29 Minimizing Colorectal Anastomotic Leaks: Best Practices to Assess the Integrity and Perfusion of Left-Sided Anastomoses

Mehraneh D. Jafari and Alessio Pigazzi

Introduction and Rationale

Anastomotic leak can be a serious complication of colon and rectal resections. Although all the factors contributing to anastomotic leak are not well understood, leaks are commonly caused by a combination of patient factors such as malnutrition, obesity, smoking, and diabetes or technical factors including excessive tension on the anastomosis, inadequate perfusion, or other errors in their construction. Leaks from right-sided (ileocolic) anastomoses are uncommon, with less than 2% reported in a meta-analysis of seven series [1]. Rates for left-sided (colorectal) anastomoses vary depending on the distance of the anastomosis relative to the anal verge and range from 5 to 18%, even among high-volume surgeons [2–5].

The sequelae of leaks can range from subclinical leaks that require no interventions to life-threatening sepsis requiring emergency surgery. Randomized trial data report mortality of 1.3–6.7% in patients with anastomotic leaks, with higher rates in anastomoses closer to the anal verge [4, 6]. Mortality after right-sided colon resections are less than 0.5%, corresponding to the lower leak rates [1].

Intraoperative examination of the anastomosis with air leak testing and rigid or flexible endoscopy should be used to evaluate for the mechanical integrity and perfusion of the anastomosis. Bowel perfusion with fluorescence angiography may be used as an adjunct to further delineate and identify areas of compromised perfusion. Endoscopy can also aid in correcting technical errors and help perform anastomotic revision intraoperatively, possibly reducing the rate of postoperative leak.

M. D. Jafari · A. Pigazzi (✉)
University of California, Irvine, Colon and Rectal Surgery, Orange, CA, USA
e-mail: apigazzi@uci.edu

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Indications for Endoscopic Evaluation

In our view, all left-sided colorectal anastomoses should be evaluated with intraoperative endoscopy. Though no randomized trial of flexible endoscopy versus air leak testing without visualization has been performed, data from large case series support evaluation with direct visualization over air leak testing alone. A single-institution review of 415 consecutive laparoscopic left-sided colorectal resections identified abnormalities on 17 (4.1%) of cases, 15 of which also had an air leak. These anastomoses were resected and refashioned, and none subsequently leaked [7]. However, a negative air leak testing does not necessarily eliminate the risk of a postoperative leak. Grading with visual inspection of the anastomoses can potentially predict leaks, allowing for intraoperative revision and lower risk of anastomotic leak. Areas of ischemia or congestion at the anastomosis warrant intraoperative revision [8]. Evaluation with fluorescent imaging that highlights the vasculature, and thus perfusion to the anastomosis, can help identify and/or confirm areas of suspected bowel ischemia, allowing for correction and reducing the risk of postoperative leakage [9]. Endoscopic evaluation carries almost no risk if properly performed and does not significantly prolong operative time. This modality is recommended for evaluation of all left-sided colorectal anastomoses.

Principles and Quality Benchmarks for Endoscopic Evaluation

When evaluating a colorectal anastomosis, surgeons should evaluate for the integrity of the anastomosis with insufflation, evaluate the perfusion of the colon and rectum at the anastomosis, and evaluate for any brisk bleeding which can be controlled.

The integrity of the anastomosis can be performed by visualization of the anastomosis with simultaneous CO_2 (or air if CO_2 is unavailable) insufflation and proximal bowel occlusion via either open or laparoscopic techniques. This combination will allow the surgeon to visualize any defect and potentially repair via suture ligation or, in cases of large defects, revise the anastomosis entirely. Any obvious defects at the anastomosis, with or without air leak, warrant immediate revision. Flexible sigmoidoscopy offers excellent visualization, but rigid proctoscopy can also be performed. We highly encourage every surgeon who performs high-risk anastomosis to perform an endoscopic evaluation with care to fully visualize the anastomosis.

