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REVIEW

Is there still a need for prophylactic intra-abdominal drainage in elective major gastro-intestinal surgery?



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Review

Summary Prophylactic drainage of the abdominal cavity after gastro-intestinal surgery is widely used. The rationale is that intra-abdominal drainage enhances early detection of complications (gastro-intestinal leakage, hemorrhage, bile leak), prevents collection of fluid or pus, reduces morbidity and mortality, and decreases the duration of hospital stay. However, dogmatic attitudes favoring systematic drain placement should be questioned. The aim of this review was to evaluate the evidence supporting systematic use of prophylactic abdominal drainage following gastrectomy, pancreatectomy, liver resection, and rectal resection. Based on this review of the literature: (i) there was no evidence in favor of intra-peritoneal drainage following total or sub-total gastrectomy with respect to morbidity-mortality, nor was it helpful in the diagnosis or management of leakage, however the level of evidence is low, (ii) following pancreatic resection, data are conflicting but, overall, suggest that the absence of drainage is prejudicial, and support the notion that short-term drainage is better than long-term drainage, (iii) after liver resection without hepatico-intestinal anastomosis, high level evidence supports that there is no need for abdominal drainage, and (iv) following rectal resection, data are insufficient to establish recommendations. However, results from the French multicenter randomized controlled trial GRECCAR5 (NCT01269567) should provide new evidence this coming year. Accumulating data support that systematic drainage of the abdominal cavity in digestive surgery is a non-beneficial and obsolete practice, except following pancreatectomy where the consensus appears to indicate the usefulness of short-term drainage. While the level of evidence is high for liver resections, new randomized controlled trials are awaited regarding gastric, pancreatic and rectal surgery.

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Strong points

- After partial or total gastrectomy, routine prophylactic drainage has not been shown to be of any benefit.
- After pancreatic resection, data suggest that absence of drainage can be deleterious and suggest a probable benefit of short-term drainage in selected patients.
- After liver resection, there is level 1 evidence that routine drainage is of no benefit in formal hepatectomy without bilio-intestinal anastomosis.
- After rectal excision, data are insufficient but the GRECCAR5 trial should provide decisive information this year.
- French surgeons are participating actively in clinical research on the topic, and particularly, in the GRECCAR5 [NCT01269567] and Pancreatic Drainage [NCT01368094] randomized trials.

Introduction

Ambroise Paré first described drainage of the abdominal cavity following gastro-intestinal surgery and it has been a surgical tradition for many years. The rationale is that drainage should allow:

- early detection of gastro-intestinal anastomotic leakage;
- better management of gastro-intestinal anastomotic leakage;
- avoidance of re-operation;
- drainage of postoperative collections (hematoma, chyle, bile, abscess...);
- shorten hospital stay;
- finally reduce postoperative morbidity and mortality.

However, the use of routine abdominal drainage has been questioned based on current evaluation of the evidence, and some authors have suggested that abdominal drains might be responsible for increased superficial and deep (organ site) surgical site infection (SSI), pain related to the drain itself, negative effects on ventilation and increased hospital stay [1,2]. Other complications specifically linked to drainage have been reported, although their exact prevalence is difficult to estimate from the literature: abscess along the drainage tract, gastro-intestinal fistula related to erosion caused by the drain, omental protrusion into the drainage tract, hemorrhage, gastro-intestinal obstruction by the drain, sub-cutaneous emphysema, and even tumor seeding along the drainage tract (0.4%) [3–5].

Moreover, the value of postoperative drainage for certain procedures has been questioned to the point that routine drainage is no longer recommended after cholecystectomy [6], splenectomy [7], and colonic surgery with intra-peritoneal anastomosis [8,9]. The French Society of Gastro-intestinal Surgery (Société Française de Chirurgie Digestive [SFCD]) made several recommendations in 1999 concerning these particular indications [10]. However, no similar recommendations have been published for other indications, such as gastrectomy, pancreatotomy, hepatectomy and proctectomy. Lastly, improvements in operative techniques, and peri-operative management (nutrition, antibiotics, etc.) have led to a decrease in postoperative complications making it necessary to call into question the routine use of drains in gastro-intestinal surgery.

The goal of this short review is to appraise the literature and the level of evidence associated with routine drainage of the abdominal cavity after gastrectomy, pancreatotomy, hepatectomy, and proctectomy. Data were analyzed in relation to the impact of drainage on the postoperative course and on the diagnosis of anastomotic leakage or collections.

Material and methods

We performed a systematic literature search of PubMed and the Cochrane database from 1990 to 2014 using the terms corresponding to the above-mentioned procedures. The references of each article were further reviewed to avoid missing any publications. Included in this review were articles concerning gastric, pancreatic, hepatic and rectal resections, with comparisons between the presence or absence of drainage (or early removal vs. classical removal for pancreatotomy). Only articles for which the entire text was available, in English or French, were included. Articles concerning emergency surgery were not included in this review.

Value of drainage after gastrectomy

Before 2004, there were no randomized studies on the value of drainage after gastrectomy, in contrast to hepatic or colorectal surgery [9]. Since then, several randomized trials have been published, some of which included subgroup analysis separating total vs. partial gastrectomy.

In 2011, a Cochrane meta-analysis was published, assembling four randomized trials and including 438 patients [11] (Table 1). No significant differences were found between patients undergoing drainage or not with regard to postoperative mortality (relative risk [RR] = 1.73, 95% confidence interval [CI]: 0.38–7.84), the rate of re-operation (RR = 2.49, 95% CI: 0.71–8.74), the rate of postoperative complications (respiratory infections: RR = 1.18, 95% CI: 0.55–2.54), SSI (RR = 1.23, 95% CI: 0.47–3.23), organ site infection (OSI) (RR = 1.27, 95% CI: 0.29–5.51), anastomotic leakage (RR = 0.93, 95% CI: 0.06–14.47), or the interval before postoperative feeding. Conversely, the presence of a drain prolonged duration of operation (9.07 min, 95% CI: 2.56–15.57), duration of hospital stay (0.69 days, 95% CI: 0.18–1.21) and was associated with drain-specific complications in two studies (i.e. 5 out of 208 patients).

