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Impact of a fiber-rich diet on abdominal adhesion formation: An experimental study

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ABSTRACT

Aims: In the current investigation, we studied the effects of a fiber-rich diet on experimental intestinal adhesion formation.

Methods: A total of 40 Wistar rats (males), weighing between 350g and 400g, were divided into two groups. Group 7% (control) received a diet consisting of 7% fiber and the other group received a diet of 17% fiber (fiber-rich). The animals underwent laparotomies to induce adhesions on the 7th day of receiving their respective diets. Seven days after laparotomy the animals were sacrificed and adhesions were evaluated quantitatively and qualitatively (Swolin).

Results: Quantitative analysis revealed that in the 7% group, 9 animals had 3 adhesions, 5 animals had 4 adhesions, 4 animals had 5 adhesions, and 1 animal died during induction. In the 17% group, 4 animals presented 2 adhesions, 6 animals had 3 adhesions, 6 animals had 4 adhesions, 2 animals showed 5 adhesions, and 1 animal died during induction. The Swolin score revealed that the 7% group had 2 animals with a score of 3, 10 animals with a score of 4, and 7 animals with a score of 5. In the 17% group, 4 animals had a score of 3, 7 animals had a score of 4, and 9 animals had a score of 5 ($p = 0.319$).

Conclusion: Our data showed that the high-fiber diet was not effective to avoid the formation of adhesions.

Key words: *Tissue adhesions, surgery, postoperative complications, dietary fiber*

Introduction

Adhesion is a natural consequence of the body's response to surgery, infection, radiation, ischemia, dissection, abrasion, reaction to a foreign body, or mechanical or thermal lesion. Surgical trauma triggers a cascade of events leading to an increase in vascular permeability that forms fibrous exudates three hours after the trauma, which in turn leads to a lower fibrolitic activity. If trauma is not resolved quickly, either through absorption or through fibrinolisis, fibroblasts and blood vessels invade the area and a re-arrangement of the cellular organization that leads to the formation of adhesions is observed [1-3].

For patients, the main consequences of abdominal adhesions are female infertility [4], chronic abdominal and pelvic pain [5], and intestinal blockage [6]. For surgeons, abdominal adhesions may represent additional complications in subsequent surgeries [7].

Abdominal adhesions may make a new surgical procedure more difficult and represent a challenge for surgeons. Additionally, surgical removal of adhesions extends surgery time and the time patients require for re-

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covery, which increases the risk of patients having hemorrhage, visceral lesions, enterocutaneous fistulas, and resection of the damaged segment of the intestine [8].

The formation of adhesions may be prevented by avoiding a larger trauma in the peritoneum during surgery [9,10] or by avoiding introducing many foreign bodies in the surgical field, by using medication to reduce local inflammatory response and by isolating traumatized tissues. Unfortunately, this knowledge is scarcely applied in surgical practice.

The early return of intestinal motility has been shown to contribute to the lysis of fibrinous exudate, preventing its organization into adhesions [11]. Attempts including the use of gastrointestinal prokinetic agent, ibuprofen, oxyphenbutazone, dexamethasone, promethazone, icodextrin solution, Sepreafilm membrane (HAL-F), Sepracoat solution (HAL-C), and hepatocyte growth factor have been made to reduce adhesion formation by promoting early intestinal motility [4,11-20]. Considering that a fiber-rich diet increases intestinal motility, we hypothesized that adopting a fiber-rich diet for a week before elective abdominal surgery could maintain intestinal peristalsis in the postoperative period, facilitating the mechanical lysis of adhesions. In our current investigation, we studied the effects of a fiber-rich diet on experimental intestinal adhesion formation in Wistar rats.

Methods

The research was performed in the Unit of Surgical Practice and Experimental Surgery and Department of Physiology of Santa Casa de São Paulo, Brazil. A total of 40 Wistar rats (males), weighing between 350g and 400g were used in this study. Animals were under artificial light-dark 12-hour periods for 14 days and received water and food ad libitum. Animals were divided in two groups. The 7% (Control) group consisted of 20 animals that received animal rations containing 7% fiber while the 17% group consisted of 20 animals that received rations containing 17% fiber. Rations were otherwise similar between groups. In both groups animals underwent laparotomy. The terminal ileum and cecum were identified (Figure 1) and an area of about 1cm x 1cm was submitted to abrasion with gauze to cause hemorraghia of the subserosa (Figure 2). The procedure was done blindly on day seven by the same surgeon.

