Surgical Endoscopy
https://doi.org/10.1007/s00464-024-11217-8

Abdominal drainage after minimally invasive distal pancreatectomy: out of sight, out of mind?

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Received: 27 May 2024 / Accepted: 19 August 2024

Abstract

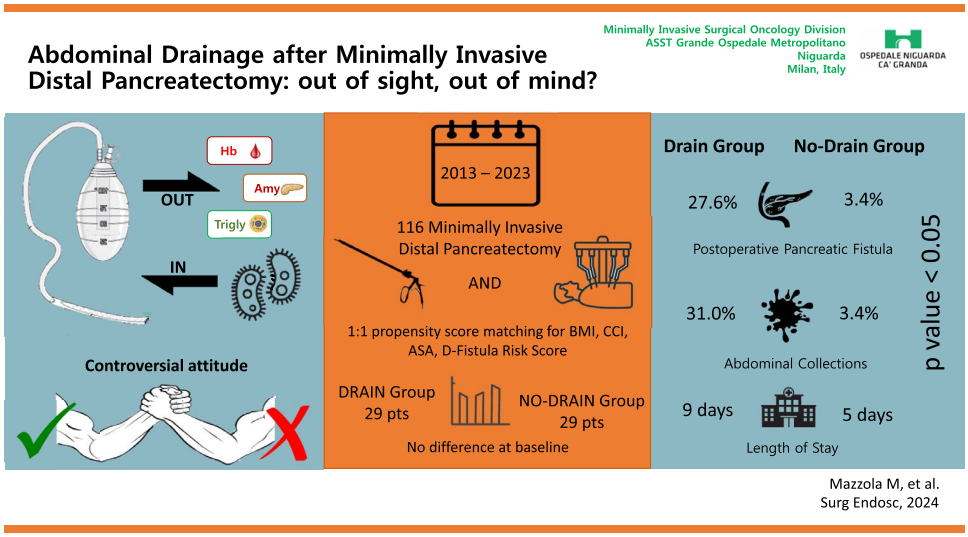
Backgrounds The use of drains in pancreatic surgery remains controversial. The present study investigated postoperative outcomes in patients undergoing minimally invasive distal pancreatectomy (MIDP) without intraperitoneal drain placement.

Methods Data of consecutive patients undergoing MIDP between 2013 and 2023 were prospectively collected. Patients were divided in drain group (DG), including patients with prophylactic abdominal drain placed, and no-drain group (NDG) including those without drain. The groups were compared in terms of postoperative outcomes, using a propensity score-matched analysis.

Results 116 patients were selected. After matching, DG and NDG consisted of 29 patients each. The rates of POPF and abdominal collection were lower in NDG in comparison to DG (3.4% vs. 27.6%, p 0.025 and 3.4% vs. 31.0%, p 0.011, respectively). The length of stay was significantly shorter in the NDG (5 vs. 9 days, $p < 0.001$). No difference between the groups was found for other outcomes.

Conclusion Drain omission was associated with lower rates of POPF and abdominal collections, as well as shorter hospital stays, not affecting the rate of severe complication, reoperation and readmission.

Graphical abstract



Keywords Abdominal drainage · Minimally invasive distal pancreatectomy · Postoperative pancreatic fistula

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Published online: 01 September 2024

Routine abdominal drain placement is a common practice after pancreatic surgery; an international survey among experienced pancreatic centers reported that almost 70% of surgeons always use a drain while only 5% never use it [1].

Traditionally, intraperitoneal drains have been used with the twofold rationale of early diagnosing postoperative pancreatic fistula (POPF) and reducing the need for postoperative percutaneous drainage by evacuating blood, pancreatic juice, or chyle [2, 3].

However the use of drains in pancreatic surgery still remains controversial, reflecting the great heterogeneity in their management in terms of positioning or omitting, time point and cut-off values of testing for removal [4]. This uncertainty has been fueled by conflicting trial results, with some studies advising against drain placement and others considering it mandatory [5–7]. One of the main limits of these studies was to frequently combine results of both, patients undergoing pancreaticoduodenectomy and distal pancreatectomy (DP), despite the unequal risk of complications and mortality between these operations, mainly due to the different pathophysiology and evolution of POPF, suggesting the need for different drain policies.

