World Journal of Gastrointestinal Surgery

Online Submissions: http://www.wjgnet.com/esps/
wjgs@wjgnet.com
doi:10.4240/wjgs.v4.i9.208

World J Gastrointest Surg 2012 September 27; 4(9): 208-213
ISSN 1948-9366 (online)
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EDITORIAL

Bowel anastomoses: The theory, the practice and the evidence base

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Received: August 17, 2011 Revised: September 4, 2012
Accepted: September 17, 2012
Published online: September 27, 2012

Abstract

Since the introduction of stapling instruments in the 1970s various studies have compared the results of sutured and stapled bowel anastomoses. A literature search was performed from 1960 to 2010 and articles relating to small bowel, colonic and colorectal anastomotic techniques were reviewed. References from these articles were also reviewed, and relevant articles obtained. Either a stapled or sutured gastrointestinal tract anastomosis is acceptable in most situations. The available evidence suggests that in the following situations, however, particular anastomotic techniques may result in fewer complications: A stapled side-to-side ileocolic anastomosis is preferable following a right hemicolectomy for cancer. A stapled side-to-side anastomosis is likely also preferable after an ileocolic resection for Crohn's disease. Colorectal anastomoses can be sutured or stapled with similar results, although the incidence of strictures is higher following stapled anastomoses. Following reversal of loop ileostomy there is some evidence to suggest that a stapled side-to-side anastomosis or sutured enterotomy closure (rather than spout resection and sutured anastomosis) results in fewer complications. Non-randomised data has indicated that small bowel anastomoses are best sutured in the trauma patient. This article reviews the theory, practice and evidence base behind the various gastrointestinal anastomoses to help the practising general surgeon make evidence based operative decisions.

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Key words: Bowel; Gastrointestinal; Stapled; Anastomosis; Anastomoses

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Goulder F. Bowel anastomoses: The theory, the practice and the evidence base. *World J Gastrointest Surg* 2012; 4(9): 208-213 Available from: URL: http://www.wjgnet.com/1948-9366/full/v4/i9/208.htm DOI: http://dx.doi.org/10.4240/wjgs.v4.i9.208

INTRODUCTION

Bowel anastomoses are common procedures in both elective and emergency general surgery. The anastomotic technique selected depends upon site of anastomosis, bowel calibre and quality and underlying disease process. One important factor in the decision to perform a particular anastomosis, however, remains individual surgical experience and personal preference.

The theory behind creating a safe, healthy bowel anastomosis remains constant, irrespective of the technique chosen. Unfortunately, however, despite the "perfect patient", healthy bowel and meticulous technique some anastomoses continue to leak resulting in significant morbidity and mortality (e.g., 22% mortality in patients with a leak *vs* 7.2% mortality in those without[1]. Approximately 4% of all anastomoses performed after resection of a colonic tumour (and a higher percentage of colorectal anastomoses) leak - reducing this rate would improve mortality[2].

Since the introduction of stapling instruments in the early 1970s one of the main choices open to the gastrointestinal surgeon is whether to create a sutured or stapled anastomosis. This question has been investigated extensively over the past 40 years with mixed results. In this article trials comparing sutured and stapled bowel anastomoses have been reviewed to provide a summary of the available evidence to help the practising general surgeon with this decision.

MEDLINE and EMBASE were searched using the following terms: (Anastomosis or anastomoses) and (bowel or colon or gastrointestinal or GI) and (sutured or handsewn or stapled). The limits were set to English language, human studies and the dates included were 1960 - March 2010. Abstracts were reviewed and articles comparing anastomotic techniques (including both randomised and non-randomised studies) were obtained. In total, 42 studies were included in this review. Articles relating to any surgical technique other than the actual anastomosis (e.g., splenic flexure mobilisation, defunctioning stomas and pouch formation) were excluded as these topics are beyond the scope of this review.

THEORY

It has been stated that "the key to a successful anastomosis is the accurate union of two viable bowel ends with complete avoidance of tension"[3]. Thus, the most important factors in the creation of a bowel anastomosis are: (1) meticulous technique; (2) good blood supply; and (3) no tension.

In addition various patient and technical factors can influence anastomotic healing as shown in Tables 1 and 2.

PRACTICE

The choice of anastomotic technique may be influenced by the diameter of the bowel ends, oedema, accessibility and site of anastomosis, contamination, available time and equipment and underlying pathology.

