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The application of artificial bionic intestine in the treatment of short bowel syndrome

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Abstract: This paper mainly discusses the application prospect of artificial biomimetic intestine in the treatment of short bowel syndrome. In recent years, many clinical workers have studied and explored it, which has become one of the hot spots of current medical research. This paper will explore the application and prospect of artificial bionic intestine in the treatment of short bowel syndrome by showing the etiology, pathophysiology, classification and classification of short bowel syndrome. Artificial biomimetic intestine can replace or partially replace the defective intestine, improve the quality of life of patients with short bowel syndrome, and restore the absorption and metabolism ability of the intestinal tract. However, due to various factors and challenges, the artificial bionic intestine is still in the stage of exploration. As a novel treatment, artificial bionic intestine has shown great potential in the treatment of short bowel syndrome. Therefore, further exploration is needed to achieve the utility of the artificial biomimetic intestine.

1. Introduction

Short bowel syndrome (SBS) is a serious disease of nutrient absorption disorder, mainly caused by intestinal resection or dysfunction[1]. According to the latest data, SBS is a series of symptoms caused by the failure of the remaining small intestine to meet the nutritional needs of the body after partial or total resection of the small intestine. At this time, the balance and metabolism of various nutrients in the patient can only be maintained by intravenous infusion of fluids, electrolytes and macronutrients[2]. SBS will cause a large amount of fluid in patients, insufficient nutrient absorption, electrolyte imbalance, increase the susceptibility to bacteria and viruses, long-term parenteral nutrition related complications, and lead to the gradual wasting of patients, their clinical manifestations are complex and diverse, including diarrhea, abdominal pain, weight loss, malnutrition, etc[3]. Traditional treatments mainly include nutritional support and drug treatment, but these methods often fail to completely solve the problem. Recently, the artificial biomimetic intestine, as an emerging treatment, has shown great potential in the treatment of short bowel syndrome.

2. The Etiology

So far, studies have shown that the etiology of SBS mainly includes congenital and acquired factors[4]. Congenital factors mainly include genetic diseases such as familial multiple intestinal polyposis, congenital intestinal stenosis, etc. Acquired factors mainly include intestinal diseases such as Crohn's disease, ulcerative colitis, intestinal tumors and other diseases that require intestinal resection, as well as intestinal dysfunction caused by trauma, inflammation, infection, etc. Among them, Crohn's disease and ulcerative colitis are the most common causes of short bowel syndrome[5]. Crohn's disease is a chronic inflammatory bowel disease that can cause intestinal stenosis, ulceration, and fistula formation, which may eventually require most of the bowel removal. Ulcerative colitis is a chronic non-specific inflammatory bowel disease that mainly affects the colon and rectum, and can also lead to bowel resection in severe cases. In addition, intestinal tumors are also an important cause of SBS[6], Especially in malignant tumors. Tumor may invade the gut directly or through intestinal lymph nodes, leading to intestinal stenosis or obstruction. In some cases, part or all of the intestine may need to be removed. According to clinical data, SBS (short bowel syndrome) is classified into three types: type I SBS is the most severe form, characterized by a small bowel length of less than 100 cm and accompanied by ileus and missing parts of the colon[7].

3. Pathophysiological Mechanism of SBS

SBS is a clinical syndrome caused by the insufficient length of the small intestine due to intestinal resection, congenital defects, disease or trauma[8]. The pathophysiological mechanism is the result of impaired absorption function, intestinal dysregulation of microflora, abnormal gastrointestinal hormone secretion and decreased immune function.

4. Medical Treatment and Classification

Clinically, according to the progression of SBS, it can be divided into three periods: acute, adaptive and chronic failure[5]. The acute period is generally one month after surgery, due to the loss of large amounts of water, electrolytes and nutrients, the patient may be life-threatening; the adaptation period is generally 1 to 2 years, the frequency of the diarrhea is greatly reduced, the imbalance of water and electrolytes, the most typical manifestation is the lack of nutrition, if the patient will generally enter the stable period, but still has insufficient vit B12 in the body[9]. However, there is relevant literature that most patients with SBS may be complicated by infection, and even lead to serious complications such as sepsis, renal insufficiency and liver insufficiency, which greatly endanger the life of patients[10].