According to the International Study Group of Pancreatic Surgery (ISGPS) Evidence Map of Pancreatic Surgery, many systematic reviews and three randomized controlled trial investigating drain omission after DP were published [8].

A recent metanalysis, found that drain omission was associated with a lower rate of major complications, POPF, and readmissions [9]. Interestingly the majority of patients in whom drain was omitted had undergone minimally invasive approach, showing a tendency to avoid drain in the context of minimally invasive surgery [10].

Minimally invasive surgery is considered less traumatic and with a lower risk of postoperative surgical site infections as compared to open surgery [11–13]. In that setting, the presence of a drain could potentially lead to a major risk of abdominal infection, thus increasing the frequency of POPF. Otherwise, due to the lower formation of peritoneal adhesions that can keep localized an abdominal collection, minimally invasive surgery could determine worse POPF evolution [14].

The aim of the present study was to investigate postoperative outcomes in patients undergoing minimally invasive distal pancreatectomy (MIDP) without intraperitoneal drain placement.

Materials and methods

Study overview

Data of consecutive patients undergoing MIDP for all indications, between 2013 and 2023 at our institution, were prospectively collected using an IRB approved database (217-29042020) and retrospectively analyzed.

Patients in whom DP was performed as a secondary procedure during gastric or colonic resection and those receiving colonic or liver resection in association with DP were excluded.

Since 2011, laparoscopy has been the preferred approach in all patients undergoing DP except for those with preoperatively known major vascular involvement (excluding splenic vessels) and anesthesiological contraindication to pneumoperitoneum. The robotic approach was introduced in our practice in February 2022, after an adequate learning curve in other fields of surgery (colorectal, oesophagogastric), and has rapidly become the only minimally invasive approach for DP.

For benign and premalignant lesions, DP with spleen-preservation (SPDP) according to the Kimura technique was usually attempted [15]; otherwise a DP with splenectomy (DPS) was performed. In patients with a suspicion of pancreatic adenocarcinoma a radical antegrade modular pancreatosplenectomy (RAMPS) procedure was usually performed [16].

The technique adopted for MIDP and the perioperative patient's management were previously described [17] and here shortly described. They remained the same during the study period, without relevant changes. After the peritoneal cavity was entered, the operations were performed with the same steps regardless of the type of approach (laparoscopic or robotic). DP was always performed with a medial to lateral approach. Pancreatic transection was performed using a 60-mm stapler with Tri-Staple technology™ reinforced with polyglycolic acid (bioabsorbable staple line reinforcement; Gore Seamguard™). Splenic vessels were sectioned using a vascular stapler or clips (Teleflex Hem-o-Lok™), when indicated.

Until 2021, an external closed passive drain (Jackson-Pratt™) was always positioned close to the transected pancreas; since January 2022, drain was routinely omitted in all patients except in selected cases for which the surgeon deemed it indicated.

In the early postoperative period, the patients received daily blood tests, continuous vitals assessment, and frequent clinical evaluations. According to internal protocol, a near-zero liquid balance was applied. When positioned, the abdominal drain was removed on postoperative (POD) 3 if drain amylases at POD 1 were less than 5000 U/L and it did not show a sinister appearance. Somatostatin analogues were not routinely used. The patient was mobilized the day after surgery. A liquid diet on POD 1 and a solid diet the day after were offered if tolerated.

The study protocol followed the ethical guidelines of the 1975 Declaration of Helsinki (as revised in Brazil 2013). Results are reported according to Strengthening

the Reporting of Observational Studies in Epidemiology (STROBE) [18].

