

Bowel Anastomosis in Acute Care Surgery

Brandon Robert Bruns¹

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Abstract

Purpose of Review Acute care surgery encompasses the disciplines of trauma, emergency general surgery, and surgical critical care. Inherent in the disease processes of trauma and emergency general surgery is the potential for profound physiologic and anatomic derangements that make the decision to create an intestinal anastomosis, as well as the technique used, a vital step in having a successful outcome for the patient.

Recent Findings The trauma literature is rife with conflicting data regarding ideal techniques for anastomosis creation. Two series by Brundage and colleagues suggest that handsewn techniques are superior, which was then contradicted by Witzke et al. Vasopressor usage and blood transfusion appear to put the patient at higher risk for anastomotic failure, as does the utilization of damage control techniques. The emergency general surgery literature is similarly contradicting, with one large retrospective study suggesting handsewn techniques to be superior and a subsequent prospective multicenter study suggesting no difference. Damage control patients do appear to have higher anastomotic failure rates, with the noted absence of good data regarding colorectal resections and ideal management strategies.

Summary With the conflicting messages throughout the literature, the acute care surgeon must utilize sound

surgical principles and techniques when deciding to perform an anastomosis and choosing a technique to utilize.

Keywords Bowel anastomosis · Bowel resection · Handsewn surgical techniques · Anastomotic failure · Stoma

Introduction

Bowel resection leaves the operating surgeon with two fairly clear options, perform an anastomosis or divert the intestinal contents to the skin with the creation of a stoma. If chosen, the creation of an anastomosis can technically be performed in a variety of different manners: stapled entirely, handsewn with suture entirely, or a hybrid encompassing both stapled and handsewn techniques. Handsewn techniques can be performed with varying suture types and in single or double-layers. Staplers come in linear and circular, cutting and non-cutting varieties. Additional decisions for the surgeon include the orientation of the bowel: end-to-end, end-to-side, and side-to-side. To further complicate decision making, side-to-side anastomoses can technically be performed in both an iso- and anti-peristaltic manner. Similarly, stoma creation can be performed as an end or diverting ostomy. In short, the surgical act of bowel resection leads to myriad decisions, all of which can lead to potential morbidity and mortality for the patient.

Perhaps the most discussed aspect of bowel anastomosis is whether to perform a stapled or handsewn technique. Proponents of stapled techniques often cite the ease and quickness of performing such a technique. In many operating rooms, the actual firing of the stapler may be performed by a medical student, thus the technical skills

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✉ Brandon Robert Bruns
bbruns@umm.edu

¹ R Adams Cowley Shock Trauma Center, University of Maryland Medical Center, 22 S Greene Street S4D07, Baltimore, MD 21201, USA

required to physically perform such a procedure are not exceedingly advanced. Proponents of the handsewn technique cite the fact that staplers are rigid instruments with fixed staple height; therefore, the nuanced and precise placement that can occur with handsewn anastomoses are not possible with stapled. Many believe sutured techniques to be superior, especially in the face of edematous bowel, given the above reason. An additional argument for handsewn techniques comes from a training perspective in that if trainees are not taught to properly suture and handsew a bowel anastomosis, they will be unable to perform a sound handsewn technique when it is mandated.

The field of Acute Care Surgery (ACS) encompasses trauma, emergency general surgery, and surgical critical care. Thus, inherent in the job description, acute care surgeons are likely to perform bowel resection and anastomosis in the urgent or emergent setting, which has the potential to further complicate intraoperative decision making. ACS is a unique specialty, because the onset of illness is completely unexpected, thus the preoperative workup and assessment are abbreviated and often incomplete. For example, it is unlikely that a 70-year-old female cigarette smoker with daily unstable angina, who presents to the Emergency Department with mesenteric ischemia and small bowel necrosis, underwent preoperative smoking cessation classes, preoperative conditioning with a walking regimen, and risk-stratification for her cardiac disease. Similarly, the 20-year-old hypotensive male who was shot in the abdomen and has perforation of his descending colon along with a shattered left kidney, did not have the time to adequately complete a mechanical and oral antibiotic bowel preparation prior to his operation. These examples, though fairly extreme, tend to be the “typical” presentation for ACS patients. The clinical presentations of ACS pathologies are often associated with excessive blood loss, bowel wall edema, non-modifiable risk factors (smoking, obesity, steroids), intraoperative hypothermia, and occasional implementation of damage control techniques, which makes bowel anastomosis in ACS a particularly stimulating and challenging topic. The purpose of this paper is to review the relevant literature as it relates to trauma and EGS bowel anastomoses with the hopes of enabling well-informed intraoperative decision making for the operating surgeon.

