Original Article

Application of initiative content reduction surgery in the treatment of abdominal giant hernia in experimental rabbits

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Abstract: Objective: The goal of this study was to explore the effects of initiative content reduction surgery on prevention of intra-abdominal hypertension (IAH) after abdominal giant hernia repair in rabbits. Methods: Abdominal giant incisional hernia (AGIH) rabbit models were established and divided into group A and group B randomly. Rabbits in both groups were treated with herniorrhaphy, the hernia contents were completely returned during surgery in the group B, while the A group received partial resection of the greater omentum and then the hernia contents were completely returned. Intra-abdominal pressure (IAP), wound complications, and death were recorded and statistically analyzed before and after surgery in the both groups. Results: There was no significant difference in IAP between the two groups before surgery (P > 0.05). The results of 3 abdominal pressure examinations after surgery showed that group A was all significantly lower than group B (all P < 0.05). There was a significant correlation between the occurrence of wound dehiscence and the increase of IAP after surgery. Conclusion: Initiative content reduction surgery can effectively prevent the occurrence of IAH and abdominal compartment syndrome (ACS) after AGIH repair in rabbits, and has application value in the clinic.

Keywords: Abdominal hernia, initiative content reduction, experimental rabbit

Introduction

Incisional hernia is one of the common complications after abdominal surgery with an incidence of about 5%-10% [1]. The definition of abdominal giant incisional hernia (AGIH) is that the diameter of the abdominal wall defect exceeds 12 cm or the ratio of hernia sac volume to abdominal cavity volume is more than 15% [2]. The incidence of abdominal hernia has increased with the increase of abdominal surgery cases year by year. Take incisional hernia for example: according to statistics, 2%-10% of abdominal surgery can lead to incisional hernia [3]. When there is no incarceration after incisional hernia repair or if the patients have no symptoms, as the volume of hernia increases, incarceration occurs, and the contents of the original abdominal cavity gradually decrease, resulting in abdominal giant hernia. Moreover, in the case of incarceration, hernia contents (intestine, omentum, etc.) are prone to necrosis, which seriously affects the quality of life of patients and even threatens their lives. At present, surgery is the only effective treatment for AGIH. Because of the influence of many factors, such as old age or obesity, the recurrence rate is 10%-30% and the complication rate is 50% [4-7]. Among them, intra-abdominal hypertension (IAH) and abdominal compartment syndrome (ACS) are serious postoperative complications. The occurrence of IAH or ACS can cause adverse effects on the organs of the whole body, such as the decrease in returned blood volume and the reduction of lung volume caused by the elevation of the diaphragm, and further affect the function of the heart and lung [8]. In addition, the occurrence of IAH can stimulate the gastrointestinal tract to cause abdominal pain and diarrhea, and the blood supply of mesenteric artery and intestinal mucosa will decrease significantly under high pressure, and
Control and abdominal wall compliance exercise. Some scholars suggest that partial resection of intestinal duct and greater omentum can prevent IAH and ACS after surgery [8]. In clinical practice, initiative content reduction surgery could significantly reduce the incidence of IAH and ACS after AGIH repair, and has a good curative effect and low recurrence rate in small sample studies at home and Abroad [12, 13]. However, this technique still lacks prospective clinical control studies with large samples and evidence-based medicine research. Therefore, the effects of this technique on the prevention and treatment of IAH after AGIH repair were explored in this study by animal experiments.

Materials and methods

Main materials

Experimental rabbits (New Zealand white rabbit), aged 1 year old, weighing 3-5 kg, were provided by Animal experiment center of Guangdong Grandhope Biotechnology Co., Ltd. Bovine pericardial crosslinked biologial patches (Guangdong Grandhope Biotechnology Co., Ltd.).

Animal modeling

One-year-old healthy rabbits were forbidden to eat and drink for 8 hours before surgery. One mL/kg of 3% pentobarbital sodium was intravenously injected through the ear margin for anesthesia. After anesthesia, the rabbits were fixed with a supine position, skin preparation, iodophor disinfection, and towel pavement was performed. A 5 cm longitudinal incision was made at a transverse finger near the left side of the median line of abdomen, and the skin and subcutaneous tissue were cut to expose the muscles. A muscle tissue with diameter of about 3 cm near the median line was resected (preserving the complete peritoneum). Skin and subcutaneous tissue were discontinuously sutured with silk thread, and closed with medical glue (Figure 1). Penicillin was orally adminis-
tered 3 days after surgery. The rabbits were raised by professionals in the animal experiment center of Guangdong Grandhope Biotechnology Co., Ltd. at the temperature of 25°C-30°C and relative humidity of 40%-60%, with discontinuous water feeding and free eating. The postoperative observation period was 1 month, and the wound healing, swelling, and abdominal mass bulging were observed. Abdominal incisional hernias occurred in all experimental rabbits within one month (about 8-10 cm in diameter) (Figure 2).

