The Importance of Intraluminal Anastomotic Fecal Contact and Peritonitis in Colonic Anastomotic Leakages

An Experimental Study

BIAGIO RAVO, M.D.,*|| NABIL METWALLY, M.D.,§ PIERRE CASTERA, M.D.,†
PAUL J. POLANSKY, PH.D.,‡ RALPH GER, M.D.,*

Ravo B, Metwally N, Castera P, Polansky PJ, Ger R. The importance of intraluminal anastomotic fecal contact and peritonitis in colonic anastomotic leakages: an experimental study. Dis Colon Rectum 1988;31:868-871.

An experimental, randomized, prospective study was performed in 64 dogs to evaluate the effect of fecal loading, solely, or in combination with induced peritonitis, on colonic anastomosis. The animals, none of which had bowel preparations, were randomized into four groups. Group I underwent sigmoid resection and standard open end-to-end anastomosis; Group II underwent sigmoid resection and an intracolonic bypass procedure; Group III underwent experimentally induced fecal peritonitis, sigmoid resection, and anastomosis; Group IV underwent induction of fecal peritonitis, sigmoid resection and an intracolonic bypass procedure. Using Fisher's exact test, results indicate a more statistically significant increased leak rate in Group III than in Group II ($P = .04$), and Group III than in Group IV ($P = .03$), but no statistically significant anastomotic leak rate between the peritonitis (III and IV) and the nonperitonitis (I and II) groups. A very significant statistical increase in leak rate ($P = .002$) was observed when comparing the 25 percent leak rate of Groups I and III (anastomosis subjected to fecal contact) with the 0 percent leak rate of Groups II and IV (anastomosis excluded from fecal contact) regardless of the peritonitis. This study suggests that the intraluminal contact of fecal loading at the colonic anastomosis is a more significant factor in anastomotic complications due to dehiscences than peritonitis *per se*. It follows, therefore, that if feces can be excluded from intraluminal contact with an anastomotic site, an anastomosis can be safely performed even in the presence of treated peritonitis. [Key words: Fecal loading; Peritonitis; Anastomosis; Intracolonic bypass procedure; Leakage, Colostomy]

*From Winthrop University Hospital, Mineola,**
State University of New York, Stony Brook,†
Pfizer, Inc., New York, New York,‡ and
Ain Shams University,
Cairo, Egypt§

Address reprint requests to Dr. Ger: Winthrop University Hospital, 259 First Street, Mineola, New York 11501.

||Present address for Dr. Ravo: via Roberto Alessandri 50, Rome, Italy 00151.

AS LONG AGO as the Halsted era[1] fecal loading has been implicated as one of the major causes of anastomotic disruption. A clinical study by Irvin and Goligher[2] showed that poor mechanical bowel preparation was associated with a significantly higher incidence of anastomotic dehiscences and suggested that neither intraoperative fecal soiling nor peritoneal sepsis played a major part in anastomotic complications. Experimentally, Hawley[3] has shown that fecal soiling or peritoneal sepsis may impair the healing of colonic anastomoses. However, investigators[3-7] studying peritonitis and anastomotic healing failed to prevent the fecal stream from coming in contact with the anastomotic site, and the effect of peritonitis on the healing of an anastomosis has always been evaluated in the presence of intraluminal intestinal content. In 1983 the intracolonic bypass procedure was introduced.[8-11] In this procedure, the fecal flow and intestinal secretions pass uninterruptedly from proximal to distal colon without allowing the fecal content to come into contact with the intraluminal anastomotic site. This was demonstrated in previous experimental studies in which the intracolonic bypass procedure was per-

formed and the severed ends of the proximal and distal colon approximated with two to four sutures only, leaving large gaps to purposely evaluate complete diversion from these gaps. . Results indicated that there was no fecal leakage from the gaps, all of which went on to heal.[8] The same results were demonstrated in the esophagus.[9] The procedure provides a good model for studying anastomoses in the presence of peritonitis and the absence of fecal loading from the anastomotic site. Using this model, a randomized prospective study has been performed to evaluate the effect of peritonitis, with or without fecal loading, on healing of the anastomosis.

Materials and Methods

Sixty-four adult mongrel dogs were prospectively randomized into four groups (Table 1). Randomization was by envelope on the day of surgery. Group I (14 dogs) underwent sigmoid resection and anastomosis. Group II (15) underwent sigmoid resection, anastomosis, and an intracolonic bypass procedure. Group III (18 dogs) underwent the induction of peritonitis, sigmoid resection, and anastomosis. Group IV (17 dogs) underwent the induction of peritonitis, sigmoid resection, anastomosis and an intracolonic bypass procedure. In Groups III and IV the peritonitis was induced by means of a 2-cm colotomy on the antimesenteric border of the sigmoid colon, through a small lower midline incision. The colon was thus returned to the peritoneal cavity and the abdominal incision closed in layers. Therapy for the subsequent peritonitis commenced 3 hours later and included intravenous fluid resuscitation, appropriate antibiotic administration, and a laparotomy where peritoneal toilette was performed and the injured colonic segment excised and reanastomosed. All animals were cared for by the same animal handlers and surgeons, did not receive bowel preparations, and were treated by the same diet, intravenous solutions, and antibiotics. Anesthesia consisted of nitrous oxide, oxygen, and halothane. The animals in Groups I and II received four doses of intravenous sodium cefoxitin and the animals in Groups III and IV received intravenous chloramphenicol and sodium penicillin G for ten days. The anastomoses were performed with 12 interrupted 3-0 silk sutures. In Groups III and IV, 3 liters of saline solution were used for the peritoneal toilette. Forty-eight hours before sacrifice at 5, 10, and 15 days, 200 mCi C14 proline was given intravenously.

