Complications of Colorectal Anastomoses
Leaks, Strictures, and Bleeding

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KEYWORDS
\begin{itemize}
\item Anastomotic leak
\item Air leak test
\item Anastomosis
\item Stoma
\item Stricture
\item Bleeding
\end{itemize}

KEY POINTS
\begin{itemize}
\item Risk factors for anastomotic failure are categorized as surgeon-related, patient-related, and disease-related.
\item Understanding the myriad of risk factors and the strength of the data helps guide a surgeon as to the safety of undertaking an operation in which a primary anastomosis is to be considered.
\item In the absence of abandoning the goal of reuniting the cut ends of the bowel, a surgeon may choose to mitigate the risk of a leak by performing a proximal diverting stoma.
\item Whether this risk can be modified by the use of adjuncts such as pelvic drains, omental wrapping, or tissue reinforcement remains unclear; however, the performance of a simple intraoperative air leak test allows a surgeon to assess if the anastomotic integrity has been compromised.
\item Familiarity with the various approaches to stricture and bleeding at the anastomosis aids in optimizing patient outcomes with the least amount of morbidity should complications occur.
\end{itemize}

INTRODUCTION

In 1887, William Halsted wrote: “The death-rate attending enterorrhaphy has been large, and, in general, the operation, even in the hands of the most skillful surgeons, has been capricious in its results.”\textsuperscript{1} Although the modern surgeon enjoys considerably more success in the performance of an intestinal anastomosis compared with one belonging to a century ago, the results have never been perfect. Unreported studies have attempted to define the characteristics of the perfect anastomosis. Although the technique has largely been standardized and the importance of the anatomy elucidated, there remains an ever-present risk of failure with significant consequences to

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the patient. Death from intestinal resections was commonplace until the middle of the twentieth century when improvements in antisepsis and anesthetic techniques and the introduction of systemic antibiotic therapy all contributed to improved outcomes. While Halsted was demonstrating the importance of the correct placement of sutures in the intestinal wall, others were attempting to improve outcomes by purging the intestine of its fecal load, a variable thought to be directly responsible for the disruption of the intestinal anastomosis. The introduction of oral antibiotics and later systemic antimicrobials also had a significant effect on the outcomes of surgery for large- and small-bowel resections. The final major advance came with the introduction of the mechanical stapler, heralding the modern era of intestinal anastomosis. Much of the dogma surrounding the performance of an anastomosis was subsequently challenged, leading to the modification or abandonment of many of these techniques in twenty-first–century operating rooms.

The integrity of any anastomosis results from a complex interaction between the surgeon, the patient, and the disease process (Table 1). The surgeon is foremost responsible to ensure the execution of a technically perfect anastomosis. In addition, there are a host of preoperative and intraoperative decisions that come to bear that are ultimately the responsibility of the surgeon and, in the end, can mean the difference between success and failure.

**SURGEON FACTORS**

Surgeons learn from the beginning that the fundamental principles of a successful anastomosis entails anastomosing 2 ends of healthy bowel that have an adequate blood supply and lack any tension after union. Although these principles seem so rudimentary, reference to their criticality is difficult to find in the surgical literature.

**Perfusion**

Newer technologies have helped shed light on the effect of tissue ischemia on anastomotic integrity both in human and animal models. One such study by Myers and colleagues describes the use of a tissue oxygen saturation (TSaO₂) probe to assess the TSaO₂ on either side of the large bowel and small bowel transected using staplers of various staple heights. The study used an adult swine model and demonstrated a significant reduction in mucosal TSaO₂ both at and 2 cm from the staple line. However, the serosa showed no such changes. These changes were independent of the staple line height, which did not seem to have an appreciable effect on tissue perfusion. In another study, the oxygen tension (PSO₂) on either side of an intestinal anastomosis was measured on dogs and compared with baseline measurements.

