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Novel anastomotic techniques

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ABSTRACT

Creating a safe and healthy bowel anastomosis remains critical for successful intestinal surgery. The selection of anastomotic technique depends on several factors, including the site of anastomosis, bowel caliber, tissue quality, and underlying disease process, but more importantly individual surgeon experience and personal preference play a major role. Other important key factors to a successful anastomosis are meticulous technique, good blood supply, and tension-free connection. However, despite the "perfect conditions" and technical advances some anastomoses continue to leak resulting in significant morbidity and mortality. Around 4% of all colonic anastomoses and even higher percentage of colorectal anastomoses leak; thus reducing this complication rate would improve mortality and health care costs. Many different techniques of colorectal anastomosis have been described in search for better outcomes and lower leak rates. In this article, I will discuss adjuncts to staplers with an emphasis on the compression anastomotic techniques and newer devices available, the potential advantages of intra-operative endoscopic evaluation of anastomosis, role of fluorescence imaging, and future directions in intestinal anastomotic technology.

Introduction

Colorectal anastomotic leak remains one of the most dreaded postoperative complications in gastrointestinal surgery. Consequently, improvements in current anastomotic techniques and development of alternative methods are essential to improving surgical and patient outcomes.[1,2] Alternatives in creating an intestinal anastomosis include compression anastomotic techniques using compression anastomotic clips, endoluminal compression anastomotic rings, AKA-2, biofragmental anastomotic rings, and shape memory alloy rings. All of the above models use a sutureless end-to-end anastomosis by compressing two bowel ends together. This leads to a necrosis and healing process, which eventually joins the two bowel ends. Reinforcement of the staple line is another new approach that attempts to reduce the shortcomings of staplers, such as leakage, bleeding, and inadequate tissue approximation. Various non-absorbable and absorbable materials are available for this purpose. Other adjuncts to colorectal anastomosis provide support to the suture line. For example, intraluminal tube or stents have been developed to function as an intraluminal diversion similar to that of a diverting stoma. This will not be discussed in this article, as these devices are currently being studied and data is rather limited.

Antibiotic-coated sutures have been also used to prevent postoperative weakness at the anastomotic site that occurs secondary to enzymatic degradation. Clinical and endoscopic evaluation of the anastomosis and objective measurement of the perfusion at the anastomotic site can potentially provide advantages. These anastomotic techniques have been shown to be comparable to the standard techniques; however, they should further be investigated and optimized before potential clinical use.

Compression anastomosis

Basic principles of restoring intestinal continuity still involve the use of sutures or metal titanium staples. With the use of a stapling device, foreign materials penetrate the intestinal wall and cause tissue damage. Sutures or metals penetrating tissues promote a localized inflammatory response and breaking of mucosal barriers that may facilitate bacterial growth within the anastomotic zone and potentially evoke anastomotic-related morbidity. The concept of compression anastomosis was first reported in 1826 by Denan, who conceived a sutureless bowel anastomosis by performing an end-to-end anastomosis using a metallic ring in an animal model. Interestingly enough it was the same year Dr. Lembert introduced an improved technique for suturing the intestine using inverted sutures. This technique ensured the application of serosa to serosa, which is considered one of the foundations for today's gastrointestinal surgery.

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The principle of compression anastomosis consists of two opposing rings trapping the cut ends of the transected bowel with simultaneous necrosis followed by healing process. Eventual sloughing of the trapped bowel releases the rings into the fecal stream. At the end of the 19th century, the concept of compression anastomosis was still evolving, and new devices were developed by Bonnier in 1885 and by Murphy in 1892.[3–6] Murphy's device, which has been referred to as "Murphy's button," consisted of two circular metallic rings scalloped in the shape of a bowl, which were held in place by a purse-string suture on either side of the lumen, inducing necrosis at the site of anastomosis. Murphy's button was extensively used; however, its clinical success was limited. Anastomotic stenosis was a relatively common complication due to either the narrow lumen of the device, or a late stricture.

