

## USE OF ALLOPLASTIC MESHES IN ABDOMINAL WOUNDS OF RATS WITH INDUCED PERITONITIS

*Uso de telas inorgânicas em feridas abdominais de ratos com peritonite induzida*

Rafael Calvão **BARBUTO**, Ivana **DUVAL-ARAÚJO**, Sumara Marques **BARRAL**, Raphael Grossi **ROCHA**,  
Cristiane de Souza **BECHARA**, Alfredo José Afonso **BARBOSA**

From the Programa de Pós-Graduação em Cirurgia, Faculdade de Medicina, Universidade Federal de Minas Gerais, Belo Horizonte, MG, Brasil (Post-Graduate Program in Surgery, Faculty of Medicine, Federal University of Minas Gerais, Belo Horizonte, MG, Brazil)

**HEADINGS** - Wound healing. Peritonitis. Hernia. Surgical mesh. Abdominal wall.

**ABSTRACT - Background:** The use of alloplastic meshes has been historically contra-indicated in patients with infection. **Aim:** To evaluate the use of polypropylene meshes in the treatment of abdominal wall defects in rats with peritonitis. **Methods:** Twenty Wistar female rats were divided into two groups: induction of peritonitis (test group) and without peritonitis (control group). An abdominal wall defect was created in all animals, and polypropylene mesh was applied. The evaluation of the tensile strength of the mesh was carried out using tensiometer and microscopic analysis of the healing area was done. **Results:** More adhesion of the mesh to the rat abdominal wall was observed in test group. The histopathological analyses showed prevalence of moderate to accentuated granulation tissue in both groups, without significant differences. **Conclusion:** The use of the mesh coverage on abdominal wall defects of rats with induced peritonitis did not show worse results than its use in healthy animals, nor was its integration to the resident tissue any worse.

### Correspondence

Ivana Duval Araujo  
E-mail: idaraujo@medicina.ufmg.br.

Financial source: none  
Conflicts of interest: none

Received for publication: 13/09/2013  
Accepted for publication: 12/12/2013

**DESCRITORES** - Cicatrização. Peritonite. Hérnia. Tela cirúrgica. Parede abdominal.

**RESUMO – Racional:** O uso de telas inorgânicas historicamente é contra-indicado em paciente com infecções. **Objetivo:** Avaliar o comportamento e cicatrização de paredes abdominais com uso de telas de polipropileno após infecções intracavitárias. **Método:** Foram estudadas 20 ratas Wistar aleatoriamente divididas nos grupos Estudo (com peritonite) e Controle (sem peritonite). Um defeito na parede abdominal foi criado em todos os animais, onde foi aplicada tela de polipropileno. Foi feita avaliação da força de tensão com uso de tensiômetro, além de análise histológica da área cicatricial. **Resultados:** Observou-se maior adesividade da tela às paredes dos animais do grupo Estudo quando comparado ao grupo Controle. A análise histopatológica mostrou prevalência de tecido de granulação de acentuado à moderado em ambos os grupos, sem diferença significativa. **Conclusão:** O uso de telas inorgânicas nos defeitos da parede abdominal em ratos com peritonite induzida não mostrou resultado pior do que aquele obtido de animais sem infecção, tanto em relação à sua integração quanto ao tecido cicatricial no defeito da parede abdominal.

## INTRODUCTION

The treatment of abdominal wall hernias with synthetic meshes was first described by Usher in the 1950s and heralded a new era of surgical history<sup>18</sup>. The characteristics of these meshes present the advantages observed in biomaterials, such as inertia in the presence of infection and the ability to maintain tensile strength. Alloplastic meshes have gained more acceptance since the development of biocompatible materials, not only because the technique is practicable, but mainly as a result of the reduction in recurrence rates<sup>11,17</sup>.

The use of polypropylene meshes in emergency surgeries and contaminated procedures has been discussed for almost 40 years, without a definite conclusion<sup>11,18</sup>. However, in many abdominal procedures, contaminated ones and even infected ones, the means to perform an effective laparotomy are required. Some clinical situations, such as patients with perforated digestive tract tumors and peritonitis, the elderly, critically ill and severely injured patients that require to be operated on the abdomen, would benefit from primary repair rather than being submitted to another operation.

