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Comparison of staple and suture techniques for end-to-end anastomosis of the small colon in horses

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SUMMARY

Two techniques for end-to-end anastomosis of the small colon were evaluated in each of 6 horses. A simple interrupted suture pattern that excluded the mucosa and was oversewn with an inverting suture was compared with a triangulated double-row pattern of stainless steel staples. Anastomotic sites were evaluated at 2 weeks, 2 months, and 6 months for extent of abdominal adhesions, lumen diameter at anastomotic sites, bursting pressures, and healing response. Clinical postoperative complications were not associated with either technique. At postmortem examination, there was extensive adhesion formation from the mesocolon to the stapled anastomotic site. The suture technique resulted in greater luminal diameters ($P \leq 0.05$), with good apposition of the tissue layers. Staples were missing as early as 2 weeks after surgery, and their loss was associated with separation of the muscularis at later evaluation periods. Regardless of technique, all but one anastomotic segment burst away from the anastomotic site along the mesenteric taenial band. For the 12 anastomoses performed in normal horses, the suturing technique was better than the stapling technique because of significantly larger lumen diameters, better anastomotic healing, and minimal intra-abdominal adhesion formation.

Improvements in diagnostic, anesthetic, and surgical techniques during the past decade have greatly increased the survival rate of horses requiring abdominal exploration for acute abdominal disease. Complications associated with intestinal resection and anastomosis, however, are a major cause of death in such patients. Comparative studies for suturing small intestine,[1-3] large colon,[4-7] and small colon[8] anastomoses in horses have yielded contradictory results. Techniques that provide an adequate anastomotic seal at one segment of intestine,[1,2] leaked at others, causing severe peritonitis.[8] Two-layer inverting suture patterns provide an adequate anastomotic seal; however, there is a tendency for the inverted anastomotic bead to cause intestinal obstruction.[2,8]

End-to-end anastomoses can be performed by means of linear stapling, by triangulating the anastomotic site of the bowel and making 3 overlapping applications.[9-11] This technique can be applied as a totally everting anastomosis along the 3 edges of the triangle or by inverting the mesenteric side of the anastomotic triangle.[10] Two studies have demonstrated the use of the totally everting technique in the small intestine of the horse.[12,13] Eversion of the intestine resulted in adhesion formation and consequent mild abdominal pain.[13] Three weeks after surgery, adhesions were extensive and strictures were associated with the anastomoses. The adhesions and strictures were even greater at 6 and 8 months, with separation of the muscularis by a thin scar.[13] In another study,[a] adhesions associated with a single-layer opposing and everting techniques of the small intestine were also frequent.

In many species, the frequency of breakdown of anastomotic lines and leakage of intestinal contents is greatest in the terminal colon, when compared with more proximal segments. Passage of solid feces through a narrow lumen, increased intraluminal bacterial concentration, a relatively poor blood supply, and increased tissue collagenase activity have been cited as reasons for poor healing in the terminal colon, when compared to more proximal segments of intestine.[14-16] An end-to-end, modified appositional suture pattern can be used successfully for small colon anastomosis in horses; however, the technique is time consuming.[8]

The study reported here was undertaken to compare a triangulated stapled anastomosis with a modified appositional suture pattern in the small colon of the horse. Criteria for comparison included the horse's postoperative clinical course, intestinal adhesion formation, anastomotic lumen diameter, bursting strength, and gross and histologic tissue response.

Materials and Methods

Six healthy horses (4 castrated males and 2 females) of various breeds, ages (mean, 12 years), and weights (mean, 445 kg) were conditioned to the study environment for at least 1 week and had been dewormed with ivermectin (200 μg/kg of body weight, PO) 2 weeks before conditioning. Only horses in good body condition were used.

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[a] Kuder CJ. *A comparison of gambee and everted stapled anastomosis in the jejunum of the horse*. MS Thesis, Michigan State University, East Lansing, 1980.