Variables and definitions

Preoperative patient data included sex, age, Charlson Comorbidity Index (CCI), ASA score, ECOG status, BMI, type of pathology, neoadjuvant treatment received and tumor location. The diameter of the main pancreatic duct and the pancreatic thickness were measured on the last preoperative computed tomography (CT), at the level of the presumed pancreatic section. Operation-related parameters were: conversion rate, operative time, associated procedures, estimated blood loss and drain placement. Conversion from MIDP to open surgery was defined as the need to complete the intervention by any type of laparotomy [19]. Intraoperative distal fistula risk score (D-FRS) [20] was calculated for each patient; high risk patients were considered those with Wirsung diameter > 3 mm and pancreatic thickness > 19 mm [21].

Length of postoperative stay was defined as the number of nights spent in the hospital from the day of the surgical procedure until discharge. Postoperative complications were recorded at 90 days and graded according to the Clavien-Dindo classification [22]; those graded ≥ 3 were considered severe. Abdominal collection was defined as any postoperative fluid collection not clearly related to bleeding, diagnosed by CT scan, associated with symptoms such as abdominal pain, pressure sensation or inflammatory signs (fever > 38 °C, leukocytosis, heart rate > 90 bpm, respiratory rate > 20/min, elevated C reactive protein and procalcitonin) needing a conservative antibiotic therapy or interventional treatment (endoscopy, percutaneous drainage, reoperation).

Pancreas-specific complications were recorded separately following the indications by the ISGPS [23–25]; consequently only clinically relevant POPFs were considered (namely grade B and C POPFs), while grade A POPFs were not taken into account. Whenever a postoperative percutaneous abdominal drainage was positioned, the amylase concentration in the drain fluid was measured.

Study endpoint

The primary endpoint was severe complication rate (Clavien-Dindo score ≥ 3) after DP in patients with (DG) and without (NDG) prophylactic abdominal drain. The secondary endpoints were overall complication, POPF, delayed gastric emptying, postpancreatectomy hemorrhage, abdominal collection, reoperation, length of stay, readmission and mortality.

Statistical analysis

Data are expressed as median and interquartile range and number and relative percentage. The normal distribution of continuous variables was assessed with the Shapiro–Wilk test. Univariate analysis was performed, and continuous variables were analyzed using the Mann–Whitney test, while categorical variables using the Fisher exact test or Chi-Square test, as appropriate. Multivariate logistic regression was carried out to identify variables independently associated with severe complications after MIDP: variables with $p < 0.05$ at univariate analysis were included in the multivariate model, using Firth's correction for rare events. To reduce the bias arising from selection and lack of randomization, a propensity score-matched (PSM) [26] was runned, with a 1:1 nearest-neighbor matching and a caliper of 0.1. Significant variables ($p < 0.1$) at univariate analysis and the ones known to affect the outcome were used to run the matching: BMI, CCI, ASA (> 2), D-FRS.

All statistical tests were two-sided and p values < 0.05 were considered significant. Data analysis was performed using SPSS®, Version 24.0 (IBM).

Results

Patient selection

In the study period, 174 patients underwent DP and 120 of these were treated by a minimally invasive approach. After exclusion of 4 patients, due to associated resection, 116 patients were selected. Among these, 87 patients received a prophylactic intraoperatively placed abdominal drainage, while in 29 the drain was not placed. Only in one patient, despite being operated during the drain omission period (after 2022), the drain was positioned due to the surgeon's personal decision and thus was considered in the DG.

Patient demographics and baseline characteristics

Baseline patients characteristics before and after PSM are shown in Table 1. In the whole population there were 57 females (49.1%), median age was 66 years (54–75), median BMI was 24.7 (22.5–26.6), and median CCI was 4 (2–6). The majority of patients had an ASA score 2 and an ECOG PS status 0 (50.9% and 67.2%, respectively). At final pathology, the more frequent diagnosis was mucinous cystic lesion and NET (33.6% and 25.0%, respectively). Using PSM, all 29 patients of the NDG were matched with 29 patients of the DG. No difference was found between the groups in terms of baseline characteristics either

Table 1 Baseline characteristics of patients undergoing MIDP before and after propensity score matching

