Ir J Med Sci (2012) 181:205–209
DOI 10.1007/s11845-011-0776-3

ORIGINAL ARTICLE

Initial experience of double-layer tension free reconstruction of abdominal wall defects with porcine acellular dermal collagen implant and polypropylene mesh

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Received: 27 April 2011 / Accepted: 13 October 2011 / Published online: 27 October 2011

Abstract
Introduction and aim Various techniques have been proposed for the repair of abdominal wall defects (AWD) with varying rates of success. Despite the development of new materials and modifications of surgical technique, no single approach has emerged as the optimum way to close large AWD. We report a method for repairing large incisional and recurrent abdominal wall hernias using a double-mesh technique. The defect is closed using an underlay biological implant and an onlay synthetic mesh, which is 'quilted' to the underlying abdominal wall and biological implant. The current study reports our initial experience with this approach in ten consecutive patients operated on for large AWD.
Methods In this prospective observational study the following data were collected: age, gender, previous surgery, co-morbidities, situation and size of the defect, antibiotic therapy, hospital stay, postoperative complications and bacteriology in case of infection. The patients were reviewed at 1, 3 and 6 months, and 1-year postsurgery.
Results Overall all ten AWD of $\geq$75 cm^2 were reconstructed successfully using the quilting technique. Median age of patients was 61 years (range 47–73 years); male:female ratio was 3:2 and median weight was 107.5 kg. Two patients developed a wound infection and were treated successfully with antibiotics. At median follow-up of 15.5 months (range 6–29 months) there was no case of recurrence.
Conclusion The use of double-layer of porcine acellular dermal collagen implant and polypropylene mesh in reconstruction of AWD can be considered a safe and effective treatment. The early short-term results are encouraging with few complications.

Keywords Abdominal wall defects · Biologic implant · Synthetic mesh · Recurrence

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Introduction

Reconstruction of large abdominal wall defects (AWD) continues to be a challenging problem for both general and reconstructive surgeons. Despite the development of new materials and modifications of surgical technique, no single approach has emerged as the optimum way to close large AWD [1]. Recent trials are unable to show sufficient evidence as to which type of mesh or which mesh position (on- or sub-lay) should be used in the repair of AWD [2]. Therefore, the ideal mesh's construction is still in progress and new strategies must be considered to enhance the success of herniorrhaphy [3]. More recently, advances in tissue engineering technology have led to the development of biomaterials derived from human and animal tissues as acellular, resorbable bio scaffolds for reconstruction of AWD. One such tissue graft derived from porcine skin is porcine acellular dermal collagen implant (PADCI) (Permacol™, TSL, UK).

Permacol™ is developed from porcine dermis by the enzymatic and chemical removal of cellular components to leave a cross-linked collagen and elastic rich biomaterial. It has already been used clinically for various urologic, gynaecologic and plastic surgery procedures [4–7]. There are several advantages to Permacol™ (the absence of a

permanent foreign body reaction, direct contact with bowel, resistance to infection, excellent mechanical properties) which makes it an attractive alternative to prosthetic mesh, especially in the situation of infection or contamination in abdominal wall replacement [4–7]. However, Permacol™ is associated with recurrence of incisional hernia. The reported recurrence rates vary from 6.7 to 20% at a mean follow up of 14–36 months [8, 9]. In our experience the use of porcine acellular dermal collagen in reconstructing complex AWD has a medium-term recurrence rate of 15% and a complication rate of 35% [8]. To maintain the advantages of a biological implant while reducing the recurrence rates of incisional hernia we combined biological and synthetic materials in the treatment of large AWD.

In this paper, we describe our initial experience using a combination of biological and synthetic materials to achieve tension-free abdominal wall closure in patients with large AWD. We describe the technique used and present our early experience in ten consecutive patients with this relatively simple technique.

Methods

Between March 2007 and June 2009, ten consecutive patients with large AWD were included in this study on an intention-to-treat basis at the Mid-Western Regional Hospital, Limerick, Ireland. Our inclusion criteria were patients with AWD arising from a large incisional or umbilical hernia. We arbitrarily defined defects measuring $\geq$75 cm^2 or greater as large AWD (Table 1). Patients with small AWD and those with groin hernia were excluded from this study. The data were collected prospectively; these included age, gender, previous surgery, co-morbidity, American Society of Anaesthesiologists (ASA) score, size of the defect, antibiotic therapy, postoperative complications, bacteriology in case of complications and follow-up. The patients were reviewed at 1, 3 and 6 months, and yearly thereafter. In addition, each patient's record was reviewed for additional primary care appointments and emergency room visits.

