Chapter

Bowel Anastomoses: Manual or Mechanical

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Abstract

An anastomosis is a connection between two tubular anatomical structures. Anastomoses have been a great surgical challenge from antiquities to modern times. Main research on the manual techniques and healing processes of digestive anastomoses took place during the 19th century. They were later improved by the advent of mechanical devices in the early 20th century. For both types of anastomoses, local and general conditions required for a good healing are the same. Many devices, both for manual and mechanical anastomoses have been developed. The devices' uses depend on their availability, surgeons usual practice and the relative difficulty of the anastomosis. The debate is still lively about the advantages and the potential inconveniences of one technique versus the other in regards to many parameters such as operating time and the incidence of anastomotic leakage.

Keywords: bowel, anastomosis, manual, stapled, outcomes

1. Introduction

Many methods of intestinal anastomoses have been performed since the earliest days of surgery, from the manual anastomoses that were developed in the 19th century to our days where stapled anastomoses are gaining significant popularity. The results of studies comparing the two techniques are still contradictory and cannot prove one's superiority over the other. Our objective in this chapter is to present a brief review of the history of bowel anastomosis, bowel healing process, and comprehensive comparison of hand-sewn and mechanical bowel anastomoses.

2. Historical aspects

Anastomosis is a connection between two solid or hollow structures. Performing a digestive anastomosis has long represented a major challenge in surgical practice, and as early as the 19th century, it was established that the first-line digestive healing required edge-to-edge facing of the walls in a sealed and hemostatic manner. The work of Antoine Lembert in 1826 had established "as a dogma" the need to oppose the serosa by inverting the digestive tunics using needles set with silk thread or catgut [1]. This theory was then questioned few months later by the Belgian Henroz, who proved the feasibility of an anastomosis by eversion using rings [1]. Europe was thus the region of abundant research on digestive anastomoses. In 1887,

Halsted demonstrated the importance of the submucosal layer as the only solid structure that guarantees the watertightness of the assembly [2]. While a large trend was for sutures to be fashioned in two planes (mucosa by overlock and seromuscular at separate points), it is to the brave tenacity of Pierre Jourdan that we owe the possibility of performing the bowel anastomosis in one plane which according to the author "held on very well" [3]. Few years later across the Atlantic, Orr clearly showed in 1969 that continuous overlock suturing in one plane was effective and safe. This message was then confirmed by several other authors [4–6]. Experimental work on the manual techniques continued to develop until the 1980s, focusing both on the type of material to use and on how to deal with the digestive tunics.

Along with the development of manual suturing, mechanical technique was also the subject of much work. In 1892, John Murphy of Chicago developed a two-button cholecysto-jejunal anastomosis technique, which was later extended to other digestive structures [7]. Most of the principles of mechanical stapling were laid down by the Hungarian Hult in 1909: compression of the tissues, form of B-staples, staggered arrangement of staples [8]. Von Petz developed in 1921 a device widely used for gastric stapling, later improved by the Japanese Nakayama [9, 10]. The former USSR contributed to the development of the mechanical stapling devices by the end of World War II. In a very large and war-torn country, it was necessary to develop easy to teach techniques for poorly trained surgeons. The research institute then created linear and circular staplers, efficient but too heavy in steel [11]. In 1958, returning from a study trip to Ukraine, American Mark Ravitch developed the technique in his laboratory in Baltimore, first on the lungs, then extended to other surgeries. He founded a company in order to establish, with his students, an entire successful range of mechanical anastomosis equipment whose main advances were: lighter and more manageable instruments, staggered staples already pre-installed and sterilized allowing several uses with the same forceps. In 1976, the first single-use mechanical stapler was marketed. Numerous technical developments contributed to the progressive improvement in the devices such as articulated grippers, and replacement of the stainless steel of the clips with a biocompatible titanium alloy [12].

3. Anastomosis healing BASIS

The healing of a digestive anastomosis is achieved through tissue regeneration processes that respond to the general laws of inflammation [13]. It does not therefore depend directly on the suturing technique. The digestive gap created will be filled in three successive stages:

1. A loose edematous infiltrate, following the vascular response to trauma: after immediate formation of a platelet nail, secondary vasodilation allows the influx of pro-inflammatory substances (histamine and prostaglandins) and the release of proteolytic substances; A cellular influx occurs in the following hours in the form of polynuclear neutrophils, macrophages then fibroblasts, cells resulting from the interstitial tissue and differentiated locally in order to produce fibrin, key element of the solidity.

2. A cellular granulation tissue then appears towards cicatricial sclerosis allowing restoration ad integrum or with a local scar.

3. Re-epithelialization begins very early (approximately 24 hours) after trauma. The mucous layer and basement membrane thicken at the wound and the

basal cells migrate to the wound, dividing and producing daughter cells. The reconstituted mucous layer is thus thinner at the level of the scar and rests on a fibrinous support frame.

