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Retromesenteric omental flap as arterial coverage in pancreaticoduodenectomy: A novel technique to prevent postpancreatectomy hemorrhage

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ABSTRACT

Background: Clinically relevant postpancreatectomy hemorrhage occurs in 10% to 15% of patients after pancreaticoduodenectomy, mainly in association with clinically relevant postoperative pancreatic fistula. Prevention of postpancreatectomy hemorrhage by arterial coverage with a round ligament plasty or an omental flap is controversial. This study assessed the impact of arterial coverage with an original retromesenteric omental flap on postpancreatectomy hemorrhage after pancreaticoduodenectomy.
Methods: This single-center retrospective study included 812 open pancreaticoduodenectomies (2012–2021) and compared 146 procedures with arterial coverage using retromesenteric omental flap to 666 pancreaticoduodenectomies without arterial coverage. The Fistula Risk Score was calculated. The primary endpoint was a 90-day clinically relevant postpancreatectomy hemorrhage rate according to the International Study Group of Pancreatic Surgery classification.
Results: There were more patients with a Fistula Risk Score $\geq$7 in the arterial coverage-retromesenteric omental flap group: 18 (12%) versus 48 (7%) ($P < .01$). Clinically relevant postpancreatectomy hemorrhage was less frequent in the arterial coverage- retromesenteric omental flap group than in the no arterial coverage group: 5 (3%) versus 66 (10%), respectively ($P = .01$). Clinically relevant postoperative pancreatic fistula occurred in 28 (19%) patients in the arterial coverage- retromesenteric omental flap group compared with 165 (25%) in the no arterial coverage group ($P = .001$). There were fewer reoperations for postpancreatectomy hemorrhage or postoperative pancreatic fistula in the arterial coverage- retromesenteric omental flap group: 1 (0.7%) versus 32 (5%) in the no arterial coverage group ($P = .023$). In multivariate analysis, arterial coverage with retromesenteric omental flap was an independent protective factor of clinically relevant postpancreatectomy hemorrhage (odds ratio 0.33; 95% confidence interval [0.12–0.92], $P = .034$) whereas postoperative pancreatic fistula of any grade (odds ratio = 10.1; 95% confidence interval: 5.1–20.3, $P < .001$) was predictive of this complication.
Conclusion: Arterial coverage with retromesenteric omental flap can reduce rates of clinically relevant postpancreatectomy hemorrhage after pancreaticoduodenectomy. This easy and costless technique should be prospectively evaluated to confirm these results.

Introduction

Pancreatoduodenectomy (PD) is the standard curative treatment of periampullary tumors. However, its overall morbidity, including postoperative pancreatic fistula (POPF), intra-abdominal collections, and postpancreatectomy hemorrhage (PPH), is still high, with rates around 60%.[1,2] Clinically relevant POPF (CR-POPF) is the main complication of PD, with an incidence ranging from 13% to 22%.[2,3] The risk of POPF can be predicted using scores taking into account underlying disease, diameter of main pancreatic duct (MPD), parenchymal consistency, and intraoperative blood loss.[3-6] The most commonly used score is the Fistula Risk Score (FRS) [3] and, in patients with FRS $\geq$7, the incidence of CR-POPF exceeds 25%.[7,8]

PPH is a life-threatening complication of PD occurring in 10%-15% of cases and associated with POPF in two-thirds of cases.[2,9-11]

