Use of biological mesh in facilitation of early closure in potentially infected abdominal wall defects

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ABSTRACT

INTRODUCTION: Abdominal wall defects with exposed bowels present a significant risk of iatrogenic and spontaneous intestinal fistulation, and early wound closure is warranted. We describe our experience with the use of biological mesh (BM) for facilitation of secondary abdominal wall closure in patients with abdominal wall defects after severe complications, including surgically inaccessible enteric fistulas.

MATERIAL AND METHODS: The present study is a prospective cohort study comprising ten patients with abdominal wall defects treated with BM. At reconstructive surgery with BM, six patients had stomas, four had wounds complicated by intestinal fistulas and three had both.

RESULTS: In five cases, the abdominal wall was closed without complications. The remaining five patients had unsuccessful primary healing of the skin, but all subsequently healed by granulation on the mesh. In two cases, BM was implanted directly on exposed bowel with inaccessible fistulas still present. Patients were discharged a median of 15 days (6-35 days) after insertion of the BM. The median follow-up was 11 months (1.5-18.5 months). Only one patient developed a hernia.

CONCLUSION: BM can be used in contaminated defects, even when primary skin closure is not achieved, or with fistulas still present causing continuous contamination of the surgical site and mesh. BM facilitates early closure of the abdomen.

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Acute postoperative abdominal wall defects with exposed bowels represent a surgical challenge and are potentially life-threatening to the patient. Exposed bowels present a significant risk of iatrogenic and spontaneous intestinal fistula formation, and early wound closure is warranted [1].

The defects can be caused by necrosis of the fascia, in some cases by wound infection and dehiscence, or by fascial lateralisation during laparostomy (open abdomen) following trauma or intra-abdominal sepsis. In case of small defects, simple tension-free suturing of the fascia can be accomplished when the intra-abdominal sepsis or wound infection has been managed. In larger defects, early closure of the wound can be impossible without causing high tension resulting in abdominal compartment syndrome, though accelerated closure is preferred in these cases.

As long as the abdomen is not frozen by adherences between the intra-abdominal organs and the abdominal wall, fascial closure can in some cases be achieved after fascial mesh traction [2]. If the abdomen is frozen, fascial closure is impossible without mobilisation of the abdominal wall from the intestines, which involves a high risk of iatrogenic small bowel perforation and subsequent formation of fistulas.

In cases of non-obtainable fascial closure, the standard treatment has been secondary closure by simple skin closure, if possible, or by granulation and, in some cases, subsequent split-skin transplantation. Both options result in ventral hernias. Alternatives to this regime have been implantation of meshes or component separation for abdominal wall reconstruction. The latter is often very extensive, and synthetic, unabsorbable meshes are associated with a risk of intestinal fistulas and with susceptibility to infection [3]. None of these options are feasible when surgically inaccessible fistulas are present.

The introduction of biological meshes (BMs) like Permacol (PM), Strattice and Surgisis has opened new alternatives. Our department has experience using PM in patients who undergo cylindrical abdomino-perineal resection for rectal cancer. The cylindrical excision leaves a large wound with radiated tissue that can be closed with a biological mesh as an alternative to flap reconstruction, e.g. gluteal flap [4]. It therefore seemed obvious to choose PM as a biological mesh for acute, potentially contaminated abdominal defects. PM is an acellular mesh manufactured from cross-linked porcine dermal collagen. The cross-linking provides resistance to collagenase degradation, and the structure readily allows colonization by host tissue and blood vessels [5]. Other BMs are derived from porcine small intestinal submucosa (Surgisis) or porcine skin (Strattice).

To our knowledge, the present study is the first to describe the use of BM in the closure of abdominal wall defects with surgically inaccessible intestinal fistulas. The aim of this study was to describe our experience with the use of a BM in secondary closure of abdominal wall defects after severe complications.