General Surgery Data

Most of the historic data on bowel anastomosis came well before the formal definition of ACS in 2005 [1]; thus, translation of anastomotic failure rates and anastomotic techniques to emergency general surgery and trauma

patients is questionable, as the patient populations in these studies typically included elective bowel resection patients. The available data in general surgery are contradictory and inconclusive and for these reasons, The Cochrane Collaboration has performed multiple systematic reviews of randomized controlled trials in an effort to draw more meaningful conclusions. In one such effort, Choy et al. examined patients with cancer and inflammatory bowel disease undergoing ileocolic anastomoses (elective and emergent) and found that stapled techniques resulted in fewer anastomotic leaks as compared to handsewn [2]. In another systematic review, colorectal anastomoses were evaluated in a 2012 Cochrane Review; however, unlike the previous work, the evidence was not conclusive enough to favor stapled or handsewn techniques; however, the authors did call for new trials in “risk situations, such as emergency surgery, trauma and inflammatory bowel disease.” [3].

A single-center study published in 2013 aimed to identify risk factors for anastomotic failure in a large cohort of patients undergoing resection and anastomosis. Trauma patients and patients undergoing diverting stomas were excluded from analysis. The study assessed 682 patients and found the following factors to be associated with anastomotic leak on bivariate analysis: perioperative blood transfusion, pulmonary disease, the presence of surgical drains, tension on the anastomosis, the presence of acute intra-abdominal infection, location of anastomosis, and malnutrition. On multivariable logistic regression, only anastomotic tension (odds ratio [OR] 10.1, 95% confidence interval [CI] 1.4–75.9), drains (OR 8.9, CI 4.4–18.4), and blood transfusion (OR 4.2, CI 1.4–12.3) were still associated with failure of the anastomosis [4]. With the exclusion of trauma patients from the analysis, along with an otherwise very heterogeneous patient population, translating these results to the ACS population is less-than-ideal.

More recently, Pinkney et al. performed a multicenter study on behalf of the 2015 European Society of Coloproctology collaborating group. The aim of the study was to evaluate patients undergoing right hemicolectomy or ileocecal resections in either an elective or emergent setting, with the specific question being whether stapled or handsewn techniques were superior. The study enrolled over 3000 patients, 2/3 whom underwent surgery for cancer. They found an overall leak rate of 8.1%, with stapled techniques being associated with more failures than handsewn [5]. Again, the heterogeneous nature of the population, along with the very specific anatomic inclusion criteria for resection, makes the translatability of this study to ACS questionable.

Trauma Patients

In an effort to address many of the above concerns regarding translatability of heterogeneous cohorts to trauma patients, investigators focused specifically on the traumatically injured patient population. In 1999, Brundage and colleagues at The University of Washington performed a retrospective analysis of 118 anastomoses in 84 patients. They reported a 7% anastomotic failure rate in the stapled cohort compared to a 0% failure rate in the handsewn group, thus concluding that handsewn techniques were superior. The study included blunt and penetrating mechanisms, as well as small bowel (101) and colon (17) anastomoses [6].