In the 1980s, the concept of compression device regained momentum. Multiple modified compression devices were introduced including a device with two magnetic rings to join the two bowel ends. Unfortunately, this model demonstrated less than ideal results and subsequently limited clinical success.[7]

Kanshin et al.[8] from Germany developed the AKA-2 anastomotic compression device (Seidel Medipool, Munich, Germany) in 1984 for colorectal surgery. The AKA-2 is a form of compression anastomotic device composed of two rings (Fig. 1), one proximal and one distal ring. The distal ring base includes pins and metal springs. The proximal ring is made of a plastic ring. The AKA-2 applicator is used to inset the rings (Fig. 2). Similar to conventional stapling devices, the applicator is inserted transanally, but instead of staples, the two ends of the bowel are compressed together with the rings and held in place by the metal pins. The lumen is recreated and cut using a circular blade. After 4–6 days, the rings are spontaneously expelled.

Biofragmentable anastomotic ring or BAR (Davis and Geck/ Cyanamid, Danbury, CT) was first introduced by Hardy et al.[9] in 1985. It consists of two identical rings that are made of polyglycolic acid and radiopaque barium sulfate. Contrary to the AKA-2, the BAR ring is bio-absorbable. In 2–3 weeks after the procedure, fragments of the rings are passed with the bowel movements.

More recently, a novel compression anastomosis device, compression anastomosis ring (CAR) (NiTi Medical Technologies) was developed. It was designed using a nickel–titanium, shape memory alloy (SMA). In colorectal surgery, two systems exist using the same shape metal allay in the form of either a clip alloy

Fig. 1. AKA-2 ring. (Courtesy of Seidel Medipool, Munich, Germany.)

Fig. 2. AKA-2 ring and applicator. (Courtesy of Seidel Medipool, Munich, Germany.)

(Compression Anastomosis Clip—CAC™; NiTi Surgical Solutions, Netanya, Israel) or a ring compression device (Compression Anastomosis Ring—ColonRing™; NiTi Surgical Solutions, Netanya, Israel). The SMA permits construction of a low rectal anastomosis during open or laparoscopic procedures. Current data demonstrate safety and efficacy comparable to conventional staple technology.

The ring is composed of a plastic anvil ring, a metal ring, and Nitinol (nickel–titanium) leaf springs (Fig. 3). The compression anastomosis ring is made of the most commonly used shape memory alloy that is highly biocompatible. The SMA returns to its pre-deformed shape under different mechanical and thermal loads. For application purposes, the ring is cooled in sterile ice-water for 5 min below 0°C just before it is applied. The insertion of the anastomosis ring requires one purse-string suture to complete. Following application of the ring, the temperature of the device in the human tissue gradually rises. As the leaf springs return to their original shape, the opening between the rings gradually closes and the compression progresses (Fig. 4). Subsequently the perfusion to the tissue trapped between the two rings is cut off and becomes ischemic and ultimately necrotic. Bowel walls along the outside of the rings, held in close proximity, allow healthy tissue to be generated until both lumens fuse. After about 1 week, the entire ring system is naturally eliminated via stool, including the sloughed tissue. A summary of the main types of compression devices is given in Table 1. The NiTi device also provides the benefit of reduced inflammation at the anastomotic site, because the compression ring results in direct serosa-to-serosa apposition without the persistence of residual foreign material.

The various methods of compression anastomosis have been shown to be at least comparable to the standard techniques of suturing and stapling techniques in regard to postoperative outcomes and complications (Table 2).

Stewart et al. compared the compression anastomotic ring (CAR) with an end-to-end anastomosis (EEA) stapler model in a series of 18 pigs. The model evaluated the strength, size, and biochemical properties of the anastomoses produced by each device and compared rates of development of anastomotic leak and stricture.[15] The aims of this study were to determine whether physical and biochemical characteristics of the formed anastomoses were similar between techniques, as well as to evaluate differences in clinical behavior of the anastomoses in a porcine model. The biochemical evaluation of the anastomoses from each technique showed no difference in collagen or elastin contents at 14-day benchmark. The final circumference of the anastomosis was found to be slightly smaller for the compression anastomosis than the stapled anastomosis (9.52 vs. 11.1 cm) in this porcine model. The strength of the anastomosis was evaluated at early and late (14 days) time points. Interestingly, the authors found that