Comparison between polypropylene and polypropylene with poliglecaprone meshes on intraperitoneal adhesion formation

Estudo comparativo entre tela de polipropileno e poliglecaprone com tela de polipropileno na formação de aderências intraperitoneais

INTRODUCTION

Incisional hernia or eventration is a protrusion of abdominal contents through a weakened area on the abdominal wall, as a result of trauma or a surgical incision. It is a common complication of abdominal surgeries, occurring in 2% to 35% of laparotomies and causing significant morbidity and mortality. A considerable number of patients presents with bowel strangulation (2%) and incarceration (6-15%)⁴.

The repair of incisional hernias is surgical, with many techniques described. The advent of the use of prosthesis could significantly reduce the recurrence rate when compared with the primary correction. Through laparoscopic approaches, the meshes reached the abdominal cavity. Thus, by being in contact with abdominal structures, they have brought complications such as adhesions, fistulae and intestinal obstructions⁵,⁶. A systematic review by Castro et al.⁷ reports that 4.7% of patients that had undergone laparoscopy required enterotomies, a condition capable of raising mortality to 2.8-7.7%⁸.

Peritoneal adhesions are present in 90% of patients undergoing abdominal surgery and can cause complications such as intestinal obstruction, infertility, chronic pelvic and abdominal pain, besides difficulties on reoperation⁹. A study by van Goor¹⁰ draws attention, also, to longer periods of hospitalization, duration of surgery, and the need for conversion of laparoscopy to laparotomy. The most commonly used surgical mesh is the polypropylene mesh, because of its flexibility, stimulation of cell growth, satisfactory inflammatory response, ease of handling and low cost. However, this prosthesis induces the formation of adhesions when in contact with intra-abdominal contents¹¹, justifying the search for meshes that would provoke less complications, while maintaining tissues’ resistance and tensile strength¹².

Within this context, several prostheses have been developed, differing in aspects such as composition material, pore size, weight, elasticity, tissue reaction, absorption and biocompatibility¹³. A review by Araújo et al.¹⁴ recommends the use of composite meshes for intraperitoneal use. Among these meshes,
figures the Ultrapro®, a partially absorbable prosthesis, composed of equal parts of polypropylene and poliglecaprone, incorporating high tensile strength, with good biocompatibility, despite the light weight. The objective of this study is to compare the formation of intraperitoneal adhesions between the meshes made of polypropylene and polypropylene associated with poliglecaprone.

### METHODS

The project was submitted to the Ethics Committee for Use in Animals of the Biological Sciences Department at the Federal University of Paraná (UFPR), under registry number 23075.006274/2014-48, having been approved.

The sample consisted of 20 male Wistar rats, aged between 100 and 120 days old each, and weighting 316 to 400 grams, with an average weight of 360.5±19.32 grams. The animals were allocated at the Vivarium of the Discipline of Surgical Technique and Experimental Surgery of UFPR during the experiment, with free access to food and water.

We randomly divided the sample into two groups, with ten rats each. We inserted both meshes in each animal on the ventral wall on the intraperitoneal face, so that each rat would be its own control. In Group 1, the polypropylene mesh was disposed on the peritoneal surface, to the right side of the midline incision, and the polypropylene with poliglecaprone mesh was placed on the left side. In Group 2, we inverted the disposition of the meshes. After 28 days of the procedure, we euthanized the rats.

The animals underwent anesthesia with 0.1ml/100g weight of a composite solution of ketamine (50mg) and xylazine (20mg), complemented with inhalatory isoflurane. We performed a midline, 4cm, xifo-pubic incision. We placed the 10x20 mm size meshes intraperitoneally, according to the group of the corresponding animal, and fixed them with 5.0 polypropylene. The skin was sutured using 4.0 nylon. Analgesia was done with a 10mg/kg intramuscular injection of dipyrone. After 28 days of the procedure, we carried the euthanasia, according to the CONCEA Guidelines for the Practice of Euthanasia, 2013, and the Brazilian Guide for Good Practice in Animal Euthanasia from the Federal Council of Veterinary Medicine, 2013. We performed it with the intravenous administration of a 10% Potassium Chloride solution, 5mg/kg, under anesthesia with intravenous Thiopental, 10mg/kg, and inhalatory isoflurane.

We then opened the abdominal cavity with a U-shaped incision that, when lifted, allowed the evaluation of adhesions. We analyzed their presence or absence, including only adhesions on the meshes and excluding those on the midline suture and on the transfixing stitches, since regardless of the prosthesis used, there is a predisposition of the tissue to form adhesions on suture locations.

