of routine postoperative abdominal image screening.[19] Consequently, it is clear that many aspects of AFCs remain to be clarified to provide useful information for clinical decision.[20–25] Meanwhile, an effective management strategy for post-PD AFCs is needed to be established.

The objective of this study was to earlier identify AFCs and evaluate the effectiveness of our management protocol on post-PD AFCs.

2. Material and methods

2.1. Preoperative work-up

From March 11, 2008, through March 15, 2018, 2064 patients underwent PD in our center. All patients were subjected to

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thorough history taking, clinical examination, and their clinical information was collected from our institutional database. Computed tomography (CT) scan was done for all patients. Age, gender, body mass index (BMI), medical history of diabetes mellitus, and preoperative serum bilirubin level were identified from the patient medical reports. Preoperative biliary drainage (endoscopic or percutaneous transhepatic) was done to cases with preoperative total bilirubin $>400\,\mu mol/L$. This study protocol was approved by the ethics committee of our college. All patients signed an informed consent regarding their understanding of the procedure and its potential complications as well as their approval of participation in the research.

All procedures were carried out by 4 senior consultant surgeons experienced in pancreatobiliary surgery and used a similar technique of dissection.[19] Pylorus-preserving PD (PPPD) was performed in 129 cases (6.25%), whereas a Whipple resection was done in 1935 cases (93.75%). If the portal vein and/or superior mesenteric vein was involved, resection of the mesentericoportal vein and an end-to-end anastomosis were carried out as reported previously.[26] The stump of the gastroduodenal artery (GDA) was left around 5 mm long and closed with a suture ligature. In patients with cancer, lymphadenectomy was routinely undertaken with skeletonization of the hepatic artery from the hepatic pedicle to the celiac axis along with removal of the retroportal pancreatic lamina on the right aspect of the superior mesenteric artery.[27] Reconstruction was as follows: pancreatojejunostomy, end-to-side hepatico-jejunostomy, and side-to-side gastrojejunostomy with a single loop.[28] The pancreaticojejunostomy was performed using a duct-to-mucosa anastomosis (n=1806, 87.5%) or, alternatively, an invaginated anastomosis (n=258, 12.5%) based on surgeon preference. A pancreatic duct stent was usually used in all pancreaticojejunostomy.[29] There were no pancreaticogastrostomies used. All patients had 2 closed suction drains placed at the time of operation, one behind the pancreatic anastomosis and the other at the level of the biliary anastomosis.[15] Seven intraoperative variables, including diameter of main pancreatic duct, pancreatic texture, type of resection (standard versus pylorus preservation), type of pancreaticojejunostomy (invagination or end-to-side duct to mucosa), mesenterico-portal vein resection, estimated intraoperative blood loss, and number of lymph nodes harvested, were identified from anesthesiologist's records and the operative reports.

2.2. Postoperative work-up

All patients were admitted to ICU on the night of the operating day. Patients received Octreotide ($100\,\mu g/8\,h$) until postoperative day (POD) 5. Parenteral antibiotic with amoxicillin/clavulanate or piperacillin/tazobactam were administered to all patients prophylactically.[28] Proton pump inhibitor Omeprazole was given in a dosage of 40 mg/12 h for 7 days. Routine blood analysis was performed 3 times a week, and more often if a likely complication was foreseen.[28] The nasogastric tube was left in place until POD 5 to protect the gastrojejunostomy.[15]