Animal grouping

A total of 100 AGIH model white rabbits were randomly divided into the experimental group (group A) and the control group (group B).

Herniorrhaphy and abdominal pressure measurement

After anesthesia, the rabbits were taken supine position, and the skin and subcutaneous tissue, muscular layer and peritoneum were punctured layer by layer with a sharp knife at the median line of the abdomen, about two transverse fingers below the mass. One end of the infusion tube was inserted into the abdominal cavity about 5 cm and fixed, and the head of the infusion tube ended with a saline bottle, which was about 100 cm higher than the pubic symphysis of the experimental rabbit. A total of 100 mL saline was injected into the abdominal cavity of the rabbit, and the saline at the end was removed. After the liquid level in the tube dropped to a stable level, the pressure value (cmH₂O) was collected at the end of inspiratory with pubic symphysis as the baseline. The skin and subcutaneous tissue were cut along the scar of the last surgery, and the hernia sac was exposed, completely separated, and opened along the median incision. Hernia contents of 50 rabbits in the group B were completely returned. circular resection of the hernial sac was performed along the hernia sac neck, peritoneum, and muscular coat were continuously sutured with absorbable lines, and then the hernia sac neck was closed. The myometrium around the hernia ring was pulled to the midline, and the muscular defect was closed by continuous suture. The bovine pericardial crosslinked biological patches were used to repair, the absorbable lines were fixed in the muscular coat, and the skin and subcutaneous tissue were sutured discontinuously (excision of excess skin). a total of 50 rabbits in the group A were resected with partial greater omentum (mainly hernia content omentum, slight adhesion of omentum, no other pathological changes), the hernia contents were returned, and the other operations were similar to group B. Postoperative abdominal pressure was measured in the same way (Figure 3).

Postoperative observation

The piezometer tube was kept for 2 days after surgery, and the abdominal pressure was measured daily by the method mentioned above. The wound local healing, swelling, patch infection, and mass bulging were observed. If there was wound dehiscence, re-surgery was performed to debridement and suture. The individual with visceral prolapse was returned the viscus and then debrided and sutured. The time and cause of death were recorded.

Statistical analysis

SPSS 19.1 Statistical Software was used for statistical analysis. The measurement data are expressed by mean ± standard deviation (X ± sd), and the changes of abdominal pressure between the two groups before and after surgery were compared by t test. The counting data are expressed by rate, and the abdominal pressure between the two groups before and after surgery was analyzed and compared by rank sum test. The incidence of wound dehis-
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Results of abdominal pressure measurement
There was no significant difference in abdominal pressure between the two groups before surgery (P > 0.05). The abdominal pressure in group B was higher than that in group A on day 0, 1, and 2 after surgery, and the difference was statistically significant (all P < 0.05) (Table 1). The abdominal pressure in the two groups after surgery was significantly higher than that before surgery, and the difference was statistically significant (P < 0.05) (Figure 4). The abdominal pressure in group A was significantly lower than that in group B on the day of the surgery (Figure 5).

Postoperative complications
Wound healing of experimental rabbits was observed within one month after surgery. In group B, there were 11 cases of wound dehiscence within one month after surgery was analyzed and compared with Chi-square test. The correlation between wound dehiscence and postoperative abdominal pressure was analyzed by binary logistic regression analysis. When P < 0.05, the difference was statistically significant.

Figure 3. Herniorrhaphy Hernia repair and abdominal pressure measurement: A: Abdominal hernia measurement; B: Pressure tap establishment; C: Abdominal pressure measurement; D: Skin and subcutaneous tissue incision; e: Hernia sac separation; f: Hernia sac measurement; G: Resected hernia sac; H: Resected greater omentum in the group B; I: Biological patch placement and fixation.
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Table 1. Average abdominal pressure (cmH₂O, X ± sd)

<table>
<thead>
<tr>
<th>Group</th>
<th>Before surgery (D)</th>
<th>Surgery day (D0)</th>
<th>1 day after surgery (D1)</th>
<th>2 days after surgery (D2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>5.05 ± 0.54</td>
<td>5.25 ± 0.54</td>
<td>5.15 ± 0.54</td>
<td>5.10 ± 0.51</td>
</tr>
<tr>
<td>Group B</td>
<td>4.93 ± 0.52</td>
<td>6.99 ± 0.65</td>
<td>7.09 ± 0.76</td>
<td>7.13 ± 0.67</td>
</tr>
<tr>
<td>t</td>
<td>1.139</td>
<td>14.371</td>
<td>14.615</td>
<td>16.820</td>
</tr>
<tr>
<td>P</td>
<td>0.257</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Figure 4. Varying curve of abdominal pressure in group A and group B: D: before surgery; D0: the surgery day; D1: 1 day after surgery; D2: 2 days after surgery; *** was P<0.001.

