Evaluation of serosal patch supplementation of surgical anastomoses in intestinal segments from canine cadavers

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Objective—To compare leakage and maximum intraluminal pressures of intestinal anastomoses with and without serosal patch supplementation in dogs.

Sample—Healthy small intestine segments from cadavers of 2 dogs euthanized for reasons unrelated to the study.

Procedures—12 enterectomy constructs were created by anastomosis of intestinal segments with a standard simple continuous suture pattern. Half of the constructs were randomly selected for additional serosal patch support. Leakage and maximum intraluminal pressures were measured in and compared between patch-supplemented and nonsupplemented constructs.

Results—Mean ± SD leakage pressure was significantly greater for the patch-supplemented anastomoses (81.8 ± 6.7 mm Hg) than for the nonsupplemented anastomoses (28.0 ± 6.7 mm Hg). Maximum intraluminal pressures were not significantly different between the groups.

Conclusions and Clinical Relevance—Serosal patch–supplemented anastomoses were able to sustain a significantly higher pressure before leakage than were nonsupplemented anastomoses in intestinal specimens from canine cadavers. The serosal patch supplementation may protect against leakage immediately after enterectomy in dogs. (*Am J Vet Res* 2013;74:1138–1141)

Gastrointestinal surgical techniques such as biopsy specimen collection, foreign body removal, or tissue resection and anastomosis are commonly indicated for diagnosis and treatment of diseases of the small intestine.[1–4] After enterectomy, surgical anastomoses can fail, resulting in leakage during the first 3 to 5 days after the procedure. Intestinal leakage or dehiscence has the potential for devastating consequences and commonly leads to peritonitis and, unless successfully treated, to death.[1–4] Leakage within 24 hours after surgery will happen when the intestinal wall is not viable or when the surgical technique used was inappropriate. The reported incidence of intestinal leakage and dehiscence is between 3% and 28% of enterectomies performed.

Presence of a foreign body within the intestine, hypotension, hypoalbuminemia, or peritonitis at the time of enterectomy are risk factors for leakage and dehiscence.[1,2] Decreasing the risk of leakage after intestinal resection and anastomosis is important for improving the long-term outcome of gastrointestinal surgery in dogs and cats (particularly in patients with 1 or more risk factors). Supplemental techniques reported to achieve this include serosal patching, omental wrapping, polyglycolic acid mesh supplementation, peritoneal graft wrapping, and fibrin sealant application,[1–12] yet little objective evidence exists that these techniques provide mechanical support or protection against leakage in the postoperative period.

In a case series[7] involving 11 dogs and 1 cat with hollow viscus perforation and leakage attributable to enterotomy, intestinal perforation, anastomosis, or cystotomy, the leakage was successfully resolved through serosal patching. Serosal patching refers to placement of a healthy segment of intestine in direct serosal-to-serosal contact, effectively creating full-thickness intestinal coverage. The term serosal patch, although common in the literature, does not clearly describe the nature of the mechanical and physiologic support provided by the supporting intestinal segment. The purpose of the study reported here was to evaluate the leakage pressure of small intestinal anastomoses supplemented with a serosal patch in dogs. The hypothesis was that anastomoses supplemented with a serosal patch would have similar failure characteristics as the anastomoses performed without a serosal patch.

Materials and Methods

Specimens—Healthy small intestine was harvested from 2 dogs immediately after euthanasia via IV infu-

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sion of pentobarbital-phenytoin sodium.[a] The dogs had been euthanized for reasons unrelated to the study. Intestines were cut into 40- to 60-cm segments, placed in sterile saline (0.9% NaCl) solution, and stored at 4°C for a period of < 72 hours. The segments were removed from the saline solution and cut into thirty 6- to 8-cm sections for use in anastomoses construction. Six intestinal sections were allocated to a control group. Twelve sections were randomly assigned to create anastomosis alone, yielding 6 enterectomy constructs, and 12 were allocated to create anastomosis plus serosal patch supplementation, yielding 6 additional enterectomy constructs. All constructs were prepared during 1 construction session.

In preparation for enterectomy simulation, the cut edge of each intestinal section was debrided to ensure that the 2 apposed sections were free of everted mucosa. Anastomoses were performed in accordance with a standard surgical technique[13] by use of 4-0 glycomer 631 swaged onto an included CV-23 half-circle, 17-mm tapered needle.[b] All anastomoses were performed by the same investigator (LAH), who placed 2 simple continuous sutures, one starting at the mesenteric border and the other at the antimesenteric border. Each line was secured with 4 complete square knots (8 throws). The simple continuous pattern was performed with suture bites placed 2 to 3 mm apart and 2 to 3 mm from the tissue edge. Tension was placed on the suture to draw it tight after each pass through the tissue to maintain constant noncrushing tension on the tissue.[10] Once an anastomosis was completed, the construct was replaced in the saline solution to prevent drying of the tissues.