As our unit protocol for postoperative monitoring, abdominal image screening (ultrasound and/or CT) was routinely carried out in all patients at least on POD 3, the day before drain removal and before discharge. Ultrasound and/or CT were also performed in any patient with clinical symptoms (fever and persistent abdominal pain), laboratory abnormalities (elevated total white blood cell count and increased C-reactive protein or procalcitonin levels), or suspicion of surgical complications (such as collections, hemorrhage, fistulae, suture dehiscence, or others). Moreover, all patients were subject to routine abdominal ultrasound or CT during follow-up visits.[19] Abdominal drains were typically removed from POD 4 to 5 if daily drainage was $<50\,mL$ of unsuspected effluent with low amylase content and negative bacterial culture.[19] Due to the serious consequences that intra-abdominal abscess and fistula might lead to, enhanced drainage would be instituted immediately in all AFCs cases without waiting for microbiology or laboratory results.[26] For the collection adjacent to intraoperatively placing drains, it was most probably due to obstruction of tube tip by fibrins. Sterile saline solution was flushed into the collections or abdominal drain was replaced to maintain adequate drainage and tube patency. For the collection remote from drains, percutaneous drainage was performed as long as it was accessible. Samples from the AFCs were sent for both laboratory test and bacteriological culture after drainage.[26] When the drain fluid turned cloudy with sediment before the abdominal drain was removed, a low-speed intermittent irrigation was added until the drain fluid returned clear.

The management strategy of post-PD AFCs in our unit is shown in Fig. 1. In hemorrhage AFCs patients, basic emergent resuscitative measures would be initiated immediately, which included aggressive fluid therapy, blood product transfusion, octreotide and proton pump inhibitor treatment, and vasoactive agent if hemodynamic instability was indicated. In situations where the hemorrhage has not "really settled," angiographic embolization would be considered. The failure to control hemorrhage by above measures may necessitate reoperation. In those patients who require reoperation, a thorough exploration of the resection site is required and if necessary, ligation of the arterial stumps (including occasionally the common hepatic artery) and inspection of the anastomosis by enterotomy. After placing drainage tubes again beside these anastomotic stomas, the abdomen was closed. Once hemorrhage is under effective control, management will be transitioned to nonhemorrhage collection protocol. In nonhemorrhage AFCs, no matter pancreatic fistula, bile leakage, enteric fistula, chyle leak, or simple abscess, successful management of this serious complication depends on close clinical examination, which requires a high index of clinical suspicion. Analysis of drainage fluid is the principal diagnostic tool, while CT, ultrasound, and pancreaticography could provide additional information. Conservative management strategies form the cornerstone of management in majority of the patients and include managing fluid balance, ensuring patency of abdominal drains, providing parenteral or enteral nutrition, and administrating antibiotics or octreotide. Repeated image-guided drainage or replacing drains is indicated if new-onset collections are observed. The indication for surgical intervention in AFCs includes worsening clinical parameters, signs of diffuse peritonitis, severe wound infection, continuous bowel dysfunction, and septic shock. The resurgical intervention is generally comprised of abdominal lavage, repositioning of drains, feeding jejunostomy, reinforcing sutures in case of minor-leak from anastomosis, completion pancreatectomy, or reconstruction (if drainage alone could not solve the problem).

2.3. Inclusion criteria

(1) Age: >18 years, <75 years;
(2) Patients with pancreatic diseases (including tumor and inflammatory disease) or nonpancreatic tumors (biliary duct cancer or ampullary tumor) who underwent pancreatoduodenectomy.

