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HEAVY-WEIGHT VERSUS LOW-WEIGHT POLYPROPYLENE MESHES FOR OPEN SUBLAY MESH REPAIR OF INCISIONAL HERNIA

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Abstract

Background: The introduction of retromuscular, preperitoneal sublay technique using polypropylene (PP) meshes had significantly decreased the recurrence rates after open incisional hernia repair. Nevertheless, recent data of single institutions reported about non-acceptable high hernia recurrences. The objective of this study was to determine early complications and the long-term course of patients who underwent open sublay hernia repair using heavy-weight versus low-weight PP meshes.

Methods: Between January 1996 and December 1997, all consecutive patients received large pore-sized, monofilament heavy-weight PP meshes (Prolene®); from January 1998 to December 2001, only large pore-sized, low-weight PP meshes (Vypro®) composed of multifilaments were used. The clinical course of all patients was registered during the hospital stay as well as 3 months and at least 12 months after surgery.

Results: Sixty-nine patients (mean age 56 ± 13 years) underwent sublay hernia repair with heavy-weight PP meshes, 106 patients (mean age 60 ± 14 years) with low-weight PP meshes. No significant differences were determined concerning age, gender, BMI, ASA score, hernia size 25 – 99 cm^2 and number of primary midline incisions. In contrast, mean hernia size and number of hernia size ≥ 100 cm^2 were significantly higher, whereas number of hernia size < 25 cm^2, ratio of recurrent hernia and length of hospital stay were lower in the low-weight PP mesh group. Minor complications (17%) appeared more frequently in the heavy-weight than in the low-weight PP mesh group (13%). One patient each with major bleeding required re-operation in both groups. One patient with lethal pulmonary embolism in the heavy-weight PP mesh group and one patient with unrecognised enterotomy and re-operation in the low-weight PP mesh group were registered. In the long-term run (mean follow-up 92 ± 20 months), patients of the heavy-weight PP mesh group complained significantly more frequently about chronic pain and "stiff abdomen" than those of the low-weight PP mesh group (46 ± 14 months). Two hernia recurrences occurred in each study group. Two of them were found after midline hernia repair at the edge of the mesh, the remainder were detected after lateral hernia repair.

Conclusion: Large pore-sized low-weight PP meshes composed of multifilaments are clearly to be favoured over large pore-sized, monofilament heavy-weight PP meshes because of better abdominal wall compliance and less chronic pain. However, both types of meshes are convincing due to high tensile strength and low recurrence rates in the long-term run.

Key words: Ventral hernia; incisional hernia; recurrence; sublay; hernia repair; polypropylene

INTRODUCTION

The incidence of incisional hernia after primary closure of the abdominal wall varies from 2% to 20% [12, 35]. This range reflects different surgical approaches (vertical midline or transverse incision) and closure techniques (interrupted or running suture of the fascia), different suture materials (absorbable or non-absorbable; multifilament or monofilament), as well as wound complications (haematoma, seroma, infection) and patient's factors (age, obesity, obstructive lung disease, malnutrition, connective tissue disease or collagen metabolic disorders) [14, 18, 40].

Open conventional hernia repair revealed high, non-acceptable recurrence rates between 25% and 52% [9, 23, 33]. The increasing use of prosthetic materials as well as the introduction of the retromuscular, preperitoneal sublay repair had significantly decreased the recurrence rates below 10% [31, 36, 38, 39]. Usher introduced established monofilament polypropylene (PP; Marlex®) meshes in clinical practise [44]. Recently, however, considerable recurrences of up to 34% are also reported for incisional hernia repair with PP meshes [3, 7, 21, 26, 28]. Factors favouring hernia recurrence certainly include technical as well as biological aspects [4, 14, 27]. The aim of this present comparative study was to determine early and late results after open preperitoneal sublay repair of incisional hernias with heavy-weight versus low-weight PP meshes.

PATIENTS AND METHODS

STUDY SUBJECTS

Between January 1996 and December 2001 all consecutive patients, who underwent open preperitoneal, retromuscular sublay repair of incisional hernias using PP meshes, were enrolled in this study. Patients suffering from parastomal hernias and patients undergoing hernia repair without PP meshes or by another technique (laparoscopic hernia repair, onlay or inlay mesh repair) were excluded from the analysis. Between January 1996 and December 1997 only large pore-sized (1.6 mm), monofilament heavy-weight PP meshes (n = 69; Prolene®; weight 109 g/m², 21 tex; Ethicon, Norderstedt, Germany) were used. From January 1998 to December 2001 multifilament low-weight PP meshes (n = 106; Vypro®, weight 55 g/m²; Ethicon, Norderstedt Germany) were exclusively inserted. These meshes are large pore-sized (3 – 5mm) and composed of non-absorbable PP multifilaments of 6.7 tex (basic fibres 1.3 tex) and absorbable polyglactin 910 multifilaments of 8.9 tex (basic fibres 0.2 tex).