	DG (n 87)	NDG (n 29)	*p*	DG (n 29)	NDG (n 29)	*p*
Gender (female)	41 (47.1)	16 (55.2)	0.453	13 (44.8)	16 (55.2)	0.430
Age (years)*	64 (53–74)	71 (64–76)	0.391	62 (52 -79)	71(64–76)	0.234
BMI (kg/m2)*	24.5 (22.6–26.6)	24.8 (21.5–26.5)	0.391	24.3 (21.6–27.1)	24.8(21.5–26.5)	0.833
CCI*	4 (2—6)	5 (4—7)	0.052	4 (1–7)	5 (4–7)	0.237
ASA > 2	21(24.1)	11(37.9)	0.158	9(31.0)	11(37.9)	0.580
ECOG			0.348			0.127
0	56 (64.4)	22 (75.9)		15(51.7)	22(75.9)	
1	27 (31.0)	7 (24.1)		13(44.8)	7(24.1)	
2	4 (4.6)	0 (0)		1(3.4)	0(0.0)	
Previous surgery	49 (56.3)	19 (65.5)	0.514	16(55.2)	19 (65.5)	0.420
Final pathology			0.754			0.794
IPMN and MCN	27 (31.1)	12 (41.4)		10(34.6)	12 (41.4)	
PanNET	23 (26.4)	6 (20.7)		7(24.2)	6 (20.7)	
Carcinoma	20 (23.1)	8 (27.6)		6(20.7)	8 (27.6)	
Metastasis	5 (5.7)	2 (6.9)		1(3.4)	2 (6.9)	
SCA	3 (3.4)	1 (3.4)		1(3.4)	1 (3.4)	
SPN	2 (2.3)	0 (0)		1(3.4)	0 (0)	
Other	7 (8.0)	0 (0)		3(10.3)	0 (0)	
Neoadjuvant chemotherapy	2 (2.3)	1 (3.4)	1.000	1(3.4)	1 (3.4)	1.00
Tumor location (Body)	37 (42.5)	14 (48.3)	0.589	14(48.3)	14(48.3)	1.00
D-FRS			0.587			0.263
Low risk	28 (32.2)	12 (41.4)		9(31.0)	12(41.4)	
Intermediate	27 (31.0)	9 (31.0)		6(20.7)	9(31.0)	
High risk	32 (36.8)	8 (27.6)		14(48.3)	8(27.6)	

Values in parenthesis are percentages unless indicated otherwise

*Numbers are expressed as median and IQR

MIDP Minimally invasive distal pancreatectomy, *DG* drain group, *NDG* no-drain group, *BMI* body mass index, *CCI* Charlson comorbidity index, *ASA* American Society of Anesthesiologist, *ECOG* eastern cooperative oncology group, *IPMN* intraductal papillary mucinous neoplasm, *MCN* mucinous cystic neoplasm, *PanNET* pancreatic neuroendocrine tumor, *SCA* serous cystadenoma, *SPN* solid pseudopapillary tumor, *D-FRS* distal-fistula risk score

before or after PSM. In particular, after PSM, the groups did not show differences concerning D-FRS, and high risk patients were 48.3% and 27.6% (p 0.263) in DG and NDG, respectively.