Surgical technique

Preoperatively, all patients were evaluated by eliciting a full history and performing physical examination. Site and size of the defects were carefully assessed clinically and by CT scanning. All patients received thromboprophylaxis with subcutaneous enoxaparin and broad-spectrum antibiotic prophylaxis preoperatively. All procedures were performed under general anaesthesia.

After standard skin preparation and draping, all patients underwent exposure of the hernia sac and the margins of the AWD were defined. In all cases with previous surgery, the cutaneous scars were excised and the hernia sac dissected to expose the edges of the AWD. The sac was opened and intraperitoneal adhesions, especially those related to the inner aspect of the anterior abdominal wall divided. Skin and subcutaneous tissue flaps were then raised to the anterior axillary lines laterally. Thus, the rectus sheath and the external oblique aponeurosis were exposed for a distance of at least 10 cm around the AWD in all directions.

Table 1 Characteristics of the patient cohort

No	Age	Sex	ASA	Type of hernia	Defect size (cm^2)	Main risk factors	Co-morbidity	Wt	No of sheets of Pc	No of sheets of Pm
1	59	F	2	Recurrent incisional	10 × 8.5	Obese, 2nd attempt	COPD, IHD	102	1	1
2	71	M	3	Incisional	24 × 15	Obesity	Asthma, COPD, CCF	117	2	1
3	65	M	3	Incisional	10 × 7.5	Obesity, warfarin	CVA, PE, CCF	105	1	1
4	73	F	2	Incisional	10 × 8	DM, obesity	IHD, DM	101	2	1
5	49	M	2	Recurrent incisional	11 × 8	Obesity, 2nd attempt	HTN	122	1	1
6	62	M	2	Recurrent incisional	35 × 10	Obesity, steroids, chemotherapy 4th attempt	Crohn's, Ca Colon	110	5	2
7	47	M	2	Umbilical	9 × 10	DM, obesity	DM	113	1	1
8	54	M	2	Recurrent incisional	10 × 12	DM, obesity 3rd attempt	HTN, DM	115	1	1
9	73	F	2	Incisional	12 × 10	Chemotherapy	Renal tumour	80	1	1
10	55	F	2	Recurrent incisional	15 × 10	DM, 3rd attempt	CRF, DM	87	2	1

Wt weight in kilogrammes, *Pc* Permacol™, *Pm* Premilene®, *COPD* chronic obstructive airway disease, *CCF* congestive cardiac failure, *CRF* chronic renal failure, *PE* pulmonary embolism, *HTN* hypertension, *IHD* ischaemic heart disease, *DM* diabetes mellitus, *Ca* carcinoma

We used a combination of Permacol™ and Premilene® to reconstruct the AWD. Permacol™ is presented as a sterile, off-white, moist, tough, flexible flat sheet in sterile saline. The size of each sheet used in this study was 10 × 15 cm in width and length and 1.5 mm in thickness. The number of sheets used depended upon the size of the defect. Permacol™ was fixed to the posterior aspect of the anterior abdominal wall using an underlay technique (Fig. 1). Permacol™ was placed deep to the rectus muscles with the edges of the defect overlapping the graft by at least 2 cm circumferentially (Fig. 2). The biological graft was fixed with interrupted horizontal mattress sutures using 0 polypropylene. If necessary, multiple sheets of Permacol™ were combined and sewn together to achieve a tension-free closure of the defect.

We used synthetic monofilament polypropylene mesh (Premilene®) as a second layer to achieve hernia repair (Fig. 3). A 30 cm × 30 cm synthetic polypropylene mesh was placed using an onlay technique over the implanted Permacol™, rectus muscles and external oblique aponeurosis (Fig. 3). The polypropylene mesh was then sutured (quilted) to the underling abdominal wall muscle and the biological graft analogous to the technique used in making a quilt (Fig. 4). Multiple closed suction drains were placed superficial to the repair. The subcutaneous fat layer was re-approximated with interrupted absorbable suture and skin was closed with clips in all patients. The operating time and any intraoperative complications were recorded.

Postoperative protocol

Postoperatively, patients were monitored closely for complications. The drains were removed, when less than 20 ml

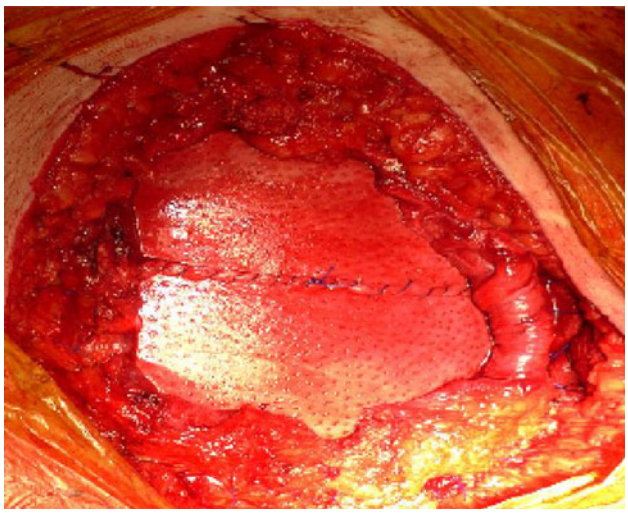

Fig. 1 Shows the placement of two sheets of Permacol™ using a sublay technique. The sheets were fixed with interrupted horizontal mattress sutures using 0 polypropylene

