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EDITORIAL PERSPECTIVE

To Drain or not to Drain? The Role of Drainage in the Contaminated and Infected Abdomen: An International and Personal Perspective

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The history of abdominal drainage is as old as the history of surgery [1]. However, abdominal drainage has always been a subject of controversy, practiced in confusion and subjected to local dogmas. Hence, a hundred years ago there were ardent enthusiasts for drainage, like Robert Lawson Tait (1845–1899), who stated: "When in doubt drain!" There were also the skeptics, like J. L. Yates (1905), who understood that "Drainage of the general peritoneal cavity is a physical and physiological impossibility." And, as always, there were the undecided, as described by Joseph Price (1853–1911): "There are those who ardently advocate it, there are those who in great part reject it, there are those who are lukewarm concerning it, and finally, some who, without convictions, are either for or against it … as chance or whim, not logic may determine."

A hundred years have passed, during which operative surgery and supporting care have progressed astonishingly; but what about drainage? Is the practice of drainage any less controversial, more rational, and less confused today? What should drainage practice be?

In this brief article I attempt to answer these questions, with the focus on drainage after emergency operations for abdominal contamination and infection. Elective procedures are mentioned only if relevant to the discussion. Percutaneous drainage of primary and postoperative abdominal collections is beyond the scope of this communication.

This article was adapted from an Internet course on surgical infections by the Surgical Infection Society of Europe.

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Classification of drainage

Surgeons, or some of them, drain the abdomen for therapeutic reasons or for prophylactic reasons:

For therapeutic reasons, drains are placed:

- to provide egress for established intra-abdominal contamination or infection (e.g., peri-appendicular abscess, diffuse fecal peritonitis)
- to control a source of infection that cannot be controlled by other means, by creating a "controlled" external fistula (e.g., a leaking duodenal suture line).

Prophylactic drainage is employed:

- to prevent recurrent infection (e.g., in the hope that by evacuating residual serum and blood, abscess formation can be prevented)
- to control "prospective" or "expected" leakage form a suture line (e.g., drainage of a colonic anastomosis, or duodenal closure, or cystic duct closure)
- to warn about complications (e.g., in the belief that drains would sound a warning bell, providing evidence of postoperative bleeding or anastomotic leakage)

Rather than dwell on the subject through rigid classifications, it is useful to deal with drainage through the eyes of a general surgeon: What is the current practice? After common abdominal procedures, what should the current practice be?

What is the current practice?

The literature is a poor source of information about how prevalent abdominal drainage is after emergency surgery. From the few published single-center studies, or collective

reviews about drainage for specific conditions, we cannot deduce trends or prevailing fashion. Therefore we polled general surgeons who are members of SURGINET, an international surgical discussion forum on the Internet [2], about their approach to abdominal drainage. Of the 700 subscribed members, only 71 replied (~ 10%). Although this response rate appears to be poor, it parallels the usual participation rate on Internet lists, with most subscribers preferring to "lurk" passively rather than be vocal.

The 71 respondents, all general surgeons, most of them nonacademic "bread and butter" surgeons, practice in 23 different countries, with the highest number responding from the USA (14). There were 18 respondents from North America; the others were from West Europe (10), East Europe (7), Asia (15)—this included Israel and Turkey—Latin America (15), and Australia and South Africa (3 each).

I should mention that surgeons who are active on such Internet lists tend to be more "interested," more tuned to the international literature and "modern practices" (whatever *modern* may mean) than the "average" surgeon, who commonly is a prisoner of local dogmas and surgical hierarchy. The results of this poll reflect the current controversies and geographical differences in practice, while showing a paradigm shift.

Common situations during which drains may be used

Acute appendicitis

Tables 1 and 2 lists the questions posed and summarizes the surgeons responses. The cases presented are not "simple" or "phlegmonous" appendicitis but complicated appendicitis: the appendix is black; usually there is some fluid around it or in the pelvis; but there is no frank pus. As shown in Table 1, only one of the respondents would leave a drain in this situation. Next, the appendix is perforated; the surgeon, working via laparotomy or laparoscopy, removes it and suctions the pus floating around it. In such cases, the surgeon may have to break adhesions formed by omentum or small bowel and expose a small abscess; with insertion of a suction device into the pelvis, a few cubic centimeters of pus are removed. Table 2 shows that almost 80% of respondents would not consider drainage in this situation. Among those who do advocate drainage, it does not seem that their geographic location influenced their decision.