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MATERIAL AND METHODS

All ten patients (six women) with acute abdominal fascial defects treated with BM at our department from May 2009 to the end of October 2010 were included. Their median age was 66 years (range 41-76 years). Two patients underwent primary operation for ventral hernia, five for leakage of enteric anastomoses, two for bowel obstruction due to adhesions and one for diverticulitis with faecal peritonitis. Five patients had to wait for two months or more before reconstructive surgery with PM could be performed. This was due to cases of septic shock, re-laparotomies due to further anastomotic leakage, intra-abdominal abscesses and extended stay in the intensive care unit (ICU). The reconstructions were further delayed due to attempts to optimize their nutritional status. At the time of reconstructive surgery with PM, six of the patients had a stoma, four had wounds complicated by intestinal fistulas and three patients had both conditions (**Table 1**).

In the cases with enteric fistulas, several different strategies concerning the dressings were attempted in a period of up to four months prior to the PM implantation, but none of them were successful due to very frequent (almost daily) leakage from the fistulas into the wound.

One patient did not have a complete fascia defect, but the fascia was thin and fragile after removal of an infected synthetic mesh. Implanting a new synthetic mesh was considered unviable due to the risk of re-infection, and PM was chosen instead.

All patients had severe co-morbidity, e.g. chronic obstructive pulmonary disease, alcohol abuse, immunodeficiency or sepsis from intra-abdominal disasters, and they were all in poor nutritional condition based on their degree of weight loss and serum-albumin levels. The mean pre-implantation serum-albumin level was 30 (95% confidence interval (CI) 25-35) (normal range 36-45 g/l). Optimisation of their nutritional status before the reconstructive surgery was ensured, if possible. There was no standardized follow-up after discharge, but all patients were seen at least once. The number of outpatient follow-ups after discharge ranged from one to 12. The last visit was between one and 18 months after discharge, a mean period of 7.8 (CI 3.7-11.8) months. Data collection on follow-up concluded on 30 November 2010.

Surgical procedure

The same surgeon performed all reconstructive procedures. The skin with subcutaneous tissue was mobilized superficially to the fascia on both sides to achieve skin closure without compromising the blood supply. Except for patient 2, a PM was placed between the subcutaneous tissue and the fascia with an overlap of 3-4 cm on all sides. In patient 2, on-lay technique was impossible due to an almost complete lack of subcutaneous tissue, and the risk of skin necrosis in case of skin mobilisation was considered too great. Instead, the mesh was sutured to the edges of the fascia from the inside without mobilisation of the skin and subcutaneous tissue. All meshes were fixed with a running long-time absorbable 2-0 suture. One or two suction drains were placed laterally between the PM and the subcutaneous tissue, and the skin was closed with a nylon suture.

Two patients had intestinal fistulas closed simultaneously with the insertion of the mesh. In two patients, closure of the fistulas was impossible due to a frozen abdomen, and the mesh was used directly on the ex-

