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ORIGINAL ARTICLE

# Dislocation of intra-abdominal drains after pancreatic surgery: results of a prospective observational study

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## Abstract

**Purpose** The use of intra-abdominal drains after major surgical procedures represents a well-established but controversial practice. No data are available regarding both the occurrence and the potential impact of their postoperative accidental dislocation. The aim of this study is to assess the actual rate of dislocation of intra-abdominal drains postoperatively and to evaluate its clinical impact.

**Methods** This is a prospective observational study using major pancreatic surgery as a model. Ninety-one consecutive patients undergoing pancreatoduodenectomy (PD) or distal pancreatectomy (DP) underwent low-dose, non-enhanced computed tomography (LDCT) on postoperative days (POD) 1 and 3 in a blinded fashion to assess the position of drains. We compared the outcomes of patients with dislocated and correctly placed drains.

**Results** Overall, drains were dislocated in 30 patients (33%), without differences between PD and DP. Most of dislocations were already present on POD 1 (77%). Postoperative complications occurred in 57% of patients, and the rate of postoperative pancreatic fistula (POPF) was 27%. The dislocated cohort had lesser morbidity (40% vs. 66%; relative risk (RR), 0.35; 95% CI, 0.14–0.86; $P = 0.020$), and the rate of POPF (3% vs. 39%, respectively; RR, 0.05; 95% CI, 0.01–0.42; $P < 0.001$). After PD, patients with dislocated drains had a shorter hospital stay (12 vs. 20 days; $P = 0.015$). No significant differences in terms of need for percutaneous drainage procedures, abdominal collections, or grade C POPFs were found between the groups.

**Conclusions** Dislocation of intra-abdominal drains is an early and frequent event after major pancreatic resection. Its occurrence might protect against the negative effects of maintaining drainage, eventually leading to better postoperative outcomes. This data reinforces the knowledge that surgical drains might be detrimental in selected cases.

**Keywords** Pancreatectomy · Drainage · Tomography, X-ray computed · Postoperative pancreatic fistula

## Introduction

The practice of prophylactically draining the peritoneal cavity after abdominal surgery is widely accepted [1–3]. For many types of intra-abdominal operative procedures requiring resection of organs and especially with gastrointestinal anastomoses, one or more drains are placed intraoperatively into specific peritoneal recesses and/or in close proximity to anastomoses. The rationale of drain placement is the prompt elimination of extruded or exudative fluids, such as blood, serum, bile, chyle, pancreatic, and enteric secretions, to prevent abdominal collections and subsequent infection or erosion of nearby structures. The second alleged aim of drain placement is to allow the early detection of worrisome postoperative complications, such as hemorrhage and/or anastomotic leakage. Moreover, in pancreatic surgery, some surgeons believe that the intraoperatively inserted drains could also be used as therapeutic whenever a pancreatic fistula (POPF) occurs for a long time, avoiding percutaneous interventional drainages afterwards.

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Two main types of surgical drains exist: open and closed. Open drains communicate with the atmosphere and allow external drainage of the peritoneum through a passive, capillary action (e.g., Penrose drain, corrugated drain). Closed drains allow external evacuation of the abdominal cavity into a "closed" collection system, such that the drained fluid is not exposed to the atmosphere. These closed system drains may be either "active" when suction under pressure is applied (e.g., Jackson-Pratt drain, Blake drain) or "passive" if no suction is applied and the drainage is evacuated wither by gravity of intra-abdominal pressure (e.g., pigtail drain) [4].

The need for and efficacy of routine abdominal drainage after major surgery has become a matter of intense debate, especially in the last several decades [5–10]. In pancreatic surgery, five randomized controlled trials and a systematic review have focused on the safety and effectiveness of routine abdominal drains after a pancreatic resection [4, 11–15]. In 2001, Conlon and colleagues from the Memorial Sloan Kettering Cancer Center first suggested that drainage should not be considered mandatory or standard after pancreatic resection [11]. Thirteen years later, however, an American trial involving nine high-volume centers acquired popularity as the Data Safety Monitoring Board stopped it prematurely because of an increased mortality from 3 to 12% in the group of patients undergoing pancreatoduodenectomy (PD) without intraperitoneal drains [12]. Recently, Witzigmann and colleagues presented another trial of about 400 patients randomized to either receive or not receive intra-abdominal drains [14]; the data analysis confirmed the findings of Conlon and colleagues [11] by showing that the omission of drains was not inferior in terms of postoperative re-interventions and even superior in terms of clinically relevant POPFs and associated complications. Another American trial found that distal pancreatectomy without drain use had mortality and postoperative complications similar to the procedure with drain use [13]. The issue of open vs. closed suction drains has been a matter of ongoing debate as well, but recent evidence suggests similar postoperative outcomes using pancreas surgery as a model [4, 16].

Of striking importance, all the abovementioned literature is supported by the assumed dogma that once drains are left in place, their position remains virtually stable. In other words, the potential for drain dislocation postoperatively is usually not even considered, to the point that the occurrence of drain dislocation from the place of "need," i.e., peri-anastomotically or near the cut edge of the pancreatic remnant, has never been reported.