For the total gastrectomy subgroup, no statistically significant difference was found in patients with or without drainage with regard to 30-day mortality (RR: 3.20, 95% CI: 0.14–75.55), postoperative complications such as respiratory infections (RR: 2.37, 95% CI: 0.39–14.23), SSI (RR: 0.23, 95% CI: 0.01–5.37), OSI (abscesses) (RR: 0.68, 95% CI: 0.04–10.24), duration of operation (median difference of 2.0 min, 95% CI: 12.16–16.16), duration of hospital stay (median difference: 0.77 days, 95% CI: 2.13–3.68), the interval before postoperative feeding (median difference 0.4 days, 95% CI: 0.87–1.76). The sample size for total gastrectomy was too small to allow analysis of rarer events such as re-operation or anastomotic leakage rates, or drain-specific complications.

For the partial gastrectomy subgroup, no statistically significant difference was found between drainage vs. no drainage with regard to 30-day mortality (RR = 1.39, 95% CI: 0.24–8.01), the rate of postoperative complications such as respiratory infections (RR = 0.95, 95% CI: 0.36–2.50), superficial SSI (RR = 1.41, 95% CI: 0.45–4.46), OSI (RR = 1.65,

Table 1 Main characteristics of published studies on the value of prophylactic drainage for gastrectomy.

Authors and references	Year	Type of study	Number of patients	Total/partial gastrectomy	Main results
Kim et al. [13]	2004	Prospective randomized	86 Drainage group 84 No drainage group	52 total gastrectomies 118 partial gastrectomies	No significant difference found in postoperative complication rate at 30 days
Alvarez et al. [12]	2005	Prospective randomized	29 Drainage group 31 No drainage group	100% partial gastrectomies	Drainage group did better: decreased hospital stay, morbidity rate, re-operation rate, interval to oral intake
Kumar et al. [3]	2007	Prospective randomized	56 Drainage group 52 No drainage group	100% partial gastrectomy	No significant difference in operative duration, delay to bowel movements, delay to food intake, duration of hospital stay, and complication rate
Jiang et al. [50]	2008	Prospective randomized	41 Fast track surgery group without drain 49 Conventional group with drain	Ratio partial/total gastrectomy not provided	No drainage group did better: shorter duration of hospital stay, decreased costs, shorter interval to bowel movements No significant difference in morbidity-mortality
Wang et al. [11]	2011	Meta-analysis of 4 randomized trials	220 Drainage group 218 No drainage group	112 total gastrectomies 226 partial gastrectomies 100 unknown	No significant difference in mortality rate, postoperative complications, re-operations Increased duration of operation and hospital stay in drainage group

95% CI: 0.28–9.88), or the interval before feeding (median difference: 0.11 days, 95% CI: 0.12–0.34). Conversely, the duration of operation (median difference: 12 min, 95% CI: 4.09–20.78) as well as the duration of hospital stay (median difference: 0.6 days, 95% CI: 0.001–1.27) were longer in the drainage group. As for total gastrectomy, the sample size for partial gastrectomy was too small to allow analysis of rarer events such as re-operation or anastomotic leakage rates, or drain-specific complications.

While the methodology of the Cochrane meta-analysis [11] is robust and includes an extensive search of the literature, some weaknesses must be noted. Firstly, the total sample was small. Secondly, certain events were so rare (chylous ascites, anastomotic and duodenal stump leak, death) that neither the published trials nor future randomized trials can provide precisions concerning the value of drainage concerning these events. Thirdly, three of the trials were from Asia, and one from South America, potentially limiting the application of results to other patient populations. There was no funnel plot to evaluate any publication bias. Moreover, several factors besides the presence or absence of a prophylactic drain could also have influenced postoperative morbidity or mortality such as:

- the use of peri-operative antibiotics;
- the nutritional status of patients;
- overall patient status.

These data, especially those concerning the nutritional status, were not clearly outlined in the above-mentioned randomized studies, and the distribution of predictive factors for complications between the two groups was not clear. Despite randomization, patient-related factors could have introduced a selection bias. Moreover, there were no available data concerning cost-effectiveness or patient comfort. Last, several other variables were not analyzed in these

studies including the type and number of drains, their location, whether they were closed suction or gravity drainage systems, the number of days left in place and the fact that their position might be modified after operation or that they might bend and become obstructed. The primary endpoint chosen (complication and mortality rates, esophago-jejunal or duodenal leak, etc.) adds to the complexity of evaluation in this meta-analysis.

The authors of this review concluded that was no evidence in favor of routine drainage after gastrectomy for cancer. Nonetheless, even with the combined patients of four randomized trials, the total sample was limited and the level of evidence of this review was low, meaning that only future trials (with larger samples) could modify the conclusions of this meta-analysis.

There are few data available to answer the question whether drainage is helpful in making the diagnosis of leakage after total gastrectomy. In the study published by Kumar et al. concerning the value of drainage after partial gastrectomy [3], only one leak was diagnosed (in one patient) in each of the two groups (drainage [$n = 56$] vs. no drainage [$n = 52$]). In this study, the leak was diagnosed based on clinical and sonographic findings. However, no information was provided as to whether drainage helped in making the diagnosis, suggesting that the contribution to diagnosis was weak.

Moreover, in two of the four published trials in the Cochrane review [11], patients who developed deep OSI without anastomotic leak were treated either with echo-guided drainage or a new surgical drainage, but not via the initial drains inserted during gastrectomy (1 case out of 29 in the study by Alvarez et al. [12], no data in the study by Kim et al. [13]).