When the PSO₂ decreased to less than 30% of the baseline, anastomotic necrosis

<table>
<thead>
<tr>
<th>Surgeon Factors</th>
<th>Patient Factors</th>
<th>Disease Factors</th>
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<tbody>
<tr>
<td>Intestinal blood supply</td>
<td>Body mass index</td>
<td>Inflammatory bowel disease</td>
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<td>Tension on the anastomosis</td>
<td>Anesthesia severity assessment</td>
<td>Metastatic carcinoma</td>
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<td>Perioperative hypoxia</td>
<td>Age</td>
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<td>Smoking</td>
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<td>Intraoperative blood loss</td>
<td>Nutritional status</td>
<td>Emergent surgery/peritonitis</td>
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<td>Operative times</td>
<td>Alcohol use</td>
<td>Steroids</td>
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<tr>
<td></td>
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<td>Infraperitoneal location</td>
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</table>
occurred within 48 hours. In another study, rats that underwent large-bowel resection and immediate anastomosis were kept in either a hypoxic or a normoxic environment for 7 days. Animals maintained in the hypoxic environment had a considerably lower anastomotic burst pressure when compared with normoxic controls. Sheridan and colleagues examined the influence of serosal oxygen tension in a human trial using an electrode on either side of a colonic anastomosis. The tissue oxygen tension (ptO₂) on the proximal and distal sides was measured before any vascular ligation or mobilization of the colon. These results were then compared with measurements taken at the same location after the anastomosis. Fifty consecutive patients were assessed (28 anterior resections, 10 sigmoid resections, 5 left hemicolecotomies, and 7 right hemicolecotomies). The investigators reported 10 clinical leaks, with ptO₂ significantly lower perianastomotically in subjects with a leak (less than 20 mm Hg) when compared with those whose anastomosis was intact. Indirect evidence of the importance of the anastomotic blood supply comes from Zakrison and colleagues who looked at the anastomotic leak rates in 223 patients admitted to an intensive care unit after 259 gastrointestinal anastomoses. They reported an overall leak rate of 9.9%; finding that the need for vasopressors in the immediate postoperative setting was associated with a higher leak rate (odds ratio [OR], 3.25; \( P = .02 \)). Milan and colleagues demonstrated that the colonic mucosal pH was the only predictor of success after left-sided resections in 90 consecutive patients. The leak rate was 22 times higher in patients with a mucosal pH less than 7.28 (a marker of anaerobic metabolism). Vignali and associates used laser Doppler flowmetry to assess the rectal stump microperfusion in 55 consecutive patients who underwent rectal resections. Measurements were taken at baseline and after vascular pedicle ligation and transection of the bowel. Anastomotic leaks occurred in 14.5% of patients, with a linear correlation between decrease in rectal stump microperfusion and leak. Flow reduction was 6.2% in patients with no evidence of a leak and 16% in those with a leak (\( P < .001 \)). These studies validate the timeless concept of the need for adequate blood supply to ensure the integrity of the colonic anastomosis, but there is no practical way to apply these techniques reproducibly in every operating room. This application may eventually be easier as new technologies find their way into operating rooms, allowing surgeons to easily and immediately assess the perfusion of tissue before performing intestinal anastomoses. Intraoperative fluorescence vascular angiography is one such tool that has been used in reconstructive and cardiac surgeries and has been shown to be effective in decreasing leak rates in colorectal anastomoses. There is no reliable clinical indicator of adequate perfusion, and surgeons are often left to rely solely on their judgment to assess the patency of the blood supply. Although the color of the mucosa is not always a reliable indicator, the absence of mucosal bleeding at the point of transection should raise concerns about its adequacy. In general, there should be no doubt about the blood supply of a right colon anastomosis, as the mesentery of the small bowel is rarely limiting in terms of reach as long as great care is taken not to undermine the transection site when dividing the mesentery. This situation is also true of the transverse colon, assuming a patent marginal blood supply, which is assessed by demonstrating pulsatile blood flow after transecting the mesentery just before ligation. Should the mesentery fail to bleed, an alternate site of transection should be considered. For an anastomosis of the colon to the rectum the length of the mesentery can be restrictive. In an effort to ensure a tension-free union of the bowel, the inferior mesenteric artery (IMA) may have to be ligated along with the inferior mesenteric vein, which can be doubly ligated just distal to the duodenum if more length is needed. If a cancer resection is being performed, it may be desirable to ligate the IMA at its origin irrespective of reach to ensure
an adequate nodal harvest. There is some controversy regarding the necessity of ligating the IMA flush to the aorta (high tie) when compared with preservation of the left colic branch (low tie). The oncological necessity of a high tie is predisposed on the fact that lymph nodes at the origin of the IMA can harbor malignant cells and recurrences following low tie are more frequent.\textsuperscript{10} The impact of the high tie may be more important for advanced carcinomas,\textsuperscript{11} and the effect of radiation may mitigate this benefit further. These benefits of a high tie have not been uniformly seen, and there is ongoing controversy about the oncological benefits of this technique.\textsuperscript{12} The significance of the high tie as it pertains to the anastomotic leak rate is based on the blood supply to the conduit. If the descending colon or transverse colon is to be used as the proximal anastomosis, the impact of the high tie is mitigated, as there seems to be an adequate marginal blood supply to maintain tissue oxygen concentration in these patients. However, this may not be true with the sigmoid colon as the marginal blood supply off of the middle colic may not be adequate to perfuse such a long conduit.\textsuperscript{13,14} If it is necessary to use the sigmoid colon as part of the colorectal or coloanal anastomosis then the left colic artery should be preserved.\textsuperscript{15,16} An alternate hypothesis was proposed by Hall and colleagues\textsuperscript{17} who measured the \textit{ptO}\textsubscript{2} of the left colon before and after ligation of the IMA in 62 patients who underwent anterior resection. Baseline data demonstrated that the \textit{ptO}\textsubscript{2} varied significantly between the sigmoid, the descending, and the transverse colon. After the IMA was ligated, the \textit{ptO}\textsubscript{2} was significantly reduced in the sigmoid colon when compared with the left or transverse colon. This difference was observed irrespective of a high tie (proximal to the left colic artery takeoff) or low tie (distal to the left colic artery takeoff). These data suggest that it is the site of transection and not the site of arterial ligation that affects the integrity of the anastomotic blood supply. Although there is conflicting data if the IMA is to be ligated at any level, the surgeon should likely consider resecting the entire sigmoid colon. The toughest cases are those in which a patient has received preoperative radiation and requires a coloanal anastomosis. The point of transection is often determined by the extent of any radiation injury to the conduit and the need to perform an adequate lymphadenectomy. This condition often necessitates the removal of the sigmoid colon and the need to bring the descending colon all the way to the pelvis. A complete mobilization of the splenic flexure is required in these cases, with the dissection of the greater omentum off of the transverse colon at its fusion with the transverse mesocolon. In addition, the retroperitoneal attachments near the tail of the pancreas should be completely freed. To gain additional length, the inferior mesenteric vein is found just lateral to the ligament of Treitz and is not paired with the artery in this location. Ligating the vein at this location often adds several centimeters to the length of the conduit and is often necessary. Great care must be exercised in preserving the marginal blood supply during these maneuvers. Although all these techniques can be performed laparoscopically/robotically, they require a great deal of skill, and the learning curve is not as steep as other parts of this procedure. If the marginal blood supply is compromised because of inadvertent injury mobilizing the flexure or wandering too close the mesenteric border during ligation of the mesentery, the conduit becomes ischemic and very likely unusable. In general, if a transverse colon anastomosis is being fashioned, both the hepatic and splenic flexure should be mobilized so that the cut ends come together easily. Although no data exist to support the use of a hand-sewn technique in this setting, it is the authors’ preference to perform an end-to-end colocolotomy. Alternatively, an end-to-end stapled anastomosis may be performed using an end-to-end stapler through a colotomy on either end or a linear staple line. A third technique has been described using a linear stapler to create a triangular anastomosis by deploying the stapler 3 separate times.
**Tension**

Many of the same techniques that the surgeon uses to ensure an adequate blood supply also facilitate a tension-free anastomosis as described earlier. The importance of tension on the integrity of an anastomosis has been poorly studied, as most experimental models of leaks rely on the assessment of bursting pressure and not stretch. An exception in the more recent literature characterized the blood flow of various intestinal segments before and after the application of a tensile force after anastomosis. Shikata and Shida found in an experimental model using dogs that the effects of tension on the submucosal blood flow was much better tolerated in the small bowel when compared with the colon. These data help to corroborate the clinical assertion that an anastomosis under tension is more likely to fail, as it is less likely that a small-bowel resection and anastomosis, given the laxity of the small-bowel mesentery, will leak when compared with a left-sided colonic resection that is more likely to be on stretch. Commonsense would indicate an anastomosis that is taught is in danger of failing for the additional reasons of mechanical forces that attempt to pull the newly anastomosed bowel away from each other. Once the anastomosis has been performed, there may be a great deal of laxity between the proximal and distal bowel (ileo-colic) or there may not be any (coloanal), and the surgeon relies on the intraoperative assessment to determine if the anastomosis will fail. As a general rule, if the cut edge of the conduit mesentery traversing over the pelvic brim is too tight to allow a finger to easily slip behind, the anastomosis may be under too much tension. Every effort should then be made to lengthen the conduit, even if this has already been attempted, as often reappraisal may identify a small adhesion to release. In general, if the mesentery is lax, there is likely little to no tension at the anastomosis.