The aim of the present study is to assess the incidence of drainage dislocation after intra-abdominal surgery and to estimate its clinical impact. Our hypothesis was that drain dislocation would negatively impact on the rate of clinically important POPFs and other related complications. Pancreatic surgery is been used as the model, because it represents an area of general surgery in which the use of drains has been considered to be crucial by many surgeons and still remains controversial for the diagnosis and treatment of postoperative complications.

## Material and methods

### Study population

This single-institution, prospective observational study was approved by the Ethics Committee for Clinical Research of the provinces of Verona and Rovigo (protocol n° 1101cesc) and it was registered with ClinicalTrials.gov (ClinicalTrials.gov Identifier: NCT03807687). All adult patients excluding women of child-bearing age scheduled for elective, standard pancreatic resection PD or distal pancreatectomy (DP) with splenectomy for any indication from January 2015 to March 2016 were considered eligible and included prospectively in the study. Specific informed consent for the study was obtained from all the patients. Patients who underwent extended resection, pancreatic anastomosis other than pancreaticojejunostomy, minimally invasive surgery, drains not placed in the standardized fashion, or unable to undergo computed tomography (CT) on postoperative day (POD) 1 were excluded. All demographics, clinical, surgical, and 90-day postoperative data were collected prospectively. Operative procedures were carried out through a standardized technique that has been previously reported [17].

The standardized positioning of drains for each procedure is shown in Fig. 1. Two flat Penrose drains (12 mm; Redax) were used according to our institutional policy for pancreatic resections [18]. With regard to PD, the drain inserted via the right flank was placed posterior to the biliary anastomosis extending to the cranial margin of the pancreatic remnant. The drain inserted via the left flank was placed posterior to the stomach and extending to the posterior surface of the pancreatic anastomosis, in close proximity to the contralateral drain. After DP with splenectomy, both drains were inserted via the left flank with one positioned near the pancreatic stump and the other in the splenic fossa. Other intraoperative data collected included the duration of the operation, blood loss, pancreatic texture (soft vs. hard), diameter of main pancreatic duct, and Fistula Risk Score (FRS) for PD [19].

### Radiologic and postoperative assessment

After a training set with abdominal ultrasound and X-ray techniques to test their reliability in drain dislocation assessment, the low-dose, non-enhanced computed tomography (LDCT) scan was identified as the imaging technique of choice for the present study. Each patient underwent two LDCT on POD 1 and POD 3. The LDCT acquisition was performed with the patient in supine position, with the arms raised over the head.

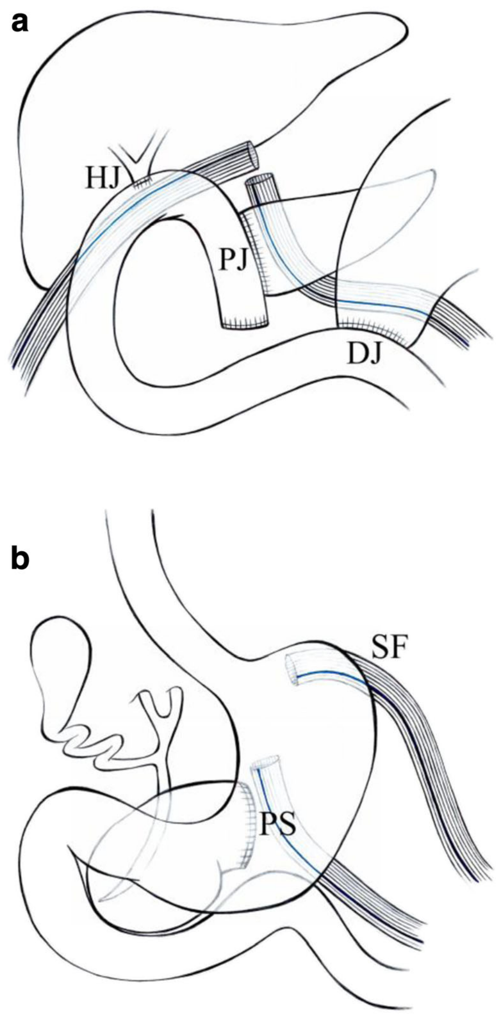


**Fig. 1** **a** Standard drains position after pancreatoduodenectomy (PD). *PJ*, pancreatojejunostomy; *HJ*, hepaticojejunostomy; *DJ*, duodenojejunostomy. **b** Standard drains position after distal pancreatectomy (DP). *PS*, pancreatic stump; *SF*, splenic fossa

Tube parameters were 120 kV, 30 mAs, and have collimation of 64 × 0.625 mm. Mean patient dose expressed by computed tomography dose index-volumetric (CTDIvol) was 1.94 mGy. One abdominal radiologist with 10-year experience in pancreatic imaging (G.Z.) reviewed prospectively the scans, using also MPR reformats as needed. A drain was defined as "dislocated" every time its tip was found in a different abdominopelvic region [20] in the coronal plane or in a position that was substantially more ventral from the standardized position in the axial plane on POD 1, on POD 3, or on both LDCT. In case of repeated event of dislocations in the same patient, that event was counted as a single one. Of note, clinicians were blinded to the results of the LDCT in terms of drain location, in order not to bias the postoperative management.