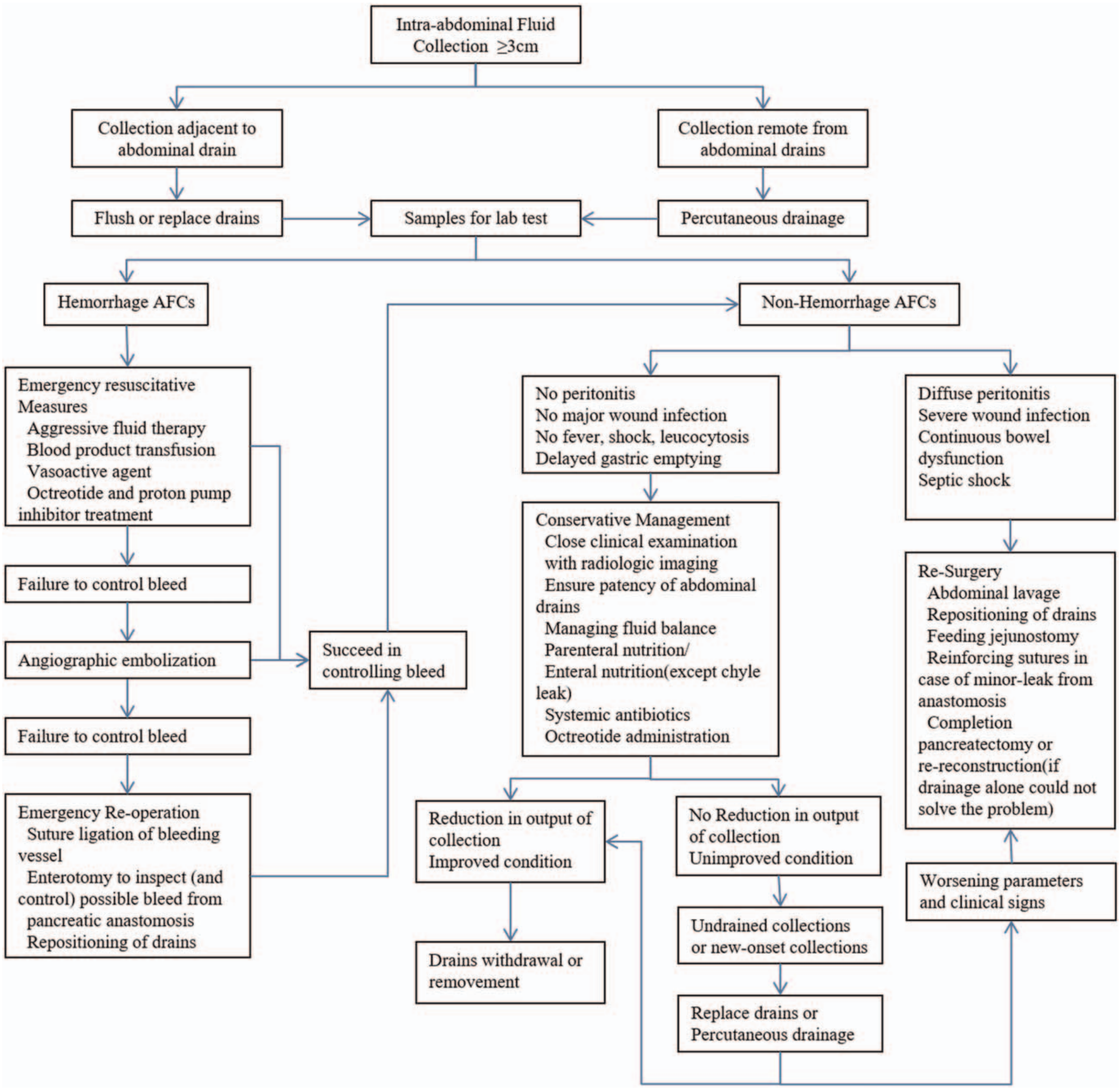

Figure 1. The diagnostic and therapeutic strategies of post-PD AFCs in our unit.

2.4. Definitions

The definitions of the complications are provided in Table 1.[28,30–38] The patients recruited in this study were divided into 2 groups according to the presence of post-PD AFCs: AFCs group and non-AFCs group. AFC patients were further divided into symptomatic and asymptomatic subgroups according to the presence of clinical symptoms, or hemorrhage and nonhemorrhage subgroups according to the nature of fluid collections. We adopted the classification system of postoperative complication proposed by Dindo et al.[30] According to this system, a severe complication was defined as grade IIIb or above and mild complication as grade IIIa or below.[39]

2.5. Statistical analysis

Patient characteristics were compared using *t* tests for continuous variables and χ^2 or Fisher exact tests for categorical variables. To select final predictors, all candidate predictors with a $P<.1$ in univariate analysis were included in a multivariate logistic regression model. Variates with $P<.05$ in the multivariate analysis were deemed independent predictors.

3. Results

As outlined in Table 2, this study included 2064 consecutive patients [1046 male and 1018 female; mean age 55.8 years (range 14–82)] who underwent PD from March 11, 2008, through March 15, 2018. Postoperative AFCs were found in 309 patients, while non-AFCs in the rest 1755 patients. The results of the univariable logistic regression analysis for AFCs are summarized in Table 3. Diameter of main pancreatic duct ≤3 mm, soft pancreatic texture, mesenterico-portal vein resection, and estimated intraoperative blood loss >800 mL were significant risk factors of AFCs post-PD at the univariable level. When these

Table 1

Definitions used in the present study.