For the evaluation, the area affected by the adhesions was projected in graph paper, on a sketch of the same size of the mesh (10x20 mm). For more precision, visceral adhesions were sectioned and put out to analyze the previously hidden portion of the mesh. From these projections over the graph paper, we obtained the percentage of mesh covered by adhesions. The mesh attached to the peritoneum was considered incorporated, and when held only by the fixation points, was treated as not incorporated.

The results were then submitted to statistical analysis through the Mann Whitney test for evaluation of the mean and the Fisher’s test for the frequency, adopting p≤0.05, or 5%, as the level of significance.

### RESULTS

There were no post-operative complications or deaths. One polypropylene mesh and seven polypropylene with poliglecaprone meshes did not show incorporation to the parietal peritoneum (Table 1). In addition, all the meshes presented with adhesions.

In Group I, the percentage of the meshes’ surface covered by adhesions on the right side (polypropylene) varied from 12% to 49%, with a mean of 25.69±13.61%, while on the left side (polypropylene with poliglecaprone), the covered surface percentage...
ranged from 13% to 100%, with an average of 
49.45%±25.57 (p<0.05) (Table 2, Figure 1).

In Group II, the percentage of the meshes’
surface covered by adhesions on the right side (poly-
propylene with poliglecaprone) varied from 8.5% to
100%, with an average of 39.95±36.77%, while on
the left side (polypropylene), the percentage ranged
from 15% to 100%, with a mean of 42.45±28.07%
(p>0.05) (Table 3, Figure 2).

Regardless of the groups, we found that the
polypropylene mesh had the percentage of the surface
covered by adhesions ranging from 10.5% to 100%,
with a mean value of 34.07±24.21%, while on the
polypropylene with poliglecaprone mesh, the covered
percentage varied from 9% to 100%, with an average
of 44.7±32.85% (p=0.12) (Table 4, Figure 3). In both
meshes, adhesions were to the omentum (98.5%) and
the spermatic cord (80%). The liver was present in
20% of cases (5% in the polypropylene and 15% of
the polypropylene with poliglecaprone) and the small
bowel in 2.5% of cases (Figure 4).

### DISCUSSION

The intraperitoneal use of surgical meshes in
the repair of incisional hernias can induce the formation
of adhesions, intestinal obstruction and fistulae. The
direct contact of the prosthesis with the viscera
contributes significantly to the process. In a study
by Halm et al., 76% of patients in which the mesh
was placed intraperitoneally developed adhesions,
of whom 20% needed bowel resection. In addition,
complications were present in 77% of patients
who required reoperation, increasing the incidence
of postoperative complications. The most feared
complication, intestinal obstruction, is associated with
higher rates of morbidity and mortality, what drives
the search for a composition of meshes that present
fewer complications, while maintaining resistance and
strength to traction.

When inserted intraperitoneally, in general
a mesh induces a foreign body reaction and the

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**Table 1. Number of incorporated meshes.**

<table>
<thead>
<tr>
<th>Incorporation</th>
<th>Polypropylene</th>
<th>Polypropylene with Poliglecaprone</th>
<th>Total</th>
</tr>
</thead>
<tbody>
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<td>13</td>
<td>32</td>
</tr>
<tr>
<td>No</td>
<td>1</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Total</td>
<td>20</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

*Fisher’s exact test à 0.0201*

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**Table 2. Percentage of mesh surface covered by adhesions in Group 1.**

<table>
<thead>
<tr>
<th>Animal</th>
<th>Right Side</th>
<th>Left Side</th>
</tr>
</thead>
<tbody>
<tr>
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<td>100</td>
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<tr>
<td>2</td>
<td>37.5</td>
<td>53.5</td>
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<tr>
<td>3</td>
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<tr>
<td>4</td>
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<td>42</td>
</tr>
<tr>
<td>10</td>
<td>19</td>
<td>20.5</td>
</tr>
</tbody>
</table>

| Mean   | 25.69      | 49.45     |
| SD*    | 13.62      | 25.57     |
| %SD*   | 53.02      | 51.71     |

* SD= Standard derivation  Mann-Whitney’s test p<0.05

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**Figure 1. Percentage of mesh area covered by adhesions in group I.**
Note: right Side – polypropylene; left side – polypropylene with poliglecaprone.
formation of adhesions, which represent a pathological process of the peritoneal healing\textsuperscript{18}. Among the main causes of adhesions are the presence of foreign bodies, peritoneal inflammation, ischemia, trauma and abrasion\textsuperscript{19}. Surgical trauma triggers an inflammatory process that comprises both vascular and cellular changes, as well as the formation of a fibrin matrix, which gradually results in the development of a tissue composed of fibroblasts, macrophages, and other inflammatory cells. This process of peritoneal repair is involved with the incorporation of the prosthesis, and may progress to the formation of adhesions\textsuperscript{20}.