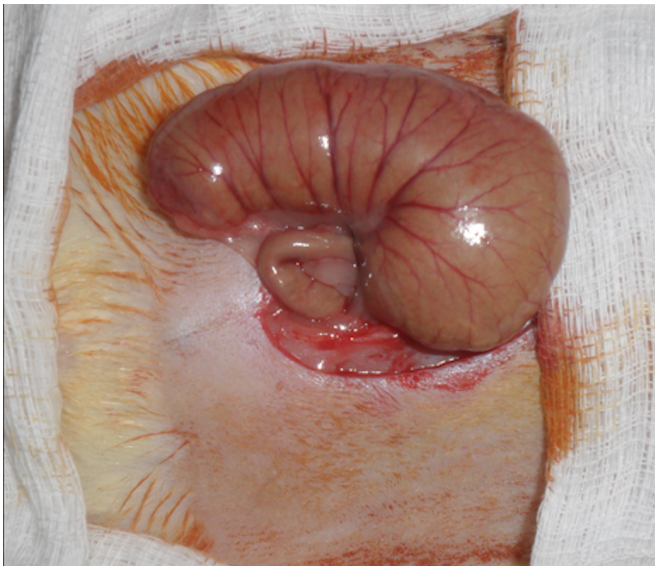

Figure 1. Cecum was exposed.

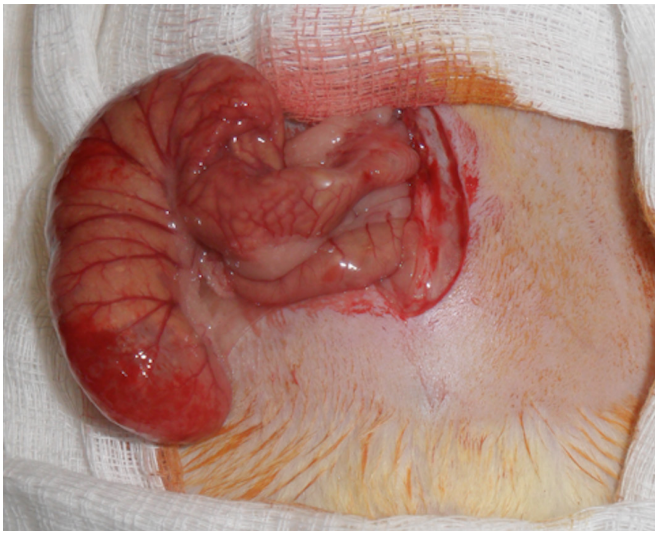

Figure 2. Cecum after abrasion.

On the 14th day, all animals were sacrificed and the evaluation of adhesions was carried out blindly. Adhesions were described according to the score suggested by Swolin [21,22] (Table 1) and considering the number of adhesions formed.

Procedure description

Anesthesia

Rats were anesthetized with ketamine and xylazine solution at 25 and 3 mg/kg doses respectively, by intramuscular injection in the internal face of the left thigh 30 minutes before surgery.

Surgical technique

With animals in the supine position a xiphopubic tricotomy was performed followed by antisepsis of the region with topical povidone-iodine solution. With sterile fields set, median incisions were done approxi-

Table 1. Adhesion score described by Swolin.

Score	Description
0	Absence of adhesion
1	<2mm length, easy to separate
2	3-10mm length, easy to separate
3	>10mm length, difficult to separate
4	>10mm length, requiring instruments to separate
5	Separation results in intestinal trauma

mately 3 cm infraumbilical followed by abrasion of the cecum and terminal ileum (Figure 6). Finally, the skin was sutured with Nylon 4.0.

Post-surgery

For seven days following the procedure, animals received food and water ad libitum.

The animals were sacrificed on day 7 postoperatively with intravenous injection of potassium chloride (10 ml 19.1%). After extensive inverted U incision (Figures 3-5), the abdominal cavity was evaluated by an experienced surgeon blindly.

Statistical analysis

For statistical analysis, one-way analysis of variance (ANOVA) was used to compare the number of adhesions per animal in each group and the Kruskal-Wallis test was used to compare the adhesion scores between the groups.

Results

Quantitative analysis revealed that in the 7% group, 9 animals had 3 adhesions, 5 animals had 4 adhesions, 4 animals had 5 adhesions, and 1 animal died during induction. In the 17% group, 4 animals presented 2 adhesions, 6 animals had 3 adhesions, 6 animals had 4 adhesions, 2 animals showed 5 adhesions, and 1 animal died during induction (Figure 7), no statistical difference was observed in this analysis ($p = 0.336$).