One technique we developed at the University of California, Irvine, involves examination and grading of the distal and proximal mucosa at the staple line. This novel technique allows the surgeon to objectively evaluate the perfusion at the index operation (Table 29.1 and Fig. 29.1a–c) [8]. Grade 1 anastomoses have no signs of ischemia or congestion and have a low risk of leak. Grade 2 anastomoses have ischemia or congestion involving less than 30% of either the colon or rectal mucosa. These anastomoses have a higher risk of leak, and intraoperative revision or diversion should be considered. Grade 3 anastomoses have more than 30%

Table 29.1 Endoscopic mucosal grading system for colorectal anastomoses

	Anastomosis appearance on endoscopy		
	Grade 1: No ischemia or congestion	Grade 2: <30% ischemia or congestion	Grade 3: >30% ischemia or congestion
Patients	92	10	4
Leaks (%)	9 (9.4%)	4 (40%)	–
Odds ratio of leak (95% CI)	Ref	4.09 (1.21–13.6)	–

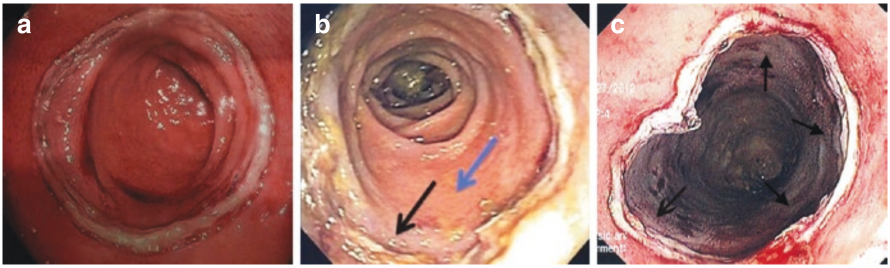

Fig. 29.1 (**a**) Grade 1 anastomosis. No areas of ischemia or congestion are noted, and the entire circumference is visible. (**b**) Grade 2 anastomosis. Less than 30% of the circumference (arrows) appears congested. (**c**) Grade 3 anastomosis. Greater than 30% of the colonic mucosa appears ischemic. All 4 Grade 3 anastomoses were revised to Grade 1 with no subsequent leaks

ischemia on either side or any ischemia on both sides of the staple line. They have a high risk of leak and should always be revised. Re-evaluation with endoscopy after revision is warranted. Please refer to Chap. 30 on salvage of the failed anastomosis for additional details on how to manage colonic ischemia.

Techniques for Assessing Tension and Perfusion During Colorectal Anastomosis Creation

A tension-free, well-perfused anastomosis is the key to reducing the risk of anastomotic leak, especially in pelvic anastomoses. Excessive tension can compromise perfusion, but overzealous division of the mesocolon will also cause ischemia. With this in mind, complete mobilization of the left side of the colon, including the splenic flexure, and division of the inferior mesenteric vein and artery (IMV and IMA) are encouraged for low anterior resections. Division of the gastrocolic ligament to the mid transverse colon and separation of the mesocolic attachment to the pancreatic tail will also provide additional colon length. After mobilization, the left colonic conduit should easily descend down toward the rectal stump without any tension. The mesocolon is often the site of persistent tension even after mobilization of these attachments, and division of the azygous portion of inferior mesenteric vein superior to the ligament of Treitz can provide additional length. Please refer to Chap. 4 on laparoscopic splenic flexure release for additional details on surgical techniques.

Perfusion of the colon can be assessed through direct visual inspection of the serosa and evaluation of blood flow after sharp division of the colon. Any concerns should prompt identification of a better perfused area for division. Further mobilization of retroperitoneal, gastrocolic, and lateral attachments may be required to avoid tension on the anastomosis. Care should be given to avoid injury of the marginal artery to avoid ischemia of the colonic conduit.

Various fluorescent dyes have been developed for assessment of bowel perfusion. The most commonly used of these is indocyanine green (ICG). This is a nontoxic, stable dye that has been used for a half century in ophthalmology for retinal angiography [10]. It is readily excreted in bile and does not stain the tissues. Allergy to the dye is extremely rare. Angiography with this dye requires specialized light sources and cameras that can capture the near-infrared spectrum, which are present on some robotic and laparoscopic camera systems. 3.75–7.5 mg of ICG dye is injected intravenously and imaging performed approximately 2–3 minutes afterward. The dye washes out after 3–5 minutes; thus, close communication with the anesthesiologist and surgeon is critical. Repeated injections can be performed if necessary. Ideally, visualization should be performed prior to division of the colon to identify a transection point between well-perfused and ischemic bowel. The proximal rectal pouch can also be evaluated simultaneously as the dye perfuses the entire bowel vasculature. Well-perfused bowel will fluoresce green or blue, and a sharp cutoff of malperfused distal bowel should be noted (Fig. 29.2). With rigid proctoscopy, fluorescent perfusion of the mucosa after anastomosis can also be visualized; however, this option is not currently available with flexible endoscopes. This technique can be used in conjunction with, but not in lieu of, direct visual inspection of the bowel's blood supply. Using both ICG imaging techniques, leak rates of only 1.4% were achieved in a phase II multicenter trial [11].

