Polypropylene and polypropylene/polyglecaprone (Ultrapro®) meshes in the repair of incisional hernia in rats[1]

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ABSTRACT

PURPOSE: To compare the inflammatory response of three different meshes on abdominal hernia repair in an experimental model of incisional hernia.

METHODS: Median fascial incision and skin synthesis was performed on 30 Wistar rats. After 21 days, abdominal hernia developed was corrected as follows: 1) No mesh; 2) Polypropylene mesh; and, 3) Ultrapro® mesh. After 21 days, the mesh and surrounding tissue were submitted to macroscopic (presence of adhesions, mesh retraction), microscopic analysis to identify and quantify the inflammatory and fibrotic response using a score based on a predefined scale of 0-3 degrees, evaluating infiltration of macrophages, giant cells, neutrophils and lymphocytes.

RESULTS: No significant difference was seen among groups in adherences, fibrosis, giant cells, macrophages, neutrophils or lymphocytes ($p>0.05$). Mesh shrinkage was observed in all groups, but also no difference was observed between polypropylene and Ultrapro mesh (7.0±9.9 vs. 7.4±10.1, respectively, $p=0.967$). Post-operatory complications included fistula, abscess, dehiscence, serohematic collection and reherniation, but with no difference among groups ($p=0.363$).

CONCLUSION: There is no difference between polypropylene (high-density) and Ultrapro® (low-density) meshes at 21 days after surgery in extraperitoneal use in rats, comparing inflammatory response, mesh shortening, adhesions or complications.

Key words: Hernia. Surgical Mesh. Polypropylenes. Inflammation. Rats.

Introduction

The most common complication of abdominal surgery is incisional hernia. Prospective studies have shown that its incidence ranges from 9% to 20%[1-2]. In the United States (US), approximately 200.000 incisional hernia repairs are performed annually at a cost of nearly 2.5 billion dollars[3].

Incisional hernia results from combined biomechanical failure on the acute abdominal fascial defect with progressive increase in intra-abdominal pressure during the postoperative period. The most frequent risk factors include closure technique, deep wound infections, malnutrition, perioperative hypotension, steroid use and aortic aneurysm[4,5].

Recurrence after hernia repair constitutes an important complication to treatment[2]. The use of meshes in the US increased from 34.2% to 65.5% in 1999[2]. A prospective, controlled, multicenter study in 2004 showed that recurrence in patients in whom mesh was used was approximately 50% lower compared to suture repair[3]. Although several materials available, no consensus exists on the best mesh for hernia repair.

The most commonly used material for abdominal wall repair is polypropylene mesh. It is low-cost and provides adequate tensile strength, although it induces intense inflammatory reactions, which is a strong stimulus for adhesion[5]. Lightweight meshes (polypropylene/polyglecaprone) have led to an appreciable improvement in biocompatibility, less retraction, easier handling, and less adhesion; however these materials are more expensive[6]. Recently, lightweight meshes recovered with polyglecaprone film were developed for repair of inguinal hernia, although no studies adress its use in abdominal hernias[7]. The objective of this study was to compare the biomechanical and inflammatory response of three different meshes on abdominal hernia repair in an experimental model of incisional hernia. In contrast to most studies[8], the present model consists of correction of an abdominal wall defect after the development of an incisional hernia in a model that mimics the development of human hernias (extraperitoneal use).

Methods

All procedures were performed with the prior approval of the Ethics Committee for Analysis of Research Projects (CAPPesq) at the Laboratory of Surgical of Physiopathology (LIM-62) at FMUSP.

Thirty adult male Wistar rats, 250-350g, from the *vivarium* of the Sao Paulo University Medical School (FMUSP), were acclimated and housed under standard conditions. All animals were allowed standard rat chow and water *ad libitum* throughout the study. Animals that died from surgery complications were excluded. The experimental design is outlined in Figure 1.