Anastomoses can be described as follows: sutured: (1) interrupted or continuous; (2) single or 2-layer; (3) end-to-end or side-to-side (or any combination); (4) various suture materials; (5) extramucosal or full-thickness sutures; and (6) size of and spacing between each suture; and stapled: (1) side-to-side or end-to-end (or any combination); (2) staple lines oversewn, buried or not; and (3) Various stapling devices.

EVIDENCE BASE

Stapling has been compared with suturing in various trials since the introduction of stapling devices in the 1970s. Between 1977 and 1986 several case series and small randomised controlled trials (RCTs) showed no significant difference in anastomotic leak rates, morbidity or mortality between sutured and stapled anastomoses throughout the gastrointestinal tract[8-11].

In 1991 the West of Scotland and Highland Anastomosis Study Group published a large RCT[12]. This study included elective and emergency anastomoses performed anywhere from the oesophagus to the low rectum, with patients randomised to a sutured or stapled technique intra-operatively. One thousand four patients under the care of 13 general surgeons in five hospitals were included. Overall clinical leak rate, morbidity and mortality were not significantly different[12].

It was concluded, following these studies, that both suturing and stapling could be performed safely throughout the gastrointestinal tract[8-12].

More recently, however, numerous studies have investigated the benefits of particular techniques in specific situations, and meta-analyses of RCTs have demonstrated differences not previously detected.

Ileocolic anastomoses

A right hemicolectomy and ileocolic anastomosis is a common procedure in the elective and emergency setting. Case series have suggested that both stapled and sutured anastomoses can be performed with a very low risk of anastomotic leak[13].

A large RCT was published in 1993 regarding elective right hemicolectomy for colonic adenocarcinoma. A statistically significant reduction in intra-operative faecal contamination was observed in the stapled group ($P < 0.02$) in addition to a non-significant trend towards a decreased leak rate (sutured 8.3% *vs* stapled 2.8%)[14].

In 2007 the Cochrane Collaboration published a meta-analysis of RCTs regarding ileocolic anastomoses[15]. Trials comparing stapled side-to-side anastomoses with any suturing technique were included. This produced 955 patients of whom 357 had stapled and 598 had sutured anastomoses. Stapled anastomoses were associated with significantly fewer anastomotic leaks than hand-sewn anastomoses (odds ratio 0.34, $P = 0.02$)[15]. Subgroup analysis revealed the same result in patients operated on for colonic cancer (odds ratio 0.28, $P = 0.01$)[15]. There was no significant difference in other complications, mortality or length of hospital stay[15].

A stapled side-to-side anastomosis is recommended following a right hemicolectomy, particularly if this operation is performed for a colonic adenocarcinoma[15].

Crohns disease

There are several factors to consider in the surgical management of Crohns disease: In addition to anastomotic healing the risk of Crohns recurrence and the need for re-operation must also be considered. This may also be influenced by anastomotic technique[16-20].

Whilst one randomised study showed anastomotic leak rates to be equivalent in the stapled and sutured groups[21], several subsequent randomised and non-randomised studies have shown a reduced risk of anastomotic leak[16,22] and a reduced risk of overall complications[17,19] with a stapled anastomosis. A reduced risk of reoperation or a delayed reoperation rate for recurrent

Table 1 Patient factors affecting anastomotic healing

Positive factors	Negative factors
Good nutritional status[4] - low pre-operative albumen and recent weight loss of over 5 kg are independent risk factors for anastomotic leakage[5,6]	High-dose steroids[4]
Haemodynamic stability[7]	Old age[4]
Healthy bowel ends and microvasculature[7]	Anaemia - haemoglobin < 11g/dL is an independent risk factor for anastomotic leakage[4,6]
	Uraemia[4]
	Diabetes mellitus[4]
	Smoking[5]
	Alcohol abuse[5]
	High risk site of anastomosis (e.g., low colorectal anastomoses)[5]
	Pre-operative radiotherapy - results vary, but some studies have shown an increased anastomotic leak rate following anterior resection after long course radiotherapy[5]
	Male sex in colorectal anastomoses - presumably as the narrow pelvis results in poor visualisation and a more challenging operation[5]

Table 2 Technical factors affecting anastomotic healing

Positive factors	Negative factors
Accurate seromuscular apposition[3,7]	Faecal contamination[5,7]
No distal obstruction[7]	Haematoma formation[5,7]
Closure of the mesenteric window[3,7]	

Crohns following a stapled anastomosis has also been demonstrated in several studies[17-19]. A RCT involving 68 patients with 7 years follow-up showed a statistically significant reduction in reoperation rate in the stapled group (stapled 18%, sutured 49%, $P = 0.022$)[18].

