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Moshe Schein

Surgical management of intra-abdominal infection: is there any evidence?

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M. Schein (✉)
Cornell University College of Medicine,
New York, NY, USA
e-mail: Mschein1@mindspring.com
Tel.: +1-718-9601295
Fax: +1-718-9601312

M. Schein
Department of Surgery,
Bronx Lebanon Hospital Center,
1650 Selwyn Ave., Suite 4F, Bronx,
NY 10457, USA

Abstract The aim of this review article was to look at the evidence supporting the surgical treatment of secondary bacterial peritonitis. Because the absolute necessity of adequate source control is not disputable and there is no question that peritoneal toilet (in whichever form) is mandatory, the main bulk of this manuscript is dedicated to the controversial issues of planned relaparotomy and laparostomy. We found little good evidence to support or refute the use of these modalities, but in the absence of evidence, one has to use experience and common sense. Ours suggest that planned relaparotomies combined with laparostomy represent, for the time being, the heaviest weaponry in the surgeon's mechanical armamentarium for the treatment of severe intra-abdominal infection. Even without level II evidence, we are convinced that these therapeutic modalities are life-saving in a well-selected group of patients. One has, however, to know when to stop and how not to harm.

Keywords Laparotomy · Relaparotomy · Laparostomy · Source control

Introduction

"A negative relaparotomy is better than a positive autopsy but is not, nevertheless, a benign procedure" [2].

The editors asked us to write about "the evidence of surgical treatment in bacterial peritonitis" for their series on current concepts in clinical surgery. We accepted the task, although we were offered no honorarium, which again provides level V evidence that while others are paid for their wisdom – we surgeons write for nothing.

To begin with, we looked up the March 1998 issue of Langenbeck's Archive of Surgery, in which Berger and Buttenschoen wrote about the "management of abdominal sepsis" [1]. They wrote: "Surgical therapy focuses on the control of the source of infection because... without resolving the source... the prognosis remains poor." With this we of course agree. The authors continued: "Adjuvant surgical measures aim at the further reduction of the bacteria load in the peritoneal cavity. Planned relaparotomy, relaparotomy on demand, and continuous closed peritoneal lavage are used... clinical results prove these methods to be equally effective although pathophysiological considerations favor closed peritoneal lavage." With this we cannot agree. Berger and Buttenschoen concluded: "We need a more sophisticated understanding of the pathophysiology of peritonitis and well designed clinical studies to define the optimal surgical treatment modalities." Yes, we agree with this but – do we understand more today, 3 years later? Do we have newer and better evidence? Is there anything new?

What's "new"?

We all control the source of the "sepsis" (e.g., remove the appendix), we suck out the pus and irrigate "a little or much," and we give antibiotics for "a few days". Some of us would use drains or leave the skin open – others would not. Nothing new, no big deal – so what should we write about? Do we need to write anything at all?

On further reflection, we realized that although there is not much new in what we can do for "abdominal sep-

sis", there is some novelty in the way we currently look at it. Such upgraded concepts allow us now a more rational utilization of the old tools at our disposal and perhaps could sooner or later bring us to the development of new therapeutic bullets or even weapons.

What does evidence mean?

A few words about what we mean when we talk about "evidence". Out of a few grading systems of evidence which exist, we prefer to use the following [2].

Evidence level

Description

1. A scientifically sound randomized controlled trial (RCT)
2. RCT with methodological "problems"
3. Nonrandomized concurrent cohort comparison
4. Nonrandomized historical cohort comparison
5. A case series without controls
   To the above "official" classification, one could add another three categories frequently used by surgeons around the world:
6. "In my personal series of *x* patients (never published) there were no complications"
7. "I remember that case..."
8. "This is the way I do it and it is the best"

Clearly, level V studies form the main bulk of literature, which deals with intra-abdominal infection, whereas level VI–VIII evidence is the main form of evidence used by surgeons in general.