No reports that specifically address complications of mesh repair in infected and contaminated surgeries have been published. This study aims to obtain experimental data that evaluates the use of mesh repair in contaminated tissues.

## METHODS

This experiment was kept according ethical principles of experimental research, and was approved by Ethical Committee of Animal Experimental Studies of Universidade Federal de Minas Gerais under Protocol Number 143/2007. Twenty Wistar female rats with weight ranged from 250 to 310 g were distributed into two experimental groups: 1) test group: induction of peritonitis, creation of abdominal wall defect, mesh repair and evaluation of tensile strength after seven days; 2) control group: absence of peritonitis, creation of abdominal wall defect, mesh repair and evaluation of tensile strength after seven days.

The animals were anesthetized with an intramuscular injection of 60 mg/kg of Ketamin (Ketamin<sup>®</sup> - Cristália, São Paulo, Brasil) associated to 10 mg/kg of 2% Xilazine (Calmiun<sup>®</sup> - União Química, São Paulo, Brasil). All surgical procedures were carried out with instruments sterilized by chemical methods.

### Induction of peritonitis

The method used was cecal ligation and puncture. After asepsis with povidine-iodine, there was made a cecal pouch using a 4.0 silk, followed by section of the colonic wall with surgical scissors for 0.1 cm, and then the abdomen was closed with continuous 2-0 nylon suture in one layer. In group B, only laparotomy and manipulation of the bowel was performed, followed by closure of the abdominal wall with continuous 2.0 nylon suture.

After 2 h, the abdomen was reopened, cleaning with saline lavage and antimicrobial (ceftriaxone 30 mg/kg) administered by intramuscular injection.

All of the animals were kept under observation for 4 h, in separate cages, and fed with glucose

solution at 25% and water.

After 4 h the abdomen of all of the animals was reopened and cavity washed with saline solution at 38° C. This was done three times with a syringe of 20 ml, under pressure (using a 25 x 7 mm needle), the excess of the saline solution was aspirated and the necrotic part of the cecum removed. All animals received an intra-muscular dose of ceftriaxone during the second anesthetic procedure and 12 h later.

### Creation of the abdominal wall defect

A flap of abdominal wall with 1 cm of diameter was removed, including the muscular and aponeurotic layers. A patch of omentum was used to protect the bowel and abdominal wall defect was treated with the use of a polypropylene mesh (Marlex<sup>™</sup>, CR BARD, Salt Lake City, UT), of 4,2 x 2,7 cm fixed intra-peritoneally, on the rectus abdominis borders with simple interrupted sutures of catgut 4,0 (Dexon - Davis Gerck American Cyanamid Company, Pearl River, NY). All of the animals were treated with analgesics during the postoperative period (Tenoxicam 0,3 mg/kg) and animals observed during seven days.

### Mesh detachment tension (MDT)

The tension necessary to detach the mesh from the rats abdominal wall was measured in Newtons (N) with the same tensiometer. Seven days after the mesh implantation, the animals were sacrificed with anesthetic overdose and put in the tensiometer (Figure 1). The skin was softly separated from the mesh, and a hook attached to the central point of the prosthesis. This hook was linked to a thread that was connected to a motor and the system of force measurement, and the MDT evaluated by applying a progressive force to the mesh. It was not possible to eliminate friction force from each procedure, but it was similar in all the animals. When the mesh detach from the tissue, there was computed the value in Newton (N).

### Histological evaluation

After the detachment, a sample of abdominal wall including the border of abdominal wall defect with the mesh was removed and fixed in formalin solution at 10%, processed by routine histological preparation, and obtained sections of 0,4µ that were stained by H&E. The histopathological parameters studied were inflammatory reaction, predominant cell type in inflammatory infiltrate, granulation tissue, giant cell reactions, fibrosis and necrosis.

MDT data was analyzed with the Kruskal-Wallis test, and considered difference to p value less than 0.05. The histological parameters were compared by means Chi-square test with Fisher-Correction, and considered difference to p value less than 0.05.

## RESULTS

The median weight of animals was 286.0 g (259.0 g to 308.0 g) for test group and 272.5 g (259.0 g to 310.0 g) for control group, with no significant differences ( $p=0.28$ ).

