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ORIGINAL ARTICLE

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Evaluation of prosthetic mesh closure in semiopen-abdomen patients

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Abstract *Background*. To avoid the adverse consequences of abdominal compartment syndrome and to reduce the high mortality the celiotomy wound in patients with abdominal sepsis was closed without tension using prosthetic mesh. This produces a semiopen situation that permits staged reinterventions together with the functional reconstitution of the continuity of the abdominal wall.
Material and Methods. Twenty-five patients with intra-abdominal sepsis of various causes were evaluated retrospectively to assess the results of semiopen management of the septic abdomen and reoperations on demand in severe peritonitis. All of the patients were in a state of neglected peritonitis, and had at least one failing organ system. The Mannheim Peritonitis Index (MPI) scoring system was used for stratification of abdominal sepsis.
Results. The mean MPI score of 25 patients was 24, ranging 10 to 33. Eight (32%) patients were reexplored (MPI = 21). There were overall 9 (36%) complications in patients with mean MPI score of 23. Six (24%) mesh-related complications (infection and enterocutaneous fistulas) developed (MPI = 19). The mean MPI score of patients without complications was 24. Four (16%) patients died with index MPI score of 26 due to fulminant hepatitis, myocardial infarction, and multiple organ failure. The admission period averaged 63 days.
Conclusions. In 25 critically ill patients with abdominal sepsis the mortality was lower than expected, relative to heterogeneous data from the literature; also, major complications occurred less frequently although the mean MPI score was high. The authors conclude that this approach is a reliable contribution to the complex treatment of these patients.

Keywords Intra-abdominal sepsis · Semiopen-abdomen · Prosthetic mesh closure · Mannheim peritonitis index

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Introduction

Peritonitis continues to be a complex illness that requires the coordinated efforts of timely surgical intervention, systemic antibiotic therapy, and supportive critical care management. The diagnosis of intra-abdominal infection is often delayed or even missed, and therefore many patients have clinically deteriorated considerably or have consequently developed the systemic inflammatory response syndrome and multiple organ failure when (re)operated on [2]. The prognosis of these patients depends on the source of the infection, severity of peritoneal inflammation, degree of physiological disorder, and the patient's previous health status [2, 3, 4, 5]. Nowadays the elimination or control of the infectious source and the reduction in peritoneal contamination by débridement and extensive perioperative lavage are still the cornerstones of primary operative treatment but are not always achievable by a single operation.

There is a great variance in surgical strategies to be followed after elimination of the source, débridement and perioperative lavage, especially in patients with severe intra-abdominal infection. These strategies vary from a conservative "wait and see" policy to the most aggressive method of "planned relaparotomy." One of these strategies, leaving the abdomen open (laparostomy), was initially used in France [8, 23]. The principle of this technique is to treat the whole abdominal cavity as if it is an abscess cavity. The main advantage of open management seems to be decompression of the abdomen; the relief of the elevated intra-abdominal pressure

improves ventilation, splanchnic circulation, bacterial clearance, cardiac output, and renal function. However, open management causes the risk of evisceration of the abdominal content, fistula formation, and development of large incisional hernias, which in conjunction with the nursing difficulties and immobilization problems are considered major limitations of this technique [5, 11, 15, 18, 24, 25, 29].

These drawbacks have generated a variety of methods combining abdominal decompression with covering of intra-abdominal organs by prosthetic mesh [1, 7, 11, 15, 17, 18, 27, 29, 31, 32]. This produces a semiopen situation with good drainage together with the functional reconstitution of the continuity of the abdominal wall. The choice of the specific technique is very much a matter of personal or institutional preference because no comparative studies exist.

In this study we report our experience with an approach consisting of semiopen management of the abdomen and reoperation(s) on demand in the surgical intensive care unit (SICU) for severe bacterial peritonitis following perforation or postoperative anastomotic leakage of the gastrointestinal tract and infected pancreatic necrosis.

Patients and methods

This study included and retrospectively analyzed 25 patients (19 men, 6 women; mean age 47 years, range 26–80) treated by semiopen management of the abdomen and on-demand reoperations for severe intra-abdominal infection at the SICU of Dokuz Eylul University Hospital between January 1995 and August 2000. All of the relevant clinical data were collected from the regular visits, operation notes, and archival data which were documented in detail at the Peritonitis Registry Data. All patients presented as surgical emergencies and had to be admitted to the SICU immediately for vigorous resuscitation and ventilatory support. Intra-abdominal infections were caused mostly by intestinal perforations in 11 patients (44%), postoperative anastomotic disruptions in 8 (32%), and infected pancreatic necrosis in 5 (20%). The severity of peritonitis was evaluated by the Mannheim Peritonitis Index (MPI) (Table 1) [3, 4].