4.1. Acute Phase

Due to various reasons, after partial resection of intestinal surgery, it will immediately enter the acute phase of SBS, which is generally 3 to 4 weeks, characterized by severe intestinal defects. During this period, the removal of the important intestinal tract causes abnormal metabolism, loss of large amounts of water and electrolytes, and excessive secretion of gastric acid due to the lack of inhibitory hormones released from the ileum under normal physiology[11]. Therefore, this period need to close, pay close attention to the patient's total excretion (including feces and urine), and timely intravenous infusion, infusion and electrolyte replacement should be many times (2h / times), the degree of the two dose is even greater than the amount of protein, this is mainly, to avoid possible damage to the kidney[11].

4.2. Adaptation Period

The clinical manifestation of the adaptation period is the continuous adaptation of the intestinal lumen structure and physiological function of the patient, which can gradually enhance the nutritional intake, relaxation and gastrointestinal peristalsis. The adaptation period is generally 1~2 years[12]. During the adaptation period, after the patient underwent a small bowel transplant or small bowel extension surgery, the bowel function gradually recovers and is able to adapt to the normal diet.

4.3. Chronic Bowel Life

Studies have shown that about half of the proportion of patients with short bowel syndrome cause intestinal failure within 2 years of initiation, and that only fewer patients can adapt[4]. During the exhaustion period, patients need to receive nutritional support therapy, such as intravenous nutrition and parenteral nutrition, in order to maintain the body's nutritional needs. At the same time, drug treatments, such as antibiotics and immunosuppressants, are also needed to control the occurrence of infection and rejection. Some patients with chronic intestinal failure have been severely impaired in intestinal function and can only be sustained through maintenance therapy and life support, and studies have shown that SBS patients cannot completely get rid of parenteral nutrition therapy[13].

5. The Working Principle of The Artificial Bionic Intestine

Artificial biomimetic intestine is a new type of intestinal function repair technology, which builds an artificial intestinal system for transplant surgery, to replace or partially replace the damaged or missing intestinal tissue, thus restoring intestinal function. At present, the application of artificial bionic intestine in the treatment of short bowel syndrome has gradually become a hot field.

The construction of artificial biomimetic intestine mainly includes two aspects: one is through biological 3D[14]Or 4D[15]Printing scaffold to support intestinal tissue growth and intestinal epithelial cell layer to restore intestinal absorption function and improve the digestion and absorption efficiency of bionic intestine. In terms of scaffolds, various materials and structures have been developed, such as biomimetic hydrogels[16], Metal scaffolds, the extracellular matrix, etc[15]. In the epithelial cell layer, intestinal epithelial cells have been successfully isolated from humans or animals and cultured by culture in vitro[17]And transplant techniques, which are planted on a stent to build an artificial bionic gut.

The working principle of the artificial bionic gut is mainly based on the digestion and absorption process of the biological gut[18]. It allows food to digest and absorb in it by mimicking the physical and chemical environment of the gut. Central to this technology is simulating microbial communities in the gut that play a key role in food digestion and absorption of nutrients.

5.1. Surgical Indications for Intestinal Transplantation

Indications for artificial biomimetic intestinal transplantation are currently limited to small bowel failure that cannot be treated by internal and surgical methods. Short bowel syndrome is one of the main causes leading to a single small bowel resection. In addition, intestinal fistula, congenital intestinal malformation, severe intestinal injury: such as traumatic intestinal rupture, inflammatory bowel disease, catheter-related complications of parenteral nutrition, such as loss of venous access and recurrent sepsis are also the main causes of intestinal transplantation[19].

5.2. The Surgical Type of Artificial Bionic Intestine

Artificial biomimetic intestinal transplantation is a high-risk procedure that requires the recipient to have a certain surgical tolerance and postoperative rehabilitation ability[20]. The surgical procedure generally includes the following steps:

Preoperative preparation: Comprehensive assessment and preparation are required before surgery, including intestinal preparation, nutritional support, infection control, etc.