Table 3 illustrates an advanced, neglected case, where the perforated appendix is associated with pus "everywhere"—in the pelvis, the right paracolic gutter, and even the upper abdomen. Table 3 suggests that, although the percentage of surgeons who would not drain remains around 80%, there is a change in the geographical pattern: none, or almost none, of the North American and Latin American surgeons, would drain, whereas many of the surgeons in Asia would. This difference has to do with how surgeons view the value of drainage in diffuse peritonitis, a complication that is discussed below.

Table 1 Would you place a drain after an appendectomy for gangrenous appendicitis?

	Number	No	Yes
North America	18	18	
Western Europe	10	10	
Eastern Europe	7	7	
Latin America	15	15	
Asia	15	14	1
Australia	3	3	
South Africa	3	3	
Total	71	70 (98%)	1

Table 2 Would you place a drain after an appendectomy for perforated appendicitis with local pus formation?

	Number	No	Yes
North America	18	14	4
Western Europe	10	8	2
Eastern Europe	7	6	1
Latin America	15	11	4
Asia	15	12	3
Australia	3	3	0
South Africa	3	2	1
Total	71	56 (78%)	15

Drainage in acute appendicitis

In 1979, O'Connor and Hugh, in their excellent review, concluded [1]: "The weight of evidence suggests that intraperitoneal drainage is of little value in appendicitis, whether the appendix is inflamed, gangrenous, or perforated. However, drains are indicated if there is localized

Table 3 Would you place a drain after an appendectomy for perforated appendicitis with diffuse pus formation?

	Number	No	Yes
North America	18	18	–
Western Europe	10	8	2
Eastern Europe	7	5	2
Latin America	15	14	1
Asia	15	7	8
Australia	3	2	1
South Africa	3	1	2
Total	71	55 (77%)	16

abscess cavity, or if the gangrenous stump closure is imperfect."

I won't burden you with detailed review of all the literature available, for Petrowsky et al. have recently produced a superb analysis of such studies [3]. After analyzing individual studies, including their own meta-analysis, these authors concluded that "drainage did not reduce postoperative complications and even appeared harmful in respect to the development of fecal fistula (the development of fecal fistula was only observed in drained patients) … drains should be avoided in any stage of appendicitis" [4].

Drainage after appendectomy for phlegmonous or gangrenous appendicitis is unnecessary. It seems that most surgeons, at least the responders to this poll, understand this. What about perforated appendicitis with local pus formation? Even though the literature cannot support—and even condemns—drainage in such situation, 22% of our responders would leave a drain. As noted later in this article, "formed" or "noncollapsible" abscesses are considered by many surgeons to be a good indication for drainage. This is probably why some surgeons are compelled to leave a drain in when any collection of pus is observed. But the abscesses associated with perforated appendicitis are never "noncollapsible": after the surgeon breaks down the walls and evacuates the pus, the potential space for the abscess is filled by adjacent bowel, mesentery, and omentum. Thus once the source of infection has been removed and the peritoneum has been cleansed by "peritoneal toilet," it is best to let the superb peritoneal defense mechanisms, supported by a short course of systemic antibiotics, complete the total eradication of bacteria without being disturbed by a foreign body (i.e. drain) [4].

Insecure closure of the appendiceal stump as a justification for drainage seems anachronistic: secure closure is also possible in the rare event that the appendix is perforated at its base, by including in the suture or stapler line a "disk" of adjacent cecal wall.

Twenty-three percent of the surgeons responding to our questionnaire would use drains if the appendicitis was associated with diffuse peritonitis. But, as we'll see later, those are the surgeons who advocate drainage in generalized intra-abdominal infection, and drainage in this situation—after the source control of infection has been achieved—represents an exercise in futility.

Acute cholecystitis

Now the surgeon is performing a "difficult" laparoscopic cholecystectomy on a patient with advanced acute cholecystitis. The dissection is not easy; it is time consuming and it is associated with irritating ooze from the liver.

Table 4 Would you place a drain following an open or laparoscopic cholecystectomy for severe acute cholecystitis?