Brundage followed her single-center study with a larger multicenter trial sponsored by the Western Trauma Association that retrospectively examined 289 anastomoses in 199 patients over a 4-year period. Stapled techniques were utilized in 175 (61%) anastomoses and sutured in 114 (39%). Anastomotic complications occurred in 17% of the stapled and 5% of the handsewn anastomoses. Again, small bowel and colon anastomoses were grouped together and the authors concluded that “anastomotic leaks and intra-abdominal abscesses appear to be more likely with stapled bowel repairs compared with sutured anastomoses in the injured patient.” Interestingly, when examining anastomotic complications in relationship to location in the gastrointestinal tract, small bowel anastomoses has a 9% complication rate, colon anastomoses 27%, and combined small bowel and colon anastomoses 28%. Patients that underwent colostomy were not accounted for in this study [7•].

In response to the works by Brundage et al., a 12-year retrospective study was undertaken at Hennepin County Medical Center in Minneapolis, Minnesota. Investigators specifically questioned grouping all gastrointestinal resections together, and instead focused their study on small bowel injuries. Investigators identified 144 anastomoses of which 34 were handsewn and 110 were stapled. In contrast to the findings of Brundage and colleagues, Witzke et al. found equivalent complication rates between the two techniques (17% intra-abdominal complication rate for stapled versus 21% for handsewn) [8]. Thus, similar to the general surgical data, confusion exists as to the superior technique, with conflicting data supporting both techniques.

The above studies were promptly followed by a 2002 effort sponsored by the American Association for the Surgery of Trauma (AAST) that had the specific aim of prospectively evaluating penetrating colonic injuries and type of anastomosis. This multicenter trial involved 19 centers and 207 eligible cases (an additional 100 cases

were managed with diversion). The overall rate of abdominal sepsis was 22.7%, with an anastomotic failure rate of 6.3% for stapled and 7.8% for handsewn. After multivariable logistic regression, only three risk factors were associated with abdominal complications: packed red blood cell transfusion (PRBC) of greater than six-units, antibiotic prophylaxis with a single-agent, and “severe fecal contamination” [9]. A separate analysis of the same data included those patients managed with fecal diversion and found no mortalities in the colon anastomosis cohort, compared with four in those having fecal diversion. Complications related to the colon were also similar between diversion (27%) and anastomosis (22%). The authors concluded that fecal diversion did not decrease the incidence of abdominal complications and thus, “primary anastomosis should be considered in all such patients.” [10] However, in a 2013 report by Fischer et al. that included 103 patients undergoing colonic resection for trauma, the authors found a 6% mortality rate in the anastomosis group versus a 0% mortality rate in those undergoing stoma creation [11]. Though not statistically significant, the clinical significance should not be minimized, and careful consideration should be utilized before rushing into anastomosis creation.

Review of the literature can reasonably lead one to conclude that the two techniques (stapled and handsewn) are likely similar as it relates to anastomotic failure. Thus, the most important determinants of a good outcome after bowel anastomosis may simply be adherence to sound surgical techniques such as avoiding tension, ensuring healthy bleeding edges of bowel, meticulous and precise handling of tissues, covering the anastomosis with omentum or placing the anastomosis in the deep recesses of the peritoneal cavity, ensuring the patency of a completed anastomosis, and avoiding any twisting of the anastomosis or mesentery. Severe fecal contamination and the transfusion of multiple units of blood products should cause the operating surgeon to pause and carefully consider the options, as these factors may contribute to anastomotic failure. In short, it is best for the operating surgeon to be aware of all the data and then utilize that information to make the best possible decision for the patient that lies on the table.

Trauma Surgery Damage Control

Since Rotondo et al. coined the term “damage control,” a technique used for the exsanguinating trauma patient with ongoing hypothermia, coagulopathy, and acidosis in 1993 [12], the technique has gained widespread acceptance and when used in the proper setting, undoubtedly saves lives. The technique continues to be widely employed with a

recent retrospective study illustrating utilization of damage control techniques in 38% of 1706 emergent trauma laparotomies [13]. As the initial operation typically involves an abbreviated laparotomy with cessation of hemorrhage and control of enteric spillage, followed by rewarming and ongoing resuscitation with correction of coagulopathy in the intensive care unit, there is much variability in the approach to intestinal injury and anastomosis. Much of this comes from the simple fact that there are multiple opportunities to create an anastomosis, versus leaving the intestine in discontinuity. Managing patients in the extremes of physiologic compromise with concomitant intestinal injury invariably brings up the question of whether or not to perform a bowel anastomosis or create a stoma, in addition to determining the optimal timing.