Principles of management – the dominance of source control

The outcome of an intra-abdominal infection (IAI) depends on the virulence of infection, the patient's premorbid reserves, and his physiological compromise. Our goal here is to assist the patient's own local and systemic defenses.

The philosophy of surgical management is simple. It revolves around *control* and comprises two steps: *source control*, followed by *damage control*.

Source control

The sine qua non of success is timely surgical intervention to stop the delivery of bacteria and adjuvants of inflammation (e.g., bile, blood, fecal fiber, barium) into the peritoneal cavity. All other measures are of little use if the operation does not successfully eradicate the infective source and reduce the inoculum to an amount that can be handled effectively by the patient's defenses, supported by antibiotic therapy. Source control frequently involves a simple procedure such as appendectomy or closure of a perforated ulcer. Occasionally, a major resection to remove the infective focus is indicated, such as gastrectomy or colectomy for perforated gastric carcinoma or colonic diverticulitis, respectively. Generally, the choice of the procedure and whether the ends of resected bowel are anastomosed or exteriorized (creation of a stoma), depends on the anatomical source of infection, the degree of peritoneal inflammation and SIRS, and the patient's premorbid reserves. Source control may be achieved, at least temporarily, by noninvasive means: for example, percutaneous drainage of diverticular abscess. We also know that some patients' own defense mechanisms – assisted by our antibiotics – successfully achieve source control without the need for an operation (e.g., perforated duodenal ulcer [3], appendiceal mass [4]).

Damage control

Damage control is comprised of maneuvers aimed at cleaning the peritoneal cavity; in bodily terms, a *peritoneal toilet*. What should it entail?

Contaminants and infectious fluids should be aspirated and particulate matter removed by swabbing or mopping the peritoneal surfaces with moist laparotomy pads. Although cosmetically appealing and popular with surgeons, there is no evidence that intraoperative peritoneal lavage reduces mortality or infective complications in patients receiving adequate systemic antibiotics [5]. Also, peritoneal irrigation with antibiotics is not advantageous, and the addition of antiseptics may produce toxic effects [6]. One may use "copious irritations" as much as one wishes, but beyond wetting the underwear and shoes, one does not accomplish much. Dedicated irrigators should remember to suck out all the lavage fluid before abdominal closure; there is evidence that leaving saline or Ringer's behind interferes with peritoneal defenses by "diluting the macrophages". Bacteria swim perhaps better than macrophages! [7].

The concept of *radical debridement of the peritoneal cavity*, by removing every bit of fibrin which covers the peritoneal surfaces and viscera, did not withstand the test of a prospective randomized study, as aggressive debridement causes excessive bleeding from the denuded peritoneum and endangered the integrity of the friable intestine [8].

Despite the dictum that it is impossible to drain the free peritoneal cavity effectively, drains are still commonly used and misused. They should be limited to the

evacuation of an established abscess to allow escape of potential visceral secretions (e.g., biliary, pancreatic) and, rarely, to establish a controlled intestinal fistula when the latter cannot be exteriorized. To prevent erosion of intestine, use soft drains for the shortest duration possible, keeping them away from bowel. In general, active suction drainage is better than the passive sort, and infective complications can be reduced using "closed" systems. Drains provide a false sense of security and reassurance; we have all seen the moribund postoperative patient with an abdomen "crying" to be reexplored while his surgeon strongly denies any possibility of intraperitoneal catastrophe because the tiny drains he inserted in each abdominal quadrant are "dry" and nonproductive. We cannot produce high-level evidence to support our aversion to drains, but the generations of surgeons who used drains for many years also never succeeded in proving their advantage.

The role of *postoperative peritoneal lavage* through tube drains which were left behind is at best questionable [9]. The basic question remains of whether it is possible to irrigate the whole abdominal cavity, as tubes or drains are rapidly "walled-off" by adhesions and adjacent tissues. You'll be irrigating nothing more than the drains' tract.

What else should we know?