In the particular setting of ascites, Mariette, in his 2008 review of the literature [14], found that in cirrhotic patients

undergoing gastrectomy, the mortality was 10%, while morbidity was 40%. In this population, the primary cause of postoperative complications after gastrectomy was ascites (14%), while the anastomotic leakage rate did not seem to be affected. Among the predictive factors for postoperative complications, the presence of closed suction drainage was associated with an increased risk of the onset of complications. In view of these data, the recommendations of this review of the literature were:

- reserving surgery to highly selected patients (Child A, normal preoperative liver function and no history of edema-ascites decompensation);
- proscription of postoperative drainage;
- if a drain was inserted, it should be removed before day three.

In conclusion, the data of randomized studies do not demonstrate any advantage in favor of routine prophylactic drainage after gastrectomy. However, these results should be interpreted with caution as the sample size varied greatly between the published series, and the level of evidence in favor of not inserting a drain seems more robust for partial than for total gastrectomy; in our opinion, certain high-risk clinical situations justify the routine insertion of a drain (technical problem during the anastomosis, positive methylene blue test, severe co-morbidities, immunosuppressive state, uncorrected severe mal-nutrition, extended resection to nearby organs, etc.). All in all, the level of evidence remains low, and even while strongly suggested, it is not possible to clearly recommend no drainage after gastrectomy, in the absence of further randomized studies (according to ClinicalTrials.gov, there are three trials underway with the value of drainage as the primary endpoint).

Value of drainage after pancreatectomy

In the 2010 report of the French Association of Surgery, the fistula rate after pancreatoduodenectomy (PD) was 14% while that after distal splenopancreatectomy was 26%. However, the true incidence is difficult to evaluate because of the extreme variability in the definition used [15].

Drainage of the abdominal cavity after pancreatectomy, and especially placement of drains in contact with the anastomosis, is widely practiced after pancreatic surgery. In a survey published by the European–African Hepato-Pancreato-Biliary Association (E-AHPBA) in 2013, drainage was used in 93% of PD and 91% of distal pancreatectomies [16]. The goal of drainage in these settings was to evacuate intra-peritoneal fluids in order to prevent collections, but also to diagnose a pancreatic fistula [17] or life-threatening intra-peritoneal hemorrhage.

Assessment of the value of drainage after pancreatectomy should take into account the specific surgical setting in which the diagnosis of fistula is made since surgical techniques, indications, and measures to prevent pancreatic fistula are variable and make the interpretation of data difficult.

Early removal of drainage after pancreatectomy

Bassi et al. published the only randomized study evaluating short-term drainage after pancreatectomy [17]. Patients undergoing either PD or distal pancreatectomy whose drainage effluent had an amylase level ≤ 5000 U/l on postoperative day 1 were included. In the absence of

any complication on day 3, the patients were randomized into two groups. The drains were removed in the “experimental” arm on day 3, while those in the control group were removed on day 5 if amylase in the drain effluent was ≤ 200 U/l, or later, at the surgeon’s discretion, if the effluent amylase was > 200 U/l. The hypothesis was that early removal of drains could decrease the pancreatic fistula rate six fold. The primary endpoint was the pancreatic fistula rate. Of note, this was a monocenter study and the operative technique was standardized. For PD, routine pancreaticojejunostomy was performed, and two Penrose drains were inserted, one on the posterior aspect of the pancreaticojejunostomy, and the second, in contact with the hepaticojejunostomy. For distal pancreatectomy, the Penrose drain was left in contact with the pancreatic stump.

The authors found a statistically significant decrease in the pancreatic fistula rate in the experimental (early removal) group (1.8% vs. 26%, $P=0.0001$). The only fistula found in this group was diagnosed after interventional radiology drainage of a peri-pancreatic collection. There were 15 pancreatic fistulas in the control group (one grade C, seven grade B and seven grade A). The only independent risk factor for the onset of anastomotic leak was late removal of the drain ($P=0.0003$, OR: 24, 95% CI: 2.7–207.9). There were several weaknesses in this study. The fact that inclusion was limited to those patients with < 5000 U/l amylase on day 1 in whom the aspect of the drainage effluent did not appear to be suspicious by the investigator constitutes a selection bias. Likewise, inclusion of patients with both PD and distal pancreatectomy prevents drawing conclusions for each individual procedure since the procedures and settings differ so much. In addition, many authors would criticise the use of a Penrose drain. One study found that use of a Penrose drain was associated with an increased rate of SSI due to retrograde contamination [18], while another suggested that the risk of pancreatic fistula was lower compared to the use of closed suction drainage [19].

The results of the randomized trial confirm those of the historical comparison in PD published by Kawai et al. who compared postoperative drain removal on day 4 to removal on day 8 [20] (Table 2). The primary endpoint in this study was the deep OSI rate; it was significantly lower when the drain was removed on day 4 vs. day 8 (3.6% vs. 23%, $P=0.003$). Likewise, the risk of need of another drainage was significantly lower in this group (3.7% vs. 34.6%, $P=0.0002$). The duration of drainage was the only independent factor associated with the risk of deep OSI ($P=0.002$, OR: 6.7, 95% CI: 1.9–22.7).

The conclusions of these studies suggest that short-term drainage is associated with a lower risk of SSI and anastomotic leak. Nonetheless the level of evidence is low. A randomized study specifically designed for PD is presently underway in France (Pancreatic drainage protocol NCT01368094, main investigator J.M. Regimbeau) and should provide a response to the question of whether short duration drainage after PD is of any value.

Absence of drainage after pancreatectomy

Five retrospective and two randomized trials have looked at the feasibility of no drainage after pancreatectomy. In 2011, Fisher et al. published the results of a historical comparison between 179 patients undergoing drainage (2004–2009) and 47 patients without drainage (2009–2010) [21]. Both PD and distal pancreatectomies were included, with no statistically significant difference in terms of distribution between the

Table 2 Main characteristics of published studies on the value of prophylactic drainage for pancreatectomies.