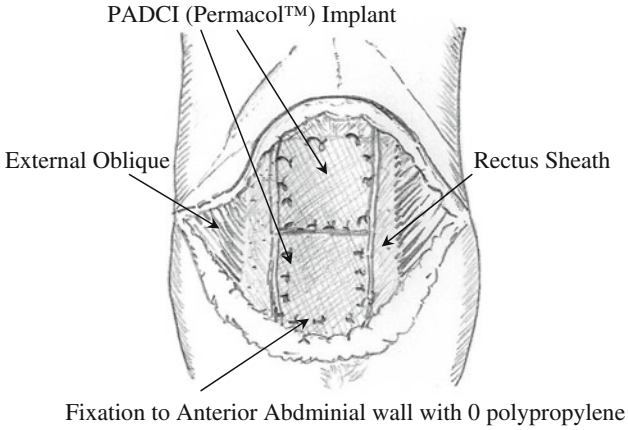

Fig. 2 Shows the placement of PADCI biologic implant directly in contact with the bowel and fixation to the posterior aspect of the anterior abdominal wall using a sublay technique

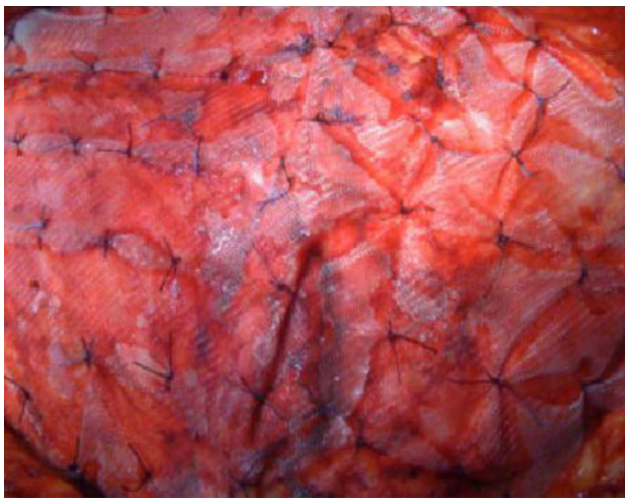

Fig. 3 Shows the polypropylene mesh sutured to the underling abdominal wall muscle and the biological graft Permacol™ using the "quilting" technique

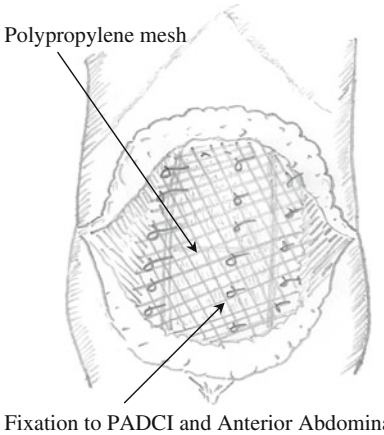

Fig. 4 Shows the placement of polypropylene mesh (Premilene®) using an onlay technique over the PADCI, rectus muscles and external oblique aponeurosis

was drained in a 24-h period. Patients were mobilized as soon as possible and discharged once the drains had been removed. Patients were evaluated at 1, 3 and 6 months postoperatively in the outpatient clinic.

The incidence of complications was determined using homogeneous definitions. We defined seroma as fluid collections that required drainage or caused symptoms. The definition of wound infection was based on clinical signs of infection and microbiologic culture. Recurrence was defined as any abnormal protrusion and or defect at the site of the prior repair with positive cough impulse on clinical examination. All patients were examined in the clinic by the consultant surgeon and the senior registrar for complications and/or recurrence of the hernia.

Results

All ten AWDs were reconstructed successfully using the double-synthetic mesh/biological graft quilting technique. Demographic characteristics of the patients in our series included a median age of 61 years (range 47–73 years), a male:female ratio of 3:2 and a median weight of 107.5 kg (range 80–122 kg) (Table 1).