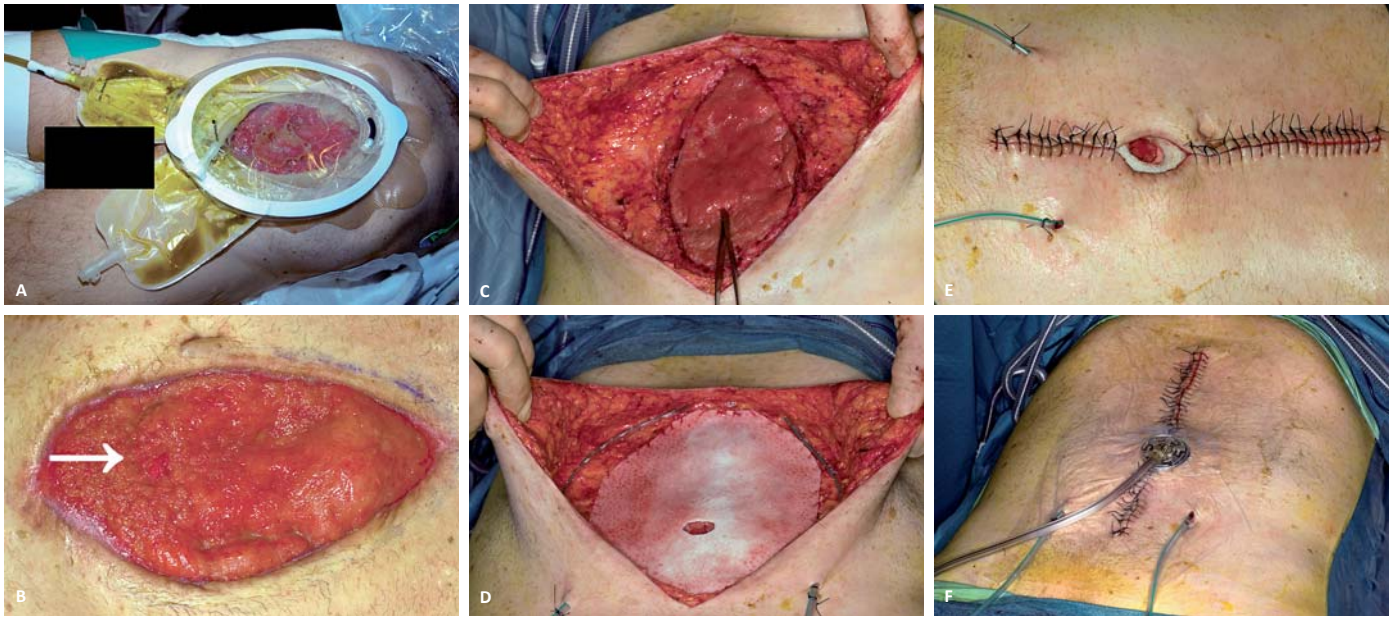
TABLE 1

Demographic and perioperative data of ten patients undergoing closure of complex, potentially infected abdominal wall defects with the use of Permacol (PM).

Patient no.	Age, years	Gender	Primary surgery	Time from initial laparostomy to closure, days	Stoma present at closure	Enteric fistula at abdominal closure	Size of fascia defect prior to closure, cm	Clinically overt infection at PM implantation
1	65	Female	Ventral hernia repair complicated by bleeding and removal of mesh	14	None	None	Unknown	None
2	66	Female	Bowel obstruction complicated by wound dehiscence	4	None	None	12 × 5	None
3	67	Male	Anastomotic leakage after anterior resection of the rectum	24	Ileostomy and colostomy	None	15 × 8	None
4	76	Male	Bowel obstruction complicated by perforation	60	None	Not closed	20 × 12	Present
5	64	Male	Anastomotic leakage after closure of diverting stoma after anterior resection	101	Colostomy	Not closed	20 × 8	Present
6	65	Female	Hartman's resection due to perforated diverticulitis	142	Colostomy	Closed	10 × 10	Present
7	41	Female	Ventral hernia repair complicated by abscess at the mesh site	29	None	None	18 × 15	None
8	73	Female	Anastomotic leakage after closure colostomy	189	Colostomy	Closed	15 ×10	Present
9	59	Female	Anastomotic leakage after left hemicolectomy	60	Ileostomy	None	7 × 7	None
10	70	Male	Anastomotic leakage after anterior resection of the rectum	28	Colostomy	None	8 × 3	None

FIGURE 1

Per-operative pictures. **A.** Before implantation of Permacol mesh and wound closure in patient no. 4. **B.** Enteric fistula marked with arrow. **C.** Skin and subcutaneous tissue mobilised. Enteric fistula marked with end of forceps. **D.** Permacol mesh sutured to abdominal wall with on-lay technique. Two suction drains placed in the subcutaneous cavity. **E.** Skin closed, fistula encircled by polyvinyl alcohol sponge. **F.** Negative wound pressure therapy applied.



posed bowels and sutured to the edges of the fascia as described above A hole in the mesh was made at the site of the fistula. The skin was closed, except at the fistula sites. A negative pressure wound therapy system containing a ring of polyvinyl alcohol sponge encircling the fistula and a polyurethane sponge covering the skin defect at the site of the fistula was placed in order to drain the fistula and protect the wound and mesh (**Figure 1**). Per-operative prophylactic antibiotics were administered. Following sufficient healing of the wound, the fistulas could easily be covered by a stoma bag (**Figure 2**).

Statistical analysis

Means are presented with 95% CIs. Statistical analyses were performed with SAS JMP 8.0.2.

Trial registration: not relevant.

RESULTS

In five (50%) of the ten cases, closure of the abdominal wall was achieved with successful skin coverage simultaneously with BM implantation. The remaining five patients also obtained full initial coverage, but primary healing of the skin was unsuccessful (**Table 2**).