**Technique**

Once the cut edges of the bowel have been attended to, the surgeon must decide how to reunite them. Although this debate may have once been relevant, there is little doubt that in the twenty-first century the surgeon’s choices to what suture or stapler to use and how to use them makes little difference in the outcome. The question of hand sewn or stapled has been asked and answered many times, and few studies have ever shown superiority of one over the other when performed properly. The most recent Cochrane review, which was published in 2012 and was an update of a previous meta-analysis, analyzed the results of 1233 patients who underwent colorectal resections and anastomosis and found that the 2 techniques were equivalent for all relevant parameters including anastomotic leak rates, both clinically and radiographically. If a surgeon chooses to perform a hand-sewn anastomosis, even the choice of one technique over another has not been shown to be superior. In fact, the state of the art for intestinal suturing has essentially remained unchanged since Antoine Lembert first described the inverted suture for intestinal anastomosis. The choice of a single or double layer of suture has been the basis of a randomized trial by Burch and colleagues who concluded that a single continuous layer of bowel apposition is quicker and has no adverse outcomes when compared with a double layer of interrupted suture. Although this study excluded anastomoses to the rectum, other investigators have demonstrated the reliability of the single-layer technique with a low rate of complications. The choice of suture material has also been extensively reviewed, and although monofilament suture produces less of an inflammatory response, there is no evidence that this or any other aspect of a specific property of suture affects the success of an intestinal anastomosis. The development of laparoscopic techniques for colorectal disease has been proved to have some short-term
benefits and does not seem to be associated with a higher risk of anastomotic leak. If a surgeon chooses to construct a colonic reservoir after proctectomy for rectal disease, there seems to be no benefit of a colonic J pouch over a transverse coloplasty in terms of anastomotic integrity, and the results compare favorably with respect to leak rates versus a straight coloanal.

**Supplemental Oxygen**

Perioperatively there are decisions that the surgeon can make that possibly mitigates the incidence of anastomotic failure. One such intervention is the use of supplemental oxygen in the perioperative period, with the hypothesis that increasing the oxygen saturation and its partial pressure in arterial blood improves the mucosal oxygen tension at the site of healing. In 1977, Kirk and Irvin examined the influence of 50% inspired oxygen on the bursting strength of rats that had undergone a colonic anastomosis. This study was negative, and no benefit was noted in the bursting strength of the anastomosis when compared with control rats breathing air. However, investigators in Turkey demonstrated that the administration of hyperbaric oxygen during a left colon anastomosis and continued for 4 days postoperatively had significant benefit in the rat model. They showed that the bursting pressure and the hydroxyproline content (a marker of collagen content) of the submucosa in treated rats were significantly higher than in the controls. This study has been replicated with similar results. Human trials are limited with respect to the effects of supplemental oxygen on anastomotic healing, although there is a wealth of data on the benefits of this intervention on the prevention of surgical site infection. Investigators from Spain demonstrated that the use of 80% FiO₂ in the perioperative period in patients who underwent anterior resections of the rectum had significantly better tissue oxygenation at the anastomosis when compared with controls breathing 30% FiO₂. Their study population included 45 patients, and there were no anastomotic complications in either group. Schietroma and colleagues looked at the effect of supplemental oxygen in the perioperative period in patients who underwent elective infraperitoneal (IP) anastomoses for rectal cancer. Subjects were assigned to either 30% or 80% FiO₂ at the induction of anesthesia and maintained for 6 hours postoperatively. There was a 46% reduction in anastomotic complications (P<.05) for those patients receiving 80% FiO₂ when compared with those who received only 30%. There was no toxicity associated with the use of increased oxygen concentration. Although the evidence for supplemental oxygen is still in its infancy, the data would suggest that at a minimum they are equivalent and likely there may be some benefit. Owing to the ease and availability of this intervention, surgeons performing left-sided, colorectal, and IP anastomoses should consider its use to mitigate the risk of leak.

**Resuscitation Strategies**

Resuscitation strategies also affect anastomotic TSaO₂, with reports in the literature generally showing a decrease in overall postoperative complications with goal-directed and restrictive fluid strategies perioperatively. Kimberger and colleagues using an experimental model of colorectal resections in pigs, suggested that the goal-directed approach is improved with the use of colloid instead of crystalloid. In their study, the use of restrictive crystalloid administration had no effect on postoperative outcomes when compared with traditional resuscitation. Brandstrup and colleagues evaluated the effects of a restrictive fluid strategy in a randomized controlled trial of 172 patients who underwent elective colorectal resections and found that patients in the restricted group (defined by perioperative maintenance of baseline weight) suffered significantly fewer overall (n = 21 vs 43 P<.0001) and major
Complications (n = 8 vs 19, P<.026). In this study, the restrictive strategy used a combination of colloid and crystalloid. Anastomotic leaks occurred in 1 patient in the restrictive group and 4 in the control group. These data were confirmed by Abraham-Nordling and colleagues45 who assessed the use of a restrictive fluid strategy in a randomized controlled trial of 161 patients who underwent colorectal surgery to assess the effect on major surgical complications. Patients in the restricted fluid strategy group received a median of 3050 mL of crystalloid compared with 5775 mL of crystalloid in the control group. Overall, major surgical complications occurred in 5% versus 15% of the restrictive group when compared with controls (P<.063). However, there were only 7 anastomotic complications, and despite 6 occurring in the control group, this did not reach statistical significance. Contrary to these findings, Futier and colleagues46 reported on 70 patients who underwent major abdominal surgery and reported that a restrictive fluid strategy (6 mL/kg/h) was associated with a higher rate of postoperative complications and anastomotic leaks when compared with a conservative approach (12 mL/kg/h). In sum, a restrictive fluid strategy perioperatively seems to be safe and may decrease the incidence of major and minor complications in patients undergoing elective colorectal surgery. However, its effect on anastomotic complications is less clear, and its implementation into everyday practice would seem more challenging than the simple use of supplemental oxygen.