Authors and references	Year	Type of study	Number of patients	Main results
Short vs. long duration of drainage				
Kawai et al. [20]	2006	Prospective historical comparison	52 Drain removal on day 4 52 Drain removal on day 8	Significantly fewer deep organ site infection and fewer <i>de novo</i> drains in short duration drainage group
Bassi et al. [17]	2010	Prospective randomized	57 Short duration drainage group 57 Long duration drainage group	Short duration drainage arm had significantly fewer pancreatic fistulas, abdominal and pulmonary complications, shorter duration of hospital stay
Drain vs. no drain				
Conlon et al. [25]	2001	Prospective randomized	88 Drainage group 91 No drainage group	No significant difference in overall complication rates or mortality
Van Buren et al. [26]	2013	Prospective randomized	68 Drainage group 69 No drainage group	No drainage group had more grade ≥ 2 complications, abscesses, collections, gastroparesis, longer duration of hospital stay. No significant difference in mortality

two groups. Of note, in the group without drainage, there were significantly more patients undergoing main pancreatic duct drainage (28% vs. 57%, $P < 0.00001$).

There was no statistically significant difference found in the mortality rate between the two groups (1% vs. 1%, $P = 0.3$), but in the drainage group there were statistically significantly more pancreatic fistulas (44% vs. 11%, $P < 0.0001$) and gastroparesis (24% vs. 9%, $P = 0.02$). Of note, the rate of percutaneous drainage and readmission were statistically significantly higher in the group without abdominal drainage (2% vs. 11%, $P = 0.001$, and 9% vs. 17%, $P = 0.007$, respectively) [21].

Two other retrospective series found a higher fistula rate associated with the absence of drainage: 16% vs. 8%, $P < 0.001$ for Mehta et al. [22]; 27% vs. 18%, $P = 0.001$ for Correa-Gallego et al. [23]. Another retrospective study of 242 patients found no difference [24].

Conlon et al. published the first randomized trial in 2001, comparing 88 patients with drainage to 91 patients without drainage [25] after PD or distal pancreatectomy. The primary endpoint was the overall complication rate. Pancreatic fistula was defined as a volume of > 30 ml/d with amylase > 150 UI/l in the drainage effluent and/or greater than three times the serum amylase level on postoperative day 5. Based on this definition, it was not possible to evaluate the pancreatic fistula rate in the group without drainage. There were no statistically significant differences found in the overall complication (63% vs. 57%) or mortality (2% vs. 2%) rates.

The second randomized study was published in 2013 and rekindled the debate of whether drainage was necessary or not. While most of the above-mentioned studies tended to show an advantage associated with the absence of drainage, the conclusions of Van Buren et al. were different [26]. In this multicenter study, nine high-volume American centers (approximately 50 PD/year) randomized patients into two groups, one with routine prophylactic drainage, the other, without. In this study, the primary endpoint was the onset within 60 days of any complication, grade II or more (complication requiring some form of treatment), according to the Common Terminology Criteria for adverse events classification. The initial goal was to include both PD and distal pancreatectomies with a total of 376 patients in each arm. However, the trial was stopped prematurely by the Data

Safety Monitoring Board, because of excessive mortality in PD without drainage. In substance, the results presented in their paper concerned 177 patients undergoing PD, randomized to either drainage ($n = 68$) or no drainage ($n = 69$). The 60-day rate of complication \geq grade II was statistically significantly higher in the group without drainage (68% vs. 52%, $P = 0.047$). Moreover, there were significantly more patients with gastroparesis (42% vs. 24%, $P = 0.021$), deep OSI (26% vs. 12%, $P = 0.03$), diarrhea (17% vs. 3%, $P = 0.005$) and intra-peritoneal collections (12% vs. 2%, $P = 0.03$) in the non-drainage group. Duration of hospital stay was significantly longer in the non-drainage group (8 d vs. 7 d, $P = 0.016$). While the 60-day mortality rate was higher in the drainage arm, the difference was not statistically significant (9% vs. 1%, $P = 0.115$). This is therefore the only prospective randomized trial specifically dedicated to PD [26].

Moreover, pancreatic texture ("soft" or "hard") has to be taken into consideration because this risk factor is associated with pancreatic fistula after PD [17]. In the study published by Bassi et al. [17], none of the patients evaluated as having a "hard" pancreas sustained a pancreatic fistula (0/38), in contrast to those who had a "soft" pancreas (16 fistulas in 76 patients), $P = 0.015$, OR = 8.0 in univariate analysis. The data in the study by Van Buren et al. [26] must therefore be judged keeping in mind that the proportion of patients with a "hard" pancreas was similar in the two groups ($P = 0.932$, 50% in each arm), and that the pancreas was "soft" in 80% of patients who died. It is therefore possible that these results do not apply to patients with "hard" pancreatic texture, for whom the risk of fistula is lower, and we can infer that no drain is needed in this subgroup.

In conclusion, the data in the literature (Table 2) are contradictory concerning the need for routine drainage or not. Of particular note is the pejorative character associated with the absence of drainage reported in the only randomized trial specifically dedicated to PD. These findings do not allow any recommendation not to drain the abdomen after pancreatectomy. Nonetheless, much of the data favors a short duration of drainage in selected patients (policy evaluated in the aforementioned Drainage Pancreas protocol NCT01368094). Another American randomized study is underway comparing drainage vs. no drainage after distal pancreatectomy (NCT01441492) and should end in 2016.

Value of drainage after liver resection

The theoretical goals of drainage after liver resection include:

- prevention of sub-hepatic and/or sub-diaphragmatic collections;
- diagnosis of postoperative hemorrhage;
- diagnosis and treatment of biliary leaks;
- drainage of postoperative ascites particularly in patients with cirrhosis.

The settings in which the value of drainage after liver resection have been studied and to which the results of this update refer, include: absence of bilio-intestinal anastomosis, absence of associated gastro-intestinal surgery, absence of bile duct injury, involving parenchymal resections of any type (excepting total vascular exclusion), elective surgery, and inclusion of both benign and malignant disease (intra-hepatic cholangiocarcinoma, colorectal liver metastases, hepatocellular carcinoma).