All patients developed organ dysfunction and had at least one failing organ system. The criteria for the failing of the organ systems are listed in Table 2. Special attention was given to the cause of the peritonitis (Table 3). All 25 patients underwent surgical intervention with early laparotomy, elimination of the focus and extensive perioperative lavage. Surgical principles applied have been described in detail elsewhere. At completion of the surgical technique the abdominal cavity is generously rinsed with several liters of warm physiological saline solution until the returning fluid is clean. No local antibiotics were used. When present, the omentum was draped in the abdominal wound. The suction tubes with multiple side holes were positioned for drainage. Because of massive visceral edema and midgut distention combined with a thickened noncompliant abdominal wall a variety of meshes were used to bridge between the edges of the fascia to prevent evisceration and to avoid abdominal compartment syndrome. Eight (32%) patients were reexplored. The admission period averaged 63 days, varying from 7 to 180 days.

Bacteriological studies were performed according to standard microbiological methods. Long-term antibiotics were given routinely. Antibiotics were switched according to sensitivity patterns.

Hospital morbidity included all local and systemic complications during and after semiopen management of the abdomen. Hospital mortality included all in-hospital deaths.

Table 1. The Mannheim Peritonitis Index

Risk factor	Weighting if present
Age > 50 years	5
Female sex	5
Organ failure[a]	7
Malignancy	4
Preoperative duration of peritonitis > 24 h	4
Origin of sepsis not colonic	4
Diffuse generalized peritonitis	6
Exudate	
Clear	0
Cloudy, purulent	6
Fecal	12

[a] See Table 2

Table 2. Definitions of organ failure (P_{O2} partial pressure of oxygen, P_{CO2} partial pressure of carbon dioxide)

Kidney	Creatinine level ≥177 μmol/l Urea level ≥167 mmol/l Oliguria < 20 ml/h
Lung	P_{O2} < 50 mmHg P_{CO2} > 50 mmHg
Shock (definition according to Shoemaker)	Hypodynamic or hyperdynamic
Intestinal obstruction (only if profound)	Paralysis ≥24 h or complete, mechanical ileus

Results

The source of peritonitis in 44% (11/25) of the patients was gastrointestinal perforation. While duodenal perforation was the most frequent source of peritonitis, the small bowel was the second most important source for diffuse peritonitis. Other than gastrointestinal perforation, the sources of infection in 52% included anastomotic dehiscence and infected pancreatic necrosis. The mean MPI score was 23 (range 14–33) for the perforation group. In the group with anastomotic dehiscence, the original operations were upper gastrointestinal in two patients, small bowel in two, and colorectal in four. The mean MPI score was 26 (range 15–32).

Sixteen patients (64%) had a polypropylene, eight (32%) a polyester, and one (4%) a polyglactin mesh inserted. In five (20%) patients the first mesh prosthesis was explanted, and the closure was performed with a different mesh. The mean MPI score of 25 patients was 24 (range 10–34). Of 8 reexplored patients (MPI score = 21) polyglactin mesh in one (MPI score = 19), polyester mesh in two (MPI score = 18), and polypropylene mesh in five (MPI score = 23) were used.

The type and frequency of bacterial and fungal isolates identified during the first semiopen management of the abdomen and on-demand reoperations are listed in Table 4.

There were overall nine (36%) complications in patients with the mean MPI score of 23 (Table 5). Six (24%) mesh-related complications were developed in

Table 3. Clinical features of patients (*MPI* Mannheim Peritonitis Index)