Suture dehiscence was observed in 11 animals, five in rats with peritonitis (test group) and six in control group. There was no significant differences ( $p=0.58$ ). The epithelization also was not different between the two groups ( $p=1.0$ ).

The median value of MDT in peritonitis rats (test group) was 62 N (45-65 N), and in control groups (without peritonitis) was 50 N (40-62 N), with more elevated value in peritonitis rats ( $p=0.02$ ).

The histopathologic analyses showed the prevalence of moderate to accentuate granulation tissue associated with the two groups. It was observed that the granulation was moderate in 40% and accentuated in 40% of the animals from control group, and moderate in 30% and accentuated in 50% of test group. The inflammatory response was moderate in 60% of the animals in each group. As regards inflammatory infiltration, it was predominantly mononuclear in 50% of the specimens of the control group and polimorphonuclear in the remainder, whereas it was mononuclear in 60% of the samples from test group (polimorphonuclear in 40%), without statistical difference ( $p=0.59$ ). Giant cell reactions were observed in 30% of the specimens from test group and in 60% of the samples from control group. Early-stage fibrosis was seen in 80% of control group samples and in 90% of test group, without statistical significance ( $p=0.17$ ).

## DISCUSSION

There are some discussions about the use of synthetic materials in infected surgical procedures, but no definitive conclusions have been reached. In fact, research on the use of alloplastic implants in unsterile environment is infrequent and it does not shed light on the most important point of the problem: is the use of synthetic meshes contra-indicated in cases of infection? Historically, the use of polypropylene meshes is described in cases of temporary closure in infected abdomen, but there is little and poor information about its definitive application in this situation<sup>4,12</sup>. Schnitt and Grinnan treated injured soldiers with infected abdomen using Marlex<sup>®</sup> mesh coverage and reported good results<sup>12</sup>. During the 70s, reported the satisfactory evolution of a patient with muscle necrosis, in which the abdominal wall defect was treated with an alloplastic mesh.

Also, patients with peritonitis and multiple organ insufficiency were treated with the use of

these meshes inserted onto the abdominal wall with a good prognosis<sup>6</sup>. On the other hand, according to other reports, there were good immediate results, but a number of long-term complications, such as chronic infections and skin erosion<sup>5,16,17,19</sup>. Besides, Voyle and cols have observed that 50% to 90% of the cases reported in the literature were unsuccessful, and it was necessary to remove the mesh<sup>19</sup>. As its the removal is not without risks - sometimes leading to bleeding, fistulas, hernias and recurrence of the infection-, historically most of the authors have been reluctant to accept its use in cases of infections or contamination<sup>3,6,9,10,17</sup>.

On the other hand, Birolini et al. were successful in a retrospective trial of 20 patients with complications. They concluded that the application of synthetic materials did not have to be avoided in cases of abdominal infection, when classical principles of surgery, such as antisepsis and hemostasia, were respected<sup>14</sup>.

The tension strength of scars may be affected by different factors such as diabetes mellitus, corticosteroids, immunosuppressive drugs, malnutrition, autoimmune diseases and even uremia. Others factors such bacterial colonization, foreign-body reaction, low blood flow associated with tissue hipoxia, high suture tension and the use of synthetic implants are also associated with decrease in healing. The biological healing in response to alloplastic material has been widely studied, but further questions are emerging in this context, which suggests that this is a challenging issue<sup>2,3,7,10</sup>. The initial migration of inflammatory cells is gradually replaced by a different panel scene, in which fibroblasts and giant cells are dominant. These alterations markedly increase the adhesion of the prosthesis to the resident tissues, which is observed during the early months.

According observed in another study<sup>2</sup>, the present study showed that there was greater adhesion of the Marlex<sup>®</sup> mesh coverage in the group of animals submitted to a peritoneal infection. This fact could be explained by a more profuse inflammatory response and the presence of a greater number of polymorphonuclear cells. Although this data was relevant, there is a need for other experimental studies, to confirm the behavior of alloplastic materials applied to infected tissues, especially in reconstructive surgical procedures.

## CONCLUSION

The use of Marlex mesh coverage onto abdominal defects produced in rats with induced acute peritonitis did not show worse results than its use in healthy animals, nor was its integration to the resident tissue any worse during the early seven days.