At least five randomized trials and two meta-analyses have compared liver resections with or without drainage [1,5,9,27–30] (Table 3). The Cochrane meta-analysis [5] included six randomized trials published between 1993 and 2006. Five studies [1,27–30] compared no drainage vs. closed suction drainage. The sixth study compared closed suction vs. Penrose drainage, and was analyzed separately [31].

The Cochrane meta-analysis included 465 patients undergoing elective hepatic resections [5]. Emergency liver

resections for trauma and resections associated with bilio-intestinal anastomosis were not included. In all, 234 patients were randomized to the drainage group vs. 231 patients to the non-drainage group. The quality of methodology was considered to be “good” in three of five studies.

While the rationale behind prophylactic drainage in hepatic resection is to prevent intra-peritoneal collections, the rate of intra-peritoneal collections requiring a new surgical drainage was 2.1% in the drainage group versus 0.9% in the non-drainage group (difference not statistically significant [NS]). Conversely, the radiologic drainage rate was higher in the non-drainage group (5.6% vs. 3.4%, NS).

No statistically significant difference was found between the two groups with regard to in-hospital mortality 2.6% vs. 2.2% (OR: 1.17, 95% CI: 0.37–3.70), re-operation rate 2.6% vs. 1.7% (OR: 1.35, 95% CI: 0.44–4.11), intra-peritoneal collections requiring re-intervention 2.1% vs. 0.9% (OR: 1.86, 95% CI: 0.73–5.50) or radiologic drainage 3.4% vs. 5.6% (OR: 0.63, 95% CI: 0.27–1.48), surgical wound dehiscence 0.4% vs. 0.9% (OR: 0.57, 95% CI: 0.07–4.41), deep OSI 4.7% vs. 2.2% (OR: 2.01, 95% CI: 0.73–5.50), biliary fistula 2.6% vs. 1.6% (OR: 1.60, 95% CI: 0.41–6.29), SSI 11.5% vs. 6.8% (OR: 1.78, 95% CI: 0.87–3.64), or pulmonary infection 4.7% vs. 3.5% (OR: 1.33 95% CI: 0.55–3.22). Conversely, there were more patients with ascites leaks (OR: 2.96, 95% CI: 1.66–5.28) and duration of hospital stay was shorter (8.1 vs. 8.5 days [OR: 2.96, 95% CI: 1.66–5.28]) in the drainage group. For the latter, the small difference, 0.4 days, became statistically significant because of the “weight” of one of

Table 3 Main characteristics of published studies on the value of prophylactic drainage for liver resection.

Authors and references	Year	Type of study	Number of patients	Main results
Belghiti et al. [27]	1993	Prospective randomized	42 Drainage group 39 No drainage group	No significant difference in mortality or complication rate. More (and more often infected) collections in drainage group
Fong et al. [28]	1996	Prospective randomized	60 Drainage group 60 No drainage group	No significant difference in postoperative course or in duration of hospital stay
Liu et al. [1]	2004	Prospective randomized in patients with chronic hepatic disease	52 Drainage group 52 No drainage group	No significant difference in mortality. More morbidity in drainage group (more SSI). Longer duration of hospital stay in drainage group
Fuster et al. [29]	2004	Prospective randomized in cirrhotic patients	20 Drainage group 20 No drainage group	Fewer ascites leaks, local complications and shorter duration of hospital stay in drainage group
Sun et al. [30]	2006	Prospective randomized	60 Drainage group 60 No drainage group	More SS complications in drainage group. No significant difference in duration of hospital stay
Petrowsky et al. [9]	2004	Meta-analysis of 3 randomized trials	154 Drainage group 150 No drainage group	Fewer deep OSI in no drainage group (NS). No significant difference in rate of biliary collections or pulmonary complications
Gurusamy et al. [5]	2007	Meta-analysis of 5 randomized trials	234 Drainage group 231 No drainage group	No significant difference in mortality, or morbidity (re-intervention, collections, wound disruption, abscess biliary leak, SSI, pulmonary infection). No significant difference in need for further drainage. More ascites leak in drainage group

SS: surgical site; SSI: surgical site infection; OSI: organ site infection; NS: non-significant.

the trials. These differences were no longer significant once when the random-effects model was used.

Of note, the authors described one instance of tumor seeding of the drainage tract in the drainage group, for an incidence of 0.4%.

Subgroup analysis according to the type of liver resection (minor vs. major), to concomitant liver disease, cirrhosis, or antibiotic prophylaxis did not reveal any statistically significant differences. Only the duration of hospital stay was significantly shorter in the drainage group, but this difference disappeared when the random-effects model was used. The incidence of SSI was 2.48 time higher in the drainage group in subgroup analysis of only those patients with closed suction drainage vs. no drainage (NS).

Moreover, the results of the randomized study (186 patients) comparing open Penrose drain to closed suction drainage [31] suggested a decrease in the incidence of intra-peritoneal collections, respiratory complications (other than infections) and shorter hospital stay in the closed suction group. Conversely, no statistically significant difference was found between the two groups concerning mortality or pulmonary infections.

The Cochrane meta-analysis [5] therefore was unable to prove that an intra-abdominal drain could prevent the onset of any intra-peritoneal collection. Moreover, even if the difference was not statistically significant, SSI occurred twice as often in the drainage group. Another potential value of drains would be to detect potentially severe and life-threatening hemorrhage after hepatic resection, and for most authors, to measure the volume and rate of bleeding. However, no statistically significant difference was found in postoperative mortality between the two groups, suggesting that drainage does not allow detection of severe life-threatening bleeding in these patients. As for biliary leaks, this event was reported in only two trials in this meta-analysis. In the first, there were no biliary leaks in either of the two groups. In the second, there were two instances of biliary leak in the drainage arm. However, the biliary leak was detected by the drain in neither of these two patients (the first case was diagnosed during revisional surgery for sepsis, while the second was detected via interventional radiology). All in all, the prevalence of postoperative bleeding or biliary leak in this meta-analysis was relatively rare, but, of note, prophylactic drainage was of no help either in the detection or the treatment of this complication. Likewise, the study did not show that drainage could prevent or alert the clinician to accumulation of ascites in the cirrhotic patient undergoing liver resection.

