ABSTRACT

Background: The use of prosthetic materials to reinforce the abdominal wall is associated with a low index of recurrence; however, intraperitoneal placement of a foreign body may lead to adhesions. The present investigation was designed to determine adhesion formation with commercially available meshes implanted laparoscopically in rabbits.

Methods: Three different meshes were implanted laparoscopically in 24 rabbits: polypropylene (mesh A), polypropylene and sodium hyaluronate-carboxymethylcellulose (mesh B), and polypropylene and expanded polytetrafluoroethylene (mesh C). Sites of implantation for each mesh (the left lower quadrant, right lower quadrant, and lower midline) were randomly determined so that every rabbit had all 3 meshes implanted. All animals underwent diagnostic laparoscopy after 28 days to grade adhesions and histological analysis of inflammation.

Results: Adhesions were noticed in 46 of the 72 meshes implanted (64%). The number of adhesions was higher for mesh C (87.5%) compared with meshes A (62.5%) and B (41.6%). The severity of adhesions was also higher for mesh C (grade I in 14, II in 6, and III in 1) compared with mesh A (grade I in 10, II in 4, and III in 1 case) and B (all of them grade II). Histological inflammatory reaction was classified as mild in 23 cases of mesh A, 15 of mesh B, and 23 of mesh C. A moderate reaction was found in 1 case of mesh A, 4 cases of mesh B, and 1 case of mesh C. Severe reaction was induced in 5 cases of mesh B. Mesh B induced a higher inflammatory reaction compared with the other meshes.

Conclusions: All meshes induced adhesions of different grades. Mesh B had fewer adhesions and more intense inflammation them did the others.

Key Words: Adhesions, Hernia repair, Laparoscopy, Mesh, Prosthetic materials, Rabbit.

INTRODUCTION

It has become clear over past decades that the use of prosthetic materials leads to a lower incidence of recurrences after abdominal wall hernia repair compared with nonprosthetic techniques. Although the incidence of complications associated with the prosthesis is low, intraperitoneal placement of foreign materials may lead to formation of adhesions, intestinal fistulas, and migration of the mesh to hollow organs. Adhesions may result in infertility, recurrent pelvic pain, small bowel obstruction, and hazardous reoperative surgeries, all of which increase health care costs.

Historically, several substances have been used to reinforce the abdominal wall, such as polyester, nylon, Teflon, steel, tantalum, silver, silicone, and others. The most suitable material for intraperitoneal use is debatable in view of the creation of new biomaterials.

The present investigation was designed to determine adhesion formation in commercially available meshes implanted laparoscopically in rabbits.

METHODS

Animals

Twenty-four New Zealand albino rabbits (Oryctolagus cuniculus) were studied. All animals were 3-month-old males, weighing from 2000 g to 2500 g.

Meshes

Three different meshes were studied: (1) mesh A: a single layer of polypropylene (SURGIPRO MESH -U.S Surgical Corp., Norwalk, Connecticut, USA); (2) mesh B: composite mesh with a layer of polypropylene and an inner layer of...
Mesh Implant

Animals were operated on after a fasting period of 12 hours. After anesthesia, pneumoperitoneum was created and kept at a maximum pressure of 10 mm Hg. Three ports were used: 10 mm in the epigastrium, 12 mm in the right upper quadrant, and 5 mm in the left upper quadrant. A piece of each mesh measuring 2 cm x 1 cm was laparoscopically secured to the peritoneum with the aid of two 4.8-mm titanium clips (MULTIFIRE ENDO HERNIA, US Surgical Corp., Norwalk, Connecticut, USA) in the left lower quadrant, right lower quadrant, and lower midline. Sites of implantation for each mesh were randomly determined with the aid of sealed envelopes in a way that every rabbit had all 3 meshes implanted.

Blood loss and trauma to the viscera were kept to a minimum. Principles of antisepsis were respected during the procedure.

Reoperation

After 28 days, the animals underwent a diagnostic laparoscopy to grade the adhesions. The procedure was taped to allow the grading of adhesions by a blinded surgeon. Adhesions were graded according to a scoring system proposed by Shimanuki et al. (Figure 1).

After reoperation, animals were euthanized. Meshes and adjacent tissues were removed and histologically analyzed. Inflammatory reaction was graded as severe, moderate, and mild according to Dixon et al.4

Statistical Analysis

Kruskal-Wallis and chi-square tests were used when appropriate. Statistical significance was defined as P<0.05. Considering a beta of 0.20 and an alpha of 0.05, the study of 24 cases provides a power of 80% (Statistical Package for the Social Sciences 11.0.1, SPSS Corp.).

Ethics

The study was approved by the local ethics committee. All procedures followed the regulations of the Brazilian College for Animal Experimentation.