Case no.	Age (years)	Sex	Indication for laparotomy	Biomaterial	MPI	Outcome
1	31	F	Perforation of the ileum (after tubal ligation)	Polyester	32	Discharged
2	80	F	Anastomotic leakage after resection of intestine	Polyester	31	Discharged
3	46	M	Intestinal infarction	Polypropylene	20	Discharged
4	52	M	Ischemic colitis with right colon perforation	Polypropylene→PTFE	19	Discharged
5	21	M	Duodenal stump leakage (abdominal stab wound)	Polypropylene	27	Died
6	46	M	Appendicitis gangrenosa perforata	Polypropylene	33	Died
7	76	M	Anastomotic leakage after resection of intestine (benign cystic mesothelioma)	Polypropylene	25	Discharged
8	38	M	Perforated duodenal ulcer	Polypropylene	27	Discharged
9	50	M	Acute necrotizing pancreatitis	Polyester→ polypropylene	10	Discharged
10	24	F	Perforation of the cecum	Polypropylene	27	Discharged
11	41	M	Traumatic perforation of the bile duct	Polypropylene	20	Discharged
12	50	M	Intestinal perforation due to Crohn disease	Polypropylene	20	Discharged
13	34	M	Anastomotic leakage after low anterior resection for carcinoma	Polyester	26	Discharged
14	76	M	Intestinal infarction and perforation	Polypropylene	29	Discharged
15	26	F	Acute necrotizing pancreatitis	Polypropylene	34	Discharged
16	43	M	Duodenal stump leakage	Polypropylene	15	Discharged
17	67	M	Anastomotic leakage after hemicolectomy for carcinoma	Polypropylene	32	Discharged
18	20	M	Traumatic perforation of the duodenum	Polyester→ polypropylene	21	Discharged
19	22	F	Perforation of the stomach	Polyester	14	Discharged
20	32	M	Afferent loop perforation	Polyester	14	Discharged
21	58	M	Anastomotic leakage after low anterior resection for carcinoma	Polyester	32	Discharged
22	55	M	Acute necrotizing pancreatitis	Polypropylene	26	Discharged
23	53	F	Perforated duodenal ulcer	Polypropylene	4	Died
24	67	M	Acute necrotizing pancreatitis	Polyglactin	19	Discharged
25	62	M	Acute necrotizing pancreatitis	Polypropylene	20	Died

Table 4. Bacterial and fungal isolates from the peritoneal exudate

Micro-organisms	*n*	%
Gram-negative aerobes	15	60
Escherichia coli	14	56
Staphyloccoccus spp.	6	24
Coagulase-negative	5	20
Aureus	3	12
Pseudomonas aeruginosa	6	24
Klebsiella pneumonia	4	16
Candida albicans	3	12

Table 5. Postoperative complications

Complications	*n*	%
Nosocomial pneumonia	2	8
Mesh reaction	2	8
Wound infection	3	12
Enterocutaneous fistula	1	4
Pancreatic fistula	1	4

three patients (MPI score = 19) with polyester and in three (MPI score = 19) with polypropylene mesh closure. The mean MPI score of patients without any complications was 24. In total four patients died (16%), of whom were in the perforated group, one in the dehiscence group, and one in the pancreatic necrosis group. Two patients died from multiple organ failure in the SICU, there were two delayed deaths on the ward, one of a myocardial infarction, the other of a fulminant hepatic failure (Table 6). The mean MPI score in the survivors was 24 (10–30), compared with 26 (20–33) among those who died.

Discussion

Despite advances in diagnoses, aggressive surgical techniques such as staged relaparotomy and laparostomy, antibiotic treatment, and intensive care,

Table 6. Postoperative mortality

Case no.	Cause of mortality	Postoperative mortality day
5	Fulminant hepatic failure	120
6	Multiple organ failure	7
23	Myocardial infarction	30
25	Multiple organ failure	15

the prognosis of severe intra-abdominal sepsis is still poor, particularly when multiple organ failure develops [2, 5, 14]. In some series mortality rates higher than 60% are reported. Basically peritonitis is not a specific diagnosis, and the therapy was introduced in 1926 by Kirschner, which is at present referred to as the standard [12]. The principal elements of this therapy are sufficient surgical elimination of the infectious source, perioperative lavage, removal of necroses, and definitive closure of the abdominal wall after introduction of local drainage. However, the problem of infection in some of the patients with difficult diffuse peritonitis can frequently not be solved by a single surgical intervention but must be treated in phases. This is the basis of the so-called planned relaparotomies (''Etappenlavage'') [5, 10, 14, 22, 24, 26, 31]. The concept of planned relaparotomy clearly aims at the mechanical cleaning of the abdominal cavity and allows the control of the primary repair of the infected focus. In addition, open management of the abdomen (''laparostomy'') has been introduced for persistent or recurrent intra-abdominal infection [2, 5, 8, 18, 21, 29, 31]. As Wittmann et al. [31] and others state, a combined approach of open management of the abdomen and planned reoperations not only treats the abdominal compartment syndrome but also allows frequent reexploration of the peritoneal cavity, early diagnosis of complications, and complete drainage of the abdomen [17, 20, 21, 25, 26, 31, 32]. From a surgical point of view, to close the infected abdominal cavity is essentially not suitable because the closure must be performed with an undesirable high tension on both the wound edges and the deep abdominal tissues, due mainly to distention of the intestine. Inserting a mesh in the course of this approach to septic abdomen, as described by Schein [24, 25] also facilitates weaning from the ventilator. The key principles are protection of the bowel with a soft, noneroding material and tension-free suture of the material [1]. Any biomaterial that conforms to these principles is a valid choice. A range of techniques for temporary closure of the abdominal wall have been described [7, 19, 20, 27, 31]. The technique is easy to perform, with materials readily available in all hospitals and are preferred by the surgeon's discretion.