Patient no. 1 developed an abscess superficially to the mesh. An attempt was made to cover the largest skin defect, measuring 7 × 12 cm with split-skin; unfortunately, the graft was rejected. The patient was discharged, and the wound healed completely after ten months of conservative wound treatment.

Wound healing in patient no. 5 was complicated by leakage from the fistula, skin dehiscence and a cavity between the mesh and the skin. Total parenteral nutrition with no oral intake was administered for twelve days to reduce the fistula output. The wound was treated with frequent rinsing and changes of dressing, and it completely healed after six months.

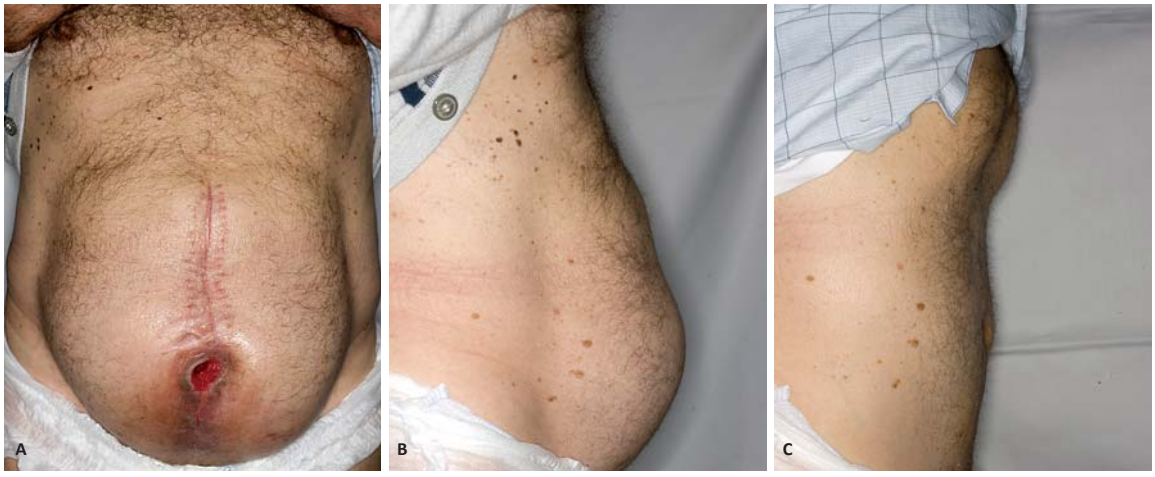
Patient no. 6 had dehiscence of the skin covering the mesh; the defect measured 6 × 3.5 cm. The defect was treated conservatively, and the patient was discharged. Four months after the PM reconstruction, a ventral hernia was clinically evident laterally to the PM. The patient is expected to need further surgery due to pain relating to the hernia. Patient no. 9 developed a small skin diastasis due to a haematoma between the mesh and the skin. Complete wound healing was achieved after two months.

Patient no. 10 had a 2-cm dehiscence of the skin (Table 2).

The mean time from primary laparostomy to reconstruction with PM was 80 days (CI 32-128 days) (Table 1). The mean hospital stay after PM reconstruction was 22 days (CI 13-31 days) (Table 2).

One patient underwent an elective ileostomy reversal 13 months after a successful PM implant. No her-

FIGURE 2



Post-operative pictures. Patient no. 4 seven weeks after abdominal wall defect closure with Permacol implantation. No hernia at the site of Permacol implantation. **A** and **B.** Supine position and lying on the left side (The Valsalva manoeuvre performed). **C.** Standing.

nias were found, and the PM was completely free of adhesions despite severe intra-abdominal adhesions in general.

DISCUSSION

Critically ill patients with an open abdomen continue to constitute a major surgical challenge. These patients require multiple procedures, which, in turn, demands considerable capacity in a surgical department. The patients need prolonged hospital and ICU stays, often many months, with associated psychological, social and financial problems [6]. Closure of the abdomen as early as possible is in everyone's best interest.