The Swolin score revealed that the 7% group had 2 animals with a score of 3, 10 animals with a score of 4, and 7 animals with a score of 5. In the 17% group, 4 animals had a score of 3, 7 animals had a score of 4, and 9 animals had a score of 5. There was no statistical difference ($p = 0.319$) (Figure 8).

Discussion

Around 93% of patients who undergo one or more abdominal surgeries have abdominal adhesions [23].

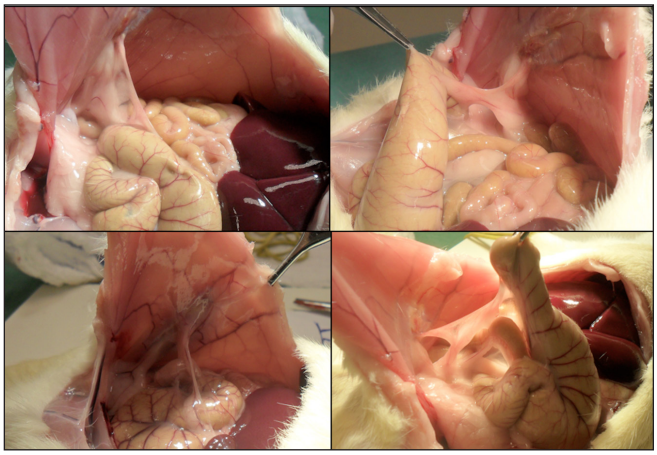

Figure 3. Adhesion of cecum with abdominal wall.

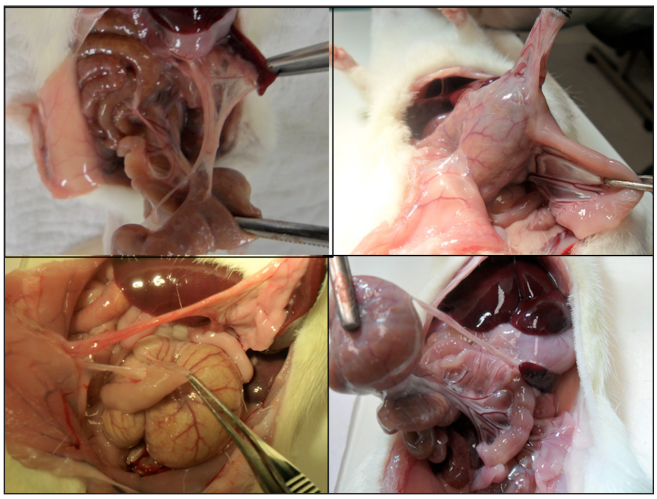

Figure 4. Adhesion of cecum with abdominal wall and other.

Figure 5. Adhesion of cecum with liver.

The Surgical and Clinical Adhesions Research (SCAR-3) study revealed that patients who undergo surgery of the lower abdomen (except for appendicectomy) have a 5% risk of being readmitted to hospital, which directly correlates with the presence of adhesions during the first five years of the post-surgery period [24]. One third

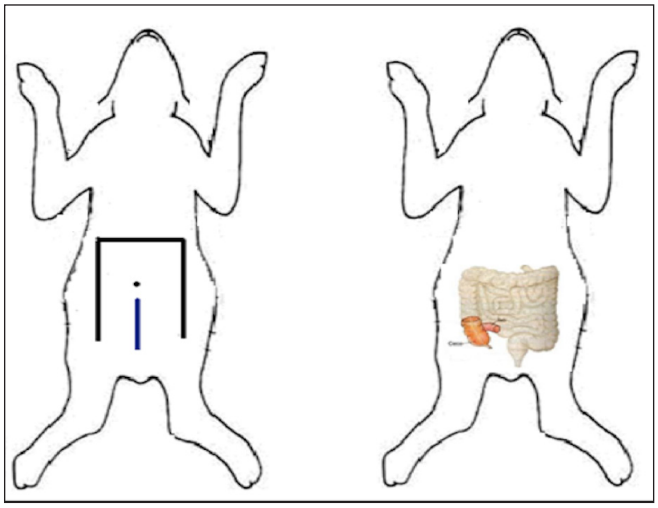

Figure 6. Left image: infra-umbilical incision in blue and inverted U incision for evaluation of adhesions; Right image: Region submitted to trauma to induce adhesions.