The most difficult problem is deciding who will benefit from such a protocol. It is likely that the approach is used too early in some patients and too late in a few. Our patients were selected on the basis of the clinical severity of their intra-abdominal catastrophe, usually with diffuse, nonlocalizing bacterial peritonitis or infected necrotizing pancreatitis. Troublesome complications do occur with the use of the mesh [16, 30]; however, most of these patients are immunosuppressed, which may reflect a causal relationship to the nonlocalizing nature of their intra-abdominal infection [7, 28, 29].

Scoring systems were introduced long ago to improve selection of high-risk patients for more aggressive therapeutic procedures in abdominal sepsis and to provide objective classification of the severity of disease [3, 4, 9, 13]. They are based primarily on the systemic consequences caused by the infectious process. The well-known Acute Physiology and Chronic Health Evaluation (APACHE) II score is strongly correlated with outcome, but it disregards any surgical aspects of the underlying disease [13]. In addition, not all data need to determine the APACHE II score are available at the time of operation [2, 3, 4]. The MPI is one of the easiest to apply, and a determination of risk is readily available during the initial operation. Retrospective data collection is possible and valid as only standard information available from the operation report or the patient's record is required [3, 4, 9].

Billing et al. [3] assessed the reliability of the MPI and its predictive power for different populations in a multicenter study including 2003 patients. Obtaining a threshold index score of 26, they found that with a score less than 21, the mean mortality rate was 2.3%, for a score between 21 and 29, 22.5%, and for a score greater than 29, 59.1%. They concluded that the MPI provided easy and reliable risk evaluation for patients with severe peritoneal inflammation. Our study used the MPI score as early prognostic evaluation, and the mean MPI score of 26 was determined in the four patients with a mortality rate of 16%.

This series of patients had varied and extremely severe pathology, reflected by a mean length of hospitalization of 63 days, and most of hospitalization time spent in the SICU. Reoperations were performed in the surgical theater, ensuring that continuity of critical monitoring and medical care was guaranteed. Nevertheless, mortality was 16% in a group of patients in whom very high mortality would not have been surprising. Complications of severe bacterial peritonitis and semiopen management of the abdomen with relaparotomy on demand developed. Mesh-related morbidity developed in six patients (24%); only one intestinal fistula (4%) was seen. It is noteworthy that no obvious major bleeding occurred in our series. Fewer pulmonary complications (8%) were found because of the strainless closure. Our overall morbidity (36%) differed only a little from that in published series.

In general there is competition among various closed and open procedures for the treatment of difficult diffuse peritonitis. There have been no controlled large-scale prospective randomized studies for the value of the treatment concepts practiced today. Such an attempt is unlikely to be carried out in the future because of the unsatisfactory comparability of a heterogeneous collec-

tion of patients, despite classification attempts through indexes and scores, the complexity of the different therapy modalities, and ethical reservations. In a review of published series Schein [25] showed that overall mortality in 551 patients treated aggressively for intra-abdominal sepsis was 32%. In a prospective, nonrandomized study including 52 cases he further concluded that planned relaparotomies might have been beneficial in patients with diffuse fecal peritonitis [24]. In contrast, Hau et al. [10] and Koperna et al. [14] recently showed that there were no significant differences in the postoperative mortality rate between "planned relaparotomy" and "relaparotomy on demand," 21% vs. 13% and 54.5% vs. 50.6%, respectively [10, 14]. Another prospective nonrandomized study that attempted to compare "close" and "open" treatment failed to show any advantage of one kind of therapy [6]. Despite the fact that there are no studies comparing surgical treatment methods for diffuse peritonitis, there now appears to be a preference in a practice for partially open therapy concepts: A review of mortality in patients with reoperative laparotomies showed mortality rates from 7 to 60% [2]. Other series using varied techniques of temporary abdominal closure have reported mortality rates ranging from 24% to 40% [7]. Thus our mortality rate of 16% seems to be on relatively low. We believe that closure of the abdomen without undesirable tension, by means of a mesh prosthesis, plays an important contribution in the reduction in the high mortality of this group of patients.

Surgical treatment of difficult diffuse peritonitis is highly demanding and complex. Relaparotomy on demand and semiopen management of the septic abdomen is the standard procedure in the presented study. Our overall in-hospital mortality was lower than expected; also, complications were treated without further problems. Thus we can safely conclude that the patient's physiological envelope, the quality of surgical work, and temporary abdominal closure are the deciding factors with regards to success in the treatment of difficult diffuse peritonitis.

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