Delayed closure of the abdomen and the use of mesh involve the risk of infection, fistulas, adhesions and herniation. Due to high risk of infection, it was considered impossible to use synthetic mesh to close the abdomen in our cases. In the four cases of fistulas, the contamination was clinically overt. To accelerate the closure, we decided to use BM owing to the allegedly low risk of infection and hence higher success rate in contaminated wounds [7, 8]. The susceptibility to infections when PM is being used has been evaluated in several studies of which most show that the PM is a good choice in a contaminated wound because it is necessary to remove the mesh due to infection only in a very small number of cases. Infections can usually be treated with local wound care, and the mesh can be salvaged [9-11]. One study [10] using PM in strangulated incisional hernia repair with some cases of bowel resection and free, contaminated intraperitoneal fluid showed no postoperative wound infections. In our patient no. 1, the PM was left in situ, even in direct relation to a subcutaneous abscess, and the mesh was salvaged with conservative wound therapy.

It has previously been demonstrated that PM can be used without skin coverage and in close relation to a stoma [12, 13]. Our study confirms this.

Biological meshes (including Surgisis) and synthetic meshes have been compared in an animal study that found BM to be more susceptible to infection than synthetic meshes like ePTFE [14]. In contrast, another study showed that Surgisis was a good choice in contaminated wounds [15]. Further studies are warranted, and the use of biomaterial seems to be no guarantee of low susceptibility to infection.

Very few studies have evaluated the use of a biological mesh in the presence of abdominal fistulas. Connolly et al [16] reported a 42% re-fistulation rate when PM was used in patients undergoing simultaneous closure of enteric fistulas and different types of abdominal wall reconstruction. However, compared with other

TABLE 2

Results and follow-up of ten patients undergoing closure of complex, potentially infected abdominal wall defects with the use of Permacol.

Patient no.	Skin closure/healing achieved by	Hernia present at follow-up	Time to discharge after closure, days	Follow-up, months
1	Secondary intent	No	34	13.5
2	Primary closure	No	14	16.5
3	Primary closure	No	11	18.5
4	Primary closure	No	15	12.0
5	Secondary intent	No	11	18.5
6	Secondary intent	Yes	27	10.5
7	Primary closure	No	6	1.5
8	Primary closure	No	35	3.0
9	Secondary intent	No	31	8.0
10	Secondary intent	No	6	8.0

types of meshes, there was no statistically significant difference in the degree of re-fistulation. In two of the cases of our study, BM implantation was performed even with the fistulas present postoperatively causing continuous contamination of the surgical site and mesh. Both patients were bandaged with a small stoma bag, and future surgical closure of the fistulas is considered impossible. However, they ended up with only a low-out-put fistula covered by a stoma bag.

Several hernia surgeons have reported favourable results from the use of the component separation (CS) technique. In CS, the various layers of the abdominal wall are separated, which makes it possible to close the fascia in the midline with primary defects as large as 20 cm. In one study, re-herniation rates were 32% [17], but lower re-herniation rates may possibly be obtained by combining CS with mesh. CS involves intra-abdominal dissection to free the bowels from the abdominal wall, and this was not considered an option in our cases of patients with frozen abdomens.

Re-herniation rates are a natural concern in any abdominal wall closure method. In two studies using PM in ventral hernia repair with a total of 48 patients, the recurrence rate was shown to be equal to that of synthetic mesh (10-15%) [18, 19] This is consistent with the 10% recurrence rate observed in our study.

Being a xenograft, PM is subject to Food and Drug Administration (FDA) regulation in the USA. A study of all adverse events regarding xenograft meshes reported to the FDA in the 1997-2008 period raised serious concerns, as 87 of 150 reported adverse events were related to PM. The adverse events included postoperative mesh infections, fistulas, mechanical failure and mesh disintegration. Unfortunately, no data are available on the number of meshes being used in the same period without adverse events. The only conclusion one can draw from these numbers is therefore that these problems do arise in the use of PM, but how often is left unsaid [20].

Based on our experience, BM is an option for use in early closure of abdominal wall defects in potentially contaminated wounds, even when skin cover is not attainable at first, hence leaving the graft exposed. BM seems to lessen the need for prolonged changes of dressing of wounds with exposed bowel and the risks associated herewith. It allows earlier closure of the abdomen, even in the presence of fistulas, as well as earlier discharge of patients. Several different BM are available, but there is no evidence to support the choice of a particular mesh.

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