	Number	No	Yes
North America	18	12	6
Western Europe	10	8	2
Eastern Europe	7	1	6
Latin America	15	14	1
Asia	15	7	8
Australia	3	2	1
South Africa	3	3	
Total	71	47 (66%)	24

Perhaps it becomes necessary to convert to an open operation in order to complete the procedure. The questions remains: "Would you leave a drain in the gallbladder bed or below the liver?" A third of the responders would (Table 4). Please note that the emphasis was on "routine drainage," and many responders mentioned that they would drain *selectively* if unhappy with closure of cystic duct, or if expecting excessive oozing.

Drainage after cholecystectomy for acute cholecystitis

A large prospective randomized study from 1991, and meta-analysis of 1,920 patients (undergoing open cholecystectomy) summarizing 10 similar studies, showed that the results in the non-drained patients matched those in the drained ones, in terms of the mortality rate and the need for reoperation and/or drainage of residual bile collections. Wound infections were more common in the drained patients [5]. Thus toward the end of the open cholecystectomy era, routine drainage—once a "sacred cow" of gallbladder surgery—was disappearing from many centers.

Did the emergence of laparoscopy influence this trend? In a recent survey of Australian surgeons, one-third reported using drains routinely [6]. One small prospective randomized study comparing drainage to non-drainage in laparoscopic cholecystectomy—attempting to assess the benefits of drainage in reducing postoperative pain and nausea by removing excessive gas—failed to show any differences in outcome [7]. If routine drainage is not beneficial in open cholecystectomy, why should it be used in the laparoscopic setting? Thus, Petrowsky et al. marked their recommendation for no routine drainage after open or laparoscopic cholecystectomy as "Grade A"—based on level 1a evidence [3]. In a prospective study in 100 patients undergoing laparoscopic cholecystectomy for acute cholecystitis all patients had a cholescintigraphy study on postoperative day 1. Bile leaks were documented in eight patients; all remained asymptomatic [8]. That most post-

cholecystectomy collections, whether composed of bile, serum, or blood, remain asymptomatic and are absorbed by the peritoneum, was well known from ultrasonographic studies during the open cholecystectomy era.

Drains are much more efficient in draining bile than feces or pus. Thus, it would be reasonable to leave a drain if the surgeon has cause to worry about an unsolved or potential bile leak. For example, when there may be a need for subtotal cholecystectomy, or when there is difficulty with controlling the opening of a cystic duct, or there might be bile staining in the lavage fluid or the gallbladder bed, hinting at the possibility that an accessory duct has been missed. Finally, there may be what appears to be an imperfect closure of the cystic duct for any of a variety of reasons.

So, although most patients do not need a drain, if the surgeon is worried about the possibility of bile leak or excessive ooze, a drain should be left in place. Most such drains would drain almost nothing; only very rarely does the prophylactic drain become therapeutic by draining a large and persisting amount of bile. When the need for a drain is uncertain, it is very important that they be removed as soon as possible. A dry drain after 24 h indicates that it has served its limited role. Lastly, Howard Kelly (1858–1943), said that "Drainage is a confession of imperfect surgery." Surgeons should be cautioned not to confirm this statement in practice: If it safer to convert to an open procedure and safely suture an ultra-short cystic duct than to rely on faulty clip closure and a drain, then the choice is clear.

Drainage after omentopexy for perforated ulcer

If you have just repaired a perforated duodenal ulcer with a patch of omentum. Would you leave a drain? Eighty percent of the respondents would not (Table 5).

The literature dealing specifically with drainage after omentopexy is scanty. A small prospective randomized trial reported by Pai et al. [9] is perhaps the most informative: in terms of management of peritonitis, drainage (multiple drains were used) did not reduce the incidence of intraperitoneal fluid collections or abscesses, and it did not improve the postoperative course. Leakage from the repaired perforation site developed in four of the patients with drains (5.3%) and in one of the patients without drainage (2.3%). All patients with leakage died. The drain site became infected in 10% of patients; one needed a laparotomy to free small bowel entangled around a drain, and another developed hemorrhage from a drain site. On the basis of this study and their own opinion, Petrowsky at al. concluded that the "…omental patch technique for perforated ulcer appears to be safe without prophylactic drainage, and routine drainage cannot be recommended" [3].

