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Comparative Study of High Powerful Magnet with Conventional Repair of Suture in the Intestinal Anastomosis of Rats

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Abstract

Background

In this study, given the importance of gastrointestinal anastomosis in surgical procedures, attempts have been made to compare the results of employing magnetic compression anastomosis and magnetic coils in intestinal anastomosis of rats.

Materials and Methods

This study was an experimental trial on 60 rats which had been randomly divided into two experiment (30) and control (30) groups. First, the rat intestine was cut off from a relatively fixed point and then magnet anastomosis was performed at the both ends of bowel in the control group and manual suture in the experiment group. Anastomosis was then examined 10 days after the surgery for possible complications with a histological analysis of the indices of tissue repair.

Results

The mean time required for performing anastomosis of the rat intestine was 735 and 366 seconds for the control and experiment groups, respectively. Also, the laparotomy performed 10 days after the first operation did not show any significant difference between two groups in terms of surgical complications such as infiltration factor of inflammatory cell and fibroblast activity ($P>0.05$). The microscopic examination indicated that the tissue reaction in the anastomosis site was better in terms of tissue repair of neo-angiogenesis intestine and collagen deposition in the magnet group($P>0.05$).

Conclusion

Given the shorter duration of the anastomosis by magnets and more favorable histological results reported in the experiment group, as well as the lack of any significant difference in complications of the two techniques, magnetic compressive anastomosis can be used as a new technique for intestinal surgeries and pertaining anastomosis. Although, we recommend that study will be done with large sample size to obtain reliable results.

Keywords: Intestines, Anastomosis, Magnets, Sutures.

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1-INTRODUCTION

In many surgical procedures, anastomosis is inevitable. Gastrointestinal tract is one of organs that is subject to numerous anastomose. For a long time, the method of re-joining two cut-off ends of the intestine has been a subject of growing interest of many surgeons (1-4). Thus, researchers have always attempted to improve gastrointestinal anastomoses. Intestinal anastomosis is one of the oldest surgical procedures (5-6).

Anastomotic devices are utilized in many surgeries such as intestinal obstruction caused by malignancy, traumatic injury of the bowel, antrostomy and congenital abnormality of the small intestine and esophagus. The method that is generally used to perform anastomoses is suturing both ends of anastomosis with absorbable or non-absorbable thread in one or two layers (7).

In some cases, it is difficult to access anastomosis and there are not enough tissues to perform anastomosis, particularly with respect to the anastomoses of pelvic floor and lower end of the esophagus, which are both time consuming and difficult to access, thus requiring new techniques such as stapling which imposes tremendous costs on patients (9, 8).

The prolonged procedure of anastomosis is one of the common problems associated with this surgery, especially when the patient's general condition is critical and surgery should be terminated immediately (10) or several anastomoses are needed. In such cases, a swifter method seems more desirable (10). The difficulty of performing gastrointestinal and non-gastrointestinal anastomoses by laparoscopic and thoracoscopic methods necessitate the employment of alternative methods to facilitate and expedite anastomosis (11).

Since the suture thread was introduced to the medical science, the question has been raised as to whether it is possible to put parts together and facilitate anastomosis without using a thread or using a device with narrower width.

Compression anastomosis is a new technique that has been the subject of growing attention by surgeons and researchers. Several studies have shown that compression anastomosis, compared to stapler and manual suture in the anastomoses, provide more favorable results such as lower costs, higher safety, improve therapeutic effect and reduced time. Magnetic compression anastomosis (Magnamosis) involves magnetic coils that are used in endoscopic surgeries of intraluminal bowel. The acceptance of this surgical technique requires more studies to investigate the effective performance of this method in humans (12).

Regarding the fact that during the last decades, many problems and complications were arisen due to a lot of experiments which had been conducted on some procedures such as surgical operations and using new medications, some comprehensive rules were established in terms of the necessity of carrying out some studies on animal and human before a particular procedure is applied or a new drug is entered the market.

Since in the present study, the magnetic compression anastomosis in the intestine as an alternative option to the traditional sutures could cause some unpredictable complications, and regarding the importance of gastrointestinal anastomosis in children and the necessity of serious attention to its possible complications, the researchers planned to try this technique on animal model, so that they could be able to test it with more certainty on human models through evaluating and comparing the two methods.

In this study, we intend to compare the results of employing magnet coils in anastomosis with the results of conventional suturing.

2- MATERIALS AND METHODS

This study is an experimental animal study in which 60 rats of the same race, age and weight (250-300 mg) were selected. They were kept and fed by an animal laboratory specialist under identical conditions for a week and then randomly assigned to two groups of experiment and control, each containing 30 subjects.

Twelve hours before the surgery, rats were only fed with a liquid diet (10% Dextrose) so that their intestine was mechanically prepared. On the surgery day, the room temperature was 23 to 25 degrees Celsius. The factors that could cause hypothermia in rates such as cold operating table or cold surgery room were removed. Also, a heater was used after the surgery to help rats gain their consciousness and recover quickly.