If things are so simple and all we need is to achieve source control, clean the peritoneum, and support the sick host – why are patients still dying from the various forms of intra-abdominal infections? To understand this, we have to be aware that people do not die only because of the disease but because of what we do (too much) or do not do (too little) to them. We must also understand the biology of inflammation and that the more we do, the more harm we may create. This brings us to the topic of planned relaparotomies and laparostomy, which remains a hotly debated subject.

Planned relaparotomies and laparostomy

Definitions and rationale

Planned relaparotomies

The policy of planned relaparotomies is decided upon during or immediately after the *first-index* operation for peritonitis, when the surgeon decides to reoperate within 1–3 days, irrespective of the patient's immediate postoperative course. The decision to reexplore the abdomen is thus part of the initial management plan. Historically, mesenteric ischemia is probably the first instance in which a planned relook laparotomy was advocated. In the context of intra-abdominal infection, the "excuse" for a relook is to control the source better, to repeat the "peritoneal toilet" – anticipating the reformation of infected collections. The inspiration behind all of this is to abort or diminish the magnitude of systemic inflammatory response syndrome (SIRS) and multiple organ failure. Penninckx et al. [10] were probably the first to report the use of planned relaparotomies in intra-abdominal infections.

Relaparotomy "on demand"

This is the "conventional approach" when, at the aftermath of the initial index operation for peritonitis, the surgeon decides to reexplore the abdomen based on clinical or radiological evidence of persistent or recurrence infection.

Laparostomy

The term "laparostomy", which implies leaving the abdomen open, was coined by P. Fagniez of Paris (personal communication). Pujol was probably the first modern to suggest that the severely infected abdomen is best treated openly like an abscess cavity [11]. The notion that peritonitis and its operative treatment often result in increased intra-abdominal pressure (IAP) has been raised sporadically throughout the twentieth century. However, the concept that the prevention or treatment of intra-abdominal hypertension –with laparostomy – is beneficial has been accepted by clinicians only very recently [12]. Laparostomy does not obviate the need for abdominal reexplorations, which in turn are facilitated by leaving the abdomen open. Thus, in practice, laparostomy has become a corollary to planned relaparotomies: if the abdomen is to be relooked at 48 hours later, why close it at all?

Planned relaparotomy indications

The indications to embark on planned relaparotomies remain poorly defined and empiric.

- In our own experience, the "best" and "strongest" indication is the *failure to obtain adequate source control* during the initial operation. A classic example is infected pancreatic necrosis after necrotizing pancreatitis. Another example is an intestinal leak, which cannot be safely repaired or exteriorized – a scenario commonly associated with postoperative peritonitis.
- The necessity to redebride or drain poorly localized, "stubborn" infective processes. For example: diffuse retroperitoneal fasciitis due to retroperitoneal perforation of the duodenum or colon.

- *Diffuse fecal peritonitis* is a relative indication used by others [13] and us [14], with the rationale that, in face of massive fecal contamination, another laparotomy is necessary to achieve an adequate "peritoneal toilet".
- "Instability" of the patient during the initial operation mandates occasionally an abbreviated "damage control"-type procedure with an obligatory, subsequent planned relaparotomy to "finish" the source control and peritoneal toilet. Obviously, when hemostatic packs have to be left in situ, their removal necessitates a relaparotomy [15].
- Wittmann – who combines an obsessive policy of planned relaparotomies with laparostomy, calling it STAR [16] – contends that reoperations allow him to "assess" high-risk anastomoses "when in the past a colostomy would have been done". We are not convinced.

The conduct of a relaparotomy

The key advice for the surgeon who plans to return into a recently operated-upon abdomen is to be gentle! The peritoneal surfaces are edematous, friable, and vascular; so is the bowel. Another important tip: know your way around. Ideally, the surgeon who has performed the original "index" procedure should be the one to reoperate or at least be present. The abdominal relook itself aims at draining all infected collections and controlling, if necessary, persistent sources of contamination. How thorough the exploration should be depends on the individual case. Sometimes there are several interloop abscesses that need to be drained and the whole bowel must be carefully unraveled; in other cases, particularly in instances of frozen abdomen, it is sufficient to explore the spaces around the matted bowel (subphrenic spaces, paracolic gutters, pelvis). The decision about the extent of exploration is crucial because the more widespread it is, the more danger it poses to adjacent structures. Then the "extent" of exploration depends on whether your operation is "directed" or "nondirected" and on its timing.