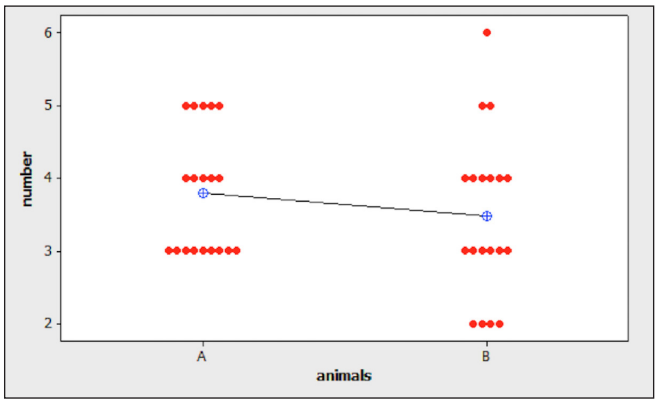

Figure 7. Number of adhesions in each group of rats.

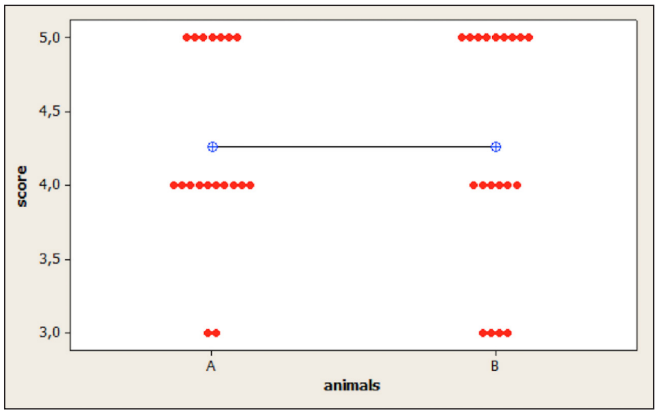

Figure 8. Individual value plot of score vs animals.

of the patients submitted to open abdominal or pelvic surgery were re-admitted at least twice in the 10-year period following the procedure due to reasons directly associated to the presence of adhesions or that could be worse due to the adhesions. More than 20% of all hospital re-admissions occurred during the first year following surgery and 4.5% occurred because of obstructions of the small intestine [25,26]. Of all patients admitted to hospital due to symptoms of intestinal blockage, 74% are associated to the presence of adhesions [27].

Despite numerous designed studies, intra-abdominal adhesions problem remains unsolved. There is not an ideal strategy. Recently published researches maintain their focus on a molecular basis. To better understand how proteins and cellular response acts to adhesion formation Wei et al studied the combined effect of Keratinocyte Growth Factor Combined and a Sodium Hyaluronate Gel. It had significantly increased the tissue plasminogen activator levels while the levels of IL-6, tumor necrosis factor (TNF-) and TGF-1 in the abdominal fluid had been lower. Fibrinolytic activity is the main mechanism that influences the adhesion formation whenever it is activated their number and density reduces. By using keratinocyte growth factor and sodium hyaluronate gel abdominal adhesion had significantly decreased [28].

Makarchian et al., in another experimental model, tested the effectiveness of heparin, platelet-rich plasma (PRP), and silver nanoparticles. According to their results platelet-rich plasma had the lower severity score, none of the rat was classified as 3 or 4 [29]. Despite all these efforts on molecular therapy and usage of medical products, we believe that different life stile would lead to better recovery of abdominal motility and lower complications due to abdominal adhesions.

In this study we observed that the number of abdominal adhesions found in rats fed a diet rich in fiber was not significantly different than those fed a regular diet ($p= 0.336$). Thus, it is not possible to say that diet may prevent the formation of adhesions caused by a surgical procedure in the abdominal cavity.

Although some animals in the fiber-rich group (17% group) presented more adhesions (two or three), a single animal in the same group showed the highest number of adhesions found in this study (six adhesions). Thus, differently than reported by Springall and Spitz [11], we did not find an association between the number of adhesions and the intestinal motility induced by a fiber-rich diet. We did not observe any statistical difference between groups for the Swolin scores of the adhesions ($p = 0.319$). In this case, the median found in the 17% group was even higher than that observed in the control group.

Conclusion

Several strategies exist to prevent the formation of adhesions in patients undergoing abdominal surgery. This study aimed to examine whether a high-fiber diet in preoperative preparation and postoperative abdominal surgery in rats could prevent formation of adhesions due to increased intestinal motility. Our data showed that a high-fiber diet was not effective to avoid the formation of adhesions.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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