Operative and postoperative outcomes

Perioperative outcomes of the whole cohort are shown in Table 2. The conversion rate was 5.2% (6 patients); all but one conversions were due to oncological reasons or technical difficulty (major vascular involvement needing vascular resection), with no urgent conversions for acute bleeding. One patient needed conversion for intraperitoneal adhesions. The overall complication rate was 37.1%, being higher in the DG (42.5 vs. 20.7%, *p* 0.035). POPF rate was 16.4% in the overall cohort; it was lower in NDG in comparison to DG (3.4% vs. 20.7%, *p* 0.039). In DG, grade B POPF occurred in 17 patients and was treated by endoscopy (6 patients), percutaneous drainage (1 patients), both of them (5 patients) and by maintaining surgically placed peritoneal drainage (5 patients). One patient experienced grade C POPF and required reoperation. In NDG only 1 grade B POPF occurred and was treated by percutaneous drainage. An abdominal collection was detected in 20 (17.2%) patients and it was associated with POPF in 59% of cases. A significant lower rate of abdominal collection was found in NDG as compared to DG (21.8% vs. 3.4%, *p* 0.023). The length of stay was significantly shorter in the NDG (5 vs. 9 days, $p < 0.001$). Four patients in DG were reoperated due to postoperative bleeding requiring lavage and drainage and one due to colonic perforation needing resection and anastomosis. Mortality rate was 1.7% not differing between the groups; 1 death was observed in each group, due to late postoperative uncontrolled bleeding (POD 15) and acute heart failure (POD 17), in NDG and DG, respectively.

Perioperative outcomes of patients after PSM are shown in Table 3. The groups did not differ in terms of performed surgery, RAMPS and conversions. No difference between

Table 2 Perioperative outcomes of patients before propensity score matching

	Overall cohort (n 116)	DG (n 87)	NDG (n 29)	*p*
Performed surgery				0.386
DPS	72 (62.1)	56 (64.4)	16 (55.2)	
SPDP	44 (37.9)	31 (35.6)	13 (44.8)	
Associated procedures	17 (14.6)	14 (16.1)	3 (10.3)	0.552
RAMPS	23 (19.8)	15 (17.2)	9 (31.0)	0.121
Duration of surgery (min)*	267 (226–322)	265 (225–330)	270 (225–295)	0.668
Conversion	6 (5.2)	6 (6.9)	0 (0)	0.334
Blood loss (ml)*	175 (92–300)	180 (100–280)	100 (50–350)	0.086
Overall complication	43 (37.1)	37 (42.5)	6 (20.7)	0.035
Severe complication (Clavien Dindo ≥ 3)	24 (20.7)	21 (24.1)	3 (10.3)	0.183
POPF (Grade B–C)	19 (16.4)	18 (20.7)	1 (3.4)	0.039
DGE (Grade A)	4 (3.4)	4 (4.6)	0 (0)	0.570
PPH (Grade B–C)	6 (5.2)	4 (4.6)	2 (6.9)	0.638
Abdominal collection	20 (17.2)	19 (21.8)	1 (3.4)	0.023
Reoperation	5 (4.3)	5 (5.7)	0 (0)	0.329
Length of stay (days)	8 (6—12)	9 (7–14)	5 (4–6)	< 0.001
Readmission	12 (10.3)	9 (10.3)	3 (10.3)	1.000
Mortality	2 (1.7)	1 (1.1)	1 (3.4)	0.439

Values in parenthesis are percentages unless indicated otherwise

*Numbers are expressed as median and IQR

SPDP Spleen preserving distal pancreatectomy, *DPS* distal splenopancreatectomy, *RAMPS* Radical antegrade modular pancreatosplenectomy, *POPF* Postoperative pancreatic fistula, *DGE* delayed gastric emptying, *PPH* postpancreatectomy hemorrhage

the groups was found in terms of median duration of surgery and blood loss (260 vs. 270 min and 180 vs. 100 ml, in DG and NDG, respectively). The rates of overall and severe complication were lower in the NDG (20.7% vs. 44.8%, *p* 0.050 and 10.3 vs. 24.1, *p* 0.164), but not reaching statistical significance. The rates of POPF and abdominal collection were lower in NDG in comparison to DG (3.4% vs. 27.6%, *p* 0.025 and 3.4% vs. 31%, *p* 0.011, respectively). No difference between the groups was found in terms of delayed gastric emptying, postpancreatectomy hemorrhage and reoperation. The length of stay was significantly shorter in the NDG (5 vs. 9 days, $p < 0.001$), while no difference was observed between the groups in terms of readmission and mortality (13.8% vs. 10.3%, *p* 0.686 and 0 vs. 3.4% in DG and NDG, respectively).