The healing process is then influenced by many factors of two categories; local and general [14]:

- Local factors:
  - *The Parietal breach* is the most dependent on surgical technique. Too much stitch spacing or improper contact creates spaces that are difficult for the granulation tissue to fill.
  - *Alteration of the granulation tissue* depends on many factors such as the extent of the necrosis, the inclusion of foci of mucous membrane and intestinal germs, the foreign body reaction to the sutures or staples.
  - *Infection* modifies the healing phenomena through enzymatic reactions altering the quality of local collagen.
- General factors

Several other factors are often neglected; however, they contribute to the quality of healing. These include the nutritional status, the defensive capacity and hemodynamic status of the patient. A digestive anastomosis should be omitted in the events of hemodynamic failure, significant patient undernutrition, significant inflammation, generalized sepsis, advanced cancer, and emergency interventions for generalized peritonitis, intestinal obstruction, or significant fecal contamination. Likewise, the presence of patient-specific immunosuppressive factors such as chronic smoking, diabetes or long-term corticosteroid therapy may prompt surgeons to either giving up performing an anastomosis, or postponing it, and/or protecting it with a temporary diverting enterostomy. These risk factors are potentially responsible for real changes in the operating strategy and must be communicated to the patient before the procedure.

- Surgical technical factors:
  - The ABSENCE OF ANY TENSION is easily achieved for mobile structures like the small intestine
  - The ANASTOMOTIC EDGES MUST BE WELL VASCULARIZED, both arterially and venously.
  - VALID ENTEROSYNTHESIS PROCESS (MANUAL OR MECHANICAL): the manual anastomosis technique must be of high quality and it is only at this precise point that the surgeon influences the quality of healing. Mechanical stapling pliers must be reliable. Two checks are useful after anastomosis: the quality control of the flanges in case of circular stapling, the airtightness test which seems useful but not essential [15];
  - HEMOSTASE OF ANASTOMOTIC SEGMENTS: Local bleeding can activate proteolytic enzymes and damage local granulation tissue. However, this last point could be in contradiction with the good vascularization of the tissues:

it is therefore necessary to find the right compromise and not to excessively electro-coagulate the digestive walls. Hemostasis with fine threads or bipolar forceps is often very useful for this purpose [15].

4. Types of anastomoses

Digestive anastomoses are designated after the two types of viscera involved (esophagus, stomach, jejunum, ileum, colon, rectum, bile duct), and, on the way in which the stoma mouths are anastomosed. The term "terminal" (T) is used when the entire mouth of the bowel is involved with the anastomosis, and the term "lateral" (L) when the side of the bowel segment and not its mouths is incorporated into the anastomosis. There are thus four types of anastomosis:

- End-to-end (TT) when the two digestive segments are "mouth-to-mouth" anastomosis.
- Terminolateral (TL) when the mouth of the first designated segment is anastomosed on the side of the second designated segment.
- Lateroterminal (LT): the reverse of the previous one.
- Laterolateral (LL) when the two segments are anastomosed side by side, the ends requiring elective closure. This is referred to as a "terminal" LL anastomosis.

Thus, a "terminal colorectal" anastomosis is the opening of the colonic mouth on the anterior or posterior surface of the rectum, while a "lateroterminal colorectal" anastomosis is the connection from the lateral surface of the colon to the rectal mouth.

- Hand-sewn anastomoses

Traditionally, anastomoses were hand-sewn. The two-layer technique generated a certain sense of security in the past but single-layer anastomoses are now preferred because they heal faster. In fact, they allow a more accurate musculo-mucosal realignment and cause less reduction in lumen size and less tissue strangulation than two-layer techniques [16].

Interrupted single-layer serosubmucosal suture is the preferred hand-sewn technique. Interrupted sero-submucosal sutures allow the best tissue apposition and cause minimal damage to the submucosal vascularization.

Continuous single-layer serosubmucosal suture is particularly effective if digestive tract's access is good and the anastomosis is technically simple as in the upper gastrointestinal tract (gastro- jejunostomy and bilio-enteric anastomoses). It is preferred to the interrupted single-layer technique in these cases because it is quicker [16].

Monofilament threads (like polydioxanone) are preferred because they usually cause less fibrosis formation than the braided ones (polyglactin). It has been noted that more inflammation is likely to happen in the braided suture lines. Local edema can lead to increased digestive transit difficulty and colicky pain [17].

- Stapled anastomoses

Three types of suturing devices have been developed: non-cutting linear suturing forceps, cutting linear suturing forceps and circular suturing forceps. However, there

exists a great diversity of materials currently available in the market that are being constant upgraded. Staplers are appealing because they are easy to use and may be quicker than some sutured anastomoses. In situations where anastomosis is difficult (low colorectal) or if multiple anastomoses are required at the end of a lengthy procedure, mechanical devices can be very useful. The anatomy of the stapled intestinal anastomosis is similar to traditional two-layer hand-sewn anastomosis and they require the same attention as hand-sewn anastomoses. Anastomoses can be made with linear or circular stapling devices, used alone or in combination. The choice of a technique (triangulation with a cutting or non-cutting linear forceps, combined use of cutting and non-cutting forceps, use of a circular forceps) is made by the surgeon during the operation. This choice depends on the dimensions of the tissue, in particular their thickness, the diameter of the viscera to be anastomosed and their site (deep or superficial anastomosis in abdominal surgery). The use of mechanical sutures respects the main principles of classical surgery, with its indications, precautions for use and contraindications [18].