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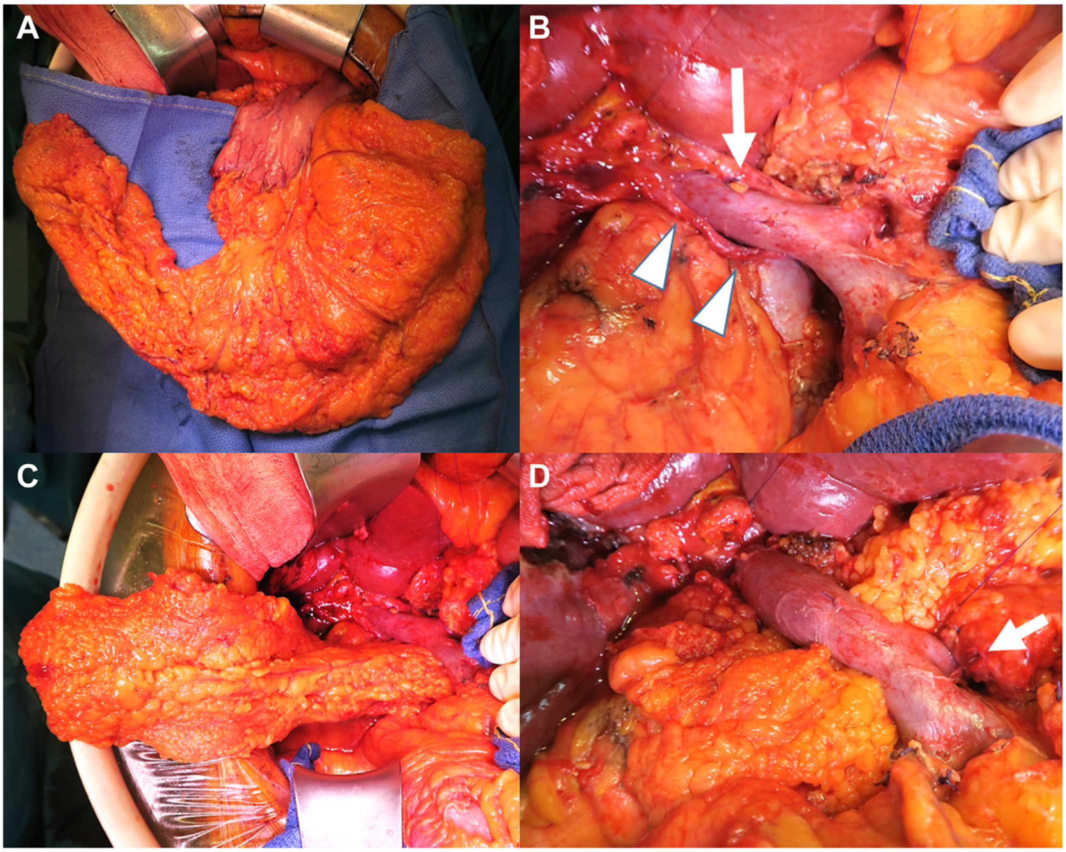

Figure. Intraoperative view of a pancreaticoduodenectomy with antrectomy: (A) « J-shape» modeling of the greater omentum, (B) before reconstruction: note the presence of the stump of GDA (*arrow*) on the HA, and a right HA (*arrowheads*) originating from the SMA, (C) retromesenteric pull-through of the omental flap, (D) adequate positioning of the omental flap between the pancreatic stump (*arrow* = main pancreatic duct) and all peripancreatic arteries.

Prevention of PPH after PD is, therefore, a major challenge, especially in patients with high FRS.[7,12] Clinically relevant PPH (CR-PPH) is usually due to an erosion of arterial stumps or a ruptured pseudoaneurysm.[13] Therefore, prevention of PPH relies on both prevention of POPF and coverage of peripancreatic arteries by either a round/falciform ligament wrap or an omental flap to isolate the exposed arteries from pancreatic anastomosis leak. In a meta-analysis published in 2020,[14] the incidence of PPH was lower in patients who underwent arterial wrapping than in those who did not (relative risk 0.58, $P = .020$). However, in a recent randomized controlled trial evaluating wrapping of the hepatic artery (HA) with the round ligament versus no wrapping, the overall CR-PPH rate was not significantly different between the 2 arms probably because most PPH did not originate from the only HA.[15]

We recently described a novel omental flap technique using a retromesenteric route to cover all exposed peripancreatic arteries and fill the precaval empty spaces after PD.[16] We hypothesized that this retromesenteric omental flap (ROF) could reduce the risk of CR-PPH after PD. The aim of the present study was to evaluate the impact of AC using an ROF on postoperative course after PD.