Risk factors for severe complications

At univariate analysis (Table 3), ECOG PS (≥ 2) was detected as possible risk factors for severe complications ($p < 0.027$). That variable, together with the presence of a drain, was included in the logistic regression. At multivariable analysis, ECOG PS (≥ 2) was the only independent predictor of severe postoperative complications (Table 4).

Discussion

The current PSM retrospective study found no significant difference in terms of 90-day overall and severe postoperative complications, mortality, reoperations and readmissions among patients undergoing MIDP with or without prophylactic abdominal drainage. Patients in whom drainage was omitted experienced fewer POPF, and abdominal collections, as well as a shorter length of hospital stay. Variables associated with postoperative severe complications were also investigated, revealing that ECOG PS, but not prophylactic abdominal drainage, was the sole factor associated with such complications.

Pancreatic surgery has evolved significantly over recent decades, with increasing emphasis on improving patient outcomes and minimizing postoperative complications which can still occur at rates as high as 50% even in high-volume centers [27]. MIDP is a well established procedure for the treatment of benign and even malignant pancreatic lesions [28]. Thanks to the advantages of a minimally invasive approach, consisting in a less traumatic surgery, MIDP demonstrated better short term outcomes, such as shorter hospital stay and reduced blood loss, in comparison to open DP, without jeopardizing oncologic outcomes [29]. However MIDP has not shown superiority over open DP in terms of severe complications and POPF.

Table 3 Perioperative outcomes of patients after propensity score matching

	DG (*n* 29)	NDG (*n* 29)	*p*
Performed Surgery			0.420
DP	19(65.5)	16(55.2)	
DPS	10(34.5)	13(44.8)	
RAMPS	4(13.8)	9(31.0)	0.115
Duration of Surgery (min)*	260(213–310)	270(225–295)	0.785
Conversion	3(10.3)	0(0.0)	0.237
Blood Losses (ml)*	180(95–275)	100(50–350)	0.248
Overall Complication	13(44.8)	6(20.7)	0.050
Clavien Dindo ≥ 3	7(24.1)	3(10.3)	0.164
CR-POPF	8(27.6)	1(3.4)	0.025
DGE (Grade A)	1(3.4)	0(0.0)	0.313
PPH (Grade B-C)	1(3.4)	2(6.9)	0.553
Abdominal collection	9(31.0)	1(3.4)	0.011
Reoperation	2(6.9)	0(0.0)	0.150
Length of Stay (days)*	9(6–14)	5(4–6)	< 0.001
Readmission	4(13.8)	3(10.3)	0.686
Mortality	0(0.0)	1(3.4)	0.313

Values in parenthesis are percentages unless indicated otherwise

*Numbers are expressed as median and IQR

DP Distal pancreatectomy, *DPS* distal pancreatectomy with splenectomy, *RAMPS* radical antegrade modular pancreatosplenectomy, *CR-POPF* clinically relevant postoperative pancreatic fistula, *DGE* delayed gastric emptying, *PPH* postpancreatectomy hemorrhage

One of the main differences between minimally invasive and open surgery is the reduced contamination of the surgical field due to avoidance of large incisions, minimal bowel manipulation and retraction, and decreased exposure to room air. This advantage could be compromised by the placement of a prophylactic drain, which establishes a connection between the external and intraperitoneal environments, thereby increasing the risk of ascending infections [13]. A multicenter retrospective study comparing routine drain versus no drain after DP revealed a high rate of drain omission (92.4%) in patients undergoing MIDP, compared to those undergoing open DP (41.7%). This suggests that surgeons were likely to feel more confident and less reluctant in omitting drains in patients undergoing MIDP [10]. Consequently, the present study exclusively focused on MIDP (both robotic and laparoscopic), hypothesizing that the potential advantage of drain omission would be more pronounced in patients treated by a minimally invasive approach, where omitting drains, given the reduced risk of abdominal infection, may outweigh the potential benefits of drain placement.