Anesthesia was inducted in all rats by the injection of ketamine under sterile conditions. The dose of anesthesia was determined based on the anesthesia guidelines for laboratory stipulated in "American College of Laboratory Animal Medicine" and the rates were injected intraperitoneally. Ketamine (100 mg/kg) with xylazine (10 mg/kg) was drawn into a syringe and injected into the base of the tail (where the tail meets the body) after holding and controlling rats by their tails. In this method, anesthesia was achieved about 15 minutes after the injection and lasted for about 30 minutes. In this study, we expected that the automatic breathing of rats continue during the surgery, but four rats developed apnea after the induction and died, which were then replaced with four other rats.

After the induction of anesthesia, the rat's abdomen was shaved and prepared with Betadine solution. Then, after installing the cover, the abdomen was scrubbed with alcohol. Abdominal cavity was opened with a scalpel no. 15 by making a 4-cm vertical midline incision. Surgical procedures in this study were performed by a specific surgical team for all groups to minimize the possible intervention of the humans which could disrupt the study.

In the control group (sutures) both ends of the intestine were anastomosed separately with a typical 5-0 silk suture. Afterwards, peritoneum with 5-0 chromic, fascia with 3-0 chromic and skin with 3-0 nylon were repaired and closed.

In the experiment (magnet) group, two flat annular magnets were used for anastomosis. They were placed at the ends of proximal stump and distal intestine to stay connected. Then, the meso defect of small intestine was repaired by 3-0 Vicryl intestine and after ensuring complete hemostasis, peritoneum with 5-0 Vicryl, fascia with 3-0 nylon and skin with 3-0 nylon were repaired and closed. The used magnet made from boron, iron and neodymium. Magnet size was 6.03× 3.25× 2.34 mm and magnetic strength was 3,000G.

To prevent the rat from chewing the sutures, sodium chloride 10% (Talkhak^{TM}) was poured on the abdominal incision in both experiment and control groups. Surgical procedures in this study were performed by a specific surgical team for all groups to minimize the possible intervention of the humans and thus the potential disturbance of the study. In both groups, the duration of operation was measured in seconds for each rat and recorded separately. After operations, rats were transferred to an incubator (temperature 23 to 25 °C), and then taken to their food cages when they gained their full consciousness. The rats went without food for 12 h until the liquid diet (dextrose 10%) was gradually added and solid foods were included to the diet 24 h after the

surgery. The rats were kept in the same condition after surgery. Each morning, the rats were examined at 7 am and after a 10-day follow-up, laparotomy was performed on the dead rats to determine whether anastomosis was the cause of death.

Ten days after surgery, laparotomy was performed on all rats again, investigating the macroscopic changes in anastomotic site such as tissue leakage, adhesion, stenosis and obstruction. Then, with a 3-cm margin from proximal and its neighboring distal, the anastomotic site was resected and intestinal loop was examined to determine anastomotic bursting pressure. To perform this action the first intestinal loop was cleansed with normal saline solution and stripped of the feces. Then, the proximal loop with 3-0 silk suture was ligated and from the distal side of loop, the 8-French catheter was inserted and fixed with a 3-0 silk suture on the intestine distal loop. The criteria for anastomotic bursting pressure is in fact the maximum amount of normal saline solution injected into the intestinal loop that normal saline leak in the site of anastomosis. The anastomotic bursting pressure is measured in terms of millimeters of mercury (mmHg) and a manometer. After determining the anastomotic burst pressure, a sample of intestine loop with anastomosis is sent for pathological examination. Histologically, the tested variables include the infiltration of inflammatory cells, fibroblast activity, neo-angiogenesis and collagen deposition at the site of anastomosis, which are investigated and graded based on the numerical scale of Ehrlich and Hunt modified by Phillips and his colleagues. (Table.1)(13). Data were analysed using SPSS software version 16 and all observations are reported by descriptive statistics. Also, Fisher's exact test and student t-test for two independent groups were used to test the research hypotheses. P- value less than 0.05 were significant. This research proposal was approved by the Ethics Committee of Mashhad University of Medical Sciences, Iran, ID number: 911231.

Table 1: Graded based on the numerical scale by Ehrlich and Hunt

Characteristics	Scores
No evidence	0
Occasionally finding	1
Light scattering	2
Abundant evidence	3
Confluent cells or fibers	4

4-RESULTS

This study is an experimental animal study in which 60 rats of the same race, age and weight (250-300 mg) were selected. The results showed that the mean duration of anastomosis was 366.0 ± 67.23 seconds for the magnet group and 735±84.90 seconds and for the patients with suture. The results of Fisher's Exact Test about macroscopic changes at the site of anastomotic 10 days after the surgery are shown in (Table.2). As can be seen, there is not any significant difference between the macroscopic changes in the site of anastomosis (tissue leakage, adhesion, stenosis and obstruction) in the two groups. The mean anastomotic bursting pressure was 143.33 ± 4.21 mmHg in the experiment group (Magnet) and 147.53 ± 4.21 mmHg in the control group, indicating no significant difference between the two groups. (p = 0.70). Chi-square test in the pathology tests did not show any significant difference in both groups in terms of inflammatory cell infiltration, fibroblast activity and collagen deposition at the site of anastomosis (Table.3).