### Intraoperative Parameters

One final piece of this complex puzzle involving the surgeon’s contribution to anastomotic failure is the intraoperative variables of blood loss and operative times. Most of these data come from retrospective databases of patients who underwent colorectal surgery who have been diagnosed postoperatively with an anastomotic leak. Because the incidence of leak is an uncommon, although widely varying, event in the literature (Table 2), this methodology can still be a powerful tool. However, the limitations of such wide-ranging studies can lead to erroneous conclusions. Nevertheless, several investigators have found in multifactorial analysis that excessive blood loss or blood transfusion and prolonged operative times are associated with a higher risk of anastomotic failure.47–56 Further confounding the analysis, the definition of excessive blood loss and prolonged operating times differs in the literature. One representative study by Telem and colleagues47 used 200 mL and 200 minutes, although this remains inconsistent. A more uniform finding entails any intraoperative transfusion is considered a risk factor for anastomotic leak, with the number of units not defined in most studies. The presence of one or more risk factors was shown to increase the incidence of anastomotic failure significantly over baseline, and in the study by Telem and colleagues47 the presence of 3 risk factors (which in their study included operative times, blood loss, blood transfusion, malnutrition, and histologically positive margins) increased the OR of a leak to 21 (95% confidence interval [CI], 2.8–175.4), with a positive predictive value of 91%. In contrast, the absence of these risks was associated with an OR of a leak of 0.21 (95% CI, 0.16–0.5). More likely, blood loss and operative times represent a surrogate for a difficult operation, and the underlying pathophysiology can only be surmised, although ischemia and inflammatory mediators probably play a role. Surgeons should be mindful of these factors in deciding on the use of a protective stoma as a reliable way to decrease the clinical consequences, the reoperation rate, and the incidence of anastomotic leak in these difficult cases. Table 2 summarizes the risk factors identified throughout the medical literature.57–60
<table>
<thead>
<tr>
<th>Study</th>
<th>Type of Resection</th>
<th>Incidence of Anastomotic Leak (%)</th>
<th>Blood Loss (mL)</th>
<th>Operative Times (min)</th>
<th>Blood Transfusion (Risk Factor: Yes or No)</th>
<th>IP Anastomosis (Risk Factor: Yes or No)</th>
<th>Other Risk Factors</th>
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</thead>
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<tr>
<td>Schrock et al, 73</td>
<td>All</td>
<td>4.5</td>
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<td>3.4</td>
<td>NS</td>
<td>NS</td>
<td>Yes</td>
<td>No</td>
<td>Low albumin, obstruction</td>
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<td>Rullier et al, 66</td>
<td>Rectal</td>
<td>12</td>
<td>&gt;240</td>
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<td>Yes</td>
<td>Yes</td>
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<td>All</td>
<td>15.9</td>
<td>&gt;600</td>
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<td>Yes</td>
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<td>Yes</td>
<td>NR</td>
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<td>Makela et al, 54</td>
<td>Left sided</td>
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<td>&gt;2000</td>
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<td>Choi et al.</td>
<td>Colonic</td>
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<td>Lee et al.</td>
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<td>Jestin et al.</td>
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<td>Buchs et al.</td>
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<td>&gt;600</td>
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**Abbreviations:** IP, infraperitoneal rectum; NR, not reported in the study; NS, not a significant risk factor.
PATIENT FACTORS

The surgeon is not the only variable in the complex interaction that results in anastomotic failure, as several patient-related factors have also been identified. Similar to the data describing risk in intestinal healing, the data on patient risk factors are not always consistent, and contradictory conclusions have often been made. For virtually every identified risk factor in this category, there is a report to refute the hypothesis. The weakest links seem to be in the category of smoking, alcohol consumption, age, and obesity, whereas the most consistent risk seems to be higher American Society of Anesthesia (ASA) classification and malnutrition/weight loss. Table 3 summarizes these risks. A consistently higher ASA classification has been shown to increase the incidence of anastomotic complications, with a score of 3 or more usually defining a high-risk population (patient with severe systemic disease and definite functional impairment).49,50,54,61 The patient’s age at the time of surgery has also been shown to be a risk factor in some series, but no consistent cutoff has emerged.62–64 Obesity is harder to quantify as a risk factor for elective colon surgery, especially in right-sided colectomies where it may be of no significance altogether.65 However, several investigators have shown that in patients who underwent left-sided and more importantly rectal resections, especially in men, obesity increases the risk of anastomotic leaks.65–68 Other modifiable patient risk factors include alcohol use and smoking, both of which have been shown to increase the risk of anastomotic leaks.58,63,69–72 In the context of alcohol use, the quantity of problematic consumption is difficult to define and is fraught with the inaccuracies of self-reporting. However, in the study by Sorensen and colleagues,53,54,63,70 patients who consumed more than 35 alcoholic drinks per week had a relative risk (RR) of anastomotic leak of 7.18 (95% CI, 1.2–43.01) when compared with patients who abstained. In the same study, smoking tobacco was associated with an RR of 3.18 (95% CI, 1.44–7.00) compared with nonsmokers. The nutritional status as defined by the serum albumin levels (varies between <3.5 and <3.0 g/dL) or the presence of preoperative weight loss greater than 10% has been reported to increase the risk of anastomotic failure in patients undergoing colorectal resections. Golub and colleagues52 reported their experience in a retrospective review of 763 patients who underwent colorectal resections with an overall leak rate of 3.4%. The most common procedure was a right colectomy. Using a multivariate analysis they demonstrated that a serum albumin level of less than 3.0 g/dL was associated with an increased risk of anastomotic leak (OR, 2.73; 95% CI, 1.29–581; \( P < .009 \)). In the study by Makela and associates,54 strictly on left-sided resections, weight loss and malnutrition had an even more significant impact on the development of anastomotic leaks (OR, 13.22; 95% CI, 2.83–61.85; \( P < .0001 \)).

