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Research Paper

Application of a new-type sutureless anastomosis stent to the primary reconstruction of the bilioenteric continuity after acute bile duct injury in dogs☆

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Abstract

Objective: To evaluate the effect of a new-type sutureless magnetic bilioenteric anastomosis stent that was used to reconstruct the bilioenteric continuity (primarily under the circumstances of severe inflammation after acute bile duct injury in dogs). **Methods**: Establishing an animal model of acute bile duct injury with severe inflammation and bile peritonitis in dogs. The new-type sutureless magnetic bilioenteric anastomosis stent was used to reconstruct the bilioenteric continuity primarily. **Results**: The experiment group anastomosis healed well with a mild local inflammation reaction, and the collagen lined up in order without the occurrence of observable bile leakage and infection. **Conclusion**: It was safe and feasible to use the new-type anastomosis stent to reconstruct the bilioenteric continuity primarily under the circumstances of severe inflammation after acute bile duct injury in dogs.

Keywords: magnet stent; bile duct injury; bilioenteric anastomosis; reconstruction

INTRODUCTION

Bile duct injury is a common serious surgery complication. Patients frequently suffered a multiple surgical blow and considerable economic losses. In order to reconstruct the bilioenteric continuity primarily under the circumstances of severe inflammation after acute bile duct injury, we invented a new-type of anastomosis apparatus—A sutureless magnetic stent for bilioenteric anastomosis.

MATERIALS AND METHODS

The sutureless magnetic bilioenteric anastomosis stent

The sutureless magnetic bilioenteric anastomosis stent is composed of the following parts: the magnetic ring A and ring B, which were made from NdFeB material. A soft magnetic alloy cone (Fe-Cr12) is produced in the spindle. It's center was holed with the same inner diameter as ring A. Titanium film was plated to the external superficies of the stent. The catheter (with lateral aperture) was glued to magnetic ring A and the magnetic cone with cyanoacrylate. The maximum magnetic intensity of the stent for the horizontal axis was 70 mT. The magnetic attraction between the magnetic ring A and B was 6.4N, 3.3N, 1.7N for the distance of 0mm, 1mm and 2mm respectively. The stents were sterilized with ethylene oxide.

Acute bile duct injury in dogs

Sixteen domestic mongrel dogs were selected from experimental animal center of Xi'an Jiaotong University's medical school. Their body weight varied from 15 kg to 18 kg regardless of gender. After 12 h

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fasting and 4h fasting for liquid, the dogs were anesthetized with an intraperitoneal injection of 2.5% thiopental(25 mg/kg). After prepared with povidone iodine and draped with sterile towels, a medial abdominal incision was selected. The cystic duct was ligated. The common bile duct(CBD) near the duodenum was educed and its distal end was ligated and its proximal end cut open. A small catheter was inserted into it and fixed it under the local skin. After 5 days when the common bile duct was dilated, cholangiography was taken to observe the CBD dilatation. Its diameters were dilated to 8-10 mm [1]. Then the catheter was removed. Thus the bile duct injury and acute peritonitis model was established in sample.

Operation on the dog models with acute bile duct injury and observation the therapeutic effect

The Dogs (with acute bile duct injury) were randomly assigned to two groups(8 animals per group). Group A was assigned to be operated using the sutureless magnetic bilioenteric anastomosis stent and group B to the manual suture anastomosis.

The second operation would be performed when bile peritonitis was serious (after the catheter pulled out for 48 hours). The dogs were anesthetized with an intraperitoneal injection of 2.5% thiopental (25 mg/kg). Their abdominal cavities were washed with normal sodium. Cholecyst was resected. The common bile duct was freed to about 1.5 cm and the anterior wall closed to leakage site was cut off. The magnetic stent was used to Roux-en-Y anastomosis in group A. The catheter was fixed on the intestinal wall and beneath the skin of the abdominal wall respectively(***Fig 1***). In group B we performed bilioenteric Roux-en-Y anastomosis operation by the traditional manual suture method with 6-0 prolene suture. The posterior anastomosis was sutured continuously and the anterior interruptedly. A catheter was placed on stoma as a stent and fixed at the mucosal layer with 5-0 absorbable suture. Same as group A, the stent catheter was fixed onto the intestinal wall and beneath the skin of the abdominal wall respectively. At the end of the anesthesia, phenylbutazone was administered to prevent postoperative pain. Penicillin intramuscular injection was administered to prevent infection, twice a day for five days, each 800,000 units.