In conclusion, in view of the results of this meta-analysis including high quality randomized trials, no argument could be made in favor of routine drainage during elective liver resections without bilio-intestinal anastomosis (level of evidence 1). However, further controlled trials are necessary to confirm these results in certain categories of patients (patients with chronic liver disease, cirrhosis), and after laparoscopic liver resection.

Value of drainage after proctectomy

The risk of anastomotic leak after total proctectomy with total mesorectal excision (TME) followed by low colorectal or colo-anal anastomosis ranges between 10% and 20% [2,32–34]. This relatively high-risk can be partly explained by collection of fluid in the non-peritonized dead space [35,36]. Effectively, after anterior resection of the

rectum, the large space left in front of the sacrum can set the stage for hematoma or seroma formation, susceptible of becoming infected. The rationale for routine prophylactic closed suction drainage is to decrease the risk of anastomotic leak by enhancing evacuation of postoperative peri-visceral fluid, and also to detect any anastomotic leak early, and to avoid re-operation [37]. The SFCD proposed a certain number of recommendations for drainage in gastro-intestinal surgery as early as 1999 [10]. These recommendations made a distinction between intra-peritoneal and infra-peritoneal colorectal anastomoses. While the level of evidence was high concerning the probable uselessness of prophylactic drainage after elective colonic surgery, the controlled studies concerning infra-peritoneal anastomoses (after rectal excision) were insufficient to come to any categorical conclusions and the consensual expert opinion favored closed pelvic suction drainage. Two studies with a high level of evidence have confirmed that prophylactic drainage was of no value after elective intra-peritoneal colonic surgery [8,9].

In a Cochrane meta-analysis that included 1140 patients in six randomized trials, 191 had undergone rectal excision, 78% of these for cancer [38]. Of note, only one of the six randomized studies concerned rectal surgery for cancer alone, and none for infra-peritoneal anastomoses alone. Moreover, concerning the goal of preventing or treating pelvic septic complications (anastomotic leak, pelvic abscess), present-day practice is not homogeneous among surgeons.

The specific problem of rectal surgery is that surgical morbidity is higher than in other colonic surgery [39]. Severe surgical morbidity includes grades III, IV and V in the Dindo-Clavien complication of surgical complications [40]. Surgical morbidity is approximately 20% according to the literature [41,42], specifically represented by pelvic septic complications, most often as a result of anastomotic disunion after rectal resection. Based on recent data from different European registries, the expected morbidity rate after sphincter-sparing rectal excision ranges from 9% to 12% [43–46]. The risk of anastomotic leak is not influenced by the type of approach (laparoscopy vs. laparotomy) [47], but is dependent on the level of the anastomosis (<6 cm from the anal verge), absence of protective ileostomy and male gender [34,44,48]. Likewise, the risk of re-intervention is between 5% and 9% [34,42], principally related to pelvic septic complications. Lastly, the risk of mortality ranges from 7% to 13% after anastomotic leak occurs, with a rate of definitive stoma between 10% and 20% [34,44,46].

The literature concerning pelvic drainage after sphincter-sparing rectal excision, excluding retrospective studies and studies evaluating intra-peritoneal anastomoses, is composed of three randomized trials [35,36,49], two comparative prospective studies [2,44] and three meta-analyses [8,9,38] (Table 4). It is important to note that the randomized study that provided most of the data described patients who had not undergone neoadjuvant radiation therapy; these patients routinely had a protective ileostomy for colo-anal anastomosis, while performance of a protective ileostomy varied according to surgeon preference for low colorectal anastomosis [36]. Overall, the three meta-analyses found no significant differences in terms of mortality or SSI. In the meta-analysis by Urbach et al., including four randomized studies with a total of 414 patients undergoing colorectal anastomosis, the authors questioned the role of early detection of pelvic sepsis via a pelvic drain since, among the 20 patients with drains who developed an anastomotic leak, the diagnosis was made

Table 4 Main characteristics of published studies on the value of prophylactic drainage for proctectomy.

Authors and references	Year	Type of study	Number of patients	Main results
Urbach et al. [8]	1999	Meta-analysis of 4 randomized trials (colon and rectum)	223 Drainage group 188 No drainage group	No significant difference in mortality, SSI rates
Petrowsky et al. [9]	2004	Meta-analysis of 8 randomized trials (colon and rectum)	717 Drainage group 673 No drainage group	No significant difference in mortality, SSI rates
Jesus et al. [38]	2004	Meta-analysis of 6 randomized trials (colon and rectum)	Subgroup rectum (2 randomized trials) 94 Drainage group 97 No drainage group	No significant difference in anastomotic leak, mortality or SSI rates
Peeters et al. [44]	2005	Multicenter randomized TME vs. Radiochemotherapy + TME	792 Drainage group 132 No drainage group	Pelvic drainage associated with less risk of anastomotic leak in uni- and multi-variable analysis

TME: total mesorectal excision; SSI: surgical site infection.

on the basis of intestinal content in the effluent in only one patient (5%) [8]. In contrast to this study, in which no specific subgroup analysis on intra-peritoneal anastomosis was performed, Jesus et al. [38] distinguished a subgroup of patients with infra-peritoneal anastomoses only. They found no statistically significant difference between the two groups concerning the anastomotic leak rate (11.7% vs. 13.4%; OR: 0.85 and a 95% CI: 0.36–2). Of note, only two randomized trials were included in this subgroup, with a total of just 191 patients: drainage $n=94$ vs. no drainage $n=97$ [35,36]. These results contrast with the outcome reported in a Dutch multicenter study on risk factors for anastomotic leak in a group of 924 patients treated by TME with or without radiation therapy; this study suggested that the absence of pelvic closed suction (RR=2.53, $P<0.001$) and the absence of ileostomy (RR=1.89, $P=0.003$) were independently associated with an increased risk of anastomotic leak. Moreover, in case of anastomotic leak, the risk of surgical re-operation was reduced when the patient had pelvic drainage and a protective stoma [44].