Of the ten patients with AWD, four had first-time repair of a large incisional hernia, one had first time repair of a large umbilical hernia and the remaining patients had two or more previous repairs for recurrent incisional hernia. A single biological graft (10 × 15 cm) was used in six patients, two grafts in three patients and five grafts in one patient. Nine patients had one 30 × 30 cm polypropylene mesh placed and one patient had two meshes placed.

All ten patients (100%) recovered well from the surgery and were discharged from hospital at a median of 8 days postoperatively. Complications and recurrences are shown in the Table 2. There was no mortality in this series. Four patients (40%) developed a complication. One patient who underwent repair of a large umbilical hernia developed infection with MRSA. Another patient with a large incisional hernia developed a wound infection; both patients were successfully treated with intravenous and oral antibiotics without the need for removal of mesh. One patient developed a localised wound seroma which was managed as an outpatient with percutaneous aspiration and oral antibiotics. One patient with asthma developed a lower respiratory tract infection and was treated with antibiotics and physiotherapy.

Median follow-up was 15.5 months (range 6–29 months). No case of recurrence was noted. All patients were satisfied with their treatment. There was no case of chronic pain, intestinal fistula or problems related to intestinal adhesion on follow-up.

Table 2 Showing the postoperative complications

Patient no	Length of stay (days)	Complications	Recurrence	Follow up in months
1	8	Nil	None	29
2	14	Nil	None	27
3	16	Wound infection (*Staphylococcus aureus*)	None	26
4	11	Nil	None	24
5	7	Wound seroma	None	17
6	9	LRTI	None	14
7	6	Wound infection (MRSA)	None	11
8	7	Nil	None	7
9	7	Nil	None	7
10	8	Nil	None	6

LRTI lower respiratory tract infection, *MRSA* Methicillin-resistant *Staphylococcus aureus*

Discussion

The management of large AWD remains a common and difficult problem in general surgical practice. The goal of a successful repair is to achieve restoration of the abdominal wall with the lowest possible incidence of complications and recurrence. The use of alloplastic materials has lowered recurrence rates [11], but their use poses other major risks [12–16]. For such reasons, alternative means of reconstructing the abdominal wall are being sought. Over the past decade component separation techniques and muscle flaps have become increasingly popular alternatives for closure of complex ventral hernias, but these techniques cannot be applied universally. Postoperative complications (20–43%) and re-herniation (8–32%) are still common with these approaches [17–19].

An ideal biomaterial for hernia repair is one that not only resists adhesions and infection but also remodels completely into the host tissue and has mechanical and biological properties similar to those of the host tissue. Newer biosynthetic materials have been developed in an attempt to satisfy some of these properties. Permacol™ is one such biomaterial, which has been successfully used in numerous types of hernia repair (inguinal, incisional, parastomal) with good results [4]. The reported recurrence rate with the use of Permacol™ is high and in our own experience the material stretches and diastasis occurs with time which causes local bulge or hernia recurrence [10, 20]. In the present study we have combined Permacol™ with a standard synthetic mesh achieving bowel cover with the biological material and strength with the synthetic material. This approach avoids bowel-related problems such as

adhesions and fistula formation while achieving wound strength to avoid recurrence. Although we have not used this technique in potentially infected fields, two of our patients developed postoperative wound infection and were successfully treated with antibiotics without the need for removal of mesh. Of note one of the infections was with MRSA. At the median follow up of 15.5 months there was no sign of recurrence or infection in either case.

In patients with co-morbidities such as morbid obesity, diabetes and or a history of infection, complications such as mesh extrusion, infection, and fistula formation have been reported with rates ranging from 23 to 78% [21]. In our study most of the patients were obese and/or diabetic and had multiple co-morbidities which make them at higher risk for surgical complications and especially recurrence. Most surgeons are reluctant to operate on such patients due to high failure rates and complications. This study shows that such complex patients can be treated successfully with few complications. The zero recurrence rates at 15.5 months may be due to the short follow-up period, but we believe that the two-layered technique may be responsible for these good results. A longer follow up is required and our patients remain under review.

The cost of biological graft material is significant and has economic implications in the management of complicated AWD. The cost of a 10 × 15 cm sheet of Permacol™ graft is approximately €2,073.00 and that of a 30 × 30 cm Premilene® mesh is €259.00. A total cost of nearly €2,500.00 per case for implant material may seem exorbitant but this has to be offset against the benefit of low recurrence rates, the avoidance of further surgery in these complicated cases. However, we did not do a formal analysis of cost in this study.

In conclusion, the use of a double-layer of porcine acellular dermal collagen implant and polypropylene mesh in tension-free reconstruction of AWD with the quilting approach is a safe and effective technique. The early short-term results are promising with few complications. This technique is encouraging and provides an alternative approach for the management of difficult AWD in complicated patients.

Conflict of interest None.

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