Postoperative management was carried out according to our institutional protocol [17, 18]. Abdominal drains were removed on POD 3 whenever the drainage fluid amylase activity on POD 1 was ≤ 5000 U/L and the fluid appearance did not appear to be "sinister" by the clinicians. For drains remaining in place after POD 3, amylase values were again measured on POD 5; drains with amylase values ≤ 200 U/L were removed, while those with values > 200 U/L and/or sinister appearance were left in place (under the clinical suspicion of a POPF) and removed when appropriate. Postoperative complications were classified according to the International Study Group of Pancreatic Surgery (ISGPS) definitions [21–24].

The main endpoint of the study was set as the rate of drain dislocation. The secondary endpoint was the assessment of complications after separating the study population into two discrete groups depending on the presence or absence of a dislocated drain(s). Complications occurring after reoperative or percutaneously placed new drains were not included in the analysis.

## Statistical analysis

Continuous variables are presented as mean values with standard deviation or median value with range whenever appropriate. Categorical variables are presented as absolute numbers and percentages referred to the corresponding cohort. Univariate analysis was carried out using chi-squared or Fisher's exact test for categorical variables; Student's *t* tests or the Mann-Whitney tests were used for continuous variables. All tests were two-tailed. *P* values < 0.05 were considered to be statistically significant. Statistical analysis was performed with SPSS software (SPSS Inc., version 20, IBM).

# Results

## Appraisal of drain dislocation

A total of 91 prospectively enrolled patients underwent either PD ($n = 58$, 64%) or DP ($n = 33$, 36%) with standard drain placement and, therefore, constituted the study population. All patients underwent LDCT on POD 1. Table 1 displays the demographics, operative, and pathologic features of the study population. Overall, abdominal drains were found to be dislocated in 30 patients (33%) (33 drains dislocated of 182 placed, 18%). No significant difference was found between PD (29%) and DP (39%) in terms of rate of dislocation ($P = 0.325$). With regard to PD, the left drain was dislocated in 13 cases (77%), the right in 4 cases (23%), and both in no one. With regard to DP, the medial drain was the only one dislocated in 6 cases (46%), the lateral in 4 cases (31%), and both were dislocated in 3 patients (23%).

With regard to the timing of dislocation, in most cases (77%), dislocation was detected on POD 1 at the LDCT (Fig. 2). The only potential clinical predictor of dislocation was a body mass index (BMI) > 23 (83% vs. 54%; $P =$ 0.006). Intraoperative predictors of eventual drain dislocation

**Table 1** Demographic characteristic and operative and pathologic details

| N (%) or mean (±SD) | Overall | | | | Pancreaticoduodenectomy | | | | Distal pancreatectomy | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Overall (N = 91) | Correctly placed (N = 61) 67% | Dislocated (N = 30) 33% | P | Overall (N = 58) | Correctly placed (N = 41) 71% | Dislocated (N = 17) 29% | P | Overall (N = 33) | Correctly placed (N = 20) 61% | Dislocated (N = 13) 39% | P |
| Sex | | | | | | | | | | | | |
| Male | 51 (56%) | 31 (51%) | 20 (67%) | 0.152* | 33 (77%) | 21 (53%) | 12 (71%) | 0.175* | 15 (46%) | 10 (50%) | 5 (39%) | 0.515* |
| Female | 40 (44%) | 30 (49%) | 10 (33%) | | 25 (43%) | 20 (48%) | 5 (29%) | | 18 (55%) | 10 (50%) | 8 (62%) | |
| Age, year | 63 (± 10) | 63 (± 11) | 65 (± 7) | 0.280† | 63 (± 11) | 62 (± 12) | 64 (± 6) | 0.314† | 65 (± 8) | 64 (± 9) | 65 (± 8) | 0.749† |
| BMI, kg/m$^2$ | 24.5 (3.9) | 24.1 (± 4.1) | 25.3 (± 3.4) | 0.177† | 23.8 (± 3.7) | 23.4 (± 3.6) | 24.7 (± 3.9) | 0.226† | 25.7 (± 4) | 25.5 (± 4.7) | 26 (± 2.6) | 0.736† |
| BMI > 23 kg/m$^2$ | 58 (64%) | 33 (54%) | 25 (83%) | 0.006* | 32 (55%) | 19 (46%) | 13 (77%) | 0.036* | 26 (79%) | 14 (70%) | 12 (92%) | 0.126* |
| Operation | | | | | | | | | | | | |
| PPPD | 58 (64%) | 41 (71%) | 17 (29%) | 0.325* | – | – | – | | – | – | – | |
| DP | 33 (36%) | 20 (61%) | 13 (39%) | | – | – | – | | – | – | – | |
| Operative time, min | – | – | – | | 398 (± 76) | 387 (± 82) | 426 (± 51) | 0.069† | 259 (± 82) | 268 (± 87) | 246 (± 74) | 0.466† |
| Pancreatic duct diameter, mm | – | – | – | | 3.8 (± 2) | 3.8 (± 2.1) | 3.6 (± 1.6) | 0.901† | – | – | – | |
| Pancreatic texture | | | | | | | | | | | | |
| Hard | – | – | – | | 23 (40%) | 14 (34%) | 9 (53%) | 0.183* | – | – | – | |
| Soft | – | – | – | | 35 (60%) | 27 (66%) | 8 (47%) | | – | – | – | |
| Blood loss, ml | 390 (± 337) | 391 (± 346) | 388 (± 326) | 0.972† | 451 (± 344) | 467 (± 394) | 414 (± 177) | 0.803† | 281 (± 301) | 235 (± 111) | 353 (± 460) | 0.378† |
| FRZ | | | | | | | | | | | | |
| Negligible (0) | – | – | – | | 5 (9%) | 4 (10%) | 1 (6%) | 0.807* | – | – | – | |
| Low (1–2) | – | – | – | | 9 (16%) | 5 (12%) | 4 (24%) | | – | – | – | |
| Moderate (3–6) | – | – | – | | 35 (60%) | 25 (61%) | 10 (59%) | | – | – | – | |
| High (7–10) | – | – | – | | 9 (16%) | 7 (17%) | 2 (12%) | | – | – | – | |
| Pathology | | | | | | | | | | | | |
| Pancreatic adenocarcinoma | 42 (46%) | 27 (44%) | 15 (50%) | 0.760* | 27 (47%) | 18 (44%) | 9 (52%) | 0.514* | 15 (46%) | 9 (45%) | 6 (46%) | 0.067* |
| Cystic lesion | 20 (22%) | 14 (23%) | 6 (20%) | | 9 (15%) | 6 (15%) | 3 (18%) | | 11 (33%) | 8 (40%) | 3 (23%) | |
| NET | 8 (9%) | 5 (8%) | 3 (10%) | | 5 (9%) | 5 (12%) | 0 (0%) | | 3 (9%) | 0 (0%) | 3 (23%) | |
| Ampullary adenocarcinoma | 7 (8%) | 5 (8%) | 2 (8%) | | 7 (12%) | 5 (12%) | 2 (12%) | | – | – | – | |
| Duodenal adenocarcinoma | 1 (1%) | 0 (0%) | 1 (3%) | | 1 (2%) | 0 (0%) | 1 (6%) | | – | – | – | |
| Distal cholangiocarcinoma | 2 (2%) | 1 (2%) | 1 (3%) | | 2 (3%) | 1 (22%) | 1 (6%) | | – | – | – | |
| Chronic pancreatitis | 3 (3%) | 2 (3%) | 1 (3%) | | 2 (3%) | 2 (5%) | 0 (0%) | | 1 (3%) | 0 (0%) | 1 (8%) | |
| Others | 8 (9%) | 7 (12%) | 1 (3%) | | 5 (9%) | 4 (10%) | 1 (6%) | | 3 (9%) | 3 (15%) | 0 (0%) | |