The debate on routine abdominal drainage after DP has persisted for many years [5]. While many surgeons advocated for abdominal drainage to evacuate blood, pancreatic juice, or chyle, or to prevent the formation of abdominal collections, studies have shown that the incidence of fluid collections at the resection margin in patients undergoing DP with prophylactic abdominal drainage was 43% at the first postoperative control. Surprisingly, the majority of these collections just caused little or mild symptoms and resolved without specific therapy, while only 9% of patients required specific treatments [30]. Thus fluid collection per se should not be considered as a problem, unless clinically relevant. In the present study, abdominal collections were found in 31.0% of patients with a higher incidence in the DG as compared to the NDG (31.0% vs. 3.4%, *p* 0.011) indicating a twofold explanation. Firstly, the low rate of abdominal collections, compared to previous studies, may be attributed to our definition, which only considered collections associated with symptoms and requiring treatment, with no routine postoperative abdominal imaging scheduled for asymptomatic patients. Secondly, the presence of the drain itself may serve as a potential source of contamination for otherwise sterile collections.

Fluid collections close to the pancreatic stump, realistically maintained by a biochemical leakage, are found in almost half of patients undergoing DP and are somewhat considered as a precursor of a POPF; however only 12–25% of patients actually develop a POPF [30, 31]. A recent observational study investigating the evolution of abdominal collections after DP without prophylactic abdominal drain showed that collections were observed in 33% of patients, but only in 12.5% of cases led to symptoms [32]. Hence not all collections evolve into POPF and necessitate treatment, and drain omission could be considered safe in all patients independently from the risk to develop a collection. Indeed the presence of a drainage could even be responsible for a worse evolution of the collection, increasing the incidence of POPF. Consistently in our study no difference was found between patients with and without prophylactic abdominal drain in terms of readmission, suggesting that drain placement appears not to reduce the risk of late complications or late-onset symptoms.

The rationale for omitting prophylactic drains is mainly based on the nature of POPF after DP. Differently from pancreaticoduodenectomy, pancreatic leakage after DP theoretically consists of sterile pancreatic juice, since no intestinal anastomosis is created, and could evolve into an asymptomatic fluid collection; the presence of a drain, favoring a communication between the outer and the peritoneal cavity, could introduce bacteria from outside and trigger 'drain-induced' infections [33, 34]. A retrospective study reported that surgically placed abdominal drain was dislocated in 39% of patients following DP at computed tomography scan and found that dislocation of surgical drains did not negatively affect postoperative outcomes but had an inverse correlation with POPF; this suggested a potential detrimental role of

Table 4 Univariate and multivariable analyses of predictors for severe postoperative complications

	Univariate analysis			Multivariate analysis	
	CD < 3	CD ≥ 3	p	OR (95% CI)	p
Gender (female)	46 (50)	11 (45.8)	0.820		
Age (> 70)	38 (41.3)	8 (33.3)	0.640		
BMI (> 30)	5 (5.4)	1 (4.2)	1.000		
ASA (≥ 3)	26 (28.3)	6 (25)	1.000		
ECOG (≥ 2)	1 (1.1)	3 (12.5)	0.027	0.092 (0.009–0.942)	0.044
Previous surgery	57 (62)	11 (45.8)	0.153		
Malignant disease	46 (50)	16 (66.7)	0.145		
Neoadjuvant chemotherapy	1 (1.1)	2 (8.3)	0.108		
Tumor location (Body)	39 (42.4)	12 (50)	0.504		
Performed surgery (DSP)	38 (41.1)	10 (42.5)	0.817		
RAMPS	21 (22.8)	3 (12.5)	0.397		
D-FRS			0.151		
Low Risk	35 (38)	5 (20.8)			
Intermediate	25 (27.2)	11 (45.8)			
High risk	32 (34.8)	8 (33.3)			
Drain placement			0.183	0.417 (0.113–1.535)	0.188
No drain	26 (28.3)	3 (12.5)			
Drain	66 (71.7)	21 (87.5)			
Conversion	3 (3.3)	3 (12.5)	0.102		
Blood Loss (≥ 300 ml)	21 (22.8)	9 (37.5)	0.190		

Values in parenthesis are percentages unless indicated otherwise

BMI Body mass index, *ASA* American Society of Anesthesiologist, *ECOG* eastern cooperative oncology group, *DSP* distal splenopancreatectomy, *RAMPS* radical antegrade modular pancreatosplenectomy, *FRS* fistula risk score

drains due to retrograde bacterial migration along the drain, leading to intra-abdominal infections, and longstanding plastic material decubitus on viscera [35].