Construction of the serosal patch was performed by placing a single section of intestine perpendicular to the anastomosis. The technique used was a modified version of the methods described by Crowe[7] (similar to the 2- or 3-segment serosal patching described, with a healthy intestinal segment wrapping around the damaged intestine) and in a veterinary surgery textbook.[14] Partial thickness sutures of 4-0 USP glycomer 631 were used to create the patch 1 cm from (but parallel to) the anastomosis, starting at the mesenteric side. The segment was secured in place with a simple continuous partial thickness technique directed toward the antimesenteric margin to finish across the mesentery from the initial mesenteric knot. The segment of intestine used for the patch was then rolled over the anastomosis, and a second simple continuous partial thickness suture line was created in a similar manner. The patch was sutured so that any tension on the anastomosis was borne by the serosal patch. Sutures were secured with 4 square knots at each end **(Figure 1)**. Upon completion, all constructs were placed in saline solution and stored at 4°C.

Pressure testing—Pressure testing of each construct was performed in random order as described elsewhere.[15] Intestinal sections in the control group were tested in the same manner as those in the other 2 groups. A 4-cm-long, 12F catheter was inserted 3.5 cm into 1 end of a section, which was then sealed with a Doyen clamp placed from the mesenteric border as close as possible to the catheter (approx 3 cm from the catheter tip). Right-angle Rochester-Carmalt forceps were applied tightly parallel to the catheter and intersected with the Doyen clamp at a 90° angle to prevent leakage. A microtip pressure transducer[c] was introduced 3 to 4 cm into the intestinal lumen at the opposite end of the section. The transducer, which was calibrated before each experiment, was connected to a data acquisition system[d] and secured with a Doyen clamp placed across the intestine and transducer. The instrumented section of intestine was then submerged in a plastic tub filled with water. The infusion catheter system was primed with saline solution that contained methylene blue (1 part methylene blue[e] to 500 parts saline solution). This colored saline solution was delivered at a rate of 999 mL/h with an infusion pump.[f]

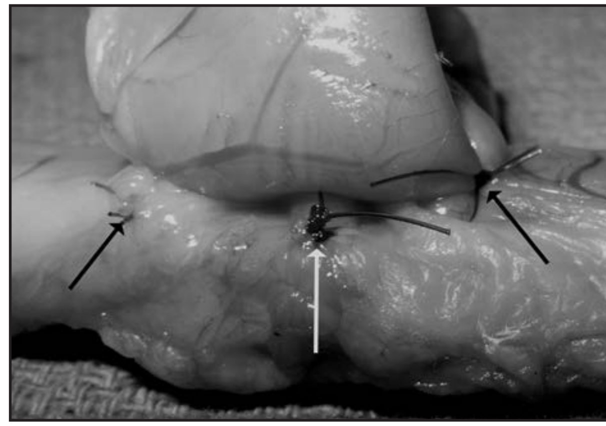

Figure 1—Photograph of an enterectomy plus serosal patch created with segments of healthy canine cadaveric small intestine. The enterectomy site (white arrow) is covered by the serosal patch that was created with 2 simple continuous, partial-thickness suture lines (black arrows).

The system was purged of air, recording of pressure measurements was begun, and infusion of the saline solution was started. Leakage pressure was defined as the pressure at which dye was first observed to leak from the constructs. Once the initial leakage pressure was recorded, testing was allowed to continue until there was a catastrophic failure of the intestine, the intraluminal pressure reached a plateau, or the maximum pressure for the sensor system was achieved. The maximum intraluminal pressure reached and method of failure for each section were recorded.

Statistical analysis—Results for intestinal anastomoses were analyzed with commercially available software.[g] The Shapiro-Wilk test was used to evaluate whether leakage-pressure data were normally distributed. One-way ANOVA was performed to compare leakage pressure and maximum intraluminal pressure between groups. Data are reported as mean ± SD. Values of $P \leq 0.05$ were considered significant.

Results

Mean ± SD leakage pressure was significantly ($P < 0.001$) higher for the anastomoses in the canine cadaveric intestinal segments that underwent enterectomy supplemented with a serosal patch (81.8 ± 6.7 mm Hg) than in those that underwent enterectomy alone (28.0 ± 6.7 mm Hg). Maximum intraluminal pressure was not significantly ($P = 0.886$) different between construct groups (169.8 ± 44.6 mm Hg for enterectomy alone and 146 ± 24.6 mm Hg for enterectomy plus serosal patch). Mild serosal tearing from the anastomosed tissue edge adjacent to the sutures was the mode of failure in the enterectomy-alone constructs. The mode of failure in the serosal patch–supplemented constructs was progressive leakage from 1 or more locations at the mesenteric margin of the serosal patch.

In the control sections, the intraluminal pressure reached a plateau evidenced by gross dye leakage (around the infusion catheter or pressure transducer) or the maximum pressure for the sensor system was achieved. At pressures > 250 mm Hg, the sections had variable evidence of serosal tearing, but there was no leakage through the submucosa or muscularis layers. The maximum intraluminal pressure for the control group was 272.7 ± 22.7 mm Hg. None of the 6 tested sections ruptured or burst. Leakage around the inflow catheter or pressure transducer at the conclusion of testing was detected in 5 specimens, and serosal tearing was evident in 4 specimens.