Table 2: Comparison of macroscopic changes in both groups of rats

Variables			Obstruction		Adhesion		Tissue leakage		Tenosis	
			Yes	No	Yes	No	Yes	No	Yes	No
Group	Magnet	Number	0	30	0	30	6	24	0	30
		Percent	0	100	0	100	20	80	0	100
	Suture	Number	4	26	3	27	4	26	4	26
		Percent	13.3	86.7	10.0	90.0	13.3	86.7	13.3	86.7
Total		Number	4	56	3	57	10	50	4	56
		Percent	6.7	93.3	5.0	95	16.7	83.3	6.7	93.3
P-value			0.112		0.237		0.731		0.112	

Table 3: Comparison of the pathological results in experiment and control groups according to a defined scale

Pathological results	Ehrlich and Hunt numerical scale	Group		P-value
	0	Suture	Magnet	
Inflammatory cell infiltration	1	0%	8.3%	0.417
	2	0%	0%	
	3	34.6%	29.2%	
	4	50%	54.2%	
	0	15.4%	15.4%	
	1	11.5%	16.7%	
Fibroblast activity	2	53.8%	0%	0.329
	3	19.2%	54.2%	
	4	15.4%	29.2%	
	0	0%	0%	
Collagen deposition	1	3.8%	16.7%	
	2	34.6%	33.3%	0.268
	3	53.8%	50%	
	4	7.7%	0%	
	0	0%	0%	

4-DISCUSSION

According to the above results, in our study, the operation duration in the magnet group was significantly lower than suture group. In almost all similar studies, the duration of operation with magnet is reported to be shorted than suture (14, 15, 16, and 17). Indeed, it is obvious that at least under elective conditions, the duration of operation would be shorter with this technique. Also, in the laparotomy performed 10 days after the first operation, there was no significant difference between the two groups in terms of complications (in all cases P>50.0). In a relatively similar study, Jamshidi et al. compared the results of magnet technique with stapler and suture technique in intestinal anastomosis of a pig. In this study, they investigated mortality rate, stenosis, obstruction, peritonitis, leak, postoperative feeding intolerance and anastomotic bursting pressure, findings that there was not any significant difference between these techniques. The duration of operation and tissue inflammation at the anastomotic model with suture technique was longer than magnet and stapler (16). In another study conducted by Yugani about the use of magnets in anastomosis, the complications of this technique such as adhesion were not significantly different from the

common Methods of surgery, and even were minor than suture, but with respect to the duration of operation, the magnet technique was shorted than suture technique (17). In microscopic examination, the tissue reaction at the anastomosis site was stronger than magnet groups' in terms of the treatment of neo-angiogenesis intestinal tissue and collagen deposition. It is worth noting that with regard to infiltration factor of inflammatory cells and fibroblast activities, there was not any significant difference between the two groups. In other studies on the effect of magnet in the process of tissue repair, it was observed that magnet technique was not significantly different from conventional suture technique. In the study of Jamshidi et al, the integrity indices of serosa, submucosal and mucosal layers have been used to investigate the degree of tissue repair after surgery, although the results were not significantly different from suture and stapler methods (16).

In a study about the use of magnets in gastrojejunostomy and jejunostomy, Pichakron found that anastomotic site was without any leak and the results of anastomotic bursting pressure and histology demonstrated the favorable effect of this method (18). In another similar study, Gonzalez reported the favorable effect of magnet application, stating the positive impact of this technique in terms of anastomotic bursting pressure and histology (19).

Lee compared anastomosis in choledochojejunostomy with Roux-en-Y and choledochojejunostomy with Roux-en –Y using Magnamosis in the animal model. The histologic examination of anastomotic site in both groups was preformed after a month. In the group with manual suture technique, leak, stenosis and severe tissue inflammation were observed whereas in the group with Magnamosis technique, there were not any signs of leak and stenosis and tissue inflammation was insignificant. The collagen deposition in the anastomotic site was regular in Magnamosis technique and irregular in anastomotic site with manual technique. (20)

Our limitation study was burst pressure; if it was too high it could indicate local ischemic that leads to leak and was increased fibrosis of sample of intestine loop with anastomosis was sent for pathological examination. In conclusion, considering the above-mentioned points, the results of this research and the studies of Jamshidi et al and Pichakron et al, it can be stated that magnet technique is an effective method in animal models. However, further studies are still required to propose this method as a safe, convenient, effective and less-aggressive alternative to the conventional anastomosis in humans.

5-CONCLUSION

Given the shorter duration of the anastomosis by magnets and more favorable histological results reported in the above group, as well as the lack of any significant difference in complications of the two techniques, magnetic compressive anastomosis can be used as a new technique for intestinal surgeries and pertaining anastomosis. Although, we recommend that study will be done with large sample size to obtain reliable results.

6- CONFLICT OF INTEREST: None.

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