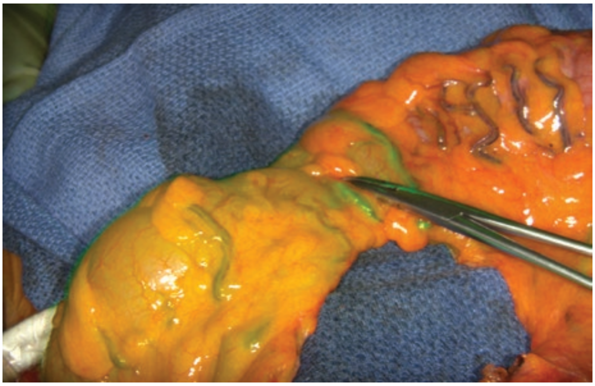

Fig. 29.2 Intraoperative ICG perfusion imaging. Green fluorescence highlights the proximal, perfused bowel. Clamp delineates the transition between perfused and unperfused bowel

Techniques for Intraoperative Endoscopy

The patient should undergo bowel preparation with oral laxatives and rectal enemas prior to the day of operation, and rectal irrigation should be performed at the start of the procedure to ensure adequate evacuation of residual rectal contents. The patient should remain in a modified lithotomy position and Trendelenburg after creation of the anastomosis. With the anastomosis under direct visualization from the abdomen, a flexible colonoscope is inserted via the anus. If a laparoscopic approach is used, the extraction incision should be temporarily closed with a wound retractor (Fig. 29.3), and the abdomen should be re-insufflated. If an open approach is used, the extraction site should be large enough to provide adequate visualization of the anastomosis. The colon proximal to the anastomosis is gently occluded with a blunt grasper by an assistant. The pelvis should be irrigated of clots, and any organs obscuring the anastomosis should be retracted away. Irrigation (water) is instilled into the pelvis to submerge the anastomosis. Any residual bubbles from instilling irrigation should be suctioned away. The rectum is then insufflated with CO_2 or air. The colonoscope or proctoscope is gently advanced to the anastomosis and beyond. Any air leak noted within the pelvis should warrant investigation of the anastomosis. If positive air leak continues after suctioning, consider repair of the anastomosis under direct visualization at the exact location of the air leak. This can be performed transabdominally with interrupted absorbable sutures to close the defect. Visualization of the defect during repair can ease accurate placement of sutures. If the anastomosis is very low, suture repair of the defect may need to be performed transanally. In either case, careful inspection via a colonoscope or proctoscope should be performed and air leak testing repeated after repair to confirm resolution of leak. If the leak persists or is associated with a large or posterior defect, revision of the entire anastomosis with either stapled or hand-sewn techniques may be required. In the setting of a small air leak that cannot be identified, in a patient who has undergone a full bowel preparation, fecal diversion with a loop ileostomy can be considered, in conjunction with placement of reinforcing sutures at the anastomosis, but only after endoscopic and/or perfusion assessment has confirmed adequate perfusion.

As the endoscope is slowly pulled back, the colon mucosa proximal to the anastomosis is inspected for any changes in perfusion. Once the entire anastomosis is in

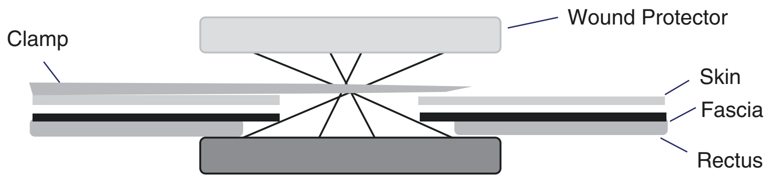

Fig. 29.3 Technique for re-insufflating abdomen by occluding the specimen extraction site. A flexible wound protector inserted into the specimen extraction site can be twisted and clamped flush with the incision to maintain pneumoperitoneum during the anastomosis creation and inspection