RESULTS

Adhesions were found in 46 of the 72 meshes implanted (64%). Mesh A induced adhesions in 15 rabbits (62.5%): grade I in 10, II in 4, and III in 1 case. Mesh B induced adhesions in 10 (41.6%) rabbits, all adhesions classified as grade II. Mesh C induced adhesions in 21 (87.5%) rabbits: grade I in 14, II in 6, and III in 1. The number and severity of adhesions were statistically higher for mesh C compared with meshes A and B and higher for mesh A compared with mesh B (P=0.0011, Kruskal-Wallis test) (Figure 2). No difference was noted in adhesion number and grade according to the sites of implantation of the meshes.

Histological inflammatory reaction was classified as mild in 23 cases of mesh A, 15 of mesh B, and 23 of mesh C. Moderate reaction was found in 1 case of mesh A, 4 cases
of mesh B, and 1 case of mesh C. Mesh B caused a severe reaction in 5 cases. Mesh B induced a higher inflammatory reaction compared with the other meshes (P<0.0045, chi-square test) (Figure 3).

DISCUSSION

The results of this study show that (a) all types of mesh induced adhesions; (b) the number and severity of adhesions were higher in the following sequence: mesh C (polypropylene + polytetrafluoroethylene) > mesh A (polypropylene) > mesh B (polypropylene + hyaluronate – carboxymethylcellulose); and (c) inflammatory reaction was higher with mesh B (polypropylene + hyaluronate – carboxymethylcellulose).

Intraperitoneal Mesh Placement

Repair of abdominal wall hernias often forces exposition of viscera to a prosthetic mesh, which may be associated with hazardous complications. New materials have been developed to minimize these complications, especially the formation of adhesions.

In theory, composite meshes with a combination of a porous outer surface that allows fibroblastic growth and an inner surface with an inert substance acting as a barrier would decrease the risk of adhesions and keep the resistance at the same time. Different composite meshes are commercially available, such as the combination of polypropylene and a membrane of sodium hyaluronate – carboxymethylcellulose or expanded polytetrafluoroethylene (e-PTFE).1

Experimental studies with different meshes show an expressive rate of adhesions, up to 65%, similar to our findings. Moreover, the type of mesh does not seem to influence the outcomes. However, the addition of a protective barrier (composite mesh) induced fewer adhesions in several previous studies of either hyaluronate-carboxymethylcellulose7–10 or e-PTFE.11 Our results, however, do not favor the use of e-PTFE.

We do not have an explanation for the discrepancy between adhesions and various meshes. It is known, however, that the composition and structure of the prosthesis can directly influence the degree of adhesion.

Methodology

We decided to restudy the effect of intraperitoneal implant of different meshes using a carefully evaluated methodology. The rabbit is a proven model for the study of abdominal adhesions,5,7 due to its low resistance to infection and a small omentum, exposing more of the viscera to the prosthesis. For the same reason, meshes were implanted in the lower abdomen. Standardization of the weight, sex, and age of the animals was used.

Laparoscopy was chosen to implant the meshes to minimize surgical aggression to viscera and abdominal wall. Evaluation of adhesions was also favored by the laparoscopic approach because observation of the adhesions to the anterior wall is facilitated by the magnification, and the procedure can be easily recorded.

A careful aseptic technique was implemented to avoid mesh contamination and alteration in inflammatory reaction. A consensus does not exist as to the best scoring system for grading adhesions macroscopically. The Shimanuki score3 was used in our study because it is easy to use and more objective than other scoring systems. Blind evaluation of the adhesions also decreased possible biases.

The study was adequately statistically powered. Twenty-four rabbits allowed the study of 72 meshes. A formal sample size calculation was used and post hoc analysis of the results showed a 90% power regarding the number of adhesions and 81% regarding the presence of severe inflammatory reaction.

Criticisms may be linked to the fact that meshes were trimmed, exposing fibers on the edges originally covered by a barrier membrane. We believe it is common in clinical practice to trim the mesh, as meshes are not custom manufactured. Besides, we noticed that the adhesions were uniformly distributed, not limited to the borders. A second point of concern is that not only the mesh but also the clips may be triggers of adhesion formation; however, no isolated adhesions to or around the clips were noticed and their placement was standardized and equal to all types of mesh.
Inflammation and Adhesion

Intuitively, higher grades of inflammation would lead to more adhesions. However, previous studies have demonstrated that a direct correlation does not exist between inflammation and adhesion.12,13 Another explanation for more intense inflammation found on mesh B is the fact that hyaluronate-carboxymethylcellulose inhibits the activity of the fibroblasts irrespective of the number of inflammatory cell stems.14

CONCLUSION

We conclude that the composite mesh with a hyaluronate–carboxymethylcellulose membrane had a lower index of adhesions despite a more intense inflammatory reaction; however, meshes with or without barriers induce abdominal adhesions and these adhesions may be clinically important. Studies of sodium hyaluronate–carboxymethylcellulose mesh should be encouraged, because there are few published reports dealing with this mesh, the material in our study that offered the best results.

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