Material and Methods

Surgical technique

From October 2012 to December 2021, 812 open PDs were performed in our institution by or under the direct supervision of 4 consultant surgeons (S.D., B.A., M.L., A.S.). In case of malignancy, antrectomy and standard lymphadenectomy, including the pancreaticoduodenal nodes, those along the right border of the superior mesenteric artery (SMA), and in the hepatoduodenal ligament, were routinely performed. Before starting reconstruction, hemostasis was carefully checked behind the pancreatic stump and close to the splenic vessels. The dorsal pancreatic artery was ligated at its origin whenever possible to secure hemostasis and facilitate pancreatic stump mobilization. Reconstruction was performed with an end-to-side pancreatico-jejunostomy (PJ), including a duct-to-mucosa technique and an externalized pancreatic stent in patients with high FRS,[7,12] then a hepatico-jejunostomy performed 20 cm downstream on the same jejunal loop and an antecolic gastro-jejunostomy 50 cm downstream the latter.

In patients without arterial coverage (no AC group), a short (5 to 10 cm) omental flap was inserted between the cranial edge of the PJ and the HA.

In patients with arterial coverage, full AC with an ROF was performed as recently described (AC-ROF group).[16] This technique was developed in 2015 and, since this date, has been used preferentially in patients with a soft pancreas, particularly when the risk of PPH was considered high, including patients needing perioperative anticoagulation therapy. Briefly, after extensive mobilization from the transverse colon, the greater omentum was reshaped into a « J-shaped» flap by dividing 1 or 2 vertical vessels (Figure, *A*) close to the right gastro-omental vessels to lengthen it and facilitate covering of all exposed peripancreatic arteries including the common and proper HA, the stumps of both GDA and right gastric artery, the proximal part of the splenic artery, the posterior and right aspects of the SMA, the stumps of the posterior pancreaticoduodenal arteries, the right aspect of the celiac axis,

Table I
Preoperative and intraoperative patient characteristics in the AC-ROF and the no AC groups

Characteristics	Overall (n = 812)	AC-ROF (n= 146)	No AC (n = 666)	P value
Preoperative				
Age, median (IQR), y	64 (55–70)	63 (56–69)	64 (54–70)	.82
Male sex (%)	447 (55)	84 (58)	363 (55)	.50
BMI, median (IQR)	24.4 (22.0–27.1)	24.8 (22.7–27.9)	24.3 (21.8–26.9)	.98
Diabetes (%)	158 (19)	28 (19)	130 (20)	.92
Smoker (%)	127 (16)	25 (17)	102 (15)	.59
ASA score (%)				.70
1	154 (19)	17 (12)	137 (20)	
2	568 (70)	110 (75)	458 (69)	
3	90 (11)	19 (13)	71 (10)	
Diagnosis (%)				.83
PDAC or pancreatitis	468 (58)	83 (57)	385 (58)	
Other	344 (42)	63 (43)	281 (42)	
Neoadjuvant treatment (%)				
Chemotherapy	282 (35)	69 (47)	213 (32)	< .01
Radiation therapy	194 (24)	47 (32)	147 (22)	< .01
Intraoperative				
Pylorus-preserving (%)	116 (14)	28 (19)	88 (13)	.06
Lymphadectomy (%)				.05
Standard	754 (93)	130 (89)	624 (94)	
Extended	58 (7)	16 (11)	42 (6)	
Venous reconstruction (%)	204 (25)	39 (27)	165 (25)	.62
Gland texture (%)				.97
Hard	457 (56)	82 (56)	375 (56)	
Soft	355 (44)	64 (44)	291 (44)	
Main duct diameter, mm (%)				.01
≥5	292 (36)	54 (37)	238 (36)	
4	113 (14)	4 (3)	109 (16)	
3	166 (20)	23 (16)	143 (22)	
2	164 (20)	37 (25)	127 (19)	
≤1	77 (10)	28 (19)	49 (7)	
Pancreaticojejunostomy (%)	788 (97)	144 (99)	644 (97)	.21
Blood loss (%)				.01
<400c	548 (67)	86 (59)	462 (69)	
401–700	170 (21)	32 (21)	138 (20)	
701–1000	55 (7)	11 (8)	44 (7)	
>1000	39 (5)	17 (12)	22 (3)	
FRS, median (IQR)	3 (1–5)	4 (2–6)	3 (1–5)	.01
FRS 7–10 (%)	66 (8)	18 (12)	48 (7)	.02

ASA, American Society of Anesthesiologists; *BMI*, body mass index; *FRS*, Fistula Risk Score; *PDAC*, pancreatic ductal adenocarcinoma.

and—when present—a right hepatic artery (HA) originating from the SMA (Figure, *B*). The omental flap was pulled tension-free through the retro-mesenteric window (Figure, *C*) and was usually placed between the venous axis and the arteries (Figure, *D*), provided that no venous compression was present, particularly in case of venous resection. Otherwise the omental flap was positioned anteriorly to all vessels. Finally, the omental flap was fixed with some stitches to the right diaphragmatic crus, the upper edge of the pancreatic remnant, and the retroportal lamina in front of the SMA.