The dogs were housed separately in a special breeding center, where they were given continuous veterinary care. The changes in general status, peritoneal drainage conditions and the incidence of anastomotic leakage were observated after the operation. Before the first and second operation, 1 week, 2 week and 1 month after the second operation, blood samples were collected respectively for the determination of blood routine and liver function. The stents in two groups were pulled out 2 weeks after the second operation. The magnets would drop into intestine and discharged along with feces after the stents were pulled out and clipped near the abdominal wall. The dogs were terminated 1 month after the second operation, the tissue of anastomotic stoma were harvested and fixed with formalin. Slices were then stained with hematoxylin and eosin. Anastomotic histological changes were observed under light microscope.

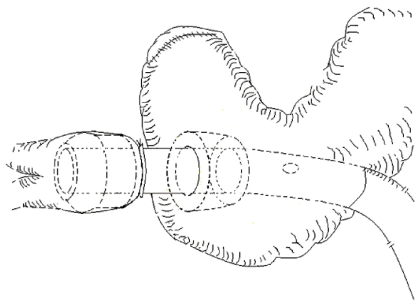

Fig 1 **The ideograph of bilioenteric Roux-en-Y anastomosis with the magnetic stent**

Statistical analysis

Statistical significance was analyzed by Student's unpaired *t*-test. The value $P < 0.05$ were considered statistically significant.

RESULTS

Clinical follow-up

The CBD dilatation was observed in the second operation and its diameter was about 7-8 mm. The bile duct wall was crisp, incrassate with edema due to severe inflammation. The average operation time of the group A and group B was 3.5 h and 4.4 h respectively. One dog of group A died of gastrointestinal bleeding on the second day after the second operation. There was no bile leakage occurring in the remaining seven dogs. The magnets were discharged along with feces after 3~4 days when stents were pulled out. There were four dogs that bile leakage occurred in group B. One dog died of wound dehiscence, while the other dogs recovered after peritoneal drainage for 7~10 days. The general state of dogs of group A was significantly better than group B.

Blood biochemistry examination

There were no significant difference in blood biochemistry examined between the two groups before

the first and second operation, and at 1 week, 2 week and 1 month after the second operation. The WBC levels showed significant difference between the two groups($P < 0.05$) after the second operation.

Histological examination

The histological examination of the anastomotic stoma of group A revealed a continuous endothelium from the biliary tract wall through the anastomotic stoma to the intestinal wall. Inflammation at the submucosal region was mild(***Fig 2a***). The muscular layer and placenta percreta has healed and the collagen fibers lined up in order (***Fig 2b***).

In group B, anastomotic stoma revealed severe postoperative adhesions, stenosis and prominent suture in the lumen. Hematoxylin and eosin (HE) staining demonstrated that more inflammatory cells were distributed in submucosa surrounding anastomotic stoma. The mucosa around suture was weak (***Fig 3a***) and the collagen was disorderly (***Fig 3b***).