*Pearson chi-square

†*t*-test

*BMI*, body mass index; *NET*, neuroendocrine tumor; *PPPD*, pylorus-preserving pancreaticoduodenectomy; *DP*, distal pancreatectomy; *FRZ*, Fistula Risk Zone

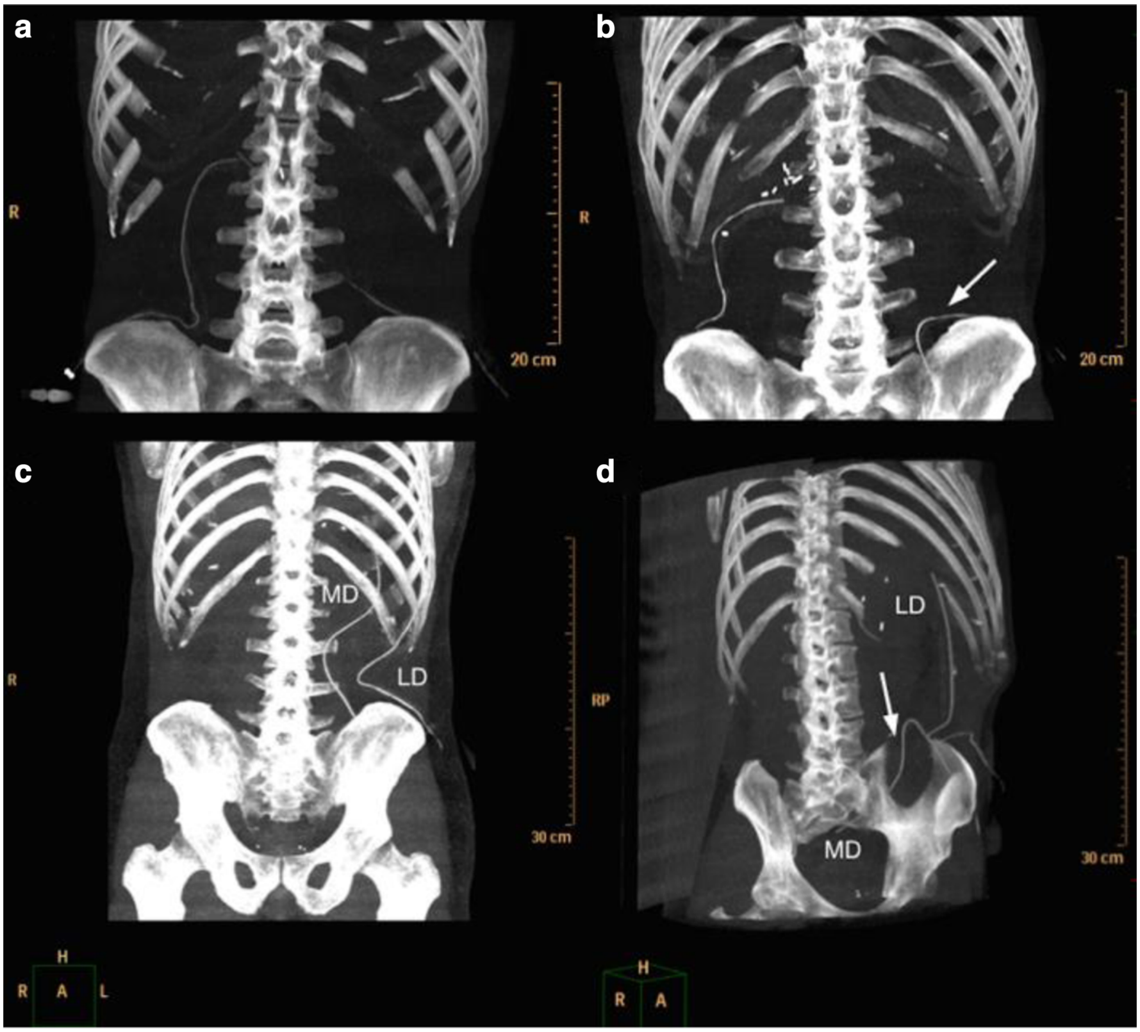


**Fig. 2** **a** Correctly placed and **b** dislocated (arrow) drains after PD in POD 1, frontal view. **c** Correctly placed drains after DP in POD 1. **d** Dislocated drains after DP in POD 3. The medial drain (MD, arrow) is misplaced in the pelvic fossa, and the lateral drain (LD) is misplaced nearby the anterior abdominal wall

including operative time and blood loss were analyzed separately for PD and DP, but none was found to be statistically significant.

## Clinical impact of drain dislocation

The overall postoperative outcome of the study population is shown in Table 2. Postoperative complications occurred in 62% of patients. For surgical complications ($n = 52$; 57%), the POPF rate was 27%. Mortality rate was 1%, and the mean duration of hospital staying was 16 days (standard deviation ± 12). Patients in the dislocated cohort had a lesser postoperative surgical morbidity (40% vs. 66%; relative risk (RR), 0.35; 95% CI, 0.14–0.86; $P = 0.020$), but when determined for the PD and the DP groups, the result was confirmed only for the PD group (35% vs. 66%; RR, 0.28; 95% CI, 0.09–0.93; $P = 0.032$); for the DP group, the morbidity was 70% vs. 54% ($P = 0.346$). POPFs occurred more frequently in the group without displaced drains (39% vs. 3%; RR, 0.05; 95% CI, 0.01–0.42; $P < 0.001$). These data were confirmed also after dichotomizing for type of pancreatectomy (PD vs. DP). Of note, no patients who underwent a PD and had the drains dislocated ($n = 17$) developed a POPF. Similarly, for the DP group, the patients with a displaced drain had a POPF rate of 8% versus those without drain displacement of 45% (RR, 0.10; 95% CI, 0.01–0.94; $P = 0.05$). The average length of hospital stay differed between groups and was greater for those with correctly placed drains (18 vs. 12 days; $P = 0.004$). This same data was confirmed also for the subset of patients undergoing PD (20 vs. 12 days; $P = 0.015$). The subanalysis regarding the dislocation effect of a specific drain did not show significant differences with regard to PD. Conversely, we found that the lateral drain dislocation did not significantly impact on the postoperative course of a DP, while the medial (pancreatic) did. In fact, DP with a dislocated medial drain showed better results in terms of overall