The abdominal cavity was routinely drained with a soft silicone drain positioned close to the pancreatic anastomosis. Octreotide (100 micrograms 3 times a day subcutaneously for 7 days) was administered and started intraoperatively in patients with a soft pancreas, depending on the surgeon's preference. Antimicrobial prophylaxis was administered depending on the risk of biliary contamination and according to a previously reported protocol.[17] Water was given on postoperative day (POD) 1 after nasogastric tube removal, a semi-liquid diet on POD 2, and solid food was started on POD 3. Amylase was measured in the drain fluid at least twice on POD 3 and 5. The drain was removed on POD 5 in the absence of complications or in case of a negative amylase measurement in the drain fluid.

In any patient who developed PPH (externalized through abdominal drainage or presenting with gastrointestinal bleeding), a contrast-enhanced CT scan, including acquisition at the arterial phase, was performed on an emergency basis, except in patients with early (≤24 hours) hemorrhage and those with severe hemodynamic instability.

This study was approved by the ethics committee of our hospital and was performed in accordance with the ethical principles of the Declaration of Helsinki.

Outcome Measurements

The primary endpoint was a 90-day rate of CR-PPH, according to the definition of the International Study Group of Pancreatic Surgery.[13] Secondary endpoints were rates of overall morbidity defined as any complication occurring within 90 days after surgery and graded according to the Clavien–Dindo classification,[18] CR-POPF,[1] rates of interventional radiology procedure and surgical reoperation to treat CR-PPH, delayed gastric emptying (DGE), length of stay, and readmission. All complications graded ≥III were considered as severe.[18] Postoperative mortality was defined as death before POD 90.

Statistical analysis

Data from a prospectively maintained database were evaluated retrospectively. Values are expressed as medians (IQR), means (SD), or the number of patients and percentages, as appropriate. All statistical analyses were performed using IBM SPSS Statistics v.25 (IBM SPSS, Inc). The chi-square test was used to compare more than

Table II
Postoperative outcomes in the arterial coverage using retro-mesenteric omental flap (AC-ROF) and in the no arterial coverage (no AC) groups

	Overall (n = 812)	AC-ROF (n= 146)	No AC (n = 666)	P value
PPH				
Any grade (%)	79 (10)	8 (5)	72 (11)	.07
Grade B + C (%)	71 (9)	5 (3)	66 (10)	.012
Transfusion (%)	52 (6)	4 (3)	48 (7)	.045
Embolization (%)	42 (5)	5 (3)	37 (6)	.29
POPF				
Any grade (%)	336 (41)	52 (36)	284 (43)	.14
Grade B + C (%)	193 (24)	28 (19)	165 (25)	.18
Percutaneous drainage (%)	44 (5)	8 (5)	36 (5)	.99
DGE				
Any grade (%)	186 (23)	34 (23)	152 (23)	.99
Grade B + C (%)	43 (5)	5 (3)	38 (6)	.36
Clavien–Dindo III–IV morbidity (%)	143 (18)	24 (16)	119 (18)	.68
Reoperation for PPH/POPF	33 (4)	1 (1)	32 (5)	.023
30-d mortality (%)	11 (1)	2 (1)	9 (1)	.98
90-d mortality (%)	14 (2)	2 (1)	12 (2)	.84
Length of stay, median (IQR), d	16 (12–26)	18 (13–27)	16 (12–26)	.10
Readmission (%)	89 (11)	16 (11)	73 (11)	.99

AC, arterial coverage; *AC-ROF*, arterial coverage using retromesenteric omental flap; *DGE*, delayed gastric emptying; *PPH*, postoperative pancreatic hemorrhage; *POPF*, postoperative pancreatic fistula.

