TISSUE INTEGRATION OF IMPLANTED POLYPROPYLENE MESHES IN TWO POSITIONS IN A RABBIT ABDOMINAL MODEL

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Abstract: The objective of the study was to describe the morphological changes of implanted polypropylene meshes in two positions at the level of abdominal walls in rabbits. Two abdominal wall defects in 10 rabbits were reconstructed with polypropylene (D-tek) mesh. Five rabbits were sacrificed on days 30 and 60 for evaluation of morphological changes of explants. At sacrifice, all implant areas were photographed and was mentioned the presence of adhesions, infection, or signs of rejection. The entire abdominal wall was then harvested and divided, each containing the implant, the “interface” between implant and native host tissue, then explants were cut for histopathology exams.

INTRODUCTION

Polypropylene (PP) mesh is today universally accepted for use in the repair of abdominal wall defects in humans (Schumpelick and Klinge, 2003). This kind of mesh was introduced in 1958 by Usher et al. (1958), and later was popularized by Lichtenstein (1986). This biomaterial has been proven not to be completely inert after implantation and does generate an inflammatory response as a foreign body reaction that differs between individuals and depends on the amount of material and the structure of the mesh (Klosterhalfen et al. 2000, Coda et al. 2003, Schachtrupp et al. 2003). Also have been described late complications such as chronic infections, migrations, and erosions (García-Ureña et al. 2007). Although pathogenetic mechanisms involved in these phenomenons are little understood, in this contributes inflammatory cascade induced by prosthetic mesh implanted. The dates existing in literature concerning using of xenografts are not correlate with using of them currently in clinical practice. The goal of our study was to better understand the biocompatibility of polypropylene meshes, fixed in two positions at the level of abdominal walls (epifascial or onlay and preperitoneal or sublay), against adherences induced by sublay position, tissue reactions, neovascularization and tissue integration after two post-operative intervals (30 and 60 days).

MATERIAL AND METHODS

A total of 10 rabbits weighing 2.5 to 3.5 kg were used for the study and they were randomized into 2 groups of five each. All animals were housed in five cages, given food and water ad lib during a ten days acclimation period before meshes implantation. We choses for the rabbit model because: (1) rabbits allow a long follow-up period; (2) size-wise simultaneous implantation of several meshes within the same host is possible; (3) this species may challenge the long-term stability of collagen matrices, as rabbits are known to have a high collagenolytic activity (Beker et al. 1975, Salgaller et al. 1985).
**Preoperative management.** Feedings were withheld 12 hours before the procedures and animals received appropriate analgesics postoperatively for pain control. Each rabbit was induced by an intramuscular injection of Xylazine (0.5 mg/kg, *Narcoyl; Intervet*) and Ketamine (50 mg/kg, *Ketaminol; Intervet*) and ventral abdominal region was aseptically prepared for the surgery.

**Surgical technique.** A 8-cm midline abdominal incision was made beginning 2 cm below the xiphoid process. The midline linea alba was incised for a distance of 4 cm (take care not to injure the underlying viscera) and lateral cuts were made into the fascia, muscle, and peritoneum and the resulting flap was retracted laterally (fig. 1). This created a standardized 4X4-cm defect in the right side. The abdominal wall defect was then closed with a 5X5-cm piece of polypropylene mesh (*D-tek, Polypropylene mesh, Limassol, Cyprus*) placed in preperitoneal plane (sublay position) (fig. 2). The abdominal edges were sutured to the mesh using interrupted 3-0 Polypropylene wires (*D-tek, Polypropylene*), 1 cm from the edge.

![Fig. 1. Parietal defect](image1.png) ![Fig. 2. Mesh placed in sublay position](image2.png)

Sutures were placed approximately 1 cm apart. Resulted a standardized repair with 1 cm of mesh underlying the abdominal wall on all margins. In the left side, without opening the abdominal wall, we fixed, epifascial, also a 4X4-cm piece of polypropylene mesh (onlay position) (fig. 3). Final aspect of the implants can be seen in figure 4.

The subcutaneous tissue was closed with a simple continuous patterns 3-0 Vicryl over both meshes, to prevent trickling of peritoneal liquid at the wound level (fig 5 and 6). This create a vicious healing. The skin incision was closed with silk interrupted sutures.
RESULTS AND DISCUSSIONS

Five animals were euthanased 30 and 60 days after implantation and the complete anterior abdominal wall was removed for macroscopic and microscopic evaluations. In Table 1 are presented morphological evaluations after this two intervals.