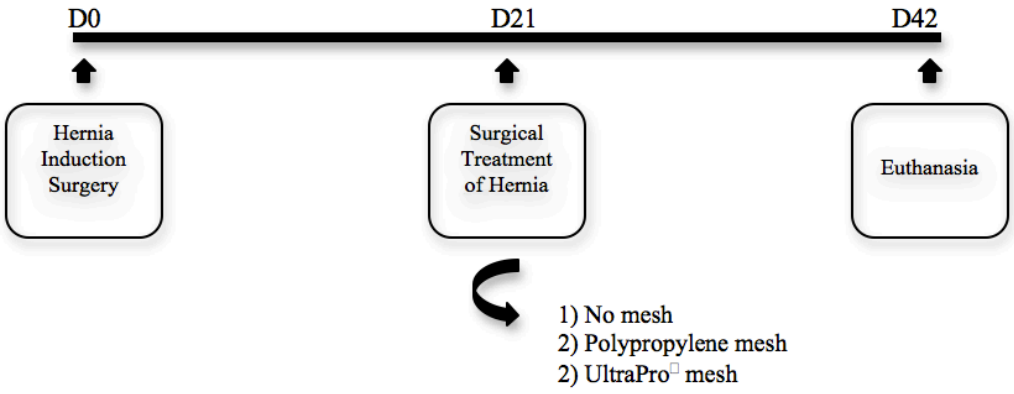

FIGURE 1 - Experimental design. D0= The beginning of the procedures; D21= 21st day after hernia induction; D42= 21st day after hernia correction.

Hernia induction surgery

Animals were anesthetized by intraperitoneal injection in the lower right quadrant of the abdomen with 0.5ml/kg of sodium thiopental 0.2%[9]. Ventral abdominal wall hair was shaved and the field was prepped with alcohol. A 4cm midline skin incision was made and subcutaneous tissue dissected from the muscle fascia transversely and vertically, 1.5cm on each side of the incision. A 3cm midline incision was made on the muscular fascias and peritoneum, followed by subsequent skin closure using non-resorbable 4-0 nylon[9,10].

Surgical treatment of hernia (D21)

At 21 days following the hernia induction procedure, rats were re-anesthetized and prepared as described above. The skin incision was identified and the prefascial plane reentered. The hernia sac was dissected free from the skin, and excised to the hernia edge, with posterior midline approach by continuous suture with absorbable 4-0 polyglactin.

At this point, the animals were distributed into three groups of ten animals each according to treatment, as follows: 1) No mesh; 2) Polypropylene mesh (high-density mesh); and, 3) Ultrapro® mesh (low-density mesh). In Mesh Groups, 4cm x 2cm mesh was placed above the muscular fascia and fixed with eight 4-0 polyglactin stitches whereas in No mesh group the hernia was corrected with suture repair using continuous suture with poliglactin 4-0. The skin closure was made with continuous suture with 4-0 nylon for all groups

Postoperative care and euthanasia (D42)

Following recovery from anesthesia, animals were given food and water ad libitum. During the survival time, animals were observed for complications such as fistula, abscess, granuloma, dehiscence, infection or hernia. Samples of abdominal wall were obtained 21 days following surgical treatment of hernia[3] after a lethal intraperitoneal dose of ketamine/xylazine.

Necropsy and macroscopic evaluation

Mesh measurements, adhesion assessment, and wound infection evaluations were performed at the time of necropsy. A midline abdominal incision was made and the skin and subcutaneous tissue were dissected from the muscular fascia. The mesh was measured and compared to its original size to evaluate material shrinkage[3]. The entire ventral abdominal wall was excised and qualitative estimation of adhesion coverage was performed through visual inspection in degrees 0-5, according to criteria previous described[11], as follows: Degree 0) Lack of adhesions; Degree 1) Reduced number of adhesions, of fibrinous character, easily undone by manipulation; Degree 2) Stable adhesions, between intestinal loops, not involving the abdominal wall, resistant to manipulation; Degree 3) Stable adhesions, between the abdominal wall and an organ or a structure, resistant to manipulation; Degree 4) Stable adhesions, between the abdominal wall and more than an organ or structure, resistant to manipulation; and Degree 5) Stable adhesions, between intestinal loops and the abdominal wall, with enteric fistulas, resistant to manipulation.

Histological evaluation

A strip was cut perpendicularly to the lateral flap incision from each rat for subsequent biomechanical analysis. The samples were immediately fixed in formalin, embedded in paraffin, sectioned, and stained. Hematoxylin-eosin staining was used to identify and quantify the inflammatory and fibrotic response using a score based on a predefined scale of 0-3 degrees, evaluating infiltration of macrophages, giant cells, neutrophils and lymphocytes, according to protocol previous described[12]. A single pathologist, blinded to treatments, analyzed slides.