Inherent in patients undergoing damage control techniques for trauma is the high likelihood of ongoing systemic hypotension. In addition to resuscitative blood products which have been shown to increase failure of anastomoses [4, 11], treatment may include vasopressor agents, which are also implicated in anastomotic failure. To better examine this concern, Fischer et al. performed an analysis of 171 patients undergoing colon resection for trauma, with 68 patients managed with damage control techniques over a 9-year period. Damage control patients underwent anastomosis 60% of the time and had a 17% leak rate, compared to 6% for non-damage control patients. Anastomotic failure was four-times as high in patients that were maintained on vasopressors after the first damage control operation. The authors concluded that diversion should be liberally utilized in patients requiring vasopressor support for blood pressure elevation [11].

Likely because colonic anastomotic failure is more common than that of small bowel, as well as the fact that a mid-small-bowel diversion is clinically unwise, much of the research surrounding damage control surgery for trauma focuses on colonic injuries and their management. Miller et al. published a 2007 6-year retrospective study of 55 destructive colon injuries, 50% of whom underwent damage control surgery ($n = 22$). Of the 22 patients with open abdomens, 11 had delayed anastomoses, six had fecal diversion, two had anastomosis at the index operation, and three died before takeback. Comparing the 11 delayed anastomoses to the 21 anastomoses that were performed in patients not undergoing damage control, they found no leaks in the damage control delayed anastomoses, versus one in the 21 non-damage control patients. Dr. Miller and his colleagues concluded that it was safe for patients undergoing damage control surgery for traumatic mechanisms to have creation of delayed colonic anastomoses [14].

Ordoñez and colleagues performed a similar analysis of patients with penetrating colonic injuries. In their series, 27

patients underwent damage control laparotomy and three of those were subsequently diverted because it was “technically impossible to restore the normal enteric transit.” Twenty-four patients then underwent delayed colonic anastomosis, with two patients developing anastomotic failure and one of those patients dying. The authors cite a success rate of 81.4% for delayed anastomoses and conclude that performing a delayed anastomosis is safe, with comparable complication rates to those undergoing single-stage anastomosis [15].

In 2011, Ott and colleagues at Vanderbilt examined 174 colectomies for trauma, with 45% of those patients undergoing damage control techniques. Colostomy was created in 44% of those undergoing damage control surgery, with the remaining 56% having an anastomosis performed, of which 27% leaked. Of the 44 anastomoses performed, 89% were performed in a delayed fashion, and the number of days the patient was left with an open abdomen did not appear to influence failure rates. The authors concluded that fecal diversion in damage control surgery should “be routinely performed” [16].

Given conflicting data and the overwhelmingly heterogeneous presentation of complicated trauma patients with colonic injuries, this author believes it impossible to recommend a single strategy for bowel anastomosis in the damage control trauma patient. As studies have shown, the cost of believing it is safe to perform a colonic anastomosis and subsequently being proven wrong when the patient develops a leak, can lead to significant morbidity and even death. Though the morbidity of performing an end colostomy reversal after fecal diversion for trauma is high and the social and financial impact on the stoma patient can be great, the very fact that the patient is alive to have such concerns should be considered a victory. It is imperative that the operating surgeon consider the patient’s comorbidities and overall trauma burden, as well as signs of ongoing shock such as blood transfusions and vasopressor usage, in making the difficult decision of whether or not to perform a colonic anastomosis.

Emergency General Surgery Patients

As one of the pillars of acute care surgery, emergency general surgery and its patients are unique in many facets. Patients undergoing bowel resection for emergent general surgical pathologies tend to be older than the standard trauma patient and often have multiple medical comorbidities. These comorbid conditions and altered physiologies often put the patient at increased risk for anastomotic failure. Additionally, the presence of these pre-existing conditions make dealing with the sequelae of anastomotic failure that much more difficult, as the physiologic reserve

may be limited. For these reasons, it is important to examine this patient population separate from the trauma patient and avoid the mistake of treating the emergency general surgery patient as one would a trauma victim.