Preoperatively, all patients received bowel preparation with laxatives and pulmonary training. Antibiotic (cephalosporins, metronidazol) as well as thromboembolism prophylaxis (low-molecular weight heparin) were provided during patient's hospital stay.

Operation Technique

After excision of the entire skin scar the hernia sac and subsequently the abdominal cavity are routinely opened [38]. A laparotomy has to be performed both for proper dissection of the preperitoneal, retromuscular space and injury prevention to adherent bowel loops below the peritoneum. Afterwards, the rectus sheath is opened around the umbilicus and dissected in the cranial and caudal direction. The blunt preparation is continued to both sides on the posterior rectus sheath behind the rectus muscles. The dissection is stopped when a sufficient overlap of 5 – 6 cm is reached in each direction. Thereby, the lateral nerves and vessels of the rectus muscle must be carefully handled to avoid their damage during the preparation. This overlap must be also attained behind the xiphoid in the case of cranial hernias and behind the pubic bone in the case of distal lesions. To ensure this overlap in case of cranial subxiphoidal hernia, the linea alba should be dissected without harming the anterior fascial layer. The posterior rectus sheath must be cut along the linea alba and the preparation extended behind the xiphoid and ribs into the muscular plain of the diaphragm. For infraumbilical hernias the preperitoneal preparation must be carried out behind the pubic bone. If necessary, the lower part of the mesh can be fixed to Cooper's ligament in order to prevent its detachment. Thus, the prosthetic material lies in the preperitoneal space below the arcuate line.

The peritoneal layer is closed with an absorbable running suture. Direct contact of the intestine with the mesh must be avoided to prevent enterocutaneous fistula formation. If the peritoneum or the hernia sac fails to be closed by suture, an absorbable mesh (polyglactin 910, Vicryl®) is sutured to the circumference of the hernia orifice and works as a temporary "buffer zone", until the mesothelial cells have closed the peritoneal defect. If required, the bowels can be covered with greater omentum. Then the mesh is placed between the rectus abdominis and the posterior rectus sheath into direct contact with the muscle fibres (Fig. 1).

Because of the self-fixation in sublay position, some 3-0 absorbable interrupted sutures are used to keep the mesh in place for the first few days. After positioning of drains the anterior fascia is closed without tension using an absorbable running suture loop. Sometimes a second mesh is necessary for closure of the fascia to prevent a retraction of the rectus muscles ("sandwich technique"). Subcutaneous drainage and the closure of the skin complete the procedure [38].

Follow-up and Statistical Analysis

The clinical course of all patients was registered during the hospital stay as well as 3 months and at least 12 months after open sublay mesh repair. All data are presented as mean ± standard error of the mean (range). Due to missing normal distribution of the data, group differences were accomplished by means of Mann-Whitney-U test. The statistical analysis was performed using SPSS version 12.0 (SPSS GmbH Software, München, Germany). Significance was set at two-tailed p-values of less than 0.05.