Type of complication	Clinical definitions
AFCs	Collection of fluid measuring at least 3 cm in diameter, diagnosed with CT scan or ultrasound[30]
Pancreatic fistula	Drainage fluid volume above 30 mL/24 h and a concentration of amylase in it greater than 3 times the normal serum amylase concentration[31]
Bile leakage	Bile leak was defined as bilious abdominal drainage confirmed by a contrast study through an abdominal drain or cholangiography.[32]
Enteric fistula	Persistent enteric secretions output into drains or overflow from wound or identified by fistulography
Hemorrhage AFCs	Evidence of blood loss from drains or on image performance associated with a decrease in hemoglobin concentration[19,33,34]
Delayed gastric emptying	Need for postoperative nasogastric decompression for >10 days or the need for reinsertion of a nasogastric tube[35]
Simple abdominal abscess	A simple abscess was defined as AFC with positive bacterial culture, but no evidence of digestive fistulae.[36]
Chyle leak	Chylous-like milky white or pale yellow; or the chylous test result was positive[37]
Negative ascites	Clear drainage fluid with low concentration of amylase and negative bacterial culture.
Hemodynamic instability	Mean arterial pressure <70 mm Hg (normal range 70–110 mm Hg) before resuscitation with intravenous fluids or administration of blood products
Pneumonia	Fever, leukocytosis, culture-positive sputum with polymorphonuclear leukocytes on Gram stain, and chest radiograph demonstrating focal infiltrates
Wound infection	Purulent drainage from the postoperative wound, requiring opening and packing of the wound
Deep venous thrombosis	Characteristic venous obstruction, demonstrated on Doppler ultrasound
Surgical mortality	Death occurring during the hospital stay or as a consequence of a postoperative complication regardless of cause[28]
Sepsis	The clinical manifestations of infection were shown by clinical symptoms, physical examination, laboratory tests such as elevation of plasma C-reactive protein and plasma procalcitonin more than 2 standard deviations above the normal value, and/or blood culture[38]
Symptomatic AFCs	AFC with any one of the following clinical presentations: fever, abdominal pain, dissection, leukocytosis, elevated C-reactive protein, or hemodynamic instability

variables were assessed in the multivariable logistic regression, all remained highly significant (Table 4). Therefore, diameter of main pancreatic duct ≤3 mm was found to be an independent risk factor of AFCs ($P<.001$), along with soft pancreatic texture ($P=.002$), mesenterico-portal vein resection ($P<.001$), and estimated intraoperative blood loss >800 mL ($P<.001$).

Postoperative outcomes were compared between AFCs and non-AFCs groups in Table 5. Surgical complications were more frequent in AFCs group than non-AFCs [Grade A pancreatic fistula: 22 (7%) cases vs 70 (4%) cases, $P=.014$; Grade B pancreatic fistula: 35 (11%) cases vs 123 (7%) cases, $P=.008$; Enteric fistula: 12 (4%) cases vs 18 (1%) cases ($P<.001$); Biliary fistula 36 (12%) cases vs 123 (7%) cases, $P=.005$; Wound infection 37 (12%) cases vs 123 (7%) cases, $P=.003$; Simple intra-abdominal abscess 22 (7%) cases vs 70 (4%) cases, $P=.014$; Hemorrhage 25 (8%) cases vs 70 (4%) cases, $P=.002$; Gastrointestinal bleeding: 19 (6%) cases vs 35 (2%) cases, $P<.001$]. AFCs group became more prone to nonsurgical complications than non-AFCs group [Pneumonia: 65 (21%) cases vs 193 (11%) cases, $P<.001$; Sepsis: 31 (10%) cases vs 53 (3%) cases, $P<.001$; Deep venous thrombosis: 14 (5%) cases vs 35 (2%) cases, $P=.007$]. Broadly, the incidence of mild complication in AFCs group is higher than in non-AFCs group (34% cases vs 20% cases, $P<.001$), whereas AFCs group after active intervention appeared to have a similar rate of severe complication with non-AFCs group [Clavien Class IIIB, IV, V: 47 (15%) cases vs 264 (15%) cases, $P=.939$; Unexpected return to intensive care unit: 40 (13%) cases vs 211 (12%) cases, $P=.647$; Reoperation: 321 (10%) cases vs 156 (9%) cases, $P=.409$; Surgical mortality: 11 (4%) cases vs 86 (5%) cases, $P=.305$].