Table 2

Macroscopic abnormal findings seen at 30 and 60 days after implantation

<table>
<thead>
<tr>
<th>Macroscopic findings</th>
<th>Day 30</th>
<th>Day 60</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Onlay mesh</td>
<td>Sublay mesh</td>
<td>Onlay mesh</td>
</tr>
<tr>
<td>Mesh infection</td>
<td>1*</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>Seromas-hematomas</td>
<td>2</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Abdominal adhesions</td>
<td>—</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Mesh pleating</td>
<td>1</td>
<td>—</td>
<td>1</td>
</tr>
</tbody>
</table>

* Animal was euthanased on the 16th day and excluded from the study.
We did not have intraoperative complications, but one rabbit was excluded from study because it developed post-operative a severe infection. Two animals observed on the 60th day had wound infections in the onlay position, but we treated them with topic antibiotics. In rest all the mesh were good incorporated into the host tissue with phenomenons of neovascularization on both intervals (fig. 7).

Seromas are common exsudative-inflammatory phenomena induced by prosthetic mesh and were observed in 3 patients. We refered to puncture of colections in most lower point and were applied rubefactions. Hematomas was effect of local venous or arterial compromise and were evacuated.

Adhesions formation (fig. 8) is due to polypropylene mesh macroporosity fixed in contact with abdominal viscera and it is a complicated process involving essentially all of the cellular components and mediators of the inflammatory response. Leukocytes, mesothelial cells, the coagulation cascade, cytokines, growth factors, and cellular metabolites have all been implicated to play a vital role (Drollette et al. 1992, DiZerega 1992). The formation of adhesions is a physiological process during the restoration and reconstruction of normal tissue surfaces. Research is ongoing to better understand the details of this intricate process. Nonetheless, the final common pathway for the development of intraperitoneal adhesion formation has been identified as the formation of an insoluble fibrin gel matrix (Liakakos et al. 2001). A homeostatic defense mechanism against adhesion formation is intraperitoneal fibrinolysis. Fibrinolysis is activated to lyse fibrinous adhesions formed by the fibrin gel matrix.

After macroscopic evaluations, the samples were excised en bloc from the interface between the meshes and the host tissue for histological exams of the behavior of the biomaterials in these areas. The samples were fixed in 10% formalin. The stain used was haematoxylin eosin. Histological evaluations were made under light microscopy.

On the 30th day post-operative, the inflammatory response was more intense in the onlay meshes, cellular infiltrate (especially macrophages, little granulocytes and eosinophils) being disposed both inter- and extra-filametary. Arround meshes filaments was evidencediated a granulation tissue, in different degrees of maturation, highly vascularisated (fig. 9). In sublay position, after 30 days we observed a weak inflammatory reaction against onlay position, with a lower number of multinuclear cells (granulomatous reaction) than in onlay position. Also fibroplasia was not so intense such in onlay position. Particular, we observed connective adipose and lax tissue on both surfaces of mesh and adjacent fibrosis, that suggest a kind of mobility of the mesh (fig.10).
After 60 days inflammatory infiltrate decreased in both fixations, multinuclear cells being in a small number. In onlay fixation, the muff of fibrous tissue was more narrow than in sublay fixation (fig.11). In addition, fibrous tissue surrounding sublay filaments has kept the proliferative phenotype, persisting fibroblastic cells and a highly microvascularization colonizing the connective tissue (fig.12).

Finally, we must say that this kind of studies are heterogeneous because of some variables which can affect the different outcomes: creation of a muscle and fascial defect, the physiologic growth of the animal, fixation of the mesh, pore size of the mesh, textile structure, weave configuration, fiber diameter, and the quantity of the material (García-Ureña et al. 2007).

CONCLUSIONS

- Polypropylene meshes generate a foreign body reaction indifferently in which position are fixed.
Onlay technique of implant is easier and is far away from the abdominal contents, but is has the inconvenient because of the need for an extensive subcutaneous dissection, so postoperative seromas/hematomas and infections are common.

Adhesions are most important complications induced by sublay technique.

Histologic both meshes induce a persistent foreign body reaction, more intense in onlay position after 30 days, and more representative in sublay position on long-term.

The sublay technique is more difficult, need experience but is a more correct position to deal with the intra-abdominal pressure forces and assure in time a better resistance of abdominal wall repaired.

Our study suggests the benefits of sublay meshes because of a safely repair on long-term of abdominal wall defects.

BIBLIOGRAPHY