A meta-analysis comparing sutured end-to-end anastomoses with other anastomoic configurations following Crohns resection was published in 2007[23]. Two RCTs and six non-randomised studies were included, giving a total of 661 patients. The leak rate of end-to-end anastomoses was 6.7% compared with 1.2% in the other anastomotic configurations group ($P = 0.02$)[23].

A large multi-centre RCT concerning anastomotic technique in ileocolic Crohn's resection has now been published[24]. One hundred and seventy-one patients were randomised to a sutured end-to-end or stapled side-to-side anastomosis. Anastomotic leak rates were the same (7% sutured, 7% stapled), as were other complications. 139 patients underwent colonoscopy on average 11.9 mo post-operatively, and endoscopic recurrence rates were similar between the two groups (sutured 42.5%, stapled 37.9%). Symptomatic recurrence rates were also similar (sutured 21.9%, stapled 22.7%). Long-term follow-up data is awaited with interest.

The majority of evidence currently favours a stapled side-to-side ileocolic anastomosis in Crohn's disease[16-23] or suggests that suturing and stapling are equivalent[24]. No evidence favours a sutured end-to-end anastomosis.

Colorectal anastomoses

The circular stapled anastomosis in both high and low anterior resections has been extensively studied. Multiple small RCTs and several larger retrospective studies have been published with conflicting results. Some have suggested that the anastomotic leak rates are similar[25-29]; some that stapling is preferable to suturing[30], and vice versa[31]. One large RCT reported that while in experienced hands the anastomotic leak rates were equivalent, when performed by a trainee the sutured anastomosis resulted in a higher leak rate[32]. A further large RCT involving 224 colorectal anastomoses (subgroup analysis of a larger trial including all GI tract anastomoses) reported a statistically significant increase in the radiological leak rate in the sutured colorectal anastomosis group, a trend towards a reduced clinical leak rate in this group, and no difference in the overall leak rate[33,34].

A meta-analysis of RCTs was published in 2001 to clarify these results[35]. Nine trials were included in which 1233 patients were randomised to a sutured or stapled elective colorectal anastomosis. The overall (stapled 13%; sutured 13.4%), radiological (stapled 7.8%; sutured 7.2%) and clinical (stapled 6.3%; sutured 7.1%) leak rates were similar between the two groups. The only statistically significant differences demonstrated were that a stapled anastomosis took less time to perform, and that it resulted in an increased risk of anastomotic strictures (stapled 8%; sutured 2%). No patient had to be re-operated on for this complication[35].

The authors concluded that there was no demonstrable superiority of one technique over the other, regardless of the level of the anastomosis. They advised that the decision regarding whether to perform a stapled or a sutured colorectal anastomosis remains a matter of surgical judgement[35].

Recent studies regarding the stapled colorectal anastomosis have suggested routine mobilisation of the splenic flexure and a stapled colo-pouch or end-to-side anastomosis. Splenic flexure mobilisation allows the better-perfused descending colon to be anastomosed to the rectum and the use of an end-to-side anastomosis or a colo-pouch tends to fill the pelvis, reducing dead space in which a haematoma or collection could develop[5].

Trauma

In 1999, a retrospective study of 84 trauma patients, who underwent 118 gastrointestinal anastomoses in a single United States trauma centre over a four-year period was published[36]. This included 101 small bowel and

Table 3 Levels of evidence

Level 1a	Evidence from meta-analysis of randomised controlled trials
Level 1b	Evidence from at least one randomised controlled trial
Level 2a	Evidence from at least one controlled study without randomisation
Level 2b	Evidence from at least one other type of quasi-experimental study
Level 3	Evidence from non-experimental descriptive studies, such as comparative studies and case-controlled studies
Level 4	Evidence from expert committee reports or opinions or clinical experience of respected authorities, or both

17 large bowel anastomoses, of which 58 were stapled and 60 hand-sewn. The leak rate was significantly higher in the stapled group (stapled 4/58; sutured 0/60; P = 0.037)[36].