The characteristics of AFCs were further analyzed and compared between symptomatic and asymptomatic subgroup in Table 6. A total of 263 patients was classified into symptomatic group, and the remaining 46 patients into asymptomatic group. There is no significant difference in the distance from intra-operatively placing tubes between 2 groups. Some types of AFCs were significantly higher in symptomatic groups than asymptomatic group, including pancreatic fistula (36% vs 20%; $P=.041$), bile leakage (27% vs 13%; $P=.043$), and abdominal abscess (16% vs 4%; $P=.039$), whereas some were similar in both groups, including enteric fistula (4% vs 2%; $P=1.000$) and hemorrhage (9% vs 7%; $P=.779$). About 67% of asymptomatic AFCs were associated with pancreatic fistula (20%), bile fistula (13%), enteric fistula (2%), hemorrhage (7%), chyle leakage (22%), and abdominal abscess (4%).

The time from surgery to the diagnosis of AFCs was recorded and the proportion of hemorrhage and nonhemorrhage subgroup is shown in Fig. 2. The median time from surgery to the diagnosis of AFCs was 5 days [interquartile range (IQR), 3–12 days]. The peak time of hemorrhage AFCs and nonhemorrhage AFCs was 24 hours and 3 to 5 days.

The clinical outcomes of patients through our unit protocol are demonstrated in Table 7. The proportion of hemorrhage AFCs resolved by reoperation and nonoperative intervention was 19.3% and 57.7%, respectively, while 24% finally died. The clinical success of nonhemorrhage AFCs by percutaneous drainage and reoperation was 90.2% and 6.2%, including pancreatic fistula (91.3% vs 4.9%); bile leak (96.2% vs 1.3%); enteric fistula (0 vs 81.8%); abdominal abscess (84.1% vs 11.4%); chyle leak (96.6% vs 0); and negative AFCs (98.3% vs 0). The mortality of nonhemorrhage AFCs is 3.7%, including 3.9% pancreatic fistula, 2.6% bile leak, 18.2% enteric fistula, 4.5% abdominal abscess, 3.4% chyle leak, and 1.7% negative AFCs.

4. Discussion

The proper prevention and treatment of the postoperative complications of the patients with PD presents a considerable technical challenge for each pancreatic surgery center.[19] Multiple factors contribute to the formation of post-PD AFCs.[40–47] Some researchers[48] reported that soft pancreatic texture and thin pancreatic duct were risk factors for fluid collections. Yeh et al demonstrated that increased intraoperative

Table 2

Preoperative characteristic, pathologies, and operative details comparisons between patients undergoing PD with and without AFCs.

	AFCs (n=309)	Non-AFCs (n=1755)
Median age, y (range)	56.7 (16–82)	55.6 (14–81)
Male/female	160/149	886/869
Median body mass index (BMI) (range)	24.6 (14.1–42.1)	24.2 (14.3–41.8)
Pathology—histology		
Pancreatic cancer	133 (43.0%)	793 (45.2%)
Ampullary cancer	62 (20.1%)	377 (21.5%)
Chronic pancreatitis	41 (13.3%)	195 (11.1%)
Endocrine tumors	15 (4.9%)	90 (5.1%)
Cystic tumor	25 (8.1%)	126 (7.2%)
Others	33 (10.6%)	174 (9.9%)
Total	309 (100%)	1755 (100%)
Diabetes mellitus		
No	262	1504
Yes	47	251
Preoperative biliary drainage		
No	258	1482
Yes	51	273
Diameter of main pancreatic duct, mm		
≤3	87	269
>3	222	1486
Pancreatic texture		
Soft	85	322
Hard	224	1433
Type of pancreatoenteric anastomosis		
Duct-to-mucosa	267	1539
invaginated	42	216
Pylorus-preserving PD		
No	288	1647
Yes	21	108
Mesentericoportal vein resection		
No	257	1653
Yes	52	102
Estimated intraoperative blood loss, mL		
≤800	247	1624
>800	62	131
Number of lymph nodes harvested		
≤20	89	524
>20	220	1231