With the advent of the laparoscopic approach and the consequent increase in the incidence of adhesions\textsuperscript{5,6,10}, the demand for meshes with lower complications has gained strength. An ideal mesh it should: not induce the formation of adhesions; not trigger allergic or foreign body reactions; not be carcinogenic, adhesive or erosive; resist infection; be adjustable to the abdominal wall; and have good resistance and tensile strength\textsuperscript{11}. However, for Minossi et al., no material would present all of them\textsuperscript{21}. The material, its weight and porosity exert influence on the formation of adhesions, on the intensity of inflammatory reaction and on the consistency and tissue organization of the peritoneum in recovery\textsuperscript{22}.

Experimental studies with surgical meshes for evaluation of biocompatibility and adhesion formation use animal models, such as rabbits\textsuperscript{23-25}, sheep\textsuperscript{26}, pigs\textsuperscript{15}, and, especially, rats\textsuperscript{11,27}. The variables analyzed include incidence, extent, quality and, in some studies, resistance to rupture and tenacity.

The polypropylene mesh with heavy weight (80-100 g/m\textsuperscript{2}) and average pore size (0.8mm) is currently the most used\textsuperscript{5}. Consecrated by its excellent biocompatibility, incorporation, maintenance of abdominal wall traction and low cost, it is associated with a high incidence of adhesions\textsuperscript{14,22}. In experimental studies, the formation of adhesions is observed in 100\% of meshes, covering from 50\% to 100\% of their surface\textsuperscript{11,12,27}. The authors described the omentum as the most often involved structure, followed by the liver and the bowel.

In this study, we observed adhesions in 100\% of animals in which we implanted the polypropylene mesh. The percentage of mesh covered by adhesions varied from 10.5\% to 100\%, with an average of 34.07\%±24.21\%. We could observe a higher formation of adhesions on the left side, where the percentage of mesh covered ranged from 15\% to 100\%, with a mean of 42.45\%±28.07\%, versus 12-49\% of surface covered and average of 25.69\%±13.61\% on the right side. Moreover, only one of the 20 implanted meshes did not show incorporation to the parietal peritoneum.

Adhesions involving the small intestine represent greater risk for development of bowel obstruction\textsuperscript{19}. However, in some cases the omentum...
might as well be involved. In addition, the heavy weight polypropylene meshes, weighting more than 40mg/m², are related to complications such as abdominal discomfort, infection and fistulae. In turn, the porosity of the material influences cell colonization and inflammatory reaction. Meshes with small pores induce a subtle cell colonization, but intense inflammatory reaction and adhesion formation. In contrast, large pore meshes, in addition to being more flexible, ensure lower foreign body reaction, allowing their integration to the tissues without the formation of a fibrous capsule.\textsuperscript{14,22}

In this context, the association of polypropylene mesh with poliglecaprone filaments would allow fewer complications compared with the classic polypropylene mesh. The absorbable component of the prosthesis, poliglecaprone, would facilitate the intraoperative handling of the mesh, on both endoscopic and open repair.\textsuperscript{15} The mesh used in this study consisted of equal parts of low weight (28g/m²) polypropylene with large pores (3-4mm) and poliglecaprone, characterized by its good biocompatibility, both histological and immunochemical, in addition to its extensive development and high tensile strength.\textsuperscript{11,15}

In an experimental model using Wistar rats, Burger et al.\textsuperscript{11} compared the polypropylene and poliglecaprone mesh to other prostheses, evaluating adhesion formation, incorporation and tensile strength. The analysis was carried out seven and 30 days after the insertion procedure. The polypropylene with poliglecaprone mesh was not superior to the polypropylene one. Schreinemacher et al.\textsuperscript{16} also did not found significant differences between the polypropylene and the polypropylene with poliglecaprone meshes when they studied adhesion formation and incorporation after seven and 30 days postoperatively in rats in a study with six prostheses. The authors reported a smaller area covered by adhesions in the group evaluated at 30 days, but this difference was not significant. In that group, also, all the animals that received the polypropylene with poliglecaprone mesh developed visceral adhesions, versus 35% in those with polypropylene mesh. As of incorporation, there were no significant differences between the meshes.

Table 4. Percentage of area covered by adhesions in both meshes, regardless of insertion side.