Starting 48 hours before surgery, each horse was given 2 L of mineral oil[b] and 60 ml of a surfactant[c] every 12 hours for 3 treatments. Hay and grain were withheld for 12 hours before surgery, but continuous access to water was allowed.

After the horses were anesthetized, they were positioned in dorsal recumbency, and sodium ampicillin (20 mg/kg) was administered IV over a 30-minute period. After preparation for aseptic surgery, impervious surgical drapes were applied. An 18- to 20-cm ventral midline skin incision was made just rostral to the umbilicus, over the linea alba. Hemorrhage was controlled by electrocoagulation.[d] The linea alba was incised to expose the peritoneum, which was bluntly incised. The small colon was exteriorized and 2 sites for small colon resection and anastomosis were selected, approximately 1 m and 2 m distal to the transverse colon. Exact resection sites were selected midway between 2 anastomotic loops of the left colic artery and vein.

Feces within the small colon were manually stripped aborally into the rectum. The lumen of the bowel 10 cm oral and aboral to the anastomotic site was temporarily occluded by a circumferential ligature of soft rubber tubing to prevent return of ingesta to the anastomotic site. The exposed segments of the small colon not undergoing resection were covered with sterile towels moistened with warm sterile physiologic saline solution. The mesenteric vessels supplying the segment to be removed were ligated with size 1 polydioxanone suture. The mesocolon between the 2 ligated areas was incised and checked for hemostasis. Crushing forceps were placed across the bowel wall at a 60° angle to the antimesenteric border of the small colon, and 15 cm of small colon was resected by transection along the crushing forceps. Gauze sponges were folded over the exposed intestinal lumen to minimize contamination.

Suture technique—Two stay sutures of size 0 polydioxanone were placed through the cut ends of the small colon, along the mesenteric and antimesenteric taenial bands. Hemostats placed on the ends of the stay sutures were held under slight tension by an assistant to maintain apposition of the cut ends of the small colon during the anastomotic procedure.

The resection and anastomosis (at this site) was closed in a two-layer pattern, using size 0 polydioxanone suture. The first layer comprised simple interrupted sutures placed from the serosa partially through the wall of the small colon so as not to incorporate the mucosa. These sutures were placed 5 mm apart and 3 mm from the wound edges. Approximately 35 to 40 sutures were placed circumferentially around the colon in this fashion. The intestine was cleansed and all contaminated equipment and drapes were discarded. Gloves were changed and new drapes were applied. The second suture pattern consisted of continuous Cushing sutures of size 0 polydioxanone that were interrupted halfway along the anastomosis. The sutures were placed 5 mm apart and 2 mm from the junctional edge of the first sutures. The second anastomotic site was evaluated for any evidence of leakage by releasing the ingesta and passing it through the anastomosis. The anastomosis was cleansed. The defect in the mesocolon was closed with a continuous Lembert patter of size 2-0 polydioxanone suture.

Stapling technique—The second anastomotic site was closed with a mechanical stapling device,[e] using a triangulation method. Three stay sutures of size 0 polydioxanone were triangulated equilaterally through the cut ends of the small colon. The first was temporarily placed at the antimesenteric border, with the remaining 2 placed bilaterally one-third the distance between the mesenteric and antimesenteric taenial bands. Hemostats placed on the ends of the untied stay sutures were held under slight tension by an assistant to maintain apposition of the cut ends of the small colon during the anastomotic procedure.

One edge of the small colon anastomosis along the mesenteric taenial band was inverted into the lumen and the stapling instrument was applied (Fig 1A). Tissue forceps were used to grasp a full-thickness layer of both intestinal walls while the staple instrument was placed along the line to be anastomosed. Care was taken to ensure that a full-thickness layer of both intestinal ends, including the mesenteric taenial bands, were in place prior to locking the instrument in position. The cartridge was then discharged to place a double staggered row of 4.5 mm "B" shaped stainless steel staples through the full thickness of both walls of the small colon to produce an inverted anastomotic line. A scalpel blade was used along the edge of the staple instrument to remove excess tissue, thus leaving an even edge of tissue along the stapled anastomotic line and leaving the stay sutures intact (Fig 1B). The 2 remaining anastomotic lines were repaired in a similar, but everting, fashion with crossing of the rows of previously applied staples (Fig 1C, 1D, and 1E). Crossing of the staples at the inverting/everting junction did not cause the stapler to misfire. Small bleeders on the staple rows were sutured with 4-0 polyglactin 910 or were electrocoagulated.