Laparostomy

Indications

For practical purposes, think that laparostomy may be indicated either when the abdomen cannot be closed or should not be closed.

Abdomen which cannot be closed:

- After major loss of abdominal-wall tissue following trauma or debridement for necrotizing fasciitis.
- Extreme visceral or retroperitoneal swelling after major trauma, resuscitation, or major surgery (e.g., rupture or abdominal aortic aneurysm).
- Poor condition of fascia after multiple laparotomies.

Abdomen which should not be closed:

- Plan to reoperate within a day or two – why lock the gate through which you are to reenter very soon?
- Closure possible only under extreme tension, compromising the fascia and creating intra-abdominal hypertension (IAHT).

Technical consideration of laparostomy

The option of simply covering the exposed viscera with moist gauze packs has been practiced for generations but is not advisable: intestine – if not matted – can eviscerate; it is messy, requiring intensive work to keep the patient and his bed clean and dry. Most importantly, it has an established risk of creating spontaneous "exposed" intestinal fistulas [17]. The exposed bowel, when dilated and friable, tends to "pop" if repeatedly injured during changes of dressing and exposure. Temporary abdominal closing devises (TACD) to cover the laparostomy wound are therefore highly recommended.

Every surgeon probably has a preferred method of TACD, be it a "Bogota bag" made of a large IV fluid bag, a ready-to-use transparent "bowel bag", a synthetic mesh (absorbable or nonabsorbable), or a Velcro-type sheath, which is advocated by Wittmann [18]. We even know a guy in South America who uses discarded nylon hose for this purpose. In fact, what you use probably does not matter, but there are a few practical points worth remembering:

- Whichever TACD is used, try to place it over the omentum – if available. This will protect the bowel.
- Suture the TACD to the fascial or skin edges. Just placing it "on top" will result in huge abdominal-wall defects, because the midline-wound fascial edges tend to retract laterally (note that this is the reason why the abdominal defect resulting from a transverse laparostomy is smaller). The larger the defect, the more problematic its eventual reconstruction.
- Using a permeable TACD (e.g., mesh) as opposed to a nonpermeable one (e.g., Bogota bag) has the advantage of allowing the egress of infected intraperitoneal fluids.
- Try to adjust the tension of the TACD to the intra-abdominal pressure.
- If you plan a relaparotomy within 24–48 h, the type of TACD used is of little importance: the TACD can be replaced at the end of the next laparotomy. The selection of TACD when no more reoperations are deemed necessary is crucial; we recommend an absorbable synthetic mesh as discussed below.
- Abdominal reentry through the TACD is simple: divide the TACD at its center; then, with your finger,

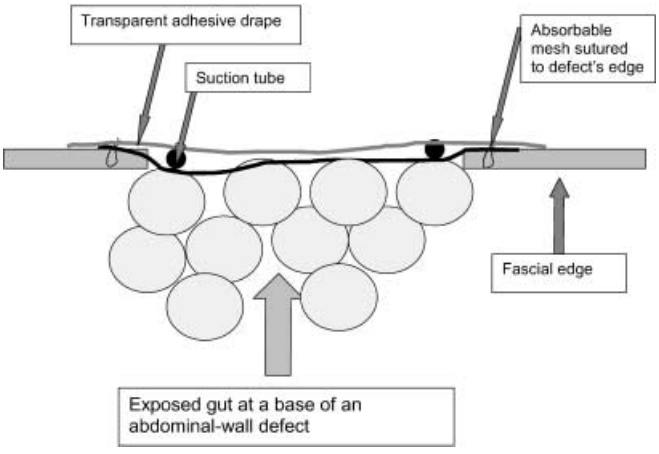

Fig. 1 The "sandwich technique" in the management of laparostomy

gently separate the omentum and viscera away from the overlying TACD. At the end of the procedure, resuture the TACD device with a running suture. Commercial zippers can be used instead, an attractive gimmick to nurses and interns.