2 categorical variables and the Student's t test for continuous variables.

To identify predictors of CR-PPH, logistic regression was performed with "CR-PPH" variable as dependent variable, and potential predictors as independent variables. The multivariate analysis was a binary logistic regression incorporating variables that were statistically significant in univariate analysis or clinically relevant.

Results

Among the 812 patients who underwent open PD, 146 underwent PD with AC using ROF and were compared with 666 PD without AC. Pre- and intraoperative characteristics of both groups are listed in Table I. In the AC-ROF group, there were more neoadjuvant treatments, including chemotherapy (69 [47%] patients vs 213 [32%] in the no AC group respectively, P < .01) or radiation therapy (47 [32%] vs 147 [22%], P < .01), a higher rate of small (≤2 mm) MPD: 65 [45%] vs 176 [26%], P < .01), and a higher rate of blood loss >700 mL (28 [19%] vs 66 [10%], P < .01). The median FRS and the rate of patients with a high FRS[7-10] were also significantly higher in the AC-ROF group: (4 [2–6] vs 3 [1–5], P < .01) and 18 [12%] vs 48 [7%], P = .02), respectively.

The postoperative outcome is given in Table II. Data regarding the delay, presentation, diagnostic method, and origin of PPH are exposed in Table III. Overall, CR-PPH (graded B–C) occurred in 71 patients (9% of the whole series) and was significantly less frequent in the AC group than in the no AC group: 5 (3%) versus 66 (10%), P = .012. Early (≤24 hours) CR-PPH occurred in 9 (13%) patients and late CR-PPH in 62 (87%), respectively. Intrabdominal presentation of CR-PPH was observed in 65 (91%) patients. In patients with early CR-PPH, upfront reoperation was performed in 8/9 (88%) patients. In patients with late CR-PPH, urgent CT was performed in 57/62 (92%) patients, and arteriography ± embolization was the preferred technique to obtain hemostasis (n = 42; 68%).

There was no significant difference between the 2 groups regarding Clavien-Dindo III–IV morbidity (24 [16%] in the AC-ROF

Table III
Presentation, diagnosis, treatment, and origin of CR-PPH

	Overall (n = 71)	AC-ROF (n= 5)	No AC (n = 66)
Delay ≤24 h	9	0	9
Presentation: intra-abdominal/gastrointestinal	9/0	-	9/0
Treatment: reoperation/only transfusion	8/1	-	8/1
Origin: HA + GDA/venous/miscellaneous	3/2/4	-	3/2/4
Delay >24 h	62	5	57
Median delay (maximum)	12 d (70)	15 d (70)	11 d (50)
Presentation: intra-abdominal/gastrointestinal	56/6	4/1	52/5
Diagnosis: CT/arteriography/endoscopy	57/3/2	4/1/0	53/2/2
Treatment			
Arteriography ± embolization	42	5	37
Reoperation	18	0	18
Only transfusion	2	0	2
Origin:			
HA + GDA	17	0	17
DPA	6	0	6
SMA	4	0	4
SA	4	1	3
RHA	3	1	2
JA	3	0	3
Miscellaneous	11	0	11
Unknown origin	14	3	11

AC, arterial coverage; *AC-ROF*, arterial coverage using retromesenteric omental flap; *CR-PPH*, clinically relevant postpancreatectomy hemorrhage *CT*, computed tomography; *DPA*, dorsal pancreatic artery; *GDA*, gastroduodenal artery; *HA*, hepatic artery; *JA*, jejunal artery; *RHA*, right hepatic artery arising from SMA; *SA*, splenic artery; *SMA*, superior mesenteric artery.