Table 5 Would you place a drain following repair of a perforated peptic ulcer with an omental patch?

	Number	No (%)	Yes (%)
North America	18	17	1
Western Europe	10	9	1
Eastern Europe	7	3	4
Latin America	15	13	2
Asia	15	9	6
Australia	3	3	
South Africa	3	3	
Total	71	57 (80%)	14

Omental patch repair, if correctly performed (not placed over the sutured perforation but included–without being strangulated—within the suture line) and tested (by instilling dye through a nasogastric tube) should be leak-proof. In addition, the presence of drain(s) when a leak occurs is usually not lifesaving [9]. A "side" leak from the duodenum is a very serious complication, almost impossible to control with simple drainage alone; instead, to improve chances of survival, re-operation is required to stop the leak (e.g., a Billroth II gastrectomy) or at least to convert the '"side" duodenal fistula to a more manageable "end" duodenal fistula (e.g., gastroenterostomy plus tube duodenostomy or duodenal exclusion). A futile reliance on the drain when a leak develops, postpones life-saving reoperation and hastens death.

What about laparoscopic omental patch repair—an increasingly popular procedure? Does it change the (non)indication for drainage? With leaks after omentopexy being so rare and large series comparing open to laparoscopic repair so scanty, it is difficult to know whether leaks are more common after laparoscopic repairs. However, surgeons who are used to open omentopexy should be alarmed to see leakage rates of 6%–16% following laparoscopic repair [10]. It may be that the "learning curve"—the inability to feel the tension placed on the sutures placed to tie down the patch or the reliance on suture closure rather than using the omentum—make the laparoscopic approach more prone to leakage. Still, I have to wonder if using a drain would help avoid disaster. I doubt it. In conclusion, for the surgeon who knows how to do a proper and safe omental repair, draining it would be superfluous. But the surgeon who is learning to do a laparoscopic repair (with the declining number of peptic ulcerations, you may never reach the top of the learning curve…), may want to leave a drain. Using a drain won't avoid the need for reoperation if leakage develops, but it may provide early warning that there is a leak that requires reoperation. However, a well-timed contrast study (with or without CT)

would provide more information than the often poorly placed and nonproductive drain.

Colonic emergencies

The questions of drainage after emergency resection of a perforated sigmoid colon, without primary anastomosis or with primary anastomosis, can be discussed together. In both situations source control has been achieved by the colectomy; thus the rational for drainage would be either "therapeutic"—to help treat the associated intraperitoneal infection—or "prophylactic"—to prevent collections or to "control" potential leakage from the suture line (e.g., rectal stump closure). About 60% of respondents to both questions (Tables 6 and 7) would not drain routinely; the slightly higher numbers who would do so after primary anastomosis probably signify that they feel that such "high-risk" anastomosis deserves a drain.

The topic of drainage after emergency left colon resection with or without anastomosis has been the subject of intense debate for 30 years. Proponents have claimed that drains would avoid reoperation if anastomotic leaks were to develop, whereas critics contended that drains actually contribute to leaks. It would be difficult to improve on the review and meta-analysis of eight high-level studies by Petrowsky et al. [3], which included both elective and emergency patients in the drained and not-drained groups. All eight studies showed no difference in postoperative complications, and some suggested higher wound infection rates in the drained patients. The authors' meta-analysis suggests a slight advantage for non-drained patients with respect to clinical leakage [3]. This confirmed an earlier meta-analysis by Urbach et al. [11], which concluded that: "Any significant benefit of routine drainage of colon and rectal anastomoses in reducing the rate of anastomotic leakage or other surgical complications can be excluded with more confidence based on pooled data than by the individual trials alone." These authors also showed that of "the 20 observed leaks, among all four studies, that occurred in a patient with a drain in place, in only one case (5%) did pus or enteric content actually appear in the effluent of the existing drain" [11]. Even the overly cautious Chocrane Review joined the chorus, concluding that "there is insufficient evidence showing that routine drainage after colorectal anastomoses prevents anastomotic and other complications" [12].