Patient risk profiles are often difficult to modify and seem to have a much more variable impact on the failure of intestinal anastomosis than surgeon factors. The presence of multiple risk factors should alert the surgeon to the potential for complication development and perhaps lower the threshold for pursuing a diagnosis of a leak postoperatively in patients with softer indications. Smoking cessation, weight loss, and modification of alcohol use certainly benefits any patient undergoing surgery. However, whether this would result in an appreciable impact on postoperative leaks is unclear based on the variability of the data. On the other hand, an anorexic patient who has had weight loss might benefit from nutritional supplementation preoperatively (preferably enterally but in some cases parenterally) for at least 7 days before surgery. Table 3 summarizes the patient-related risk factors in the literature.
<table>
<thead>
<tr>
<th>Type of Resection</th>
<th>Age</th>
<th>Obesity (Variably Defined)</th>
<th>Smoking</th>
<th>Alcohol Use</th>
<th>ASA ≥3</th>
<th>Malnutrition (Variably Defined)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Golub et al, 52 1997</td>
<td>All</td>
<td>–</td>
<td>–</td>
<td>NR</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Sorensen et al, 70 1999</td>
<td>All</td>
<td>&gt;63</td>
<td>–</td>
<td>+</td>
<td>+</td>
<td>NR</td>
</tr>
<tr>
<td>Makela et al, 54 2003</td>
<td>Left sided</td>
<td>NR</td>
<td>&gt;27</td>
<td>–</td>
<td>Yes</td>
<td>+</td>
</tr>
<tr>
<td>Konishi et al, 48 2006</td>
<td>All</td>
<td>–</td>
<td>–</td>
<td>NR</td>
<td>NR</td>
<td>–</td>
</tr>
<tr>
<td>Eberl et al, 59 2008</td>
<td>Rectal</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>Suding et al, 53 2008</td>
<td>All</td>
<td>–</td>
<td>–</td>
<td>NR</td>
<td>NR</td>
<td>–</td>
</tr>
<tr>
<td>Buchs et al, 49 2008</td>
<td>All</td>
<td>–</td>
<td>+</td>
<td>NR</td>
<td>NR</td>
<td>+</td>
</tr>
<tr>
<td>Asteria et al, 63 2008</td>
<td>Rectal</td>
<td>&gt;68</td>
<td>+</td>
<td>+</td>
<td>NR</td>
<td>+</td>
</tr>
<tr>
<td>Bertelsen et al, 58 2010</td>
<td>Rectal</td>
<td>–</td>
<td>–</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

**Abbreviations:** +, positive risk factor; –, not a risk factor; NR, not reported.
DISEASE FACTORS

The final factor that contributes to anastomotic complications is the impact disease processes have on the healing of newly formed colorectal anastomoses.

Emergent Surgery

As a general rule, an anastomosis performed under emergent conditions has a greater propensity to leak.55,61,67,73–76 Choi and colleagues61 reviewed their series of 1417 patients who underwent colorectal resections for malignancy, all above the peritoneal reflection, with an anastomotic leak rate of 1.8%. Surgeries done emergently experienced a leak rate of 44%, although the overall numbers were low (11/25). The investigators did not differentiate the location of the leaks for their emergent cases, but the study cohort included all types of resections. This distinction is important, as generally surgeons are more reluctant to perform left-sided anastomoses in the context of an emergent procedure but are more willing to do so on the right. Biondo and colleagues67 analyzed their experience with left-sided colonic emergencies and reported a leak rate of 5.7%. All patients (n = 211) in their cohort had primary resections and anastomosis for left-sided colonic emergencies (peritonitis, 106; obstruction, 98, and hemorrhage, 4), with on-table colonic lavage. Lee and colleagues74 compared their results of left- versus right-sided colectomies in 243 patients who presented with an obstructing cancer (right sided, n = 107; left sided, n = 136). Most patients had a resection and primary anastomosis, although left-sided anastomoses were lavaged on table at the discretion of the surgeon. The overall leak rate was 6.1%, with no difference noted between left- and right-sided resections. There are not enough data to conclude that there is no difference in the risk associated with the site of the pathologic condition; however, given the data, it is safe to say that emergent colectomies are associated with a higher leak rate than those done electively. In the absence of shock and fecal peritonitis, the vast majority of patients can be considered for a primary anastomosis, right or left, when taken in the broader context of all other risk factors and the possibility that an on-table colonic lavage may reduce the risk of leak in emergent left-sided resections.

Infraperitoneal Location of Pathology

There are several compelling data that the anastomosis at highest risk of leak is the one situated below the peritoneal reflection.49,50,55,56,59,61,62,66,75,77–80 The exception to this rule is the perineal proctectomy in which a hand-sewn coloanal anastomosis is created without the cover of a protective stoma with consistently good results.81,82 This paradox demonstrates the complexity and the host of factors that may all contribute to anastomotic failure. Although perineal proctectomy has low associated leak rates (despite being a coloanal anastomosis), a similarly located anastomosis above the anal verge in the context of low rectal cancers is an independent risk factor for leak irrespective and independent of preoperative radiation and other surgery- and patient-related risks.54,56,59,60 Table 2 also shows the reported leak rates based on the type of resection along with the location of the anastomosis. As demonstrated, the incidence is consistently higher for rectal resections and almost uniformly associated with IP anastomoses. In the study by Sorensen and colleagues,70 the reported anastomotic leak rate for 333 unselected consecutive patients was 15.9%. The RR of colorectal anastomotic leaks in a multivariate analysis was 11.06 (95% CI, 3.32–36.85) when compared with ileocolic and colocolonic anastomotic leaks. Among rectal resections alone, the distance from the anal verge is itself a consistent independent risk factor for leaks. Law and Chu51 looked at leak rates after rectal surgery, comparing
patients with a distal anastomosis (lower third of the rectum, \( n = 396 \)) with patients whose anastomosis was in the middle or upper third of the rectum (\( n = 226 \)). The overall leak rate was low when compared with studies of rectal resections at 5.6%. The mortality was similar in both cohorts, despite a higher hazards ratio of 6.3 for leak in the low rectal group (95% CI, 3.4–46.7; \( P < .0001 \)). Confounding many of these rectal cancer cohorts is the potential impact of previous radiation therapy on leak rates. The use of radiation therapy in Law and Chu’s cohort was not stated, although they comment that it was not routine. Matthiessen and colleagues\(^83\) reported on 436 patients who underwent rectal resections with an overall leak rate of 12%. Rectal cancer was the indication in 91% of the cases, and preoperative radiation was given in just 16%. The leak rate for anastomosis less than 6 cm from the anal verge was 24% compared with 13% for all others. In a multivariate analysis, anastomotic height was proved to be an independent risk factor (\( P < .001 \)). In this same study, patients who had preoperative radiation therapy (most patients received short-course radiotherapy) had a leak rate of 31% compared with just 9% for those who were not treated. Radiation was also found to be an independent risk factor in a multivariate analysis (\( P < .005 \)). The use of radiation has been shown in other studies to be an independent risk factor for leaks,\(^{50,84}\) although this is not uniformly observed.\(^{85}\)