blood loss was another independent risk factor for post-PD AFCs by univariate and multivariate analysis.[25,49–51] The factors that might increase blood loss during operation included a more advanced stage of the disease such as portal vein invasion or superior mesenteric vein, adhesions due to prior operations, jaundice-associated coagulopathy, obesity, and concurrent pancreatitis.[25,49–51] A similar conclusion was reached in our study that the diameter of main pancreatic duct ≤3 mm, soft pancreatic texture, mesenterico-portal vein resection, and estimated intraoperative blood loss >800 mL were closely related with the formation of AFCs. Under such circumstances, enhanced drainage strategy might like to be undertaken, which included more intraoperative site drainage, more frequent postoperative image checkup, and longer duration of drainage.

It is universally accepted that AFCs is often associated with a series of serious complications.[52] Liu et al[53] suggested that intra-abdominal collection correlated with post-PD delayed gastric emptying rates significantly. Zink et al[23] found that 74.7% (62/83) of post-PD fluid collections were proven abscesses, and 61.4% (51/83) were complicated by pancreatic

Table 3

Univariable logistic regression: risk factors for AFCs.

Variable	Odds ratio (95% confidence interval)	*P*
Age	1.047 (−0.261 to 2.355)	.116
Body mass index (BMI)	0.400 (−0.167 to 0.966)	.166
Diabetes mellitus	1.063 (0.799–1.414)	.675
Preoperative biliary drainage	1.062 (0.806–1.399)	.672
Diameter of main pancreatic duct	1.880 (1.509–2.343)	<.001
Pancreatic texture	1.545 (1.234–1.935)	<.001
Type of pancreato-enteric anastomosis	1.101 (0.817–1.483)	.529
Pylorus-preserving PD	1.094 (0.729–1.641)	.702
Mesentericoportal vein resection	2.509 (1.957–3.218)	<.001
Estimated intraoperative blood loss	2.433 (1.922–3.080)	<.001
Number of lymph nodes harvested	0.958 (0.763–1.202)	.708

Table 4

Multivariable logistic regression: independent risk factors for AFCs.

Variable	Odds ratio (95% confidence interval)	*P*
Diameter of main pancreatic duct	2.075 (1.555–2.769)	<.001
Pancreatic texture	1.588 (1.191–2.118)	.002
Mesentericoportal vein resection	2.978 (2.055–4.318)	<.001
Estimated intraoperative blood loss	2.808 (1.998–3.948)	<.001

Table 5

Comparisons on outcomes of PD patients with versus without postoperative AFCs.

Total patients undergoing pancreaticoduodenectomy	AFCs (n=309)	Non-AFCs (n=1755)	*P*
Any complication except AFCs	151 (49%)	614 (35%)	<.001
Surgical complications	105 (34%)	439 (25%)	.001
Pancreatic fistula	71 (23%)	316 (18%)	.039
Grade A	22 (7%)	70 (4%)	.024
Grade B	35 (11%)	123 (7%)	.014
Grade C	22 (7%)	123 (7%)	.904
Enteric fistula	12 (4%)	18 (1%)	.001
Biliary fistula	36 (12%)	123 (7%)	.007
Delayed gastric emptying	25 (8%)	158 (9%)	.665
Wound infection	37 (12%)	123 (7%)	.004
Simple intra-abdominal abscess	22 (7%)	70 (4%)	.024
Hemorrhage	25 (8%)	70 (4%)	.003
Gastrointestinal bleeding	19 (6%)	35 (2%)	<.001
Ileus	9 (3%)	53 (3%)	1.000
Nonsurgical complications	93 (30%)	369 (21%)	<.001
Pneumonia	65 (21%)	193 (11%)	<.001
Sepsis	31 (10%)	53 (3%)	<.001
Pulmonary embolism	7 (2%)	35 (2%)	.667
Cardiocirculatory failure	19 (6%)	123 (7%)	.714
Renal failure	13 (4%)	72 (4%)	1.000
Liver failure	9 (3%)	53 (3%)	1.000
Deep venous thrombosis	14 (5%)	35 (2%)	.013
Patient outcomes			
Unexpected return to intensive care unit	40 (13%)	211 (12%)	.647
Reoperation	32 (10%)	156 (9%)	.392
Surgical mortality	11 (4%)	86 (5%)	.381
Clavien classification			
Mild (I, II, IIIA)	104 (34%)	355 (20%)	<.001
Severe (IIIB, IV, V)	47 (15%)	264 (15%)	.939