All anastomoses were evaluated at the time of death and only anastomotic dehiscences seen by the naked eye were regarded as leaks. All anastomoses were then removed and examined grossly. Some specimens were examined histologically, and all specimens were analyzed for hydroxyproline content and radioactivity counts (this will form the subject of a separate communication). Cultures were taken from the peritoneal cavity of animals in Groups III and IV. Solid food feeding started on the third postoperative day. The statistical studies were carried out by the Fisher's exact test.

TABLE 1. *Randomization of 64 Female Dogs by Groups*

Group	No. of Dogs	Procedures
I	14	No bowel preparation; resection + anastomosis; (evaluation of anastomosis with fecal contact)
II	15	No bowel preparation; resection + intracolonic bypass procedure + anastomosis; (Evaluation of anastomosis without fecal contact)
III	18	No bowel preparation + peritonitis; resection + anastomosis; (Evaluation of anastomosis with fecal contact and peritonitis)
IV	17	No bowel preparation + peritonitis; resection + intracolonic bypass procedure + anastomosis; (Evaluation of anastomosis without fecal contact and with peritonitis)

The operative technique of the intracolonic bypass procedure has previously been described.[12,13] The Coloshield™ (manufactured by Deknatel, Lake Success, New York) comes in three diameters (32 mm, 38 mm, 44 mm) and is a soft pliable tube that resembles a surgical glove and can adapt to colonic contractions; it is not a stent. It is important to anastomose the Coloshield to the submucosa of the everted proximal colon by anterior and posterior continuous interlocking 2.0 polyglycolic acid sutures, making sure that the throws are close enough to obtain a watertight anastomosis. This will allow the Coloshield to protect the anastomosis for at least two weeks before it is naturally expelled from the anus after two to three weeks.

Results

Group I (14): Six dogs were killed at 5 days, five at 10 days, and three at 15 days. One dog of the group to be killed at 10 days died following an abdominal wound disruption. There were three leaks (21 percent), one of which was associated with a pelvic abscess (Table 2).

Group II (15): Six dogs were killed at day 5, four at day 10, and five at day 15. There were no mortalities, leaks, or wound infections. One dog developed a partial bowel obstruction at the site of the tubo-colonic anastomosis due to a technical error; the anterior and posterior walls of the tubocolonic anastomosis had been sutured together, and the proximal bowel was distended and the site of a perforation.

Group III (18): Eight dogs were killed on day 5, three on day 10, and seven on day 15. There were four deaths. Five leaks (28 percent) were noted; in two animals killed at day 15 the leaks were associated with abscess formation. Six wound infections occurred (Table 2).

TABLE 2. *Results (64 Female Dogs)*

Group	Total No. of Dogs	Day 5	Day 10	Day 15	% L Rate
I	14	6	5	3	
			M 1		21%
		L 2	AWD 1	L 1	
				A 1	
II	15	6	4	5	0%
		PBO 1			
III	18	8	3	7	
		M 2		M 2	
		L 3		L 2	28%
		WI 4	WI 1	WI 1	
				A 2	
IV	17	7	5	5	
		M 1	M 1	M 2	0%
		WI 1	WI 1	W 1	
			A 1		
			PBO 1		

M: mortality; L: anastomotic leakage; WI: wound infection; A: abscess; PBO: partial bowel obstruction; AWD: abdominal wound disruption.

Group IV (17): Seven dogs were killed on day 5, five on day 10, and five on day 15. Three wound infections occurred, but there were no leaks. One intra-abdominal abscess and one partial bowel obstruction were noted in two dogs killed at day 10.

Cultures from the peritoneal cavity of the animals of Groups III and IV grew multiple organisms, including coliforms, bacteroids, peptostreptococci, enterococci, and clostridia. In comparing leak rates among groups it was found that there was a statistically significant higher leak rate in Group III than in Group IV ($P = .03$), and in Group III than in Group II ($P = .04$).

No statistically significant leak rates were found when the peritonitis groups (III and IV) were compared with the nonperitonitis groups (I and II). Instead, a more statistically significant increase in leak rate ($P = .002$) was found at the anastomosis with fecal contact (Groups I and III) than in the anastomosis without fecal contact (Groups II and IV) regardless of peritonitis.