Table IV
Risk factors of grade B-C postpancreatectomy hemorrhage: univariate analysis

	Overall ($n = 812$)	Grade B-C PPH ($n = 71$)	Grade A PPH or no PPH ($n = 741$)	P value
Age median (IQR)	64 (55–70)	66 (58–70)	64 (55–70)	.330
Male sex (%)	447 (55)	41 (58)	406 (55)	.632
BMI (kg/m^2) (median, IQR)	24.4 (22.0–27.1)	25 (22–28)	24 (22–27)	.161
Neoadj. chemotherapy (%)	282 (35)	18 (25)	264 (36)	.082
Neoadj. radiation therapy (%)	194 (24)	11 (15)	183 (25)	.082
Pancreatic soft texture (%)	355 (44)	33 (46)	424 (57)	.081
MPD diameter ≥3 mm (%)	571 (70)	26 (37)	215 (29)	.180
Externalized MPD stent (%)	115 (14)	10 (14)	71 (14)	.984
Venous reconstruction (%)	204 (25)	10 (14)	194 (26)	.025
Blood loss >400 mL (%)	264 (33)	24 (34)	240 (32)	.808
FRS 7–10 (%)	66 (8)	8 (11)	57 (8)	.291
AC-ROF (%)	146 (18)	5 (7)	141 (19)	.012
Preventive use of octreotide (%)	317 (39)	25 (35)	292 (39)	.489
POPF of any grade (%)	336 (41)	61 (86)	275 (37)	< .001
Grade B-C POPF (%)	193 (24)	57 (80)	139 (19)	< .001

χ^2 test and Mann–Whitney U test.
AC, arterial coverage; *AC-ROF*, arterial coverage using retromesenteric omental flap; *BMI*, body-mass index; *FRS*, fistula risk score; *Neoadj.*, neoadjuvant; *MPD*, main pancreatic duct; *PPH*, postpancreatectomy hemorrhage; *POPF*, postoperative pancreatic fistula.

group vs 119 [18%] in the no AC group, $P = .18$), CR-POPF (28 [19%] in the AC-ROF group vs 165 [25%] in the no AC group, $P = .18$) or CR-DGE. CR-POPF treatment (percutaneous drainage) was also similar in both groups. There were fewer reoperations for PPH or POPF in the AC-ROF group: 1 (0.7%) versus 32 (5%) in the no AC group ($P = .023$). There were no reoperations for CR-PPH in the AC-ROF group.

Ninety-day mortality rate was similar between both groups: 2 (1%) in the AC-ROF group versus 12 (2%) in the no-AC group. The causes of death were liver failure due to HA thrombosis ($n = 1$) and POPF complicated by PPH ($n = 1$) in the AC-ROF group, and POPF complicated by PPH ($n = 9$) or sepsis ($n = 1$), hepatic failure due to extensive portal thrombosis ($n = 1$) and myocardial infarction ($n = 1$) in the no AC group.

In the 65 patients (8% of the overall population) at high risk of POPF (FRS = 7–10), the CR-PPH rate was 1/20 (5%) in the AC-ROF group versus 7/45 (16%) in the no AC group ($P = .23$). Of the 71 patients who developed CR-PPH, 17 (24%) were receiving therapeutic anticoagulation for cardiac disease or thrombo-embolic complications when bleeding occurred: 4 in the AC-ROF group (4/5 = 80%) and 13 in the no AC group (13/66 = 20%). Among the 5 patients with CR-PPH in the AC-ROF group, bleeding originated from splenic artery in one patient, right HA arising from the SMA in another one who was receiving therapeutic anticoagulation, and 3 patients had an unidentified origin despite repeated angio-CT (including 2 receiving therapeutic anticoagulation).

In the AC-ROF group, one patient (0.7%) developed partial flap necrosis diagnosed on a CT scan and treated conservatively by prolonged peripancreatic drainage, and one additional patient developed postoperative HA thrombosis with intramural dissection on angio-CT. This patient developed extensive arterial thrombosis despite percutaneous stenting and eventually died from sepsis and hepatic failure. The overall rate of postoperative portal thrombosis was 4% (32/812), including 6% (9/146) in the AC-ROF group and 3% (23/666) in the no AC group ($P = .13$). In patients who had venous resection ($n = 204$), the rate of postoperative portal thrombosis was 3/39 (8%) and 10/165 (6%) in the AC-ROF and in the no AC groups, respectively ($P = .71$). No patient developed bowel obstruction related to ROF.