Surgeons decide to drain in these situations for a few reasons:

The first is to help combat or prevent residual or recurrent intra-abdominal infection, respectively, by removing secretions or draining the peri-colic abscess found and already drained during operation. The futility of peritoneal drainage in achieving such goals has been discussed above (see acute appendicitis) and will be reemphasized below.

The second is to drain the anastomosis should it leak. But, first, high risk, prone to leakage anastomoses should not be constructed in the emergency situation; and, second, as the literature points out, drains do not help much if leakage develops—not to speak about the false sense of security it tends to provide.

The third is to provide drainage to the rectal closure (Hartmann pouch)—should it leak. But a solid stapler or hand closure of the healthy rectum away from the colonic inflammation should provide a leak proof

Table 6 Would you place a drain following a Hartman's procedure for perforated sigmoid diverticulitis or cancer?[a]

	Number	No	Yes
North America	18	15	3
Western Europe	10	8	2
Eastern Europe	7	2	4 (1 not doing colons)
Latin America	15	12	3
Asia	15	6	9
Australia	3	1	2
South Africa	3	3	
Total	71	47 (66%)	24

[a] Three mentioned no routine drainage but may drain if rectal stump closure is questionable

Table 7 Would you place a drain following a colectomy and primary anastomosis for perforated sigmoid diverticulitis or cancer?

	Number	No	Yes	Comments
North America	18	14	3	1 (never did primary anastomosis)
Western Europe	10	5	5	
Eastern Europe	7	2	3	1 (not doing colons); 1 (never did primary anastomosis)
Latin America	15	10	4	1 (never did primary anastomosis)
Asia	15	3	11	1 (never did primary anastomosis)
Australia	3	1	2	
South Africa	3	3	–	
Total	71	43 (60%)	28	

Table 8 Would you drain the peritoneum in generalized peritonitis?

	Number	No	Yes
North America	18	17	1
Western Europe	10	8	2
Eastern Europe	7	2	5
Latin America	15	12	3
Asia	15	5	10
Australia	3	2	1 (only the pelvis)
South Africa	3	1	2
Total	71	47 (66%)	24

closure. When, however, the closure seems 'too difficult' then the rectal stump should be left partially open as advocated by John Goligher [13]. Be it as it may; only a pathological optimist could hope that feces will climb up the drain up the pelvis, that is if the drain is not already clogged by fibrin, clots or pure feces. In conclusion: drains after emergency colonic resection are waste of time!

Drainage in generalized peritonitis

In the case of generalize perotinitis, only about a third of respondents would drain the peritoneal cavity (Table 8). The distribution of responses here parallels that of replies to questions 3, 5, 6, and 7, suggesting that Asian and Eastern European surgeons believe in the value of drainage in localized and diffuse intra-abdominal infections.

Obviously, no comparative studies of drainage versus non-drainage in patients with diffuse peritonitis have been conducted, because the futility of drainage in this situation was perceived long ago by experts in surgical infections. The modern view, endorsed by the Surgical Infection Society and offered by Rotstein and Meakins [14], maintains: "It is impossible to drain the peritoneal cavity in patients with diffuse peritonitis. Therefore, the use of drains in these patients is not indicated unless (1) the drain is to be used for postoperative lavage; (2) the drain is placed into a well-defined abscess cavity, or (3) the drain is used to establish a controlled fistula."

I recall, when I was a junior resident, postoperative patients with multiple rubber drains sticking out of each and every quadrant of their distended bellies. Those drains produced some old blood, or perhaps a little pus or foul-smelling fluid. When such patients died, their death was often blamed on "pneumonia." How stupid we were—believing that those drains were useful! Gradually we came to understand how worthless they are: all intraperitoneal drains are sealed off by adjacent tissue within 24–48 h, unless they are "perfused" by liquid effluent, such as bile. In peritonitis, a round suction drain would drain almost nothing, and a non-suction rubber drain (e.g., Penrose, corrugated) would simply drain itself—the infected tract it has created.

The only indication for using a drain in general peritonitis is to control an uncontrollable source of infection, such as a leaking duodenal suture line or a leaking gastroesophegal anastomosis. I am skeptical of the terms "well-defined abscess" or "formed abscess" as indications for peritoneal drainage. Such "abscesses" are pus collections that are part of the peritonitis; after evacuation, they should be treated like the rest of the infected peritoneum: let peritoneal defenses and antibiotics do the job. Without doubt, postoperative peritoneal lavage, as mentioned earlier [14], belongs to history.