In conclusion, it is therefore difficult to propose any formal recommendations concerning the utility of pelvic drainage after rectal excision, and in particular for cancer, because the data come from subgroup analyses or non-comparative studies. A French randomized trial from the Groupe de REcherche Chirurgical sur le Cancer du Rectum (GRECCAR5, NCT01269567), which goal was to evaluate the impact of pelvic drainage on the risk of pelvic sepsis after rectal excision for cancer and infra-peritoneal anastomosis, is now terminated. The results of this study should be known during the year 2015.

Conclusion

The policy of routine drainage of the abdominal cavity in elective gastro-intestinal surgery is currently under evidence-based scrutiny. The interpretation of the current literature should take into account the type of surgery and the quality of the studies.

For gastrectomy, the level of evidence is low, but the results of four randomized trials and one meta-analysis suggest there is no necessity to drain for neither total nor partial gastrectomy.

Concerning pancreatotomy, the data do not allow recommendation against drainage, and tend to point to a

probable benefit in short-term drainage in selected patients. An answer might come from the French study underway.

For liver resection, the level of evidence is high: there is no need to drain the abdomen routinely in the absence of bilio-intestinal anastomosis.

As concerns proctectomy, the level of evidence is low and the analysis does not allow any conclusion on the utility of pelvic drainage after rectal excision. Here again, the results of the GRECCAR5 trial are awaited this year.

All in all, the literature increasingly suggests that routine drainage of the abdominal cavity is obsolete, except in the case of pancreatotomy where short-term drainage seems to have its place.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References

- [1] Liu CL, Fan ST, Lo CM, et al. Abdominal drainage after hepatic resection is contraindicated in patients with chronic liver diseases. *Ann Surg* 2004;239:194–201.
- [2] Yeh CY, Changchien CR, Wang JY, et al. Pelvic drainage and other risk factors for leakage after elective anterior resection in rectal cancer patients: a prospective study of 978 patients. *Ann Surg* 2005;241:9–13.
- [3] Kumar M, Yang SB, Jaiswal VK, et al. Is prophylactic placement of drains necessary after subtotal gastrectomy? *World J Gastroenterol* 2007;13:3738–41.
- [4] Nomura T, Shirai Y, Okamoto H, et al. Bowel perforation caused by silicone drains: a report of two cases. *Surg Today* 1998;28:940–2.
- [5] Gurusamy KS, Samraj K, Davidson BR. Routine abdominal drainage for uncomplicated liver resection. *Cochrane Database Syst Rev* 2007;3:CD006232.
- [6] Monson JR, Guillou PJ, Keane FB, et al. Cholecystectomy is safer without drainage: the results of a prospective, randomized clinical trial. *Surgery* 1991;109:740–6.
- [7] Cerise EJ, Pierce WA, Diamond DL. Abdominal drains: their role as a source of infection following splenectomy. *Ann Surg* 1970;171:764–9.
- [8] Urbach DR, Kennedy ED, Cohen MM. Colon and rectal anastomoses do not require routine drainage: a systematic review and meta-analysis. *Ann Surg* 1999;229:174–80.