Each surgeon (Hanson, Nixon) performed only 1 type of anastomosis in all horses. The surgeries were ordered, so that the type of anastomosis on the proximal and distal small colon was alternated in each successive horse.

The anastomotic site was evaluated for any evidence of leakage by passing ingesta through the anastomosis, and the serosal surface was cleansed. The defect in the mesocolon was closed with a continuous Lembert pattern of size 2-0 polydioxanone suture, and the small colon was placed inside the abdominal cavity. The abdomen was rinsed with warm physiologic saline solution (22 mg/kg of body weight) containing 10 IU of sodium heparin/ml and 1,000 IU of potassium penicillin/ml. The fluid was retrieved from the abdominal cavity via suction. A perforated polyvinyl abdominal drain[f] was placed within the abdomen, exiting 5 cm rostral to the skin incision. It was heparinized and closed for postoperative drainage of abdominal fluid.

The linea alba was apposed with a simple continuous suture pattern of a double strand of size 2 polyglactin 910 suture. The subcutaneous tissues were apposed with a simple continuous suture of size 2-0 polyglactin 910. A continuous interlocking pattern of size 0 polymerized caprolactum suture was used to appose the skin.

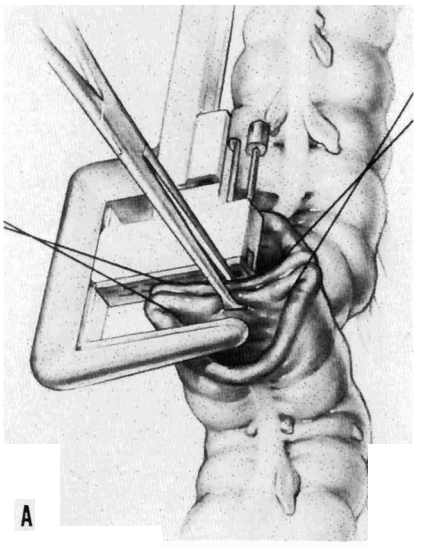
Procaine penicillin G, gentamicin sulfate, sodium heparin, and flunixin meglumine were administered for 3 days after surgery (22,000 IU/kg, IM, q 12 h; 2.2 mg/kg, IV, q 8 h; 40 IU/kg, IV, q 8 h; and 0.5 mg/kg, IV, q 8 h, respectively). Lactated Ringer solution (44 ml/kg) was given IV during the first 12-hour period, after which limited but increasing amounts of alfalfa hay and water were provided. Hay and water were provided ad libitum, within 48 hours postoperatively. Rectal temperature, pulse, respiration, and clinical status were recorded every 2 hours during the initial 12 hours, and every 4 hours thereafter. Mineral oil was administered (4 L) the first postoperative day.

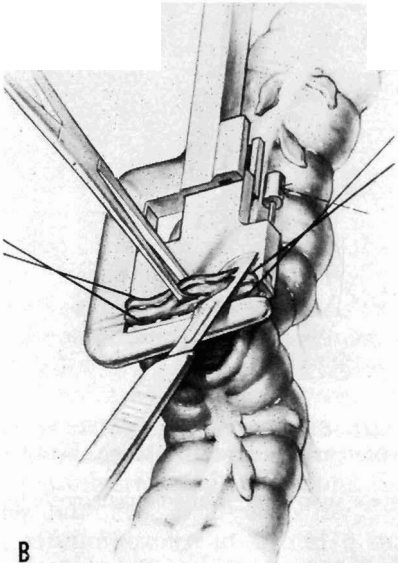
At 2 weeks (n = 2), 2 months (n = 2), and 6 months (n = 2) after surgery, the horses were euthanatized. Postmortem examination of the anastomotic sites and abdominal viscera was performed on each horse. The anastomoses were then resected and evaluated by radiography, a bursting strength test, and histologic examination.