Another retrospective study countered this[37], showing that of 144 small bowel anastomoses (110 stapled; 34 sutured) there was no significant difference in anastomotic leak rate or other intra-abdominal complication. It did, however, show that enterotomies which did not require resection were best treated by sutured repair[37].

In 2001 a multi-centre retrospective study (which included patients from the 1999 study) compared the incidence of complications following emergency bowel resection and anastomosis in trauma[38]. Data over a four-year period from five US Level 1 trauma centres was included, producing a total of 199 patients with 289 anastomoses (175 stapled; 114 sutured). The injury severity score and the distribution of small bowel and large bowel anastomoses in the two groups were not significantly different. Results showed an increased leak rate in the stapled group (7/175 stapled; 0/114 sutured; P = 0.04) and an increased risk of intra-abdominal abscess in the stapled group (19/175 stapled; 4/114 sutured; P = 0.04)[38].

A recent study compared stapled with sutured colonic anastomoses following penetrating trauma[39]. This was a prospective, multi-centre non-randomised study including 207 patients. They found no significant difference in anastomotic leak rate or other abdominal complications between the two groups, concluding that sutured and stapled colonic anastomoses are equally valid. These results should be interpreted with caution, however, as the stapled and sutured groups were not well matched: patients who had a sutured anastomosis were significantly more likely to have waited over six hours from time of injury to operation, and patients who had a stapled anastomosis were significantly more likely to have required a massive blood transfusion[39].

The problem with all of these studies is that they are not randomised, so results are subject to bias[36-39]. However this currently remains our best available evidence, and suggests that stapled small bowel anastomoses may be best avoided in trauma[36,38]. The question of the stapled colonic anastomosis remains uncertain.

Reversal of loop ileostomy

Several studies have compared methods of small bowel anastomosis in elective reversal of loop ileostomy. Randomised and non-randomised studies have not previously shown any significant difference in anastomotic leak rate[40-43], however the rate of post-operative bowel obstruction can be affected by anastomotic technique[44,45]. Mobilising the ileostomy spout and closing the enterotomy, rather than resecting the spout and performing an anastomosis can reduce the risk of small bowel obstruction[44], as can performing a stapled side-to-side anastomosis rather than a sutured end-to-end anastomosis[45].

A meta-analysis of six previous studies (two RCTs and four non-randomised studies) including 1965 participants was published in 2008[46]. This showed no statistically significant difference in complications between stapled and sutured anastomoses. There was, however, a non-significant trend favouring stapled anastomoses with regard to lower small bowel obstruction rates, anastomotic leaks and shorter operating times[46].

A large retrospective study has since been published, showing an increased rate of anastomotic leaks in sutured anastomoses following elective reversal of loop ileostomy (stapled 4/203, sutured 9/122, P = 0.039)[6].

Following mobilisation of a loop ileostomy either excision of the spout and a stapled side-to-side anastomosis or mobilisation of the spout and sutured closure of the enterotomy are reasonable options[6,44-46]. Resection and sutured anastomosis is not the preferred technique, although the evidence for this is mainly from retrospective, non-randomised studies[6,44-46].

CONCLUSION

The theory behind a good bowel anastomosis remains consistent, whether a stapled or sutured technique is employed: the bowel ends must have a good blood supply, be under no tension, and be anastomosed with meticulous technique. Either stapled or sutured techniques are suitable in most situations. In recent years, however, evidence has shown particular anastomotic techniques to be advantageous in specific settings - in this article the available literature is reviewed to provide the on-call general surgeon with the information required to make an evidence-based decision regarding anastomotic technique. The strength of this evidence depends upon the type of study used to reach each conclusion (Table 3).

In the case of ileocolic anastomoses following a right hemicolectomy for cancer, level 1a evidence recommends the use of a stapled side-to-side technique. In contrast, level 1a evidence has shown that sutured or endoluminal circular stapled techniques are equally suitable for colorectal anastomoses. There is level 1b evi-

dence suggesting that a stapled side-to-side anastomosis may be advantageous in a Crohns ileocaecal resection, although there is some conflicting data as discussed. In trauma patients level 3 evidence suggests that following a small bowel resection a sutured anastomosis will result in significantly fewer leaks and intra-abdominal abscesses than a stapled technique.

There are many factors which affect healing after bowel anastomosis. Personal experience, patient factors and intra-operative findings need to be considered with the available evidence before the final decision regarding anastomotic technique is made by the operating surgeon.

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