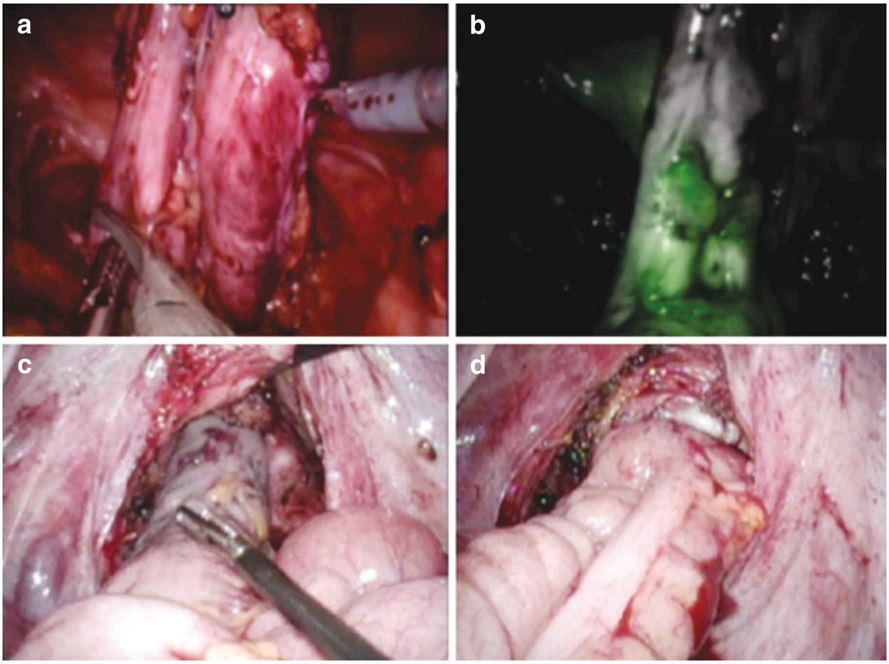

Fig. 29.4 (**a**–**d**) Intraoperative evaluation of a high-risk low rectal anastomosis with laparoscopic techniques for revision. Colon is shown prior to transection in white light (**a**) and with ICG fluorescence imaging (**b**). The distal colon appears ischemic after the initial anastomosis is performed (**c**) and well perfused after complete revision of the anastomosis with viable bowel (**d**)

view, any clots and debris are gently irrigated away with the endoscope flush. Signs of ischemia or congestion are noted, and the approximate extent around the circumference of the anastomosis is determined (Fig. 29.1a–c). If the area is small (UCI Grade 2), suture reinforcement may be adequate. If a UCI Grade 3 anastomosis is noted, takedown and revision of anastomosis with possible diversion must be considered (Fig. 29.4a–d). The remainder of the rectal remnant is inspected as the endoscope is removed. Retroflexion should not be performed to avoid undue tension on the anastomosis. The rectum should be desufflated with suction. If any brisk arterial bleeding is encountered, endoscopic clips can be utilized to control bleeding. If clips are not available, the area should be visualized intraabdominally, and suture ligation should be attempted.

Pitfalls and Troubleshooting

Evaluation of the anastomosis with intraoperative and endoscopic assessment is a straightforward technique that is readily applicable in elective colon resections. The surgeon should be familiar with basic endoscopy techniques. The major pitfall with endoscopic evaluation is incomplete or inaccurate assessment of the anastomosis. Assessment of the degree of ischemia requires experience, but simple grading systems such as the one provided in this chapter are useful benchmarks. Determining the need for revision must be tailored for each patient's situation, with the understanding that immediate revision in a non-inflamed and non-contaminated field will be technically easier than revision in the setting of a clinically significant leak.

Incomplete assessment of the anastomosis is technically preventable by ensuring sufficient exposure to allow for careful inspection of the entire circumference of the anastomosis. It is essential to irrigate any clots or stool and ensure sufficient insufflation so that mucosal folds do not obscure the anastomosis. Therefore, we recommend rectal irrigation prior to anastomosis. Proximal occlusion of the colon will help retain gas within the rectum, and a well-made anastomosis will not leak with normal levels of insufflation. Flexible, rather than rigid, endoscopy greatly facilitates evaluation of the anastomosis by multiple observers in the operating room and allows for endoscopic intervention. Ensuring that the anastomosis is well exposed from the abdomen, and the bladder and uterus are retracted off the rectum, will also improve visualization.

Outcomes

Many methods for evaluating anastomotic leaks have been described in the literature. Gross assessment of the anastomosis without endoscopic evaluation is neither sensitive nor specific for predicting leaks [12]. A meta-analysis of 20 studies evaluating air leak testing with out endoscopy found no significant decrease in postoperative leaks, even if diverting ostomies were created after repair of the anastomosis (OR 0.61, 95% CI 0.32–1.18, $p = 0.15$) [13]. The overall leak rate across all studies was 11.2%, consistent with ranges of 10–15% in randomized colorectal surgery trials [3, 4]. These findings highlight the importance of direct endoscopic inspection of left-sided colorectal anastomoses.