A recently published randomized clinical trial demonstrated the safety of a no-drain policy in patients undergoing DP (both open and minimally invasive), showing fewer severe complications and POPF in patients without routine drainage [36]. The authors reported that the advantage of drain omission was more pronounced in low-risk patients, progressively diminishing in intermediate- and high-risk patients. Consistently, our study found a lower rate of POPF in patients without drains, along with a shorter length of stay and a decreasing trend in overall and severe complications, confirming the role of POPF as the main driver of postoperative complications in patients undergoing DP [20]. In the present study a subanalysis for fistula risk was not performed due to the small sample size; however the groups did not differ in terms of D-FRS. Moreover, there is still no widely accepted predictive model for POPF after DP with a lack of independent external validation and comparison; in addition D-FRS was developed on a patients cohort having at least one drain placed close to the pancreatic transection margin, strongly limiting its validation in a context of no-drain policy [37, 38].

The present study presents several limitations. Data were retrospectively analyzed and based on a single-center experience, potentially limiting their validity in other settings; however, unlike other PSM studies limited by heterogeneity due to different drain policy and surgical technique among different centers, MIDPs were always performed following the same steps, with the same perioperative management [10]. In all patients pancreatic parenchymal section was performed using a particular stapler, limiting external validity. However the ISGPS expert consensus guidelines reported no difference in the POPF rate between the various techniques of stump management (handsewn versus stapling versus energy-based tissue sealing device); this would suggest a shift of attention from the section of the pancreas, which is often followed by the development of a collection, regardless of the strategy used for the section, to the clinical or non-clinical evolution of the collection [39]. The study period was slightly long introducing potential bias in terms of technology, more performing instruments and learning curve effect. In particular, the shift from laparoscopic to robotic DP may have introduced a bias; however several recent multicenter studies showed that both the approaches are comparable in terms of major complications and POPF [40, 41]. A potential treatment bias may have been introduced, as the

drain could be positioned at the surgeon's discretion even in patients operated during the "no drain policy" period; however, among these, only one patients had a drain placed, limiting this bias. To minimalize selection bias, a PSM analysis was run, including BMI, CCI, ASA, D-FRS which are well known factors able to affect the occurrence of POPF and complications. Although the diameter of the main pancreatic duct was measured on preoperative computed tomography at the level of the presumed pancreatic section, this measurement may not always correspond exactly to that of the intraoperative section site. Finally, the short time interval used for recording the results (90 days) may have caused the loss of some events that occurred later.

In conclusion, our study provides evidence supporting the safety and feasibility of omitting prophylactic drains after MIDP. Drain omission was associated with lower rates of POPFs and abdominal collections, as well as shorter hospital stays, not affecting the rate of overall and severe complication, reoperation and readmission. These findings suggest that routine drain placement may be omitted independently of patients' risk of POPF; patients who develop complications can in any case be treated in due time, without compromising their safety.

Funding Dr. Michele Mazzola, Dr. Antonio Benedetti, Dr. Alessandro Giani, Dr. Pietro Calcagno, Dr. Andrea Zironda, Dr. Michele Paterno, Dr. Alessandro Giacomoni, Dr. Paolo De Martini, Dr. Giovanni Ferrari received no financial support for the research, authorship, and/or publication of this article.

Declarations

Disclosure Michele Mazzola, Antonio Benedetti, Alessandro Giani, Pietro Calcagno, Andrea Zironda, Michele Paterno, Alessandro Giacomoni, Paolo De Martini, Giovanni Ferrari have no conflicts of interest to disclose.

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