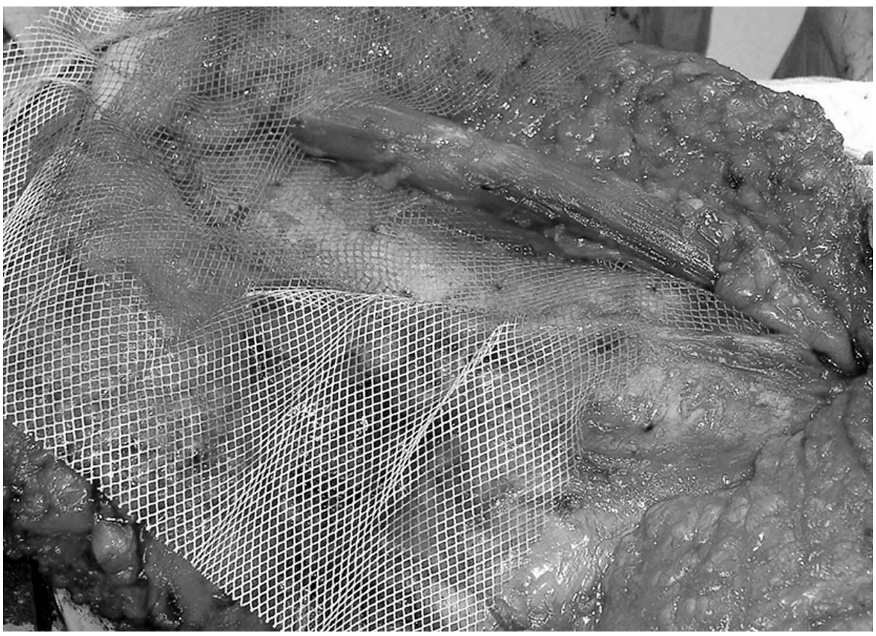

Fig. 1. Sublay position of large pore-sized, low-weight PP mesh between the rectus muscle and posterior rectus sheath. Some 3-0 absorbable interrupted sutures are used to keep the mesh in place.

RESULTS

PATIENT CHARACTERISTICS

Sixty-nine patients (mean age 56 ± 13 years, range 24 – 80 years; 36 male, 33 female) underwent sublay hernia repair with heavy-weight PP meshes from January 1996 to December 1997 (Table 1). Their mean ASA score was 2 ± 1 points (1 – 4). Fifty subjects (72%) had a body-mass index (BMI) ≥ 25 kg/m^2. The hernia size was > 100 cm^2 in 42 patients (61%). The mean hospital stay was 11 ± 3 days. At the primary operation, 51 patients (74%) received midline incision, the remainder underwent transverse incision of the upper or lower abdominal wall. Thirty-six patients (52%) suffered already from recurrent hernia.

Between January 1998 and December 2001, 106 patients (mean age 60 ± 14 years, range 28 – 82 years; 62 male, 44 female) received sublay hernia repair with low-weight PP meshes (Table 1). Their mean ASA score was 2 ± 1 points (1 – 4). Seventy-three patients (69%) had a BMI > 25 kg/m^2. The hernia size was > 100 cm2 in 77 patients (73%). The mean hospital stay was 9 ± 2 days. At the primary operation, 82 patients (77%) underwent midline incision. Forty-eight patients (45%) suffered already from recurrent hernia.

No significant differences were measured concerning age, gender, BMI, ASA score, hernia size 25 – 99 cm2 and number of primary midline incisions. In contrast, the mean hernia size and the number of hernia size > 100 cm2 of the low-weight mesh group were significantly higher, whereas the number of hernia size < 25 cm2 and ratio of recurrent hernia as well as the length of hospital stay were significantly lower compared to the heavy-weight mesh group (Table 1).

Table 1. Characteristics of patients who underwent open sublay repair of incisional hernia using heavy-weight or low-weight polypropylene mesh.

	Heavy-weight mesh (n = 69)	**Low-weight mesh (n = 106)**	**P-value**
Age, years	56 ± 13 (24 – 80)	60 ± 14 (28– 82)	NS
Male (%)	36 (52%)	62 (59%)	NS
BMI (kg/m2) > 25 (%)	50 (72%)	73 (69%)	NS
ASA score, points	2 ± 1 (1 – 4)	2 ± 1 (1 – 4)	NS
Hernia size, cm^2	129 ± 110 (6 – 550)	155 ± 40 (30 – 500)	< 0.05*
≥ 100 cm2 (%)	42 (61%)	77 (73%)	< 0.05*
25 – 99 cm2 (%)	18 (26%)	25 (23%)	NS
< 25 cm2 (%)	9 (13%)	4 (4%)	< 0.05*
Former midline incision (%)	51 (74%)	82 (77%)	NS
Recurrent hernia (%)	36 (52%)	48 (45%)	< 0.05*
Hospital stay, days	11 ± 3 (6 – 20)	9 ± 2 (5 – 17)	< 0.05*

BMI = body mass index; * p < 0.05 indicates significant differences in Mann-Whitney-Test.

Table 2. Early complications after open sublay repair of incisional hernia using heavy-weight or low-weight polypropylene mesh.

	Heavy-weight mesh (n=69)	**Low-weight mesh (n=106)**	**P-value**
Minor complications (%)	12 (17%)	14 (13%)	NS
Haematoma	2	2	
Seroma	2	3	
Wound infection	2	1	
Pulmonary infection	3	4	
Urinary tract infection	1	–	
Prolonged ileus	2	4	
Major complications (%)	2 (3%)	2 (2%)	NS
Haemorrhage	1	1	
Pulmonary embolism	1	–	
Enterotomy	–	1	

* p < 0.05 indicates significant differences in Mann-Whitney-Test.