**Table 2** Outcomes

| $N$ (%) or mean (±SD) | Overall | | | | Pancreaticoduodenectomy | | | | Distal pancreatectomy | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Overall ($N$ = 91) | Correctly placed ($N$ = 61) 67% | Dislocated ($N$ = 30) 33% | $P$ | Overall ($N$ = 58) | Correctly placed ($N$ = 41) 71% | Dislocated ($N$ = 17) 29% | $P$ | Overall ($N$ = 33) | Correctly placed ($N$ = 20) 61% | Dislocated ($N$ = 13) 39% | $P$ |
| Morbidity | 56 (62%) | 42 (69%) | 14 (47%) | 0.041* | 35 (60%) | 28 (68%) | 7 (41%) | 0.055* | 21 (64%) | 14 (70%) | 7 (54%) | 0.346* |
| Surgical | 52 (57%) | 40 (66%) | 12 (40%) | 0.020* | 33 (57%) | 27 (66%) | 6 (35%) | 0.032* | 19 (58%) | 13 (65%) | 6 (46%) | 0.284* |
| Medical | 23 (25%) | 18 (30%) | 5 (17%) | 0.185* | 12 (21%) | 10 (24%) | 2 (12%) | 0.478‡ | 11 (33%) | 8 (40%) | 3 (23%) | 0.456‡ |
| Postoperative pancreatic fistula | 25 (27%) | 24 (39%) | 1 (3%) | 0.001‡ | 15 (26%) | 15 (37%) | 0 (0%) | 0.003‡ | 10 (30%) | 9 (45%) | 1 (8%) | 0.050‡ |
| B | 22 (24%) | 21 (34%) | 1 (3%) | 0.001* | 13 (22%) | 13 (21%) | 0 (0%) | 0.015* | 9 (27%) | 8 (40%) | 1 (8%) | 0.073* |
| C | 3 (3%) | 3 (5%) | 0 (0%) | | 2 (3%) | 2 (5%) | 0 (0%) | | 1 (3%) | 1 (5%) | 0 (0%) | |
| Biochemical leak | 2 (2%) | 1 (2%) | 1 (3%) | 1.000‡ | 2 (3%) | 1 (2%) | 1 (6%) | 0.504‡ | 0 (0%) | 0 (0%) | 0 (0%) | – |
| Biliary leakage | 3 (3%) | 2 (3%) | 1 (3%) | 1.000‡ | 3 (5%) | 2 (5%) | 1 (6%) | 1.000‡ | – | – | – | |
| Enteric leakage | 2 (2%) | 2 (3%) | 0 (0%) | 1.000‡ | 0 (0%) | 0 (0%) | 0 (0%) | | 2 (6%) | 2 (10%) | 0 (0%) | 0.508‡ |
| Chyle leakage | 3 (3%) | 3 (5%) | 0 (0%) | 0.548‡ | 3 (5%) | 3 (7%) | 0 (0%) | 0.548‡ | 0 (0%) | 0 (0%) | 0 (0%) | |
| Postpancreatectomy hemorrhage | 17 (19%) | 12 (20%) | 5 (17%) | 0.729* | 12 (21%) | 9 (22%) | 3 (18%) | 1.000‡ | 5 (15%) | 3 (15%) | 2 (15%) | 1.000‡ |
| A | 6 (7%) | 4 (7%) | 2 (7%) | 0.978* | 3 (5%) | 2 (5%) | 1 (6%) | 0.961* | 3 (9%) | 2 (10%) | 1 (8%) | 0.932* |
| B | 7 (8%) | 5 (8%) | 2 (7%) | | 5 (9%) | 4 (10%) | 1 (6%) | | 2 (6%) | 1 (5%) | 1 (8%) | |
| C | 4 (4%) | 3 (5%) | 1 (3%) | | 4 (7%) | 3 (7%) | 1 (6%) | | 0 (0%) | 0 (0%) | 0 (0%) | |