Table 6

Type of post-PD AFCs.

	Symptomatic AFCs n=263	Asymptomatic AFCs n=46	*P*
Location to intraoperatively placing tubes			.086
Adjacent	8	4	
Remote	255	42	
Laboratory and clinical analysis			
Hemorrhage	23 (9%)	3 (7%)	.779
Pancreatic fistula	94 (36%)	9 (20%)	.041
Bile leakage	72 (27%)	6 (13%)	.043
Enteric fistula	11 (4%)	1 (2%)	1.000
Abdominal abscess	42 (16%)	2 (4%)	.039
Chyle leak	19 (7%)	10 (22%)	.005
Negative ascites	47 (18%)	15 (32%)	.028

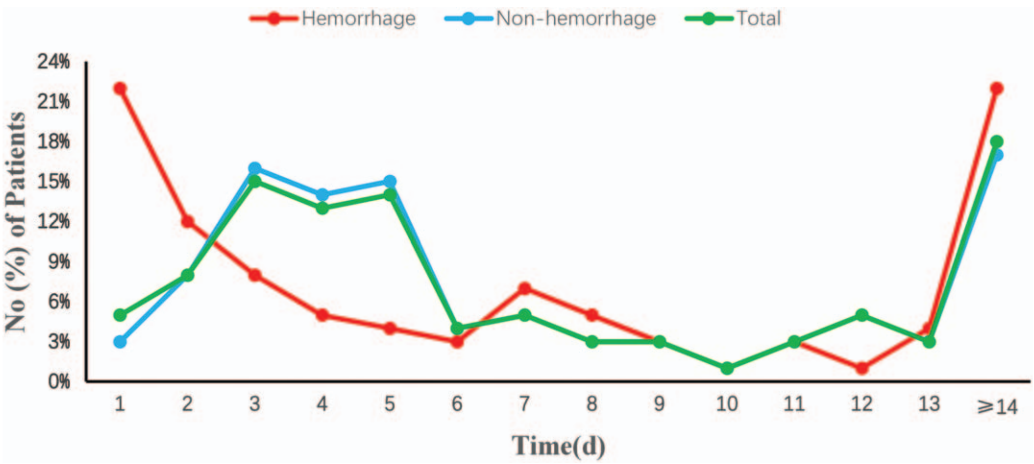

Figure 2. The time from surgery to the diagnosis of AFCs.

fistula. In the research by Feng et al,[54] intra-AFCs could be independent risk factors for post-PD hemorrhage. In our study, AFCs could produce a higher rate of mild complications compared with non-AFCs, but it got a similar incidence of severe complications through active intervention.

Previous reports suggested that about half of AFCs are asymptomatic and resolve spontaneously.[12,19,21,55–58] According to this stereotyped experience, imaging tests were usually carried out only in patients with symptoms suggestive of intra-abdominal complications (pyrexia, abdominal distension or abdominal pain, and so on), and asymptomatic AFCs patients do not mandate drainage in most centers.[59] However, protocol in our unit could allow for early identification and monitoring of more potential abdominal complications especially in asymptomatic patients. Our study found about 67% of asymptomatic AFCs are associated with pancreatic fistula (20%), bile fistula (13%), enteric fistula (2%), hemorrhage (7%), chyle leakage (22%), and abdominal abscess (4%). We would probably have been misguided by previous stereotyped experience to neglect these cases, which needed to be promptly treated just because of no positive symptom manifested. Moreover, some of AFCs may be partly attributed to displacement or occlusion of drainage tubes, routine postoperative abdominal image, and corresponding remedy could help to prevent the deterioration by dysfunctional tubes. Upon further analyses, we discovered that POD 3 to 5 could be the “peak time” when AFCs was detected. Thus, routine postoperative abdominal image screening was recommended at least earlier than POD 3.