**Steroid, Immunomodulators, and Inflammatory Bowel Disease**

The use of prednisone and other immunomodulators to treat inflammatory conditions can also have an effect on anastomotic leak rates, although the major risk factor for postoperative complications remains the routine use of oral or parenteral steroids.\(^{48,52,53,55,86}\) The duration and extent of treatment likely affect the level of risk, although good data on the timing and safety of cessation are lacking. These effects may be mitigated in patients with inflammatory bowel disease, as it may be more critical that the associated inflammation and systemic effects of their disease be controlled.\(^{87}\) However, the wealth of data on patients with Crohn disease (CD) and ulcerative colitis (UC) suggests that the use of steroids increases postoperative septic complications in general, with less evidence that the anastomotic leak rates are higher.\(^{88–90}\) Immunomodulators also seem to be safe in this patient population, as does anti-TNF alpha therapy. Although data exist only for infliximab (IFX) and not the newer human monoclonal antibodies, there does not seem to be any substantial evidence in favor of stopping this treatment before elective colorectal surgery.\(^{91–94}\) There remains uncertainty about the effect of anti-TNF alpha therapy in patients with UC undergoing restorative proctocolectomy. This treatment is relatively new, but the effect on postoperative complications and ileal J-pouch-anal anastomotic failure has been reported with different conclusions. Selvaseker and colleagues\(^95\) studied 301 patients who underwent restorative proctocolectomy for medically refractory UC and analyzed the effect of preoperative IFX therapy on postoperative complications (IFX, \( n = 47 \); no IFX, \( n = 254 \)). They found that IFX therapy was linked to increased occurrence of anastomotic leaks (\( P < .02 \)) and infectious complications (\( P < .01 \)). This study was performed before 2005; therefore, the use of IFX for the treatment of UC was off label, and bias certainly could have existed with respect to disease severity and overall health status of the patients in the study group. Mor and colleagues\(^96\) were successful in eliminating this bias by reporting on disease severity and patient comorbidity. Their results supported the findings that IFX increased the occurrence of anastomotic leaks and infectious complications. These findings were refuted by 3 studies, which concluded that there was no such association between IFX therapy and postoperative pouch anal leaks or pelvic sepsis.\(^{97–99}\) One of these
studies (Ferrante and colleagues\textsuperscript{98}) even concluded that the postoperative complications in their cohort were attributed to the use of steroid and not IFX.

Several factors have also been reported to increase the risk of anastomotic complications in patients undergoing resection for CD. These factors include histologically involved margin of resection,\textsuperscript{47} intra-abdominal abscess or fistula at the time of surgery, malnutrition, and reoperative surgery for CD.\textsuperscript{88,90} In addition, several investigators have suggested that a side-to-side anastomosis is associated with lower leak rates than an end-to-end anastomosis in CD, but the mechanics of why this occurs are not well understood.\textsuperscript{100–102}

Evidence seems to support the tapering of steroids when possible in patients undergoing elective or urgent colorectal resections, but the cessation of immunomodulators and anti-TNF alpha therapy does not seem to be necessary. Because most surgeons are inclined to perform a stapled side-to-side anastomosis, its use in patients with CD seems particularly appropriate. Intra-abdominal sepsis should be controlled preoperatively when possible in all instances, which may prove particularly important in CD. The use of preoperative nutritional supplementation in patients with documented malnutrition is warranted whenever possible.

**Malignancy**

The previous section described the risk of anastomotic failure in low rectal cancer, but this was more related to the location of the IP anastomosis and not the primary pathologic condition itself. Malignancy has several potential issues that may contribute to variable leak rates. One such is the use of certain chemotherapeutics. There are some reports of the use of bevacizumab leading to an increased risk of anastomotic complications when used both before and after surgery. These complications typically occur in the early postoperative period, but case studies have demonstrated that there can be a delayed effect even as long as 30 months postoperatively.\textsuperscript{103} It is reasonable therefore to wait a minimum of 6 weeks after the administration of bevacizumab before performing elective colorectal resections and to delay initiation of therapy for at least 28 days after surgery. In addition to the effect of drug therapy, metastatic colorectal cancer has been shown to be an independent risk factor for anastomotic leak, and surgeons should be vigilant to counsel the patient in need of a resection for stage IV disease regarding both the increased incidence and the profound impact of anastomotic failure.\textsuperscript{71,104}

**Trauma**

The treatment of colonic injuries has undergone significant changes during the past century, evolving from a policy of mandatory colostomy use to that of primary repair or resection and anastomosis when possible. The American Association for the Surgery of Trauma (AAST) multicenter trial assessing the safety of primary repair or resection and anastomosis compared with diversion concluded that diversion was unnecessary in the absence of significant fecal contamination and shock.\textsuperscript{105} The method of anastomosis does not seem to have an effect on the risk of leak in this setting.\textsuperscript{106} The increase in the number of damage control techniques has also affected the development of anastomotic leaks. Ott and colleagues\textsuperscript{107} performed a cohort-matched study on 174 patients with colonic injuries initially managed with resection and anastomosis in the setting of an open abdomen who underwent a damage control laparotomy. They identified a significantly higher leak rate among patients whose abdomens were left open compared with those whose abdomens could be primarily closed (27% vs 6%, \( P = .002 \)). Leaks also occurred more frequently in patients requiring blood transfusions and after left-sided resections. Unfortunately, nearly all
presumed risk factors have in some manner been associated with the development of anastomotic leak in the setting of trauma. There is a paucity of prospective data in this cohort to provide high-level evidence to base recommendations on, and surgeons are often left to rely on their experience and judgment in this scenario.

MITIGATING THE RISK OF ANASTOMOTIC FAILURE

A thorough knowledge of the risk factors associated with anastomotic failure is not enough to prevent leaks, and surgeons continue to look for ways to help mitigate this terrible complication. Bowel preparation, once thought to be essential to the success of a colorectal resection, has increasingly become irrelevant in modern surgery, although still widely practiced. Oral and parenteral antibiotics essential for the control of postoperative surgical site infections do not seem to have a significant role in the prevention of anastomotic leaks. The medical industry has continued to improve on stapler technology, and there has been some interest in the use of materials to buttress the staple line in newly formed anastomoses. However, there has not been any success in human colorectal trials, whereas results in animal models are mixed. Also on the fringe is the use of the omentum to biologically “buttress” or protect a newly formed anastomosis. Data are mixed, with some reports stating an advantage in terms of leak rates.