In conclusion, it is important to understand that drains in diffuse peritonitis are senseless. However, recurrent or persistent intra-abdominal infection may develop, requiring percutaneous drainage or reoperation. A drain won't change this, and the fact that computerized tomography (CT) is not available in your environment should not change the indications for drainage, as discussed further below.

Obligatory drainage

What were the situations considered "obligatory for drainage"? This nonstructured question allowed respondents to reply in their own words. The responses were then edited and listed according the categories shown in Table 9. There is not much science here, but only common sense as practiced by experienced surgeons. Their priorities are as follows:

- The number of one indication, and rightly so, was the high probability leakage of bile or pancreatic juice. The fluid bile and pancreatic juice are well collected and evacuated by drains. A drain placed for a biliary or pancreatic leak may be life saving and curative.
- The second indication for drainage was the case of an established pus-containing abscess. Thus, many surgeons believe that a well-formed collection of pus deserves a drain. Many respondents emphasized the term "noncollapsible abscess" or "thick-walled abscess" as an indication for drainage. I wonder, though, does one really find such abscesses within the abdomen?
- The third most common indication for placing a drain was the surgeons' lack of satisfaction with "source control." Respondents expressed this indication in many different ways. It overlapped with other indications, such as bile leak, urinary leak, or impossibility to exteriorize leaking proximal jejunum or duodenum.

Table 9 In which situations would you always drain?

	Situation	Number of respondents	Comments[a]
1.	High probability of leakage of bile or pancreatic juice	37	
2.	Established pus-containing abscess	31	Many emphasized "thick wall" or "noncollapsible abscess"
3.	Not satisfied with "source control"	11	Some say, "When I expect a leak"
4.	Difficult duodenal suture line	6	
5.	High probability leak of urine	4	
6.	Esophageal suture line	2	
7.	Expected bleeding	3	Usually 24–48 h of drainage

[a] There was significant overlap between replies. Isolated replies: "Never always," "after laparotomy," "extensive pelvic dissection," "pressure from Boss."

- A difficult duodenal suture line—i.e., the prone to leakage duodenal stump after Billroth II gastrectomy—is another reasonable indication for prophylactic drainage. The retroperitoneal duodenum is more susceptible to leakage, and thus draining it would make sense (e.g., after duodenotomy to control post-ERCP [endoscopic retrograde cholangiopancreatography] hemorrhage).
- Other indications, such as prophylactic drainage when leakage of urine is likely or drainage of esophageal suture lines, are also reasonable. About drainage for expected bleeding, it was said: "If you have to use drains to take care of postoperative hemorrhage, then you did not finish the operation." In most cases in which drains are placed for bleeding or oozing, they are unnecessary and produce little; they also produce little when severe bleeding develops—showing only the tip of the iceberg.

Which drains?

When asked which drains to use, the respondents came up with a potpourri of devices made by different manufacturers, and named differently across the geographical locations. In Table 9 replies are classified according to whether the drains are "active" (round tubes connected to suction) or "passive" (round or flat drains, depending on

Table 10 Which type of drain do you use?

Location	Number	Active/suction	Passive	Other/comments
North America	18	JP (13)		Sump (1, "if large chunks of tissue")
		Blake (4)		
		"Round closed" (1)		
Western Europe	10	"Easy flow" (2)	Robinson-passive (1)	Not stated (1)
		JP (1)	"Round passive" (1)	
		Redivac (1)	JP-passive (1)	
		"Suction" (1)	"Passive" (1)	
Eastern Europe	7	Blake (1)	"Passive" (1)	Not stated (2)
			"Closed passive" (3)	
Latin America	15	JP (4)	Penrose (5)	"Usually 'closed' but 'corrugated' if fecal fistula expected" (1) Latex (? passive" (1) "Suction in pelvis for blood but passive for anastomoses" (1)
		"Suction" (1)	"Rubber" (2)	
			Corrugated (1)	
			"Closed nonsuction" (1)	
Asia	15	"Closed suction" (6)	Corrugated (1)	Not stated-1
		JP (2)	Latex (1)	"Simple tube"-1
		Redivac (1)	Portex (1)	
			"Tube in cavities, corrugated in soft tissues" (1)	
Australia	3	JP (2)		Blake or Penrose-1
		Blake (1)		"Tubular"-1
South Africa	3		JP-passive (1)	
Total	71	41 (59%)	22	

gravity). Table 10 suggests that 60% of respondents prefer "active" drains. While North American surgeons use predominantly "active" drainage (mostly the Jackson Pratt [JP] drain), surgeons elsewhere use a mishmash of tubes, with suction or without, and flat drains (e.g., Penrose, or the "corrugated" rubber).