Transplantation surgery: General anesthesia is required during the procedure, using laparoscopic or open surgery or combined laparoscopic and colonoscopy techniques. First, the original intestine needs to be cut off, and then the artificial bionic intestine is implanted into the abdominal cavity and legally connected to the two broken ends to repair the suture. Artificial biomimetic intestine is generally composed of a scaffold and an epithelial cell layer, which can provide mechanical support, while the epithelial cell layer can restore the absorption and metabolic function of the intestine.

Postoperative care: After surgery, vital signs and intestinal function recovery should be closely monitored, along with corresponding nutritional support and drug treatment. Regular postoperative follow-up and examination are also required to ensure the normal function and rehabilitation of the artificial bionic intestine.

5.3. Monitoring and Prevention of Transplant Immune Response

Since the artificial biomimetic gut is an allograft, it may be rejected by the immune system. Therefore, the immune response needs to be closely monitored after surgery[21], And take the corresponding prevention and control measures.

Immunosurveillance: Regular immunosurveillance is required after surgery, including serological testing, histological testing and imaging testing. Serological tests can detect antibody levels and immune cell numbers; histological tests can observe the histological changes of the transplanted intestine; and imaging tests can assess the function and blood flow of the transplanted intestine.

Immunosuppressive therapy: In order to reduce immune responses, postoperative immunosuppressive therapy is required. Commonly used drugs include cyclosporine, tacrolimus[22], Methylprednisolone et al. These drugs can inhibit the activity and proliferation of immune cells and reduce the occurrence of rejection reactions.

Nutritional support: adequate nutritional support is required to maintain nutritional status and immune function[23]. Nutritional support can be provided by oral administration, intravenous fluids, etc.

Infection control: Infection control needs to be strengthened after surgery to avoid the impact of infection on the immune system[24]. Patients need to maintain good personal hygiene practices and avoid exposure to pathogens. At the same time, it is necessary to closely monitor the infection situation and take timely corresponding treatment measures.

6. Application of Artificial Biomimetic Intestine in the Treatment of SBS

Artificial biomimetic intestine can restore intestinal function and improve the quality of life by replacing or partially replacing the damaged or missing intestinal tissues. In the artificial biomimetic gut, epithelial cell layers with absorption function and scaffold function can be constructed[17]. These structures can promote the growth and repair of intestinal tissue and restore intestinal absorption and metabolic functions. At present, artificial biomimetic intestine has been widely used in the treatment of short bowel syndrome. Studies have shown that artificial biomimetic intestines can effectively restore intestinal function, effectively improve nutritional

status, and reduce symptoms such as diarrhea and weight loss. In addition, the artificial bionic intestine can also improve the immune function by regulating the intestinal flora, so as to further improve the therapeutic effect. However, the artificial biomimetic intestine is still in the research and exploration stage, and further research and clinical validation are needed to determine its safety and efficacy.

7. The prospect of Artificial Biomimetic Intestine in the Treatment of SBS

Although artificial biomimetic intestine has achieved some preliminary results in the treatment of short bowel syndrome, it still faces many challenges in its clinical application, such as the biocompatibility of biomaterials and long-term stability[25]. However, as technology advances, these issues are expected to be addressed. In the future, artificial biomimetic intestine is expected to become an important treatment for short bowel syndrome.

8. Summary

Some progress has been made in artificial bionic intestine as a novel treatment. In animal experiments, an artificial biomimetic intestine has been successfully constructed[15][17], And demonstrated that it can restore intestinal function, promote nutrient absorption and weight gain. In clinical trials, some preliminary studies have also been conducted, but it is still in the exploratory stage. In general, the application of artificial biomimetic intestine in the treatment of short bowel syndrome has broad prospects. It can restore intestinal function and improve the quality of life by replacing or partially replacing the damaged or missing intestinal tissues. However, there are still some technical and ethical issues to be addressed, such as biocompatibility of stent materials, stability and safety of cell implants. Therefore, further research and exploration are needed to realize the clinical application of artificial biomimetic intestine.

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