In 2013, Farrah and colleagues at Wake Forest Baptist Medical Center in Winston-Salem, published their 4-year retrospective experience with an EGS-specific patient population undergoing bowel resection and anastomosis. They identified 231 patients that underwent 233 anastomoses (100 handsewn and 133 stapled). The most common indication for surgical intervention was small bowel obstruction, average age was 58.9 years, overall mortality was 3.9%, and an 11.1% rate of anastomotic failure was present in the study population. Comparing handsewn and stapled techniques, investigators found a significantly higher anastomotic failure rate for stapled (15%) techniques versus those anastomoses that were handsewn (6.1%). Operative times were also significantly shorter in the stapled group when compared to handsewn. After multivariable logistic regression, the three variables associated with anastomotic failure were: stapled anastomotic techniques (OR 2.65, CI 1.08–6.50), age (OR 1.051, CI 1.043–1.059), and admission albumin (OR 0.437, CI 0.244–0.784) [17••]. With the only modifiable risk factor of the three being technique, the authors suggested that handsewn techniques were superior in the emergency general surgery setting.

With Farrah's study as the backdrop, the stapled versus hand-sewn: a prospective emergency surgery study (SHAPES) was initiated in July 2013, with results published in 2017. Sponsored by the AAST, this was a multi-institutional effort encompassing 15 geographically diverse medical centers across the United States. Over the 2.5-year study period, 595 patients underwent 649 anastomoses in an urgent/emergent fashion for EGS-specific pathologies. The most common pathology was small bowel obstruction at 23.3%, median age was 62 years, overall mortality 7.7%, and an overall anastomotic failure rate of 12.5%. Interestingly, this is the first study, to the author's knowledge, to show there was no difference in operating times between handsewn and stapled techniques [18•].

In comparing the two different anastomotic techniques, handsewn failure rate was 15.4% compared to 10.6% for stapled ($p = 0.07$). Patients who underwent handsewn techniques had longer hospital lengths of stay (14 vs. 10 days), more intensive care unit days (5 vs. 0 days), and a higher mortality (14.2 vs. 5.1%) than patients undergoing stapled anastomoses. Additionally, patients undergoing handsewn anastomoses had lower preoperative hemoglobin levels, higher International Normalized Ratios (INRs), higher lactate levels, lower albumins, and worse renal function compared to stapled anastomoses. Thus, though the handsewn techniques appeared to be performed in

patients that were more ill, the anastomotic failure rates were statistically equivalent before statistical adjustment. After multivariable logistic regression, the factors associated with anastomotic failure were initial contamination (OR 1.965, CI 1.183–3.265) and being managed with an open abdomen (OR 2.529, CI 1.492–4.286). Stapled versus handsewn technique was not associated with failure of the anastomosis (OR 0.919 CI 0.554–1.526) [18•].

Small bowel to small anastomoses had an 12% overall anastomotic failure rate and small bowel to large bowel had an 11% overall anastomotic failure rate. When looking at large bowel to large bowel, the anastomotic failure rate was 23% [18•]. Though not statistically significant, it is this author's opinion that this 23% failure rate should give the operating surgeon pause before proceeding with an anastomosis between two colonic segments. These results are somewhat difficult to interpret, as patients that had a fecal diversion were not part of this study, thus the true number of patients undergoing colonic resection is likely underestimated. Further evaluation of colonic resection and the ideal management strategy (anastomosis versus diversion) in the emergency general surgery patients should be undertaken.

Emergency General Surgery Damage Control

The concept of damage control surgery has been adopted by acute care surgeons managing emergency general surgical conditions. Indications may include the desire to have a second look at bowel to ensure viability, abdominal compartment syndrome, excessive contamination, or the lethal triad (hypothermia, coagulopathy, acidosis). Patients that are left open are physiologically more deranged than those that are primary closed, with a 6-month mortality of 36% and over 2/3 of patients requiring post-discharge medical care [19]. Additionally, leaving the abdominal fascia likely predisposes to increased edema and friability of the bowel; therefore, these patients are again examined separately from the standard emergency general surgery patient.