| Delayed gastric emptying | 11 (12%) | 9 (15%) | 2 (7%) | 0.328‡ | 10 (17%) | 9 (22%) | 1 (6%) | 0.253‡ | 1 (3%) | 0 (0%) | 1 (8%) | 0.394‡ |
| A | 3 (3%) | 3 (5%) | 0 (0%) | 0.571* | 3 (5%) | 3 (7%) | 0 (0%) | 0.448* | 0 (0%) | 0 (0%) | 0 (0%) | 0.394* |
| B | 5 (6%) | 4 (7%) | 1 (3%) | | 5 (9%) | 4 (10%) | 1 (6%) | | 0 (0%) | 0 (0%) | 0 (0%) | |
| C | 3 (3%) | 2 (3%) | 1 (3%) | | 2 (3%) | 2 (5%) | 0 (0%) | | 1 (3%) | 0 (0%) | 1 (8%) | |
| Symptomatic abdominal collection | 32 (35%) | 25 (41%) | 7 (23%) | 0.097* | 21 (36%) | 18 (44%) | 3 (18%) | 0.076‡ | 11 (33%) | 7 (35%) | 4 (31%) | 1.000‡ |
| Non fistula-associated | 13 (14%) | 7 (12%) | 6 (20%) | 0.275* | 8 (14%) | 6 (15%) | 2 (12%) | 1.000‡ | 5 (15%) | 1 (5%) | 4 (31%) | 0.066‡ |
| Spontaneous wound drainage | 11 (12%) | 9 (15%) | 2 (7%) | 0.328‡ | 8 (14%) | 7 (17%) | 1 (6%) | 0.415‡ | 3 (9%) | 2 (10%) | 1 (8%) | 1.000‡ |
| Pulmonary morbidity | 22 (24%) | 18 (30%) | 4 (13%) | 0.120‡ | 12 (21%) | 10 (24%) | 2 (12%) | 0.478‡ | 10 (30%) | 8 (40%) | 2 (15%) | 0.245‡ |
| Cardiac morbidity | 2 (2%) | 0 (0%) | 2 (7%) | 0.106‡ | 1 (2%) | 0 (0%) | 1 (6%) | 0.293‡ | 1 (3%) | 0 (0%) | 1 (8%) | 0.419‡ |
| Readmission | 15 (17%) | 11 (18%) | 4 (13%) | 0.766‡ | 7 (12%) | 7 (17%) | 0 (0%) | 0.093‡ | 8 (24%) | 4 (20%) | 4 (31%) | 0.681‡ |
| Mortality | 1 (1%) | 1 (2%) | 0 (0%) | 1.000‡ | 0 (0%) | 0 (0%) | 0 (0%) | | 1 (3%) | 1 (5%) | 0 (0%) | 1.000‡ |
| Re-intervention | | | | | | | | | | | | |
| Percutaneous drainage | 5 (6%) | 2 (3%) | 3 (10%) | 0.327‡ | 3 (5%) | 2 (5%) | 1 (6%) | 1.000‡ | 2 (6%) | 0 (0%) | 2 (15%) | 0.148‡ |
| Relaparotomy | 10 (11%) | 8 (13%) | 2 (7%) | 0.488‡ | 7 (12%) | 5 (12%) | 2 (12%) | 0.565‡ | 3 (9%) | 3 (15%) | 0 (0%) | 0.261‡ |
| Hospital stay, days | 16 (±12) | 18 (±13) | 12 (±8) | 0.004† | 18 (±13) | 20 (±14) | 12 (±9) | 0.015† | 13 (±10) | 15 (±11) | 11 (±7) | 0.228† |

*Pearson chi-square

†*t*-test

‡Fisher's exact test

postoperative morbidity (33% vs. 75%; RR, 0.17; 95% CI, 0.03–0.88; $P = 0.044$), minor abdominal morbidity (22% vs. 71%; RR, 0.12; 95% CI, 0.02–0.71; $P = 0.019$), POPF (0% vs. 42%; $P = 0.032$), and length of staying (8 vs. 15 days; $P = 0.008$) (see Table 3).