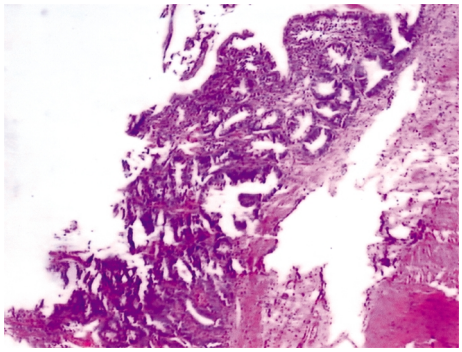

Fig 2a Mucous layer of anastomotic stoma in group A (HE, × 10)

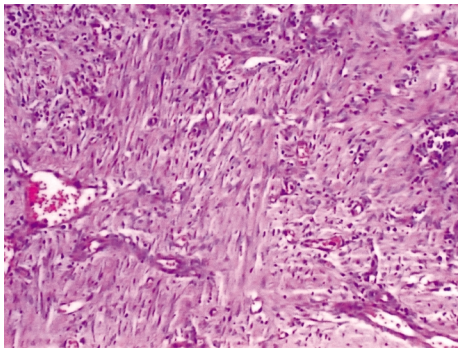

Fig 2b Muscular layer of anastomotic stoma in group A (HE,× 10)

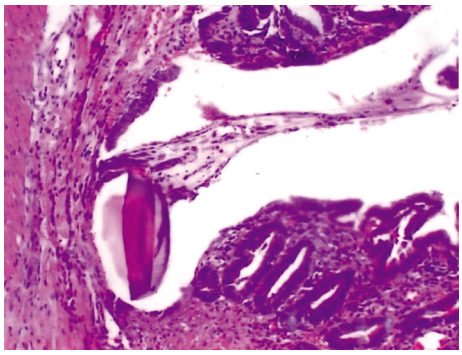

Fig 3a Anastomosis mucous layer of group B(HE, × 10)

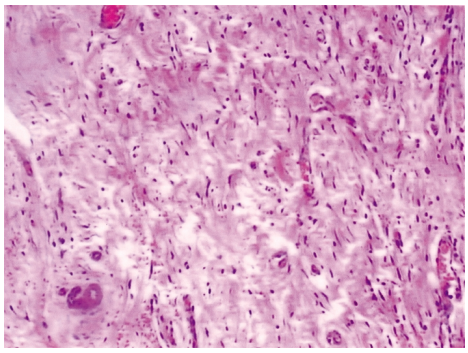

Fig 3b Anastomosis muscular layer of group B(HE, × 10)

DISCUSSION

Magnetic anastomosis was firstly used in microvascular anastomosis by Obbro in 1978[2]. Then it was applied to esophageal stricture, ureteroneocystomy, colorectal anastomosis, gastrojejunostomy and vascular anastomosis, which have shown good results [3-8]. Saveliev reported that endoscopic magnetic cholecystodigestive anastomosis had been applied to palliative treatment of malignant obstructions of distal bile duct[9,10]. A case of recurrence of cholangitis, a case of biliary stricture after pancreatic cancer, and anastomotic stenosis in patients with end-to-end anastomosis and bilioenteric anastomosis after liver transplantation were treated with magnetic anastomosis, which also achieved satisfactory results[11-13].

Nd-Fe-B magnetic materials have been widely used as dental implant material. Titanium-faced layer of magnets increased the biocompatibility and the ability of anticorrosion. It was easy to place the spindle stent into the CBD.

The general situation, healing status and inflammatory reaction of dogs in group A were better than group B. A shorter operation time, seamless anastomosis and mild inflammatory response may have contributed to their recovery. Autopsy revealed no bile pond and obvious inflammation surrounding anastomotic stoma tissues, while there was high incidence of bile leakage in group B.

Histological examination revealed in group B, more suture, more submucosal inflammatory cells,

weaker mucosa, disorderly collagen fibers around anastomotic stoma, anastomotic leakage and scar stenosis. It proved that the existence of suture had an adverse impact to anastomotic healing. Perhaps it may be a significant cause of complication(after primary reconstruction operation) in bile duct injury surgery.

There was no significant difference in postoperative liver function of dogs between the two groups. It was considered that the diameter of the anastomotic stoma was no less than normal after the bile duct expansion in the first operation, even in three dogs with anastomotic stenosis as in group B. Whether the anastomotic diameter will be different with collagen scar formation and remolding, further observations are required.

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