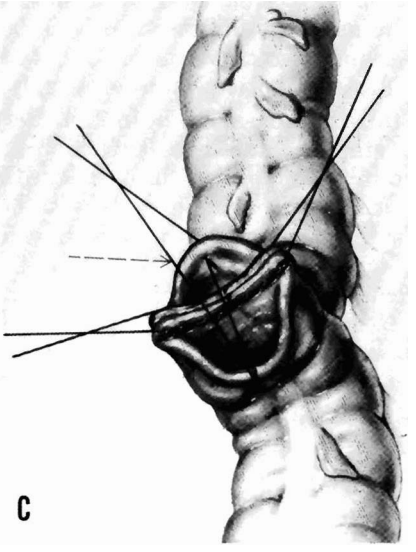
Evaluation

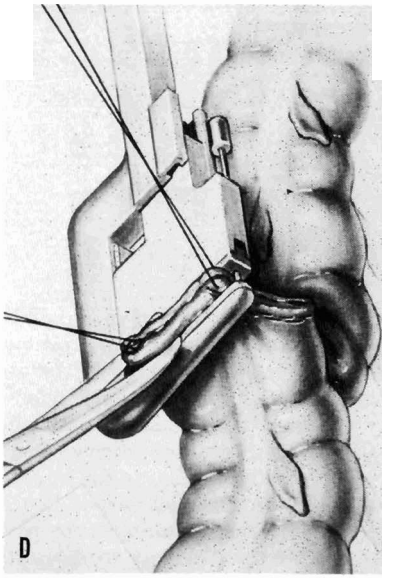
Lumen Diameter—Each end of the removed segment of small colon was placed over the bulb of a 75-ml Foley catheter that had been placed through the cut end of a 60-ml syringe casing. Contrast medium[g] (30 ml) diluted 50% with water was injected into the lumen of the small colon, was dispersed, and then was removed manually. The catheter bulbs were distended with air

[b] Mineral oil, Chevron, Gainesville, Fla.
[c] Dioctynate oral solution, The Butler Company, Columbus, Ohio.
[d] MF 360A, Aspen Laboratories Inc, Littleton, Colo.
[e] TA-90 4.5 mm, United States Surgical Corp, Norwalk, Conn.
[f] Redi-Vacette, Bio-Med, Bourbon, Ind.
[g] Colibar, Veterinary Radiographic Systems, Maitland, Fla.









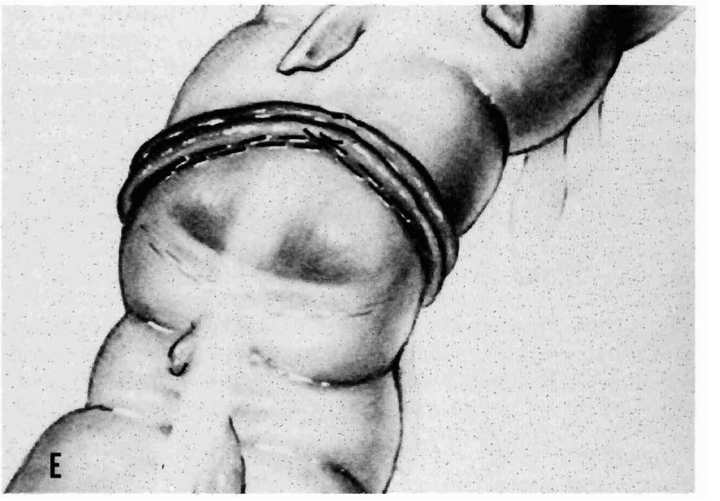


Fig 1—Using the principle of triangulation, the small colon anastomosis is created with 3 applications of a 91.5-mm mechanical stapling device TA-90, 4.5 mm (reprinted with the permission of United States Surgical Corp, Norwalk, Conn).