## Discussion

In the ongoing debate regarding the usage of intra-abdominal drain after major abdominal surgery, the occurrence of drain dislocation has never been systematically considered yet. All the available randomized controlled trials have focused on the assessment of optimal drain strategies and have assumed that these drains have remained where the surgeon left them. Postoperative imaging and/or re-interventions, however, frequently reveal a dislocation of the surgically placed drains, but there are no reliable data regarding potential consequences in the clinical practice. The present study was aimed to assess the actual incidence of drain dislocation and its impact on postoperative outcomes.

We used pancreatic surgery as a model because its outcomes are believed by many surgeons to be affected by the strategies of drain management [25]. Surprisingly, we found that surgical drains are dislocated in approximately one of every three cases, regardless of the presence of a surgical anastomosis (PD vs. DP). Moreover, the occurrence of drain dislocation appears to be an early event, because it was

**Table 3** Outcomes after DP considering median drain position only

| | Distal pancreatectomy | | | |
|---|---|---|---|---|
| *N* (%) or mean (±DS) | Overall (*N* = 33) | Correctly placed (*N* = 24) 73% | Dislocated (*N* = 9) 27% | *P* |
| Morbidity | 21 (64%) | 18 (75%) | 3 (33%) | 0.044‡ |
| Surgical | 19 (58%) | 17 (71%) | 2 (22%) | 0.019‡ |
| Medical | 11 (33%) | 10 (42%) | 1 (11%) | 0.212‡ |
| Postoperative pancreatic fistula | 10 (30%) | 10 (42%) | 0 (0%) | 0.032‡ |
| B | 9 (27%) | 9 (38%) | 0 (0%) | 0.068* |
| C | 1 (3%) | 1 (5%) | 0 (0%) | |
| Biochemical leak | 0 (0%) | 0 (0%) | 0 (0%) | – |
| Biliary leakage | – | – | – | |
| Enteric leakage | 2 (6%) | 2 (8%) | 0 (0%) | 1.000‡ |
| Chyle leakage | 0 (0%) | 0 (0%) | 0 (0%) | |
| Postpancreatectomy hemorrhage | 5 (15%) | 5 (21%) | 0 (0%) | 0.290‡ |
| A | 3 (9%) | 3 (13%) | 0 (0%) | 0.331* |
| B | 2 (6%) | 2 (8%) | 0 (0%) | |
| C | 0 (0%) | 0 (0%) | 0 (0%) | |
| Delayed gastric emptying | 1 (3%) | 1 (4%) | 0 (0%) | 1.000‡ |
| A | 0 (0%) | 0 (0%) | 0 (0%) | 1.000‡ |
| B | 0 (0%) | 0 (0%) | 0 (0%) | |
| C | 1 (3%) | 1 (4%) | 0 (0%) | |
| Symptomatic abdominal collection | 11 (33%) | 9 (38%) | 2 (22%) | 0.618‡ |
| Non fistula-associated | 5 (15%) | 3 (13%) | 2 (22%) | 0.597‡ |
| Spontaneous wound drainage | 3 (9%) | 3 (13%) | 0 (0%) | 0.545‡ |
| Pulmonary morbidity | 10 (30%) | 10 (42%) | 0 (0%) | 0.032‡ |
| Cardiac morbidity | 1 (3%) | 0 (0%) | 1 (11%) | 0.273‡ |
| Readmission | 8 (24%) | 6 (25%) | 2 (22%) | 1.000‡ |
| Mortality | 1 (3%) | 1 (4%) | 0 (0%) | 1.000‡ |
| Re-intervention | | | | |
| Percutaneous drainage | 2 (6.1%) | 2 (8%) | 0 (0%) | 1.000‡ |
| Relaparotomy | 3 (9.1%) | 3 (13%) | 0 (0%) | 0.545‡ |
| Hospital stay, days | 13 (±10) | 15 (±10) | 8 (±2) | 0.008† |

*Pearson chi-square

†*t*-test

‡Fisher's exact test

already evident on POD 1 in most of the cases (77%). This finding might lead to the hypothesis that factors taking place immediately after the drains are positioned intraoperatively may play a major role in the dislodgement of the drain position. One of these factors might be the changing of operating room bed positioning back to a flat baseline that follows the placement of the drains, which occurs before the abdominal wall is closured. This hypothesis suggests that drains should be positioned intraoperatively after the repositioning of the surgical bed to a flat baseline position as a policy to decrease their dislocation. In our analysis for preoperative predictors of drain misplacement, we found that BMI was the only statistically significant factor that appears to affect the incidence of drain dislocation. Of note, the BMI is a well-recognized risk factor for overall postoperative morbidity [26, 27]. Adding to a greater risk for bleeding due to dissection, the presence of a substantial amount of peripancreatic visceral fat and other retroperitoneal tissue might lead to a more difficult drain positioning into the abdominal cavity, eventually resulting in drain dislocation. Therefore, even more attention should be paid in these patients in attempts to decrease the rate of drain dislocation. We are aware that, particularly at the end of long and demanding operation, the last steps might be negatively affected by the relative exhaustion of the operative team. Therefore, we reinforce the concept that also the last operative maneuvers are still important and may play a key role in determining postoperative outcomes.