Diverting Stoma

Perhaps the most effective intervention available to surgeons to decrease the incidence of anastomotic failure is the use of a protective stoma to divert the fecal flow away from the newly created anastomosis. Although most of the literature on the use of protective stomas comes from studies in rectal surgery, the results should be applicable to all anastomoses. It has been suggested that a covering stoma only mitigates the clinical impact of anastomotic failure without preventing leaks, despite multiple investigators and 3 recent meta-analyses, including the Cochrane review authored by Montedori and colleagues, refuting this assertion. In this review of the published literature, the use of a diverting stoma in rectal cancer surgery resulted in both a decreased incidence of anastomotic leak (RR, 0.33; 95% CI, 0.21–0.53), as well as the need for urgent reoperation (RR, 0.23; 95% CI, 0.12–0.42).

Pelvic Drains

The use of pelvic drains after rectal resection was based on the assumption that blood and fluid naturally accumulate in the presacral space. It was thought that any infected collection would naturally point toward the suture line, with resultant disruption and leak. Although several investigators have concluded that the use of closed-suction pelvic drains results in fewer anastomotic complications, others have not. Some reports conclude that the use of pelvic drains is associated with a higher leak rate, and their use have been identified as an independent risk factor for anastomotic disruption. Jesus and colleagues published a meta-analysis of the study of the use of pelvic drains and their effect on the anastomotic integrity. Of the 1140 patients reviewed encompassing 6 randomized controlled trials, there was a 5% leak rate in both groups. There was also no advantage in the numbers of patient requiring reintervention (6% vs 5%).

Air Leak Testing

An immediate test of an anastomotic integrity is to assess for an air leak, which is easily performed for colorectal and left-sided resections and may help prevent or
identify anastomotic leaks. Ricciardi and colleagues reviewed the outcomes of 825 left-sided resections and found evidence that 8% of those tested showed positive results for an air leak. Postoperative leaks occurred in 7.7% of anastomoses that tested positive, in 3.8% of those that tested negative, and in 8.1% of those that were not tested (P < .03). Furthermore, the anastomotic leak rate was 12.1% when an anastomosis that initially showed positive results was suture repaired, so that they were air tight compared with 0% when they were completely redone or were diverted proximally (P = NS). Beard and colleagues performed a randomized trial of 145 patients who underwent left-sided and rectal resections to intraoperative air leak testing or nothing. In the test group, air leaked from 25% of anastomoses, which were repaired. Clinically relevant anastomotic leaks occurred in 4% of the test group and in 14% in the no test group (P = .043). Although these benefits have not been uniformly demonstrated, no investigators have shown that air leak testing is harmful, and likely never will. Owing to the potential benefit and the ease of performing this air test, surgeons should consider it as a routine part of their practice for left-sided and rectal resections. Because of the absence of data and the increased difficulty in anastomosis proximal to the splenic flexure, no recommendations can be made.

ANASTOMOTIC STRicture AND BLEEdING

**Stricture**

Anastomotic stricture after a colon anastomosis is a well-known but poorly defined complication. What may be a “small” narrowing to some is a tight stricture or even “wide open” to others. Furthermore, outside of symptoms or scheduled endoscopic follow-up, the anastomosis may not be evaluated for months or years. As such, it is difficult to determine the actual rate of stricture formation for colorectal anastomoses. Ambrosetti and colleagues reviewed their experience in 68 patients who underwent elective laparoscopic sigmoid colectomy using a double-stapled colorectal anastomosis. They defined a stricture purely based on symptoms, identifying 22 patients (32%). Of these, only 12 patients (18%) eventually needed dilatation of their anastomosis. The investigators could not identify any risk factors that predisposed to stricture formation in their patient population. In a study of 179 patients (94 men) who underwent a colorectal anastomosis, Bannura and colleagues defined stenosis as the inability to pass a rigid sigmoidoscope through the anastomosis. By using this criterion, a stricture was present in 21.1% of the cases. Unlike in the study by Ambrosetti and colleagues, male sex and evaluation within 4 months of surgery were independently associated with the development of a stenosis in stapled colorectal anastomosis. In 2012, Neutzling and colleagues updated their Cochrane review that consisted of 9 randomized controlled trials with 1233 patients (622 stapled and 611 hand-sewn) who underwent a colorectal anastomosis. Although there were no other significant differences in evaluated metrics between the 2 methods, the investigators found that stricture was more common in a stapled anastomosis (risk difference [random-effects model] 4.6%; 95% CI, 1.2%–8.1%).

**Treatment**

Most strictures respond well to nonoperative means. In many cases, the simple passage of formed stool adequately distends the anastomosis and avoids the need for any further intervention. Depending on the location of the anastomosis, digital rectal examination with finger or Hegar dilators also aids in relieving distal strictures. Overall, dilation is a highly successful technique for the management of strictures and can be performed using either a rigid instrument or with the aid of pneumatic balloons. In a study of 256 consecutive patients who underwent low anterior resection,
Werre and colleagues\textsuperscript{136} identified 21 patients (8.2\%) with a stricture of the colorectal anastomosis. Stricture symptoms presented after a mean period of 7.7 months. Follow-up data were available for 15 of these patients. Because these were distal anastomoses, an endoscopic Savary dilation technique, with bougies of increasing diameters (10–19 mm), were used over a series of sessions. Normal defecation with complete resolution of symptoms occurred in 10 of the remaining 15 patients. In 5 patients, there was only partial improvement, but only 3 of them required reintervention. No complications occurred as the result of the dilations. A normal defecation pattern was never regained if more than 3 dilations were necessary.