Which drains are best? The various types of drains and their functional characteristics have been aptly described by O'Connor and Hugh [1]. Preferably, a drain should be soft and malleable to minimize the real dangers of pressure necrosis and erosion of bowel and blood vessels. "Passive" drains work by capillary action, gravity, or overflow caused by slight pressure differences. "Active" drains are connected to a source of suction. "Passive" drains are considered to be an "open system," proven to be associated with contamination of the drain tract by retrograde spread of skin bacteria ("Drains drain both ways"). In theory, applying a sterile colostomy bag over a drain site should convert the open system to a closed one, but I doubt whether this remains "closed" for more than a day. Some authors claim that "passive" drains are relatively inefficient in the upper abdomen because of the negative, inward sucking pressures generated during respiration [1], but others claim the opposite [15].

"Active" drains tend to become clogged by sucked in tissue or clots, the higher the sucking pressure, the more prone to blockage the drain is. "Sump" suction drains (double-lumen systems) are more resistant to blockage, but they are usually of rigid construction and thus not considered safe for prolonged use in the peritoneal cavity. Interestingly, a study of drainage after cholecystectomy showed that a single "passive" drain was twice as effective as a single "active" suction drain; also, the "sump" type drain was as effective as the passive one [15].

The flat and soft "active" JP is the only intraperitoneal drain that I use, usually for the rare case of difficult cholecystectomy. This is also the drain I would use for other indications, as when expecting a duodenal or pancreatic fistula. Surgeons who drain peritonitis should remember that a suction drain will become plugged with fibrin and pus within a few hours, and an "open" passive drain would serve mostly as a unilateral *autobahn* (toward the inside) for skin bacteria. For surgeons who place drains adjacent to colonic anastomoses, I wonder if they really believe that round suction drains would evacuate feces? To form a channel capable of transferring fecal material to the outside, it is necessary to use a large passive tube (e.g. a "corrugated" drain) through a generous (two-finger) opening in the skin and abdominal wall. But by doing so we would go back to the old days when such complications as drain site hernias, intestinal obstruction, bleeding, and drain site abscess formation ensued. For a list of complications associated with the various drains, see Table 11.

Table 11 Complications of intraperitoneal drains and its prevention

Complication	Complication
Drain "fever"	Failure to retrieve (caught by fascial sutures or torn)
Drain tract infection	
Drain tract hernia	"Lost" drain: migration into the abdomen or breakage
Drain tract bleeding	
Intestinal obstruction	Contamination of sterile tissues
Erosion of bowel	Prevention of healing of fistulas
Erosion of vessels	

The complications cited above are real; some are rare, but I experienced each of them in the "dark ages" of my career. Most can be prevented by correct placement and management of drains (see Table 12); better yet, by avoiding drains when their use is not indicated. This leads me to the best news coming from this poll: the majority of respondents from all regions claimed that they are now draining less (Table 13).

Regional differences in practice

Another look at the various tables reveals that North American surgeons tend to be abandoning drainage for most indications, whereas surgeons in Asia and Eastern Europe still seem to be enthusiastic about drainage. Such differences in practice are in particular notable with regard to drain placement in diffuse intra-abdominal infections and emergency colonic surgery.

Now we may ask why North American surgeons, as well as West European and South American surgeons, tend to rely less on drains. The shift in habits has surely occurred gradually and is the result of multiple factors.