Large series examining the use of intraoperative endoscopy in evaluating anastomoses demonstrated significant reductions in leak rates when compared to patients who had not undergone endoscopy. A series of 215 rectal cancer patients matched for demographics, AJCC stage, and tumor location demonstrated a 4.2% leak rate after endoscopy vs. 12.1% with air leak testing alone ($p = 0.004$) [14]. Of note, only 1 of the 26 patients with postoperative leaks after air leak testing alone had had a positive air leak test. A series of 415 consecutive patients who underwent intraoperative endoscopy reported a 4.1% rate of abnormalities requiring revision. No postoperative leaks occurred in these patients [7]. The overall leak rate in this series was 2.1%, much lower than the 13% rate reported in a recent Cochrane review of the literature [15]. However, neither group reported a systemic method of evaluating the integrity of the anastomosis.

A simple classification scheme has been developed at our institution to grade the quality of colorectal anastomoses (Table 29.1) [8]. This is the only reported systemic method of grading colorectal anastomoses with intraoperative endoscopy.

Table 29.2 Evaluation of anastomoses with ICG

Study	Series type and comparison	*n*	% Left-sided anastomosis	Leak rate	Change in operation due to ICG imaging *n* (%)
Jafari [11]	ICG series	139	100%	2 (1.4%)	9 (6.5%)
Ris [18]	ICG series	30	6 (20%)	0 (0%)	3 (10%)
Boni [19]	ICG series	42	100%	0 (0%)	2 (4.7%)
	Matched cases	38	100%	2 (5.3%)	–
Kudszus [17]	ICG group	201	NA	7 (3.4%)*	28 (13.9%)
	Matched cases	201	NA	15 (7.5%)	–
Protyniak [20]	ICG group	76	47 (61.8%)	0 (0%)	4 (5.2%)
Foppa [21]	ICG group	160	NA	NA	4 (2.5%)
Kawada [22]	ICG group	68	28 (41.1%)	3 (4.5%)	18 (26.5%)
Kim [23]	ICG group	123	100%	1 (0.8%)*	13 (10.6%)
	Matched cases	313	100%	17 (5.4%)	–
Kin [24]	ICG group	173	17 (9.8%)	13 (7.5%)	8 (4.6%)
	Matched cases	173	17 (9.8%)	11 (6.4%)	–
Hellan [25]	ICG group	40	27 (67.5%)	2 (5.0%)	16 (40%)
Boni [26]	ICG group	107	22 (21%)	1 (0.9%)	4 (3.7%)

NA not available
$*p < 0.05$

Using this scheme, 106 consecutive patients were evaluated intraoperatively, and significant differences in leak rates were noted between Grade 1 and 2 anastomoses (OR of leak 4.09, 95% CI 1.21–13.63, $p = 0.023$). There were no significant differences in patient demographics, indication for resection or operative approach. The majority of anastomoses were Grade 1 (86.7%), and these had a leak rate of 9.8% (9/96). Five of these patients had a symptomatic leak requiring intervention. Grade 2 anastomoses had a significantly higher leak rate of 40% (4/10), and two patients required intervention. Four patients had Grade 3 anastomoses initially, and all underwent immediate revision to a Grade 1 anastomosis. This study highlights the usefulness of a grading system to guide intraoperative decision-making.

The use of ICG for evaluating bowel perfusion during colorectal operations has gained traction in recent years as newer models of minimally invasive camera systems have included the necessary optics. A recent meta-analysis of five case-control series demonstrated a significant reduction in postoperative leaks with the use of ICG imaging (OR 0.34, 95% CI 0.160.74, $p = 0.006$) [16]. The majority of the benefit was noted in resections for cancer (1.1% with ICG vs. 6.1% without, $p = 0.02$). A series of 402 patients with matched controls demonstrated a lower leak rate and fewer reoperations with ICG use (3.1% vs. 7.7%, $p = 0.04$) [17]. In a prospective trial of ICG in laparoscopic left-sided colorectal operations, operative plans were informed by perfusion assessment in 8% of cases, and the anastomotic leak rate was 1.2% [11]. ICG is a simple to use, low-risk method of perfusion assessment that can provide important information to guide intraoperative planning and reduce postoperative complications from leaks. See Table 29.2.

Conclusion

Anastomotic leaks from colorectal anastomoses dramatically increase the morbidity and mortality of colorectal operations. However, the risk of this complication can be minimized with close attention to the quality of the anastomoses. Minimizing tension, optimizing perfusion, and evaluating the newly created anastomosis are essential to ensure its integrity. Endoscopic visualization and bowel perfusion assessment with fluorescent dyes are simple techniques that can be readily incorporated into any colorectal operation.

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