<table>
<thead>
<tr>
<th>Animal</th>
<th>Polypropylene</th>
<th>Polypropylene with Poliglecaprone</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>18.5</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>37.5</td>
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</table>

Mean: 34.07, 44.7
SD*: 24.21, 32.85
%SD*: 71.09, 73.51

\( * SD = \text{Standard derivation} \quad \text{Mann-Whitney's test } p<0.05\)
Bellón et al.\textsuperscript{25} analyzed the polypropylene with poliglecaprone mesh and other prostheses in the correction of defects of the abdominal wall in rabbits. With respect to adhesions, there was no significant difference when compared to the polypropylene mesh. Still, the adhesions were observed through laparoscopy after 72 hours of the procedure, showing no difference when analyzed seven and 14 days postoperatively.

Aramayo et al.\textsuperscript{23} produced an incisional hernia in 40 rabbits and evaluated three prostheses used for repair. The area of adhesion induced by the polypropylene mesh was significantly larger when compared with the mesh made of polypropylene with poliglecaprone.

Bellón et al.\textsuperscript{24}, in an experimental model using rabbits, compared the lightweight polypropylene mesh with the polypropylene with poliglecaprone one. After analysis at 14 and 90 days after the procedure, they concluded that the formation of adhesions in the peritoneal face of the prosthesis was significantly less extensive on the mesh with absorbable component at 90 days. The adhered structures were the omentum and the bowel.

The results of the current work agree with those presented by different studies regarding adhesion formation. All meshes induced the formation of adhesions and there was no significant difference between them. For the mesh made of polypropylene with poliglecaprone, the percentage covered by adhesions ranged between 8.5 and 100%, averaging $44.7\pm32.85\%$ ($p=0.12$). After evaluating each animal within a group, we noticed a significant difference on adhesion formation between them, which hinders the establishment of a pattern. This variation may be related to the individual response of each of the animals. This prosthesis also presented a higher incidence of adhesions involving the liver, 15% versus 5% with the polypropylene mesh.

When inserted on the left side, the percentage of mesh covered by adhesions was significantly higher when compared with the polypropylene mesh. However, when analyzed regardless of the insertion site, none of the meshes proved to be significantly superior to the other. The different intra-abdominal organ disposition between the sides and the increased mobility of the omentum, which was present in 98.5% of the sample adhesions, may justify this disparity. In turn, as of incorporation, the difference was significant. Out of 20 implemented meshes, seven did not show incorporation, as opposed to only one of the polypropylene meshes.

Among the modifications applied to prostheses used in laparotomy closure, the addition of absorbable material to the mesh composition aims to reduce the induction of foreign body reaction, while enhancing the complacency of the abdominal wall\textsuperscript{28}. In theory, these changes would ensure lower adhesion formation. However, according to the exposed, the composite mesh was not superior to the standard one. For some authors, also, the foreign body reaction induced by the partially absorbable meshes was higher in the early stages after the procedure, and normalized in a later analysis by Bellón et al.\textsuperscript{24}.

It is important to observe that it is difficult to extrapolate the results of experimental studies to the practice in humans, considering that these models use mostly rodents. The biological response of the animals used in experiments can be different from that presented by humans. Furthermore, the different analysis periods used by different studies,

![Figure 4. Adhesions in animals 6 and 10 from Group I (polypropylene mesh on the right and polypropylene with poliglecaprone mesh on the left). Note: * = spermatic cord; # = omentum.](image-url)
as well as their different methodologies, contribute to limit the application of experimental studies in medical practice. Despite increasing research, there are no available meshes that do not induce adhesion formation, and their use remains a challenge, especially when left in contact with abdominal viscera.

The analysis of the results shows that, in rats, both studied meshes have the same ability to form adhesions.

**A B S T R A C T**

**Objective:** to compare intraperitoneal adhesion formation in rats when using polypropylene and polypropylene with poliglecaprone meshes. **Methods:** we used twenty male, Wistar rats, divided in two groups. In group 1, the rats received the polypropylene mesh on their right side and the polypropylene with poliglecaprone mesh on their left side. In group 2 the position of the meshes was inverted. After 30 days, we analyzed the presence or not of adhesion formation, including only those over the meshes. The findings undergone an analysis through the Mann-Whitney test, at a level of significance of $p \leq 0.05$. **Results:** all meshes presented adhesions. We verified that, for the polypropylene meshes, the percentage of their surface covered by adhesions varied from 10.5 to 100%, with an average of 34.07±24.21%, while for the polypropylene with poliglecaprone mesh, the percentage covered by adhesions varied between 8.5% and 100%, with an average of 44.7±32.85% ($p=0.12$). **Conclusion:** both meshes lead to adhesion formation, none being superior to the other.

**Keywords:** Hernia. Tissue Adhesions. Surgical Mesh. Comparative Study.

**REFERENCES**

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