Our own TACD of choice is the "sandwich technique" [19]: absorbable permeable synthetic mesh is sutured to the fascial edges. Two tubes (sump drains) are placed at the sides of the abdominal defect over the mesh, brought out through the skin, and connected to suction to collect the abdominal effluents. Sheaths of stoma adhesive are placed on the healthy skin surrounding the defect; a large adhesive transparent sheath ("Steridrape" or "Opsite") is placed "on top" to cover the entire abdomen. Hence, the viscera are protected, the laparostomy's output is measurable, and the patient is clean and dry, with demands on nursing minimized (Fig. 1).

Results and complications

Since, in practice, planned relaparotomies are usually combined with laparostomy, it is impractical, if not impossible, to discuss separately the results of these modalities. Because of the multifaceted nature of patients subjected to these therapies – which in turn are immensely complex – proper randomized controlled trials comparing it with "conventional surgical approaches" are probably impossible to perform [20]. On the average, the mortality rate stated by series reporting experience with planned relaparotomies and/or open abdomen has remained steady, around 30% and up to 52% [21].

The best effort to "control" the results was by Hau et al. [22], who matched (for APACHE II, age, site, and cause of infection and the ability to obtain source control) 38 patients undergoing planned relaparotomy with 38 patients undergoing "on-demand" relaparotomies. The mortalities in the two groups were 21% and 13%, respectively (nonsignificant difference). Postoperative multiple organ failure was more frequent in the group of patients undergoing planned relaparotomies than in the group undergoing on-demand procedures, as were infectious complications (68% vs 39%, respectively). Infectious complications were due to more frequent suture leaks, recurrent intra-abdominal sepsis, and septicemia in the "planned" group. This study was criticized because in one of the 18 participating hospitals – which performed a large number of planned relaparotomies – only one patient died while in another center the mortality was 50%. This suggested differences in patient selection and/or local expertise. Another prospective, consecutive, nonrandomized trial by the Surgical Infectious Society (SIS) [23] showed no significant difference in mortality between patients treated with a "closed-abdomen technique" (31% mortality) and those treated with variations of the open-abdomen technique (44% mortality). The authors suggested, as did others [24], that the outcome in peritonitis depends more on the severity of the acute disease and amount of host response than on how we technically manage it or on recurrent peritoneal infection.

The largest published clinical experience with planned relaparotomies is by Billing et al. from Munich [25], who treated 377 patients suffering from diffuse peritonitis. The mortality rate for their 152 patients treated with planned relaparotomies was 37.5%, as compared to 21% in patients treated conventionally. The mortalities for the two treatment modalities in patients in whom source control was achieved during the first operation were 19% and 10%, respectively. When, however, source control was not obtained during the initial operation, the mortality rate in patients undergoing planned relaparotomies was 59%, as compared to 86% in those treated conventionally. Overall, when source control was successful during the first operation, the mortality rate was 14%; when unsuccessful, it was 64%. This experience points to the crucial importance of source control and suggests that planned relaparotomies are beneficial when the source is not well controlled during the first operation.

Not surprisingly, the more reoperations one does, the greater is the surgical morbidity – usually manifested by intestinal and hemorrhagic complications [26]. Also, it is conceivable that reoperations add fire to the cytokine-generated local and systemic inflammation [27, 28], acting possibly through the "second hit" mechanism.

What is the verdict: do planned relaparotomies reverse, prevent, or aggravate SIRS and multiorgan dysfunction? Is its benefit: risk ratio favorable? This leads us into the discussion of controversies.

Controversies

Are planned relaparotomies beneficial?