Discussion

Anastomoses performed with segments of healthy small intestine from canine cadavers leaked at a higher intraluminal pressure when supported with a serosal patch than when no support was present. A principle difference between the technique reported here and that reported elsewhere[7,14] is that we did not place a second segment of intestine at the antimesenteric border but provided protection to 60% to 70% of the anastomotic circumference with only 1 intestinal segment. This modified technique of serosal patch construction has been used for > 20 years without any obvious complications in dogs undergoing enterectomy at Colorado State University. In the present study, the maximum intraluminal pressure was not affected by supplementation with a serosal patch because all enterectomy constructs tested reached a plateau attributable to leakage exceeding the inflow volume.

The anastomoses supplemented with a serosal patch were able to sustain a significantly higher leakage pressure than the unsupplemented anastomoses, providing evidence that the patch could be used to protect against intestinal leakage and its associated complications in dogs undergoing enterectomy. Both types of anastomoses leaked at a pressure higher than the reported jejunal pressure in dogs (6 to 25 mm Hg[16]). The amount of pressure required to produce leakage was defined as the testing pressure at which methylene blue dye began to leak from the construct. It is entirely possible that we could not observe the leakage of the group supplemented with serosal patch as soon as it happened because the anastomoses were completely covered by the patch. However, the patch was placed in a manner to prevent stretching of the anastomosis before the patch was torn from the wall of the intestine. Therefore, the anastomoses supplemented with a patch were subject to less tension until a higher intraluminal pressure was achieved than were nonsupplemented anastomoses.

The maximum intraluminal pressure reached with each construct did not differ significantly. Maximum pressure achieved with the fluid infusion technique used was similar to or greater than the pressures attained in other studies[16,17,h] (15 to 185 mm Hg). The high variability in maximum pressures recorded in these studies may have been attributable to different techniques of anastomosis creation and pressure testing. The leakage pressures attained in the serosal patch constructs in the present study exceeded the reported mean ± SD maximum pressure of 32 ± 6.2 mm Hg in the jejunum of clinically normal dogs.[h]

The mode of anastomosis failure differed between enterectomy construct groups in our study. Anastomoses supplemented with a serosal patch had marked leakage of the methylene blue principally from the mesenteric region. The unsupplemented anastomoses had leakage with mild serosal tearing circumferentially at the sutures bites. These findings suggested that the serosal patch may protect against catastrophic failure (the pressures recorded in this experiment exceeded expected physiologic limits).

Limitations of the present study include the nonphysiologic method of testing and the use of cadaveric tissues, which may hold sutures or behave differently than intestinal tissues in live dogs. Previous leakage testing[17] has demonstrated that sutured sites of enterectomy leak at pressures greater than those expected to cause clinically relevant failures. Although most constructs leak at supraphysiologic pressures, some unpredictably fail at lower than expected pressures. Testing of the fresh cadaver control tissues in the present study was performed to ensure that tissue breakdown had not occurred and to enable us to evaluate the tissue strength relative to results in other studies.[1–4,18–22] The control segments of intestine used sustained supraphysiologic pressure prior to leakage. Histologic evaluation the intestinal segments used was not performed because the dogs were believed to be free of gastrointestinal disease and their intestines macroscopically appeared healthy. Results for the control specimens suggested that the intrinsic tissue properties of the intestine remained intact and were not altered by preservation in saline solution at 4°C. We did not evaluate the continued patency of the segment of intestine used to create the patch. The patches were applied to reproduce a clinical situation, and macroscopically, they appeared to remain patent during the testing. Although the technique for creation of a serosal patch was in some ways different from that reported elsewhere,[7,14] the purpose of the study was not to evaluate the specific technique but rather to demonstrate that serosal patching can be used to protect against initial leakage at enterectomy sites in dogs.

The present study provided evidence to support the beneficial effects of serosal patching at an enterectomy site. A serosal patch provides higher pressure protection against leakage of a surgical anastomosis than an anastomosis alone.

a. Beuthanasia-D Special, Intervet Inc, Merck Animal Health, Summit, NJ.
b. Biosyn, 4-0 USP, provided by Covidien Animal Health, Mansfield, Mass.
c. Mikro-Tip catheter transducer, Millar Instruments Inc, Houston, Tex.
d. SonoLab, Sonometrics Corp, London, ON, Canada.
e. Fisher Scientific, Pittsburg, Pa.

f. Harvard Apparatus, Holliston, Mass.
g. JMP, SAS Institute Inc, Cary, NC.
h. Cochran S, Twedt DC, Boscan P. Evaluation of gastric transit time, motility, and pH during sevoflurane anesthesia in dogs (abstr). *Vet Anaesth Analg* 2011;38:3.

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