In the second part of the study, we sought to evaluate whether drain dislocation has a role in affecting the postoperative course. In contrast with our hypothesis that dislocated drains would increase the incidence of POPF and other related postoperative morbidity, we found that the dislocation of surgical drains did not negatively affect the outcome. In fact, patients who had their drains maintained in the correct position actually had a significantly greater rate of overall postoperative morbidity and particularly of postoperative pancreatic fistula, resulting in a greater postoperative hospital stay. Although definite conclusions cannot be drawn from this single prospective surgical series, the findings of this study should be carefully evaluated. It has been well-established that maintaining surgical drains for greater durations than required might result in increased postoperative morbidity [3, 17, 25, 28]. This increased morbidity related directly to the drains is believed to be related to the migration of bacteria from the skin retrograde along the drain that leads to intra-abdominal infections and longstanding plastic material decubitus on vital organs. Our striking result regarding the pancreatic drain of DP, when no anastomoses are performed, seems to reinforce these mechanisms as the main determinants of postoperative complications. With this possibility in mind, surgeons should be aware that early drain removal, when appropriate, might prevent such postoperative outcomes. It is likely that, in our series, the absence of a "sinister" appearance of the drainage fluid from drains that were dislocated may have led to their earlier removal, and as such, the potentially negative effect of maintaining the drain in place near the anastomosis or the cut edge of the pancreatic remnant may actually have been avoided. The occurrence of POPF has been postulated as an example of such a negative role played by longstanding maintenance or even the early placement of drains [17]. Indeed, the drains themselves may maintain a clinically unimportant "biochemical leak" leading to its shift to a clinically relevant leak (grades B and C POPF) [21]. Noteworthy, on retrospective analysis, the dislocation of surgical drains did not fail to identify any critical postoperative condition, such as bleedings (postpancreatectomy hemorrhage) or late POPF. In other words, the risk of missing a critical complication due to drain dislocation was less than the risk related to its longstanding maintenance in place.

Integrated with the recent literature, these results have influenced our institutional drain management by shifting towards a selective drainless policy after pancreaticoduodenectomy in patients at negligible low risk for POPF [25, 28]. Moreover, once drains are placed, their tips are kept far away from the pancreatic anastomoses and the pancreatic stump in case of a DP.

We are aware that our study has several limitations. First, as a pilot study, no definite statistically robust conclusions regarding the occurrence of drain displacement can be made. We used pancreatic surgery as a model, and a strength of this model is that the management of drains in this setting has been claimed to be crucial for the postoperative outcome. The actual applicability of the present findings to other areas of general surgery remains unclear. Another limitation of the study is the use of the open passive Penrose drains only. However, active and passive drains are associated to similar outcomes in terms of wound infection, intra-abdominal infection, overall morbidity, and additional open procedures for postoperative complications [4, 16]. Of note, no data regarding dislocation of the other types of abdominal drains, like the closed suction ones, are available at the time. Moreover, we made no attempt to calculate the required study sample size, because there was no data in the literature that we could find on which to base the calculation. The study population might be considered as accurate, but possibly, different results might have been obtained by its further expansion. As a strength of the study, the surgeons taking care of the postoperative course were blinded to the results of the study LDCT in terms of drain location, so that any potential bias in drain management has been avoided.

## Conclusion

While never considered in the literature so far, dislocation of intra-abdominal drains appears to be both common and an early event occurring in one of three major surgical procedures, at least involving the pancreas. Its occurrence does not appear to be detrimental for the final postoperative outcome, and the earlier dislocation and removal of a drain might protect against the negative effects of its maintenance. We stress, however, that our study did not attempt to answer the question of whether a peripancreatic drain is necessary after a major pancreatic resection.

**Authors' contributions** Giovanni Marchegiani: study conception and design, analysis and interpretation of data, drafting of manuscript, critical revision of manuscript. Marco Ramera: study conception and design, acquisition of data, analysis and interpretation of data, drafting of manuscript. Elena Viviani: acquisition of data, critical revision of manuscript. Fabio Lombardo: acquisition of data, critical revision of manuscript. Adam Cybulski: acquisition of data, critical revision of manuscript. Marco Chincarini: acquisition of data, critical revision of manuscript. Giuseppe Malleo: study conception and design, critical revision of manuscript. Claudio Bassi: study conception and design, critical revision of manuscript. Giulia A. Zamboni: radiological review of all CT studies, critical revision of manuscript. Roberto Salvia: study conception and design, critical revision of manuscript.

## Compliance with ethical standard

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This article does not contain any studies with animals performed by any of the authors.

**Informed consent** Informed consent was obtained from all individual participants included in the study.



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