Any surgical maneuver which successfully eliminates the source of contamination/infection and/or evacuates contaminants and pus has to be beneficial; this is an axiom. The problem is that planned relaparotomies represent a double-edged sword – achieving the above goal while injuring the host. Indeed, the strict adherence to the policy of planned relaparotomies represents "overkill". If one operates until the abdomen is clean, then in retrospect the last operation is unnecessary. In view of the high morbidity of multiple relaparotomies, we believe that, in the long run and overall, we serve the patient better with an aggressive policy of postoperative on-demand percutaneous CT-guided drainage procedures or/and CT-directed on-demand laparotomies. Doing so, one can go directly where the action is, sparing the rest of the abdomen and sparing the patient the trauma of "blind" exploration.

However, postoperative abdominal imaging does not become accurate before postoperative days 5 to 7; thus, the first postoperative week – before the infective process has become localized - offers a window of opportunity for planned relaparotomies. It is then when one or two planned relaparotomies may help to control the source better and eliminate heavy contamination. It is our opinion that at a later phase everything has to be done on demand based on the patient's condition, findings on clinical examination (when the abdomen is left open, one can easily place a hand in one of the gutters and feel gently around), and imaging. We do not believe that we will ever have objective data to solve this controversy further. Let us use rational and common sense instead.

Is laparostomy beneficial?

The physiological benefits of a "decompressing" laparostomy for significant intra-abdominal hypertension (IAHT) – causing abdominal compartment syndrome – are well proven in trauma and general surgical patients [13]. There is also a large body of experimental studies strongly suggesting that elevated intra-abdominal pressure promotes systemic absorption/translocation of peritoneal endotoxin and bacteria, thus increasing the mortality rate of peritonitis in small and large animals [29]. Although the issue of raised intra-abdominal pressure and its treatment with laparostomy has not been studied specifically in the setting of peritonitis, it is clear that treating IAHT is beneficial. Laparostomy however is not free from complications; therefore, though a "borderline" IAHT contributes to the overall morbidity, the risk:benefit ratio of prophylactic laparostomy in such situations is not clear yet. In our practice, we reserve laparostomies for patients with severe IAHT, those who "cannot be closed" or those whom we plan to reexplore.

When to stop?

Planned relaparotomies are classically continued until the "abdomen is macroscopically clean". When the source is controlled, however, two or three relaparotomies are sufficient to sterilize the peritoneal cavity [16]. Persistence of sepsis thereupon signifies SIRS or tertiary peritonitis due to opportunists such as Candida. Van Goor et al. [13] suggested the presence of less than 105 CFU/ml in the peritoneal cavity – achieved after the mean of three laparotomies – a useful criterion to stop reoperating. Clearly, the continuation of relaparotomies in a clean abdomen or in the face of tertiary peritonitis is contraproductive but not detrimental.

Conclusions

Relaparotomies and laparostomy are therapeutic measures that are indicated in a minority of patients. Planned relaparotomies are indicated – and probably beneficial – during the early postoperative phase, when the source has not been adequately controlled at the index operation or when contamination/infection has been tremendous or associated with necrotic tissues. Laparostomy is indicated and beneficial when the abdomen cannot be closed without creating significant intra-abdominal hypertension. Our approach in such selected patients would be to start with one or two planned relaparotomies. Thereafter, once CT imaging becomes accurate, to continue aggressively but selectively – based on clinical judgement and imaging – with *directed*, on-demand relaparotomies and/or percutaneous drainage procedures. Directed reoperation guided by CT imaging allows one to approach the problem through a fresh incision away from the central mass of mated bowel – sparing it the potentially damaging effects of your hands and instruments.

Planned relaparotomies combined with laparostomy represent for the time being the heaviest weaponry in the surgeon's mechanical armamentarium for the treatment of severe intra-abdominal infection and other postlaparotomy abdominal catastrophes. Even without level I or II evidence, we are convinced that these therapeutic modalities are life-saving in a selected group of patients. One has, however, to know when to stop and how not to harm.

We were asked by the editors to discuss "evidence" – we failed! In the absence of good evidence, surgeons have to use their experience and common sense [30].

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