- With improved surgical technique, antibiotic administration, and better imaging, results of emergency abdominal procedures improved, and surgeons encountered fewer complications that allegedly could have been prevented by drains. This provided surgeons with a new sense of confidence: why leave drains if the drains are deemed mostly unnecessary?
- Readily available CT scanning also added to the surgeons' confidence. The mysterious postoperative abdominal cavity is no more a black box; we can see it on the CT. As a result, there is no need to rely on a drain to warn of an abscess.
- Obviously, the immense success of image-guided percutaneous drainage of intra-abdominal collections and abscesses has added further to that confidence. It has also taught surgeons a great deal about the methodology of drainage itself, demonstrating that

Table 12 The placement and management of drains

Insertion
• Choose a suitable drain for the specific job, but in general prefer the softest and smallest.
• Place drain carefully in the desired region, trim it to remove excessive length, but leave some "slack."
• Place the drain away from bowel wall or vessels.
• Try to bring omentum between the drain and vital structures to prevent erosion.
• Bring drain out through the skin, away from the main wound to prevent wound infection.
• Plan the shortest tract possible and, depending on the indication for drainage and the type of drain, try to exit it in a dependent location.
• When closing the main wound, be careful not to catch the adjacent drain with the fascial sutures.
• Secure the drain to skin with suture and tape.
Management
• Use a closed system whenever possible.
• Use low suction to prevent sucking adjacent tissue into drain's holes.
• To keep a small-caliber tube drain patent, it can be flushed twice daily with a small amount of saline under sterile conditions.
• When fistula is established (e.g., biliary), suction can be disconnected and a drain connected to a dependent bag, draining on gravity.
• Be careful that the drain tip is not abutting the visceral defect it is draining—this would prevent closure of the defect: check for drain position with a sonogram.
Removal
• Remove as soon as drain is not productive or seems to have outlived its prophylactic task.
• Long-term drains should be removed in stages to prevent abscess in the deep tract.
• Removal and shortening of drains could be guided (selectively) with sonograms and/or a computerized tomography scan.
• When shortening the drain, re-fix it to the skin to prevent proximal migration.

you do not need huge tubes, for many days, to get rid of an abscess. Thus, the elaborate rituals surrounding management of drains were evaporating as well.

- Modern surgeons found out that they did not need drains to "prevent or treat" persistent or recurrent infection after, say, perforated appendicitis. They learned that most patients would do well with source control (appendectomy) and antibiotics. And if not, they could call for a CT scan and, if necessary, drain whatever is there under CT guidance.

Table 13 Do you use drains as frequently as you did during your residency?

	Number	Les or "much less"	More	Same/comments
North America	18	18		
Western Europe	10	7		3
				"Drains never big deal" (1)
Eastern Europe	7	6		1
Latin America	15	15		
Asia	15	13		2
Australia	3	3		
South Africa	3	3		
Total	71	67 (95%)		4

This leads us to question the persisting enthusiasm for drains in Asia and East Europe. Perhaps the relative unavailability of postoperative CT in developing countries has left surgeons continue to rely on drains. Or they are more forcefully subjected to local dogmas, entrenched by strict discipline. This latter feature seems likely. In my practice, we abandoned routine drainage in the mid-1980s, well before CT and percutaneous drainage were available to us. Nevertheless, we understood then what surgeons should understand today: with CT or without CT, most drains used are unnecessary and counterproductive. This brings us back to William Stewart Halsted's motto: "No drainage is better than the ignorant employment of it."

Conclusions

The use of routine drainage in contaminated and infected abdominal surgery is declining but still practiced in some regions of the world. Drains should be used very selectively: when their placement is the only way to control the source of infection, to provide escape for highly predicted leaking fluids (bile, pancreatic juice, urine), to drain a noncollapsible abscess (a rare occurrence), or to drain, for short duration, a very oozy surface. Prophylactic drainage

Fig. 1 "Which one is draining? What shall I do? Re-operate? Order a CT scan? Aha, I know: I should have left more drains…" [Illustration by Perya Perelygin, MD; from: Schein's Common Sense Emergency Abdominal Surgery. Schein M, Rogers P, editors, New York, Springer-Verlag, 2004]

of intestinal anastomosis is useless, and drainage of the general peritoneal cavity is senseless (Fig. 1).

"Although more than five million surgical drains are used each year in the United States, their effectiveness, therapeutic indications, and efficiency remain an unsolved controversy"

–J. P. Moss

It was a controversy but it is no more!

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