Table 3. Late complications after open sublay repair of incisional hernia using heavy-weight or low-weight polypropylene mesh.

	Heavy-weight mesh (n=69)	**Low-weight mesh (n=106)**	**P-value**
Follow-up (months)	92 ± 20 (76 – 107)	46 ± 14 (13 – 82)	< 0.05*
Chronic pain (%)	14 (20%)	4 (4%)	< 0.05*
"Stiff abdomen" (%)	26 (38%)	4 (4%)	< 0.05*
Recurrence rate (%)	2 (3%)	2 (2%)	NS
Midline hernia repair	1	1	
Lateral hernia repair	1	1	

* $p < 0.05$ indicates significant differences in Mann-Whitney-Test.

Early Complications during Hospital Stay

In the heavy-weight group minor complications (17%) appeared more frequently than in the low-weight mesh group (13%), but the differences for each symptom were not significant (Table 2). Moreover, we registered one patient each with major bleeding and subsequent re-operation in the heavy-weight as well as low-weight mesh group. Finally, one patient with lethal pulmonary embolism in the heavy-weight mesh group and one patient with non-recognized enterotomy, subsequent re-operation and mesh removal in the low-weight mesh group were documented during hospital stay.

Long-term Follow-up

In the long-term follow-up (92 ± 20 months), patients of the heavy-weight mesh group significantly more frequently complained about chronic recurrent pain (20%) and "stiff abdomen" (38%) compared to the low-weight mesh group (46 ± 14 months; Table 3). Moreover, there have been 2 hernia recurrences in each study group without significant differences. Two of them were found after midline hernia repair at the edge of the mesh, the remainder were detected after lateral hernia repair (Table 3). Hereby, the lateral abdominal wall revealed an extended relaxation despite incorporated mesh material.

Discussion

Incisional hernias may occur after abdominal operations, having been reported in 2% to 20% of all patients undergoing laparotomy [12, 13, 32, 35]. Vertical midline or paramedian incisions exhibit the highest incidence of hernia formation. Some risk factors for the development of incisional hernia recurrence can be clearly identified: size of fascial defect > 5cm; patient's age, obesity, wound infection, diabetes, obstructive lung disease, benign prostatic hypertrophy, malnutrition, or connective tissue disease [18, 40]. Recently, biological approaches have been introduced to the understanding of the pathogenesis of hernia formation after simple closure of abdominal wall [10, 14, 18, 40]. The composition of scar tissue with a lowered collagen type I/III ratio may lead to a reduced tensile strength and later hernia recurrence [14, 18]. Skin fibroblasts obtained from adults with inguinal hernias produced collagen with a reduced type I/III ratio [10, 40].

Suture repair techniques, i.e. simple closure, vest-over-pants repair or Mayo procedure, are associated with high recurrence rates between 30% and 50% [9, 23, 29, 33, 43]. Thus, the absence of healthy and suitable tissue for hernia repair underlines the demand for reinforcement of the abdominal wall using prosthetic material. The introduction of synthetic meshes has provided the opportunity to perform a tension-free repair, thereby significantly reducing recurrence rates as well as wound complications [31, 36, 39, 41]. The ideal prosthetic material for the reinforcement of the abdominal wall should: (1) not be physically altered by tissue fluids, (2) be chemically inert, (3) not produce foreign body reactions, (4) be non-carcinogenic and non-allergenic, (5) resist mechanical strains, and (6) have the ability to be sterilised [1, 20]. In principle, two different types of materials may be used according to their absorption behaviour:

1. Absorbable meshes (polyglactin 910 [Vicryl®]; polyglycolic acid [Dexon®]). They are completely replaced by connective tissue resulting in an unstable scar. These meshes are recommended only for temporary abdominal closure or infected wounds, but not for stable incisional hernia repair.
2. Non-absorbable meshes (polypropylene [PP; Marlex®, Prolene®, Surgipro®, Vypro®]; polyester [Mersilene®]; polyamide [Nylon®]; expanded polytetrafluoroethylene [ePTFE; Gore-Tex®]). Polypropylene, polyester and polyamide meshes induce an extended desmoplastic tissue reaction resulting in the formation of a sheet of scar, which uses the mesh as a scaffold for its formation. Since these types of meshes are incorporated into the abdominal wall very well, they are suggested to be suitable for stable incisional hernia repair. In contrast, ePTFE meshes may also induce an inflammatory reaction with local oedema, collagen formation and neoangiogenesis. However, these meshes will be completely encased by a surrounding layer of scar tissue like a foil; it is only loosely attached resulting in an unstable host-tissue fixation [2]. The use of ePTFE is associated with fewer visceral adhesions,

but also less fibrocollagenous ingrowth into the abdominal wall [5]. Nowadays, ePTFE meshes are predominantly used for laparoscopic intraperitoneal onlay mesh repair of incisional hernias.