## REFERENCES

1. Birolini C, Utiyama EM, Rodrigues AJ Jr, Birolini D. Elective colonic operation and prosthetic repair of incisional hernia: does contamination contraindicate abdominal wall prosthesis use? *J Am Coll Surg* 2000; 191: 366-72.
2. Cerise EJ, Busuttil RW, Craighead CC, Ogden WW. The use of mersilene mesh in repair of abdominal wall hernias: a clinical and experimental study. *Ann Surg* 1975; 181: 728-34.
3. Corcione F, Cristinzio G, Maresca M, et al. Primary inguinal hernia: the held-in mesh repair. *Hernia* 1997; 1: 37-40.
4. D' Acampora AJ, Lopes A, Ludwig FC, Lima AG. Peritoneostomia no tratamento da peritonite difusa: análise de onze casos. *ACM arq catarin méd* 1989; 18(1): 15-19.
5. Dayton MT, Buchele BA, Shirazi SS, Hunt LB. Use of absorbable mesh to repair contaminated abdominal-wall defects. *Arch Surg* 1986; 121: 954-60.
6. Dibello JN Jr, Moore JH Jr. Sliding myofascial flap of the rectus abdominus muscles for the closure of recurrent ventral hernias. *Plast Reconstr Surg* 1996; 98: 464-69.
7. Ferrando JM, Vidal J, Armengol M, Gil J, Manero JM, Huguet P, Segarra A, Quiles MT, Schwartz S, Via MAA. Experimental evaluation of a new layered prosthesis exhibiting a low tensile modulus of elasticity: long-term integration response within the rat abdominal wall. *World J Surg* 2002; 26: 409-15.
8. Ferraz ED, Vieira OM Técnica de fechamento progressivo na laparostomia e descompressão abdominal. *Rev Col Bras Cir* 2000. 27(4):237-244.
9. Geisler DJ, Reilly JC, Vaughan SG, Glennon EJ, Kondylis PD. Safety and outcome of use of nonabsorbable mesh repair of fascial defects in the presence of open bowel. *Dis Colon Rectum* 2003; 46: 1118-23.
10. Kelly ME, Behrman SW. The safety and efficacy of prosthetic hernia repair in clean-contaminated wounds. *Am Surg* 2002; 68: 528-29.
11. Parker SJ, Watkins PE. Experimental models of Gram-negative sepsis. *Br J Surg* 2001; 88: 22-30.
12. Schmitt JH Jr, Grinnan GLB: Use of Marlex mesh in infected abdominal war wound. *Am J Sur* 1967; 113: 825-828.
13. Schein M, Geceltes G, Freinkel W, et al. Peritoneal lavage in abdominal sepsis: a controlled clinical study. *Arch Surg* 1990; 125: 1132-35.
14. Simão TS, Rocha FS, Moscon FB, Pinheiro RR, Barbosa FEAS, Faiwchow L. Vacuum dressing technique to temporary cover of laparostomy. *ABCD arq Bras Cir Dig* 2013. 26(2):147-150
15. Sebben GA, Rocha SL, Von Bahten LC, Biondo-Simões MLP, Ramos FHA, Pilonetto M, Zonatto LM. Infection on the meshes implantation área in the abdominal wall of rats with induced bacterial peritonitis. *Acta Cir Bras* 2006. 21(3):155-160.
16. Stone HH, Fabian TC, Turkleson ML, Jurkiewicz MJ. Management of acute full-thickness losses of the abdominal wall. *Ann Surg* 1981; 193: 612-17.
17. Temudom T, Siadati M, Sarr MG. Repair of complex giant or recurrent ventral hernias by using tension-free intraparietal prosthetic mesh (Stoppa technique): Lessons learned from our initial experience (fifty patients). *Surgery* 1996; 120:738-44.
18. Usher FC, Wallace AS. Tissue reaction to plastics. A comparison of Nylon, Orlon, Dacron, Teflon and Marlex. *Arch Surg* 1959; 76: 997-99.
19. Voyles CR, Richardson JD, Bland KI, et al. Emergency abdominal wall reconstruction with polypropylene mesh. *Ann Surg* 1981; 194: 219-23.