Figure 5. Comparison of abdominal pressure distribution between two groups of rabbits on the surgery day D0: the surgery day.

2 cases of wound dehiscence, no visceral prolapse and death, and the incidence of wound dehiscence was 4.0%. Chi-square test showed that there were significant differences in the incidence of wound dehiscence between the two groups. There were 9 rabbits in group B that died 8-20 days after surgery, and all of them had visceral prolapse, intestinal dilatation, and tissue edema. Only 1 case died of anesthesia accident in the group A (Table 2). In addition, the experimental rabbits in the both groups had normal diet and defecation after surgery. Additionally, a few of them showed obvious edema but recovered without special treatment. No patch infection or incisional hernia recurrence was found in all subjects. Patch specimens were taken out 1 month later, and patches in all surviving individuals were in good condition.

Death of mice was taken as dependent variable, and abdominal pressure as independent variable, and the mean abdominal pressure in group B was about 7 cmH₂O. Analysis of the assignment (abdominal pressure > 7 = 1, and ≤ 7 cmH₂O = 0) by binary logistic regression analysis showed a significant correlation between death and abdominal pressure on day 0, 1, and 2 after surgery (Table 3).

Discussion

Patients with abdominal giant hernia have a very long history, are often severely obese, and are associated with a variety of chronic diseases [4, 5]. In this case, if the contents of the hernia are completely returned during surgery, combined with postoperative gastrointestinal deterioration, postoperative fluid resuscitation,
were used in this study. The use of animal models makes the appearance of rare diseases in the human body to be well simulated and has a positive and important significance in the completion of the process of disease development and treatment [20, 21]. The results of this study showed that during the abdominal giant hernia repair in experimental rabbits, the complete return of hernia contents resulted in a significant increase in postoperative abdominal pressure, which is consistent with the conclusion of clinical retrospective study. In clinical practice, IAH was found in all abdominal giant hernia patients with complete return of herniation contents during surgery. In addition, postoperative fluid resuscitation and intestinal edema, hypofunction resulted in an increase in the contents of the abdominal cavity, and forced closure of the abdominal cavity after resection of the hernia sac resulted in a decrease in the abdominal volume, implantation of artificial materials. Abdominal muscle tension caused by postoperative pain and postoperative abdominal band protection resulted in lower abdominal compliance. The combined effects of these factors eventually led to a sharp increase in abdominal pressure in patients. Clinically, increased abdominal contents, reduced abdominal volume or decreased abdominal compliance may lead to IAH. Additionally, intra-abdominal infection, abdominal aortic aneurysm rupture, intestinal obstruction, severe abdominal trauma, retroperitoneal hemorrhage, pneumoperitoneal laparoscopic surgery, acute pancreatitis and abdominal giant hernia surgery are common surgical causes [22]. All kinds of patches are widely used in the treatment of abdominal hernia, and in this experiment, the bovine pericardial crosslinked biological patches were used to repair [23-25]. The suture of hernia in both groups was performed by patches with appropriate size for hernia, because studies have found that the appropriate size of patches can reduce complications [26] and influence of patch size was excluded in this study. Nine cases died in the group without volume reduction during postoperative observation, all of

On the basis of the previous theories and the practices of small samples, the new surgical methods and new materials, which often need to be verified by animal experiments in clinic,
them had wound dehiscence and visceral prolapse, accompanied by severe intestinal edema. Statistical analysis showed that there was a significant correlation between wound complications and abdominal pressure, so the cause of death was wound dehiscence caused by IAH. The increase of abdominal pressure can reduce the blood supply of the abdominal wall by reducing cardiac output and increasing abdominal blood flow resistance. Some studies have shown that IAH can prolong stitch removal time of abdominal incision [27]. The use of initiative content reduction during the surgery can greatly reduce postoperative abdominal pressure, which is consistent with the clinical findings [18]. The incidence of wound complications in the experimental group was significantly lower than that in the control group, indicating that the initiative content reduction surgery can reduce the wound dehiscence and visceral prolapse by reducing the postoperative abdominal pressure, thereby reducing the postoperative mortality.

The observation period of this experiment was relatively short, and the complications after surgery might not be comprehensive. Moreover, due to limited funds, the function of related organs was not tested. The intestinal duct was not resected in the initiative content reduction surgery because of its high difficulty of operation, thus, the safety of primary repair with biologic patches needs to be further studied in animal experiments. In the following experimental study, the safety of primary repair with patches was explored after partial intestinal excision by initiative content reduction surgery and the effect of initiative content reduction surgery on the long-term prognosis of abdominal giant hernia.

In conclusion, initiative content reduction surgery can effectively prevent the occurrence of IAH and ACS after AGIH repair in rabbits, and has application value in the clinic.

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Disclosure of conflict of interest

None.

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