Because of their outstanding properties, PP meshes are the most widely used prosthetic material in open retromuscular sublay repair for incisional hernia. Early wound complications such as haematoma, seroma or infection are rarely reported in 15% to 27% [8]. Even after long-term follow-up, hernia recurrence rates are clearly below 10%, if there is a sufficient overlap [8, 22, 25, 30, 38, 39, 42]. The sublay position behind the rectus muscles provides a large contact area between the PP mesh and the adjacent aponeurosis. The mesh is pushed against the ventral abdominal wall, thus creating optimal conditions for good anchorage of the mesh to the fascia [8, 38]. In most cases, hernia recurrence results due to surgical errors, i.e. haematoma mesh lifting, undersized mesh with insufficient overlap at the edges, or inadequate lateral inferior and medial inferior mesh fixation followed by migration and hernia formation at the fascial edge. The overlap should be at least 5–6 cm in all directions, particularly at the cranial edge behind the xiphoid and caudal behind the pubic bone [12, 38].

PP meshes show a very high stretch and tensile strength, which is five times as high as the maximum physiological stress. Thereby, the inflammatory reaction and the extent of scar tissue depend on the amount and structure of the incorporated material. It is responsible for local wound complications, i.e. seroma and infection, as well as the abdominal wall compliance [39]. About 20% of patients exhibit a significant reduction of the abdominal wall mobility after implantation of large heavy-weight PP meshes [17, 34]. Obviously, the type of polymer, the weight in g/m2, the proportion of pores in % and, therefore, the surface area in contact with the recipient tissues plays key roles for the evaluation of biocompatibility and the host reaction [19]. New large pore-sized, low-weight PP meshes (Vypro®) being still strong enough to resist maximal physiological stress of the abdominal wall were developed [39]. However, the construction of these meshes requires the use of multifilaments to prevent an inappropriate stiffness of the textile material. Furthermore, absorbable filaments had to be added to improve ease of handling. This is followed by a relative increase of the foreign-body surface with a supposed increased risk for bacteria adherence. In contrast, the construction of a large pore-sized, low-weight mesh allows the reduction of both the material weight and the corresponding surface area [15]. Using these materials has been associated with a tendency to less pain, mesh awareness, and lack of symptoms such as "stiff abdomen" [39, 45]. And those few patients suffering from wound infection, even if is present, can be successfully treated by antibiotics with the PP mesh in situ [11].

Our data correspond very well with other single-institutional and randomised controlled trials [6, 24, 36-38]. Twenty percent of those patients undergoing reinforcement of the abdominal wall with large pore-sized heavy-weight PP meshes complained about chronic pain. Moreover, 38% of them reported about foreign-body sensations within the abdominal wall or a "stiff abdomen" in the long-term run. In contrast, only 4% of those subjects undergoing open sublay repair with low-weight PP mesh complained about foreign-body sensations, "stiff abdomen" or pain at the lateral edge of the implanted mesh. Finally, very low recurrence rates were detected for both study groups suggesting the highly standardised surgical technique.

Besides undersizing or dislocation, hernia recurrence at the edge of the mesh may also appear due to shrinking of the mesh. Meshes with high PP contents may shrink to about 20% to 50% of their original size after weeks or months [1, 16]. In contrast, meshes with low PP amounts showed less inflammatory response and subsequently less shortening. Shrinkage might be responsible for secondary folding in cases of poor elasticity and small pores. It is a consequence of the physiological wound contraction, initially by dehydration of soft tissue and later by maturation and cross-linking of the collagen fibres. The contraction depends on the extent of inflammation and scar formation resulting from the material used [16]. Thus, an overlap of at least 5 cm is required to achieve a sufficient reinforcement of the abdominal wall after shrinkage [38].

Conclusions

Although the ideal prosthetic material has not been found, PP meshes exhibit a lot of outstanding properties for open sublay repair of incisional hernia. Since the inflammatory reaction depends on the amount and structure of the incorporated material, large pore-sized low-weight PP meshes composed of multifilaments are clearly to be favoured over large pore-sized, monofilament heavy-weight PP meshes because of better abdominal wall compliance and less chronic pain. Both types of meshes are equally convincing due to high tensile strength and low recurrence rates in the long-term follow-up.

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