Univariate analyses to identify predictors of CR-PPH are given in Table IV. Comparatively to patients with grade A PPH or no PPH, patients who developed grade B–C PPH underwent less frequently venous reconstruction (10 [14%] vs 194 [26%], $P = .025$) or AC with ROF (5 [7%] vs 141 [19], $P = .012$) and developed more frequently POPF of any grade (61 [86%] vs 275 [37%], $P < .001$) and grade B-C POPF (57 [80%] vs 139 [19%], $P < .001$). Variables included in the multivariate analysis were the ones identified by the univariate analysis (ie, venous reconstruction, AC-ROF, POPF) and the FRS as a clinically relevant variable. Considering that a significant part of POPF were graded B to C because they were associated with CR-PPH, we included only POPF of any grade in the multivariate analysis. The factors independently associated with CR-PPH were AC with ROF (OR = 0.56; 95% CI: 0.34–0.95, $P = .030$) and POPF (OR = 10.13; 95% CI: 5.05–20.33, $P < .001$) (Table V).

Table V
Risk factors of grade B-C postpancreatectomy hemorrhage: multivariate analysis

	OR	95% CI	P value
FRS 7–10	1.06*	(0.47–2.40)	.890
Venous reconstruction	0.69	(0.73–4.22)	.318
AC-ROF	0.56	(0.34–0.95)	.030
POPF of any grade	10.13	(5.05–20.33)	< .001

AC-ROF, arterial coverage with retromesenteric omental flap; *FRS*, fistula risk score; *OR*, odds ratio; *POPF*, postoperative pancreatic fistula.
The authors compared 146 pancreaticoduodenectomies (PD) with arterial coverage using a retromesenteric omental flap (AC-ROF) to 666 PD with no arterial coverage, and observed less grade B+C post-pancreatectomy haemorrhage (PPH) in the former group (3*vs*.10%, p=0.01), despite more patients with a fistula risk score≥ 7 (12*vs*.7%, respectively; p<0.01). In multivariate analysis, AC-ROF was a protective factor of grade B-C PPH.
* Per additional point.

Discussion

The present study compared postoperative outcomes of 812 patients who underwent open PD including 146 ones with AC using ROF and 666 without AC. Despite a higher FRS in the patients who had AC with ROF, we observed a significantly lower incidence of CR-PPH in this group (3% vs 10% in patients with no AC, $P = .012$). Particularly, in the 65 patients at high risk of CR-POPF identified by an FRS ≥7, the rate of CR-PPH was 5% in the AC-ROF group versus 16% in the no AC group ($P = .23$), and the rate of reoperation for CR-PPH or CR-POPF was lower in the former group: 1% versus 5% ($P = .02$). Also, there were no reoperations for CR-PPH in the AC-ROF group. Lastly, we observed only one specific complication of ROF in a patient who developed partial flap necrosis. In multivariate analysis, AC with ROF was an independent protective factor for CR-PPH, whereas POPF of any grade was an independent risk factor for CR-PPH. These results suggest that AC with ROF is useful in reducing the risk of CR-PPH after PD in patients at a high risk of POPF.

CR-PPH, usually due to erosion of an arterial stump or a ruptured pseudoaneurysm, is a life-threatening complication of PD.[13] A recent French survey[9] reported that half of postoperative deaths after PD were due to PPH, which is associated with POPF in 60% of cases.[2,7,–11,14] Despite treatment of PPH based on interventional radiology with a 75% overall success rate,[19] this event remains challenging and is still associated with a mortality rising up to 20%.[11] On the other hand, reoperation for hemostasis, which frequently includes disassembly of pancreatico-digestive anastomosis, is associated with a 40% mortality rate.[11,20] Prevention of CR-PPH after PD is, therefore, a major challenge, particularly in patients with a high FRS.[7,12]

First of all, the prevention of PPH relies on the prevention of POPF. Although this topic has been extensively studied, some issues remain unanswered. The rate of CR-POPF is similar after PJ and pancreato-gastrostomy, but severe morbidity, including CR-PPH, seems to be higher after pancreato-gastrostomy.[7,21,22] In a meta-analysis of randomized controlled trials[23] and in a large multicentric cohort including only patients with a high FRS,[12] somatostatin analogs have no significant preventive effect on CR-POPF. The benefit of wrapping the pancreatic anastomosis with an omental flap or a round ligament flap to prevent POPF has not been demonstrated yet.[14,24] Only transient intubation of the MPD with an externalized drain may be used to reduce the risk of POPF, but only in patients at high risk for this complication.[7,12,25,26] However, despite the routine use of this technique in high-volume centers, rates of CR-POPF and CR-PPH in this subset of patients can reach 44% and 32%, respectively.[7]