In Farrah's series, 18% of patients underwent damage control techniques [17••] versus 28% of patients managed with an open abdomen in the SHAPES cohort [18•]. In both series, the anastomotic failure rate was significantly higher in patients managed with an open abdomen versus those that were closed at the index operation [17••, 18•]. The Farrah study had 81 patients left in discontinuity at the index operation, with equivalent anastomotic failure rates whether the anastomosis was performed at the index operation or at a subsequent operation [17••]. The overall open abdomen anastomotic failure rate in the SHAPES cohort was 21.9%, with no statistical difference between

Table 1 Open abdomen in emergency general surgery outcomes

| | Farrah et al. | Bruns et al. |
|-------------------------------------|---------------|---------------|
| Patients | 41/233 (18%) | 165/595 (28%) |
| Lactate | 4.3 mmol/L | 2.2 mmol/L |
| Discontinuity after index operation | 81% | 73% |
| Anastomotic failure | 24% | 22% |
| Mortality | NR | 18.2% |

NR not reported

handsewn (25.2%) and stapled (17.5%). Similar to Farrah's work, most anastomoses in SHAPES open abdomen patients were created in a delayed fashion (Table 1), with no difference in failure rates between those created at index operation leading to open abdomen and those created at subsequent operations [18•].

Though neither study was adequately powered to address EGS patients managed with an open abdomen, we do know that this is an increasingly utilized technique in the physiologically deranged patient or if a "second-look" approach to bowel viability is chosen [19, 20]. Based on available data, it does appear that a delayed approach to anastomosis in EGS patients managed with an open abdomen is equivalent to the creation of an anastomosis at index operations leading to open abdomen; however, it is also clear that more anastomotic failures can be expected in patients managed with an open abdomen. At this time, the numbers are too small to definitively support handsewn versus stapled techniques, though it is likely that bowel edema and increased bowel friability will be present in the open abdomen, a situation which many think warrants handsewn anastomotic techniques.

Given the previously discussed 23% colo-colonic anastomotic failure rate in the SHAPES study, this author is typically reticent to perform a large bowel to large bowel anastomosis in an emergency general surgery patient managed with an open abdomen. As these patients are older and likely have less physiologic reserve than the prototypical trauma patient, the better part of valor may be to perform a colostomy, with the plans of returning to "fight another day"; however, quality data are lacking in this area.

Conclusion

Despite research efforts to study the issue of bowel anastomosis in ACS, no clear message has emerged to guide intraoperative decision making. ACS patients undergoing urgent/emergent operative therapy are more likely to receive multiple blood transfusions, be increasingly

hypothermic, have systemic malperfusion, and have increased bowel wall edema and friability. For these reasons, the simple decision to create an anastomosis must be carefully deliberated. Additionally, the timing of that anastomosis in a patient managed with an open abdomen must be made with consideration of the patient's physiology and ongoing metabolic derangements. Regarding the technical aspects of the anastomosis creation, conceptually, the idea of precise placement of a needle through the bowel wall and the ability to adapt to changes in caliber of the intestine is attractive; however, it does not appear that this has been borne out in the data. Without a randomized controlled trial, which inherently removes surgeon judgment from the equation and is thus unlikely to be successful, it is unlikely that we will ever have an evidence-based answer. From a training perspective, one thing is for sure, if surgical trainees are not taught handsewn anastomotic techniques during training, they will be beholden to the stapler for the entirety of their career.

ACS patients pose unique challenges and the acute care surgeon must be able to synthesize the entire complexity of the clinical scenario when making decisions related to bowel anastomosis. Meticulous attention to surgical techniques and sound decision making, with close attention to detail in the postoperative period, are essential to a successful anastomotic outcome.

Compliance with Ethics Guidelines

Conflict of interest The authors declare no conflicts of interest relevant to this manuscript.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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