Once an intra-abdominal collection is identified, it is first choice to reposition operatively placed drain or place a percutaneous drainage under image guidance.[51,60] Effective drainage could convert the digestive leakage into controlled ones instead of making intra-abdominal abscess formation around the anastomotic site.[61] Furthermore, drainage will not only help

Table 7

Management and clinical outcomes in patients with AFCs.

												Nonhemorrhage (n=309)										
	CM	AE	RO	Total	PD	RO	Total	PD	RO	Total	PD	RO	Total	PD	RO	Total	PD	RO	Total	PD	RO	Total
Management	4 (16%)	15 (57%)	7 (27%)	26	94 (91%)	9 (9%)	103	75 (97%)	2 (3%)	78	0	11 (100%)	11	38 (86%)	6 (14%)	44	29 (100%)	0	29	60 (100%)	0	60
Mortality	0	4 (27%)	2 (29%)	6 (23%)	0	4 (44%)	4 (4%)	1 (1%)	1 (50%)	2 (3%)	0	2 (18%)	2 (18%)	1 (3%)	1 (17%)	2 (5%)	1 (3%)	0	1 (3%)	1 (2%)	0	1 (2%)

AE=angiographic embolization, CM=conservative management, PD=percutaneous drainage, RO=reoperation.

prevent pain and potential complications such as ileus, fever, and sepsis, but also serve as an early warning sign of anastomotic leak and associated hemorrhage.[62–66] Clinical cure of AFCs could be achieved in majority of the patients by enhanced drainage combined with other conservative management strategies, including 91.3% (94/103) pancreatic fistula, 96.2% (75/78) bile leak, 84.1% (37/44) abdominal abscess, 96.6% (28/29) chyle leak, and 98.3% (59/60) negative ascites in our study. Kazanjian et al[67] evaluated 436 patients who underwent PD. A total of 55 (12.6%) developed AFCs; 52 patients (94.5%) had successful conservative management with percutaneous drainage, 4 required repeated percutaneous drainage, and only 3 patients (5.5%) had reoperation. Surgery still plays a crucial role in enteric fistula, failure in controlling intra-abdominal hemorrhage by angioembolization, inaccessible deep abdominal abscesses without any safe image approach, and persistent clinical deterioration.[27] All 11 enteric fistula patients in our study experienced reoperation after percutaneous drainage because of thick viscosity of abscess contents from enteric dehiscence even though the catheter was in proper position.

This study's limitations deserve commentary. First, due to the lack of definite practical guidance for intra-AFCs, the indication and timing of the drainage strategy was made empirically instead of evidence-based. Second, this was a nonrandomized retrospective analysis from a single center, and as such, there were potential biases for comparison. Third, the type of surgical technique used and of the ability and strategies to manage patients' complications reflect the diversity in our center. However, our data reflect the common practice in our country where post-PD AFCs is diagnosed and treated in both academic and community settings. It shows that diagnostic and therapeutic strategies of this complications have been well standardized and mortality and morbidity are improved over historical data. The large cohort of patient and completeness of the collected data support the strength of this study. The results of the present analysis will hopefully lead to a prospective randomized study with the ultimate goal of a centralized national program for pancreatic surgery.

Author contributions

Ning Zhao, Tao Peng, and Heshui Wu conceived and designed the study. Ning Zhao, Xin Li, Jing Cui, and Jiongxin Xiong collected and analyzed data. Ning Zhao and Jing Cui wrote the paper. Zhiyong Yang, Chunyou Wang, and Tao Peng reviewed and edited the manuscript. All authors read and approved the manuscript.

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