- Sutureless anastomoses

They have been in use since Murphy's button in 1892 [19]. Nowadays, sutureless devices include compression magnetic rings, tissue glue, laser-YAG or self-gripping mesh. But most of these techniques remain experimental [20–22].

5. Choice between manual and mechanical anastomoses

The choice of anastomotic technique is between hand-sewn sutures and staples, because sutureless anastomoses remain experimental. The selection of technique is often made on the grounds of personal convenience, cost, and personal experience. Objective evidence has failed to show an outstanding benefit that would favor the use of staples over manual sutures. Most randomized trials comparing a variety of suture techniques with staples did not confirm the advantage of stapled anastomoses in terms of leaks, mortality or cancer recurrence. The increased rate of stapled anastomoses stenosis is well documented. Only few strictures require treatment, usually by dilation or endoluminal incision/resection. Surgeons in training should adopt an anastomotic method that is easily reproductible. Hand-sewn single-layer techniques (continuous or interrupted) should be mastered before relying on stapling devices, allowing the surgeon to take action if technical problems occur with stapling.

Stapled intestinal anastomoses have been widely studied and are preferred over hand-sewn anastomoses because of their safety and efficacy profiles [23–25]. There is evidence suggesting that decreased operative time and anastomotic leak rates may be associated with the use of a stapled technique, in some types of anastomoses such as ileocolic anastomosis [26]. Overall, the evidence that is available has shown no difference between stapled and hand-sewn anastomotic techniques [27–30]. Stapled anastomoses are supposed to take less time, therefore, the operative stress on the patient should be lower leading to faster recovery with lower rate of postoperative ileus and shorter hospital stay as Bragg et al. could show in their study (operating time $p = 0,02$; anastomotic failures $p = 0,03$; hospital days $p < 0,01$) [31]. Jurowich et al., compared stapled versus hand-sewn anastomoses in 4062 patients with right sided hemicolectomy due to right colon cancer, published similar results even though less operating time did not translate into shorter overall hospital stay in that study [31]. The occurrence of post-operative ileus also depends on the extent of the resection, the intraoperative fluid management, the use of minimally-invasive

surgery versus open surgery and many more factors. It is the combination of many of those parameters that contribute to the development of postoperative ileus and therefore a consecutive prolonged hospital stay [31–33].

Higher hospital readmission rate after bowel resection is often associated with anastomotic leakage [34]. Some authors showed a 30-day readmission rate around 10% after hand-sewn colo-rectal surgery, slightly higher than those with stapled anastomoses [35]. Determining the type of anastomosis (stapled or hand-sewn) which may lead to a reduced risk of anastomotic leak is still a matter of debate. On one hand, some authors like Farrah et al., showed a 2-times elevated risk of developing anastomotic leakage after stapled anastomoses compared to hand-sewn anastomoses. Nordholm-Carstens et al. in Denmark, conducted a retrospective cohort study that found 5.4% anastomotic leaks in the stapled versus 2.4% leaks in the hand-sewn group, this was statistically significant ($p = 0.004$) [36]. In contrast, Choy et al., in a Cochrane Database Review, showed a significantly lower anastomotic leakage rate in stapled anastomoses. These conflicting results may be attributed to the different ways of performing the stapled and sutured anastomosis, varying stapling and suture material and varying experience of the surgical team [37–39].

Performing perfect anastomoses is, of course, associated with higher levels of training and experience of the surgeon. It has always been a subject of discussion if and which anastomoses can be safely performed by an intern or surgical trainee. Schineis et al. in Germany provided some evidence that bowel anastomosis can be as safely performed by a surgical trainee as by a more experienced surgeon [40]. Cost is one of the major concerns that may prohibit the use of stapling devices. The impact of the use of stapling devices on hospitals' costs has rarely been explored. Devices cost may differ from hospital to another due to individual contracts negotiated between the individual hospitals and the distributing industries, it also varies between different countries [40].

6. Conclusion

There is a lot of debate around the choice of hand-sewn versus stapled intestinal anastomosis in view of multiple variables such as surgeon's convenience and experience, results concerning hospital length of stay and occurrence of anastomotic leakage. Stapled anastomoses seem to be favored compared to hand-sewn anastomoses in terms of operation time, cost in the operating rooms and total hospital costs in many studies on adult patients. Finally, it is up to the surgeons, in accordance to their usual practice and their individual patients' needs, to choose one technique over the other.

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