Discussion

An incision in the bowel wall leads to an inflammatory response that is necessary for healing. A colonic anastomosis heals completely in about 12 to 14 days. The most critical period in the healing of an anastomosis is in the first three to five days. During this period there is an increased collagen lyses, which means that the two approximated cut ends of the bowel are held together mainly by the uniting sutures. The increased collagen lyses in the first few days leads to a low bursting strength at the anastomotic site that is easily demonstrable. By the 12th to 14th days, however, the pressure needed to disrupt

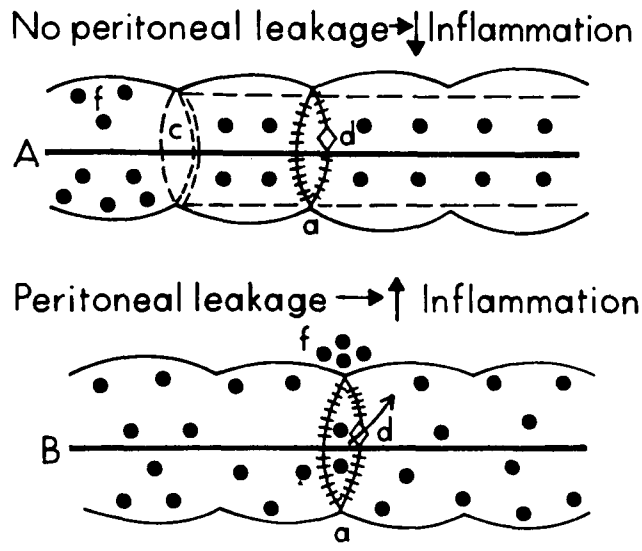

FIG. 1. Significance of fecal exclusion from the anastomotic site. A. Fecal exclusion from the anastomosis by the Coloshield results in the prevention of fecal leakage into the peritoneal cavity through dehiscences. B. No fecal exclusion from the anastomosis results in fecal leakage into the peritoneal cavity through a dehiscence. f: feces; c: Coloshield; d: dehiscence; a: colonic anastomosis.

an anastomosis is much higher than the pressure needed to burst a normal colonic segment.[4,5,14] Goligher *et al.*[15] have shown that a Gastrografin® enema, performed 14 days after low anterior resection, yielded a 69 percent radiologic leak rate at the anastomotic site. Gastrografin enemas performed in the early postoperative period may show that the true radiologic rate is even higher. In this study there were more gross leaks at 5 days than at 10 or 15 days.

Anastomotic gaps between sutures are likely to be present from the time of operation. If fecal content could be prevented from leaking through these gaps, the inflammatory process could be limited; this is especially so in the presence of peritonitis where the bowel wall is additionally inflamed.

This study has demonstrated that if the intraluminal fecal content can be prevented from coming into contact with the anastomotic site and leakage into the peritoneal cavity avoided, especially in the presence of peritoneal inflammation, the leak rate can be reduced. This experimental study reinforces the contention of Irvin and Goligher[2] and other investigators that intraluminal fecal content (fecal loading), even more than intraoperative fecal soiling and peritonitis, is responsible for an increased rate of anastomotic disruption and leakage. If continued contamination of the peritoneal cavity by the intraluminal bowel content can be prevented, the peritoneal inflammatory process becomes self-limiting and an anabolic collagen deposition can occur early in the healing process (unpublished data) (Fig. 1).

If Group I is considered as a control group for Group III, as has been done by authors who have studied the effects of peritonitis on an anastomosis, there is a high anastomotic leak rate in Group III; others have confirmed this.[3-7] Excluding the fecal content from the anastomotic site, by the Coloshield, however, even in the presence of peritonitis, as in Group IV, leads to a significant lower leak rate in this group, demonstrating the importance of fecal exclusion from the anastomosis. Regardless of peritonitis, when the 25 percent anastomotic leak rate of Groups I and III (anastomosis with intraluminal fecal contact) is compared with the 0 percent leak rate of Groups II and IV) (anastomosis without intraluminal fecal contact) a significant statistical increase in leak rate ($P = .002$) is observed in Groups I and III, indicating again the important role of the presence of feces in anastomotic complications regardless of peritonitis. This study suggests that the presence of fecal loading at the anastomosis, with or without peritonitis, is one of the main factors responsible for the anastomotic complications rather than peritonitis *per se*, as has been contended in the past.[3-7]

The classic view is that anastomoses in the presence of peritonitis should be discouraged. This may be questioned, however, because in this experiment, where the fecal stream is being intraluminally diverted from the anastomosis by the intracolonic bypass procedure, anastomoses were safely performed in the presence of peritonitis. In a clinical setting, 28 patients with perforated diverticulitis and peritonitis, for whom many surgeons would have performed either a two-stage procedure or added a covering colostomy, have had primary resections and intracolonic bypass procedures performed without anastomotic leaks.[13] Since this report 45 patients have been treated successfully. These results corroborate the experimental data. As a result of these experimental and clinical data, it is suggested that primary anastomoses can be performed in those emergency situations where the colon is unprepared, such as trauma, perforation, or obstruction, or whenever a covering colostomy is considered necessary; the fecal flow is diverted and prevented from coming in contact with the anastomosis, with the intracolonic bypass procedure.

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