- [9] Petrowsky H, Demartines N, Rousson V, et al. Evidence-based value of prophylactic drainage in gastrointestinal surgery: a systematic review and meta-analyses. *Ann Surg* 2004;240:1074–84.
- [10] Mutter D, Panis Y, Escat J. Drainage in digestive surgery. *French Society of Digestive Surgery. J Chir* 1999;136:117–23.
- [11] Wang Z, Chen J, Su K, Dong Z. Abdominal drainage versus no drainage post-gastrectomy for gastric cancer. *Cochrane Database Syst Rev* 2015;5:CD008788.
- [12] Alvarez Uslar R, Molina H, Torres O, et al. Total gastrectomy with or without abdominal drains. A prospective randomized trial. *Rev Esp Enferm Dig* 2005;97:562–9.
- [13] Kim J, Lee J, Hyung WJ, et al. Gastric cancer surgery without drains: a prospective randomized trial. *J Gastrointest Surg* 2004;8:727–32.
- [14] Mariette C. Is there a place for esogastric cancer surgery in cirrhotic patients? *Ann Surg Oncol* 2008;15:680–2.
- [15] Delpero JR, Paye F, Bachellier P. *Cancer du pancréas. Monographie de l'Association Française de Chirurgie (AFC)*. Paris: Arnette; 2010.
- [16] Melloul E, Raptis DA, Clavien PA, Lesurtel M. Poor level of agreement on the management of postoperative pancreatic fistula: results of an international survey. *HPB* 2013;15:307–14.
- [17] Bassi C, Molinari E, Malleo G, et al. Early versus late drain removal after standard pancreatic resections: results of a prospective randomized trial. *Ann Surg* 2010;252:207–14.
- [18] Yeo CJ. Pancreatic surgery 101: drain, no drain, early drain removal, or late drain removal. What are the data? Where do we go from here? *Ann Surg* 2010;252:215–6.
- [19] Schmidt CM, Choi J, Powell ES, et al. Pancreatic fistula following pancreaticoduodenectomy: clinical predictors and patient outcomes. *HPB Surg* 2009;2009:404520, <http://dx.doi.org/10.1155/2009/404520>.
- [20] Kawai M, Tani M, Terasawa H, et al. Early removal of prophylactic drains reduces the risk of intra-abdominal infections in patients with pancreatic head resection: prospective study for 104 consecutive patients. *Ann Surg* 2006;244:1–7.
- [21] Fisher WE, Hodges SE, Silberfein EJ, et al. Pancreatic resection without routine intraperitoneal drainage. *HPB* 2011;13:503–10.
- [22] Mehta VV, Fisher SB, Maithel SK, Sarmiento JM, Staley CA, Kooby DA. Is it time to abandon routine operative drain use? A single institution assessment of 709 consecutive pancreaticoduodenectomies. *J Am Coll Surg* 2013;216:635–42.
- [23] Correa-Gallego C, Brennan MF, D'Angelica M, et al. Operative drainage following pancreatic resection: analysis of 1122 patients resected over 5 years at a single institution. *Ann Surg* 2013;258:1051–8.
- [24] Adham M, Chopin-Laly X, Lepilliez V, Gincul R, Valette PJ, Ponchon T. Pancreatic resection: drain or no drain? *Surgery* 2013;154:1069–77.
- [25] Conlon KC, Labow D, Leung D, et al. Prospective randomized clinical trial of the value of intraperitoneal drainage after pancreatic resection. *Ann Surg* 2001;234:487–93.
- [26] Van Buren G, Bloomston M, Hughes SJ, et al. A randomized prospective multicenter trial of pancreaticoduodenectomy with and without routine intraperitoneal drainage. *Ann Surg* 2014;259:605–12.
- [27] Belghiti J, Kabbej M, Sauvanet A, Vilgrain V, Panis Y, Fekete F. Drainage after elective hepatic resection. A randomized trial. *Ann Surg* 1993;218:748–53.
- [28] Fong Y, Brennan MF, Brown K, Heffernan N, Blumgart LH. Drainage is unnecessary after elective liver resection. *Am J Surg* 1996;17:158–62.
- [29] Fuster J, Llovet JM, Garcia-Valdecasas JC, et al. Abdominal drainage after liver resection for hepatocellular carcinoma in cirrhotic patients: a randomized controlled study. *Hepatogastroenterology* 2004;51:536–40.
- [30] Sun HC, Qin LX, Lu L, et al. Randomized clinical trial of the effects of abdominal drainage after elective hepatectomy using the crushing clamp method. *Br J Surg* 2006;93:422–6.
- [31] Uetsuji S, Kwon AH, Komada H, Okuda Y, Imamura A, Kamiyama Y. Clinical evaluation of closed suction drainage following hepatectomy. *Surg Today* 1997;27:298–301.
- [32] Karanjia ND, Corder AP, Bearn P, et al. Leakage from stapled low anastomosis after total mesorectal excision for carcinoma of the rectum. *Br J Surg* 1994;81:1224–6.
- [33] Carlsen E, Schlichting E, Guldvog I, et al. Effect of the introduction of total mesorectal excision for the treatment of rectal cancer. *Br J Surg* 1998;85:526–9.
- [34] Matthiessen P, Hallbook O, Rutegard J, et al. Defunctioning stoma reduces symptomatic anastomotic leakage after low anterior resection of the rectum for cancer: a randomized multicenter trial. *Ann Surg* 2007;246:207–14.
- [35] Merad F, Hay JM, Fingerhut A, et al. Is prophylactic pelvic drainage useful after elective rectal or anal anastomosis? A multicenter controlled randomized trial. *French Association for Surgical Research. Surgery* 1999;125:529–35.
- [36] Brown SR, Seow-Choen F, Eu KW, Heah SM, Tang CL. A prospective randomized study of drains in infra-peritoneal rectal anastomoses. *Tech Coloproctol* 2001;5:89–92.
- [37] Hilsabeck JR. The presacral space as a collector of fluid accumulations following rectal anastomosis: tolerance of rectal anastomosis to closed suction pelvic drainage. *Dis Colon Rectum* 1982;25:680–4.
- [38] Jesus EC, Karliszek A, Matos D, Castro AA, Atallah AN. Prophylactic anastomotic drainage for colorectal surgery. *Cochrane Database Syst Rev* 2004;2:CD002100.
- [39] Alves A, Panis Y, Trancart D, Regimbeau JM, Pocard M, Valleur P. Factors associated with clinically significant anastomotic leakage after large bowel resection: multivariate analysis of 707 patients. *World J Surg* 2002;26:499–502.
- [40] Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg* 2004;240:205–13.
- [41] Marijnen CAM, Kapitejn E, Van de Velde CJH, et al. Acute side effects and complications after short-term preoperative radiotherapy combined with total mesorectal excision in primary rectal cancer: report of a multicenter randomized trial. *J Clin Oncol* 2002;20:817–25.
- [42] Alves A, Panis Y, Mathieu P, Kwiatkowski F, Slim K, Mantion G. Mortality and morbidity after surgery of mid and low rectal cancer: results of a French prospective multicentric study. *Gastroenterol Clin Biol* 2005;29:509–14.
- [43] Marusch F, Koch A, Schmidt U, et al. Early postoperative results of surgery for rectal carcinoma as a function of the distance of the tumor from the anal verge: results of a multicenter prospective evaluation. *Langenbecks Arch Surg* 2002;387:94–100.
- [44] Peeters KC, Tollenaar RA, Marijnen CA, et al. Risk factors for anastomotic failure after total mesorectal excision of rectal cancer. *Br J Surg* 2005;92:211–6.
- [45] Faucheron JL, Rullier E. *Cancer du rectum. Monographie de l'Association Française de Chirurgie (AFC)*. Paris: Arnette; 2009.
- [46] Eriksen MT, Wibe A, Norstein J, et al. Anastomotic leakage following routine mesorectal excision for rectal cancer in a national cohort of patients. *Colorectal Dis* 2005;7:51–7.
- [47] Guillou PJ, Quirke P, Thorpe H, et al. Short-term end points of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomized controlled trial. *Lancet* 2005;365:1718–26.
- [48] Rullier E, Laurent C, Garrelon JL, et al. Risk factors for anastomotic leakage after resection of rectal cancer. *Br J Surg* 1998;85:355–8.
- [49] Sagar PM, Hartley MN, Mccie J, Mancey-Jones B, Sedman P, May J. Randomized trial of pelvic drainage after rectal resection. *Dis Colon Rectum* 1995;38:254–8.
- [50] Jiang ZW, Li JS, Wang ZM, et al. Prospective randomized study of abdominal drains in gastric cancer surgery. *Chin J Pract Surg* 2008;28:761–2.