Statistical analysis

Data were analyzed with IBM SPSS statistic software. One-way ANOVA was used to determine differences in the incidence of recurrent incisional hernias, weight and shrinkage of the mesh among groups. The Kruskal-Wallis test was used to determine differences in histological evaluation, adherences and complications. Values were reported as the mean±standard error. $p<0.05$ was considered significant.

Results

Rodent weight was equivalent among groups, as measured at necropsy (No mesh: 397.40g±31.9; Polypropylene mesh: 407.02g±29.42; UltraPro® mesh: 399.31g±28.22; p=0.749). No significant differences were seen in fibrosis (p=0.964), macrophages (p=0.430), lymphocytes (p=0.827), giant cells (p=0.503) or neutrophils (p=0.641) among the groups (Figure 2).

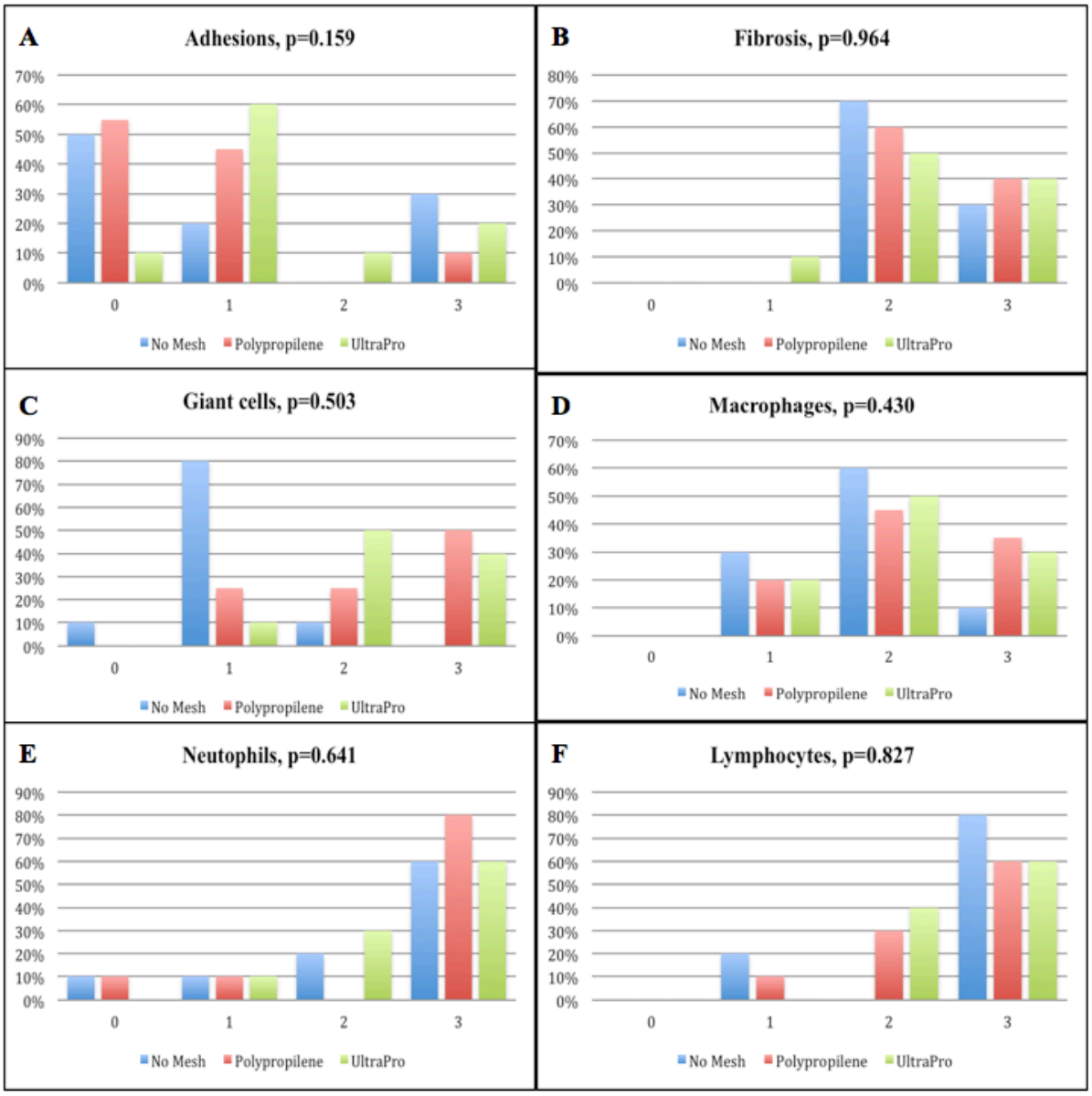

FIGURE 2 - Assessment of adhesions (**A**), fibrosis (**B**) and inflammatory response (**C-F**) in rats in rats treated for incisional hernia without mesh, with Polypropilene or UltraPro® meshes.