Surgical techniques to prevent postPD PPH include covering arteries that are at risk of bleeding with round ligament plasty (RLP) or an omental flap. These methods were assessed in a meta-analysis published in 2020[14] including 2936 patients, and comparing PD with or without coverage (RLP or omentoplasty) of arteries near the pancreatic anastomosis. None of these flaps were associated with a decrease in the PPH rate. However, all these studies were retrospective, with no precise description of the arterial covering techniques, as also observed in a nationwide series.[27] Furthermore, in the meta-analysis, bleeding occurred from the HA or GDA stumps in only 60% of the cases, suggesting that coverage of all exposed arteries is needed.[7] Interestingly, this meta-analysis did not report specific complications of RLP or omental flaps. More recently, 3 retrospective studies and one randomized controlled trial evaluated the value of RLP to protect the HA and the GDA stumps[15,28,29] or all peripancreatic vessels.[30] Two of the 3 retrospective studies were comparative and reported that RLP was effective in reducing the risk of CR-POPF after PD,[29] or only grade C POPF after both PD and distal pancreatectomy.[30] Three of the 4 studies reported several cases of CR-PPH originating from HA incompletely covered by the RLP or from other arteries than HA.[15,28,29] Particularly, in a multicenter randomized controlled trial[15] comparing HA wrapping with RLP with no wrapping after PD, the rate of CR-PPH from the only HA was lower in the wrapping group (2.9 % vs 7.1%, $P = .071$), but the overall rate of CR-PPH from all sites was not significantly different between both arms (9.7% vs 14.8%, respectively). Globally, those data suggest that covering only HA with RLP alone does not effectively reduce the rate of PPH after PD and that a larger flap is needed to cover all exposed peripancreatic arteries.

Compared with previous reports evaluating omental flaps, the present study used an original route through the retromesenteric window. Using this route, the omental flap can cover all exposed peripancreatic arteries but also fill retro-mesenteric and precaval spaces to reduce the risk of deep collections close to the SMA, the celiac axis, and the inferior vena cava. In these locations, any collection resulting from POPF can favor PPH from stumps of the inferior pancreaticoduodenal arteries on the SMA.[31] This positioning of the omental flap can explain the significantly lower risk of CR-PPH in the AC group: 3% versus 10%, $P = .02$. It is noteworthy that 4 of the 5 patients (80%) in the AC-ROF received therapeutic anticoagulation when bleeding occurred. Furthermore, the use of ROF was associated with a significantly lower rate of reoperation for CR-PPH or CR-POPF: 1/146 (1%) versus 32/666 (5%) in the no AC group ($P < .023$), which could be explained by a lower rate of CR-PPH but also of deep collections related to POPF with ROF. Contrary to its potential benefits, the retromesenteric route could be at risk of ischemic damage of a thick flap if not thinned enough in patients with visceral obesity. Lastly, the present study does not suggest that AC with ROF increases the risk of postoperative portal thrombosis, even in patients who had venous resection.

Study limitations

This study has several limitations, including its retrospective design despite prospective data collection and a possible historical bias. The definition of patients at high risk of POPF we used is possibly imperfect because the FRS proposed by Callery et al[3] does not include certain relevant risk factors of POPF, including gender, BMI, and preoperative radiation therapy.[4-6] Moreover, some of the risk factors of POPF were not equally distributed between groups. For example, in the AC-ROF group, a small diameter MPD—a well-demonstrated risk factor of POPF—was significantly more frequent than in the no AC group, but also preoperative radiation therapy, which has a protective effect on the risk of POPF.[6] Lastly, octreotide was used to prevent POPF according to the surgeon's preferences. Nevertheless, the present series is strengthened by a standardized surgical technique in a high-volume center.

In conclusion, AC using ROF can reduce the rate of CR-PPH after PD. This simple and cost-free technique could be useful in patients carrying a high risk of POPF. Specific ROF-related complications seem to be very rare. These encouraging results should be confirmed in a randomized controlled trial considering all relevant risk factors of POPF.

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Conflict of interest/Disclosure

The authors have no conflicts of interests or disclosures to declare.

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