In the study by Ambrosetti and colleagues,\textsuperscript{134} dilation was performed in 12 patients with a median stenotic diameter of 7 mm at a mean time of 176 days postoperatively. Eight patients had only 1 session, 3 patients had 2 sessions, and 1 patient had 3 sessions. This study highlights the need for patient education to manage expectations regarding the oft-needed requirement for multiple treatments. There were no complications, and all patients were symptom-free after dilatation. Araujo and Costa\textsuperscript{137} used pneumatic balloon dilatation in 24 symptomatic patients with benign colorectal anastomotic stricture using a through-the-scope balloon technique. In this series, dilation was successful in 22 (91.7\%) patients, and there were no procedure-related complications. The mean number of sessions required was 2.3. The investigators were unable to identify a correlation between the number of dilation sessions and stricture recurrence. Several others have reported the successful use of dilation to treat symptomatic anastomotic strictures in greater than 95\%, symptomatic relief in 70\% to 100\% of patients after the initial dilation, and 85\% to 100\% relief with subsequent sessions.\textsuperscript{138–140} Failure to manage symptomatic stenosis with endoscopic techniques is correlated with previous radiotherapy, local recurrence of malignancy, and a prior large anastomotic dehiscence.\textsuperscript{140}

For patients who fail pneumatic balloon dilatation of their symptomatic stricture, there exist a few additional options that may avoid the need for laparotomy or permanent stoma. A group from the United Kingdom studied the efficacy of self-expanding metallic stents and endoscopic transanal resection of strictures in managing high-grade benign colorectal anastomotic strictures after the failure of first-line therapies, demonstrating 90\% satisfaction rates at a median follow-up of 29 months. Complications in this cohort included reoperation for bleeding, asymptomatic anastomotic perforation, and technical failure in an acutely angulated stricture.\textsuperscript{141} Biodegradable stents have shown similar efficacy.\textsuperscript{142} Other reported options that have proved successful include the use of electroincision (radial incisions of the scar) along with pneumatic balloon dilation,\textsuperscript{143} circular and linear stapler re-resection of the stricture,\textsuperscript{144} and dilation with concomitant corticosteroid injection.\textsuperscript{145}

\textbf{Bleeding}

Bleeding after a gastrointestinal anastomosis is usually minor and self-limited. On occasion, a perforating vessel or trapped mesentery can result in symptomatic hematochezia and require intervention to control. When performing a stapled side-to-side anastomosis, the staple line should be inspected for evidence of pulsatile bleeding at the enteroenterostomy and controlled with a suture. After an end-to-end stapled anastomosis, evidence of significant bleeding may be harder to assess even with proctoscopic examination during the air leak test. Fortunately, clinically significant postoperative bleeding remains an uncommon entity. In a study involving 1389 colorectal procedures, clinically relevant bleeding from the colorectal anastomosis occurred in 7 patients (0.5\%).\textsuperscript{146} Although higher rates of bleeding (1.8\%) have been reported,\textsuperscript{147} the definition of what entails “significant bleeding” varies from study
to study. Despite the low incidence of clinically significant bleeding after intestinal anastomoses, the early postoperative manipulation of a new anastomosis can be a harrowing experience. For that reason, some investigators advocate the routine use of endoscopy to evaluate the anastomotic line intraoperatively.\textsuperscript{148} In this study, 338 patients who underwent a colorectal anastomosis were assessed. Immediate postanastomotic endoscopy was performed in 85 of these patients, with 5.9\% requiring endoscopic intervention with a hemoclip as determined by the operative surgeon. Overall, the rate of clinically significant postoperative bleeding in both groups was similar, as was the need for postoperative intervention (2.8\% in the nonendoscopy group vs 2.4\% in the endoscopy group), making it difficult to make any recommendations.

\textbf{Treatment}

In most cases, the patient remains hemodynamically stable, and no intervention is required. The rate of transfusion requirement is routinely less than 5\%.\textsuperscript{147} In the review by Martinez-Serrano and colleagues,\textsuperscript{146} bleeding in 6 of the 7 patients resolved with conservative treatment including endoscopy. Only 1 patient required surgical treatment, and there was no mortality and no anastomotic leaks in these 7 patients. Cirocco and Golub\textsuperscript{147} reported nonoperative therapy to be successful in 14 of 17 patients (82\%), using endoscopic electrocoagulation in 6 patients (43\%) and blood transfusion alone in another 6 patients (43\%). The investigators concluded that endoscopic electrocoagulation can be safely and effectively used on a newly created anastomosis to control unremitting anastomotic hemorrhage. Alternative endoscopic techniques include the use of submucosal injection of 10 mL adrenaline (1:200 000) in saline at the bleeding point, with good results.\textsuperscript{149} The use of the endoscopic hemoclip has been well described in upper gastrointestinal procedures and in colonic diverticular bleeding; however, its application in postoperative anastomotic bleeding for colon or rectal anastomosis is lacking.\textsuperscript{150,151} Anecdotally, the author (DR) has successfully used the endoscopic hemoclip to control bleeding at a colorectal anastomosis in the postoperative period. Finally, although rarely required, surgical exploration with oversewing of the anastomosis or resection may be needed for select recalcitrant cases.\textsuperscript{152}

Bleeding is a rare event after intestinal anastomosis, and endoscopic techniques have largely replaced the need for laparotomy or other surgical interventions. It is advisable that the operative surgeon performs or be present when endoscopic manipulation of a newly created anastomosis is required.

\textbf{SUMMARY}

The intestinal anastomosis is an essential part of surgical practice, and with it comes the inherent risk of breakdown and leaks. In colorectal surgery, the consequences of such a leak is disastrous, as bacteria-laden stool accesses the peritoneal cavity, sometimes ending in lethal consequences. Risk factors for anastomotic failure are categorized as surgeon related, patient related, and disease related. Some of the risks are modifiable (malnutrition, smoking, and blood loss), whereas others are an inherent part of colorectal surgery (IP location of pathology, need for radiation, and emergency surgery). Understanding the myriad of risk factors and the strength of the data help guide a surgeon as to the safety of undertaking an operation in which a primary anastomosis is to be considered. In the absence of abandoning the goal of reuniting the cut ends of the bowel, a surgeon may choose to mitigate the risk of a leak by performing a proximal diverting stoma. Whether this risk is modified by the use of adjuncts such as pelvic drains, omental wrapping, or tissue reinforcement remains unclear; however,
the performance of a simple intraoperative air leak test allows a surgeon to assess if the anastomotic integrity has been compromised. More importantly, it allows the surgeon the option of completely redoing it, repairing it, or diverting proximally with the expectation that the outcome will be better than if nothing is done or if the test is omitted. Similarly, familiarity with the various approaches to both stricture and bleeding at the anastomosis aids in optimizing patient outcomes with the least amount of morbidity should these complications occur.

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