Differences in adhesions were not significant among groups (p=0.159). Similarly, meshes shrinkage was similar between mesh groups (Polypropylene mesh: 7±9.9cm vs. UltraPro® mesh: 7.4±10.1; p=0.967).

Complications included fistula, abscess, granuloma, sero-hematic collection, and wound dehiscence (p=0.46, Table 1). One of the rats in No mesh and Polypropylene groups developed recurrent incisional hernias, but no significant difference in hernia recurrence was found among groups (p=0.363).

TABLE 1 - Incidence of postoperative complications in rats treated for incisional hernia without mesh (n=12), with Polypropilene (n=11) or UltraPro® (n=10) meshes. p=0.46.

Complications	No Mesh	Polypropilene	UltraPro®	TOTAL
Fistula	1 (8%)	0 (0%)	0 (0%)	**1 (3%)**
Abscess	1 (8%)	0 (0%)	0 (0%)	**1 (3%)**
Granuloma	3 (25%)	3 (27%)	2 (20%)	**8 (24%)**
Dehiscence	2 (17%)	1 (9%)	0 (0%)	**3 (9%)**
Sero-hematic collection	1 (8%)	0 (0%)	0 (0%)	**1 (3%)**
Hernia	0 (0%)	0 (0%)	1 (10%)	**1 (3%)**
Total	**8 (66%)**	**4 (36%)**	**3 (30%)**	

Discussion

Despite 200.000 ventral hernia repairs being performed annually, no gold standard for the technique exists. Mesh has been shown to decrease recurrence rates, yet concerns about increased complications and costs prevent its systematic use. An ideal mesh would help to prevent the recurrence of incisional hernias and other complications such as wound infections, wound pain, and suture sinus. Although various studies addressed the use of different meshes and techniques for abdominal wall closure after incisional hernia repair, no ideal material or technique has yet been found[3,11].

Several experimental model of hernia repair have been developed, particularly to evaluate the biomechanical and tissue reaction to the mesh material. The first and most commonly used involves resection of abdominal wall and correction of the defect with a mesh made from synthetic or biological materials. In the second model, fascial incisions are made and only the skin is closed, inducing a hernia formation within next weeks. The hernia can be corrected through various methods, and then evaluated[8]. The model used in this study, mimics the development of human incisional hernias and also allows a prefascial placement of the meshes, similar to surgical repair of human incisional hernias.

No mesh group was used to compare recurrence rates of hernia and differences in inflammation caused by the mesh and suture repair. There were no differences between this group and either meshes group.

Adhesions were analyzed by a classification proposed previosly[12,13]. Most authors found that the occurrence of adhesions increased with the use of polypropylene[3,14] and Ultrapro®[3]. However, none of these meshes was designed for intraperitoneal use. We found no significant difference between the meshes groups in its extraperitoneal use.

The time of euthanasia was based on previous studies that observed the presence of cellular infiltrate, which is characteristic of chronic inflammation[12,15]. All groups still had presence of macrophages besides neutrophil infiltration, in contrast to other studies[15,16].

In this study, no difference was seen among the groups in fibrosis, macrophages, lymphocytes, giant cells or neutrophils. However, a tendency toward higher numbers of giant cells was seen in both mesh groups, suggesting a greater reaction caused by the mesh, in agreement with the literature[17].

Polypropylene mesh is most commonly used because it is easily handled and relatively low cost. Several studies have shown that polypropylene causes a pronounced and persistent inflammatory reaction, is well incorporated in the surrounding tissue of the abdominal wall and causes a strong stimulus for adhesion formation[9]. These studies also reported a higher incidence of fibrosis, adhesions, and fistula compared to light-weight meshes[11]. Although this mesh was designed for extraperitoneal use, most experimental studies assessed the response and complications of polypropylene intraperitoneal placement[18].

Conclusion

Polypropylene (high density) and UltraPro® (low-density) meshes in extraperitoneal use, for hernia repair in rats, showed similar inflammatory response, mesh shortening, adhesions and complications.

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