A—The distal one third of the bowel (mesenteric side) is approximated with traction sutures in an inverting serosa-to-serosa manner. An additional clamp is placed at the mesenteric taenial band to ensure that all tissue layers are incorporated within the jaws just beneath the traction sutures.

B—With the retaining pin pushed into place, the jaws are closed and the staples are discharged. The margin of tissue protruding through the jaws is excised without dividing the traction sutures, before the stapling device is removed.

C—The anterior lips of the bowel at the antimesenteric taenial band are bisected with an everting traction suture (arrow), thus forming a triangle, the base of which is the distal staple line. The end of the distal staple line is included as the jaws close prior to discharge of the staples. The margin of tissue protruding through the jaws is excised, leaving the apical traction suture intact before the stapling device is removed.

D—The remaining side of the triangle is closed with a third application of the stapling device. The end of the distal staple line and the apex of the triangle are included to obtain a secure closure of the anastomosis.

E—The complemented anastomosis has 1 inverted (mesenteric side) and 2 everted staple lines.

TABLE 1—Time to passage of first feces and duration of soft feces in small colon anastomoses

Horse No.	Hours to passage of first feces	Duration of passage of soft feces (h)	Blood in first feces	Abdominal hemorrhage (duration)
1	19	47	No	Yes (48 H)
2	17	101	Yes	No
3	33	182	No	Yes (36 H)
4	23	120	No	No
5	11	144	No	No
6	23	120	Yes	No

until the small colon was sealed with the inside of the casing, thus dispersing pressure over a large area, preventing isolated leakage of air, and facilitating handling of the segments.

Pressurized room air was applied through one Foley catheter, while a mercury manometer attached to the opposite Foley catheter was used to measure the pressure within the intestinal lumen. Each segment was distended to an internal pressure of 15 mm of Hg and was radiographed perpendicular to the mesentery and in a mesenteric-antimesenteric plane. Measurements from these 2 views were used to determine the mean lumen diameter of the anastomotic site. Measurements 4 cm orally and aborally from the anastomosis were used to determine mean normal (control) diameter.

Bursting pressure—Immediately after radiography, the bursting pressure of the isolated segment was determined by a modification of a previously described technique.[17-22,a] One Foley catheter was attached to a pressure transducer connected to a calibrated laboratory physiograph.[h] The segment of small colon was placed underwater and oxygen was infused into the intestine via the opposite Foley catheter at a rate of 1.5 L/min. The bursting pressure was indicated by a simultaneous rapid decrease in the chart recording and leakage of gas bubbles into the water. Two normal segments of small colon from each horse were used as controls and were tested in the same manner.

Statistics—Repeated measures were used with analysis of variance to analyze both lumen diameters at the anastomotic sites and the bursting pressures. Four factors were included in the analysis of lumen diameter: closure (sutured or stapled anastomosis), site (surgery or control site), time postoperatively (2 weeks, 2 months, or 6 months), treatment (staple, suture, or normal), and horse. Since only 2 of the 6 horses could be evaluated at each time point, the horse factor was considered to be nested within time. Significant interactions were investigated, using post-hoc multiple comparisons. The significance level chosen for all tests was $P \leq 0.05$.

Results

Postoperative clinical evaluation—All horses were bright and alert within 24 hours postoperatively and were fed 3 flakes of hay twice daily by 48 hours. The first passage of feces was observed at a mean of 21 hours, with a return to normal fecal consistency at a mean of 119 hours (Table 1). Blood was evident in the first feces of horses 2 and 6. After the third day, no horse required analgesic therapy.

Gross pathologic findings—Adhesions were related to the stapled anastomoses in all horses and to the sutured anastomosis in horse 5. The mesocolon was the source of all adhesions, which were most severe along the everting triangular portions of the stapled anastomosis. Horse 2 also had an omental adhesion to the antimesenteric taenial band surface at the stapled anastomosis. None of the adhesions disrupted the longitudinal anatomy of the small

[h] Model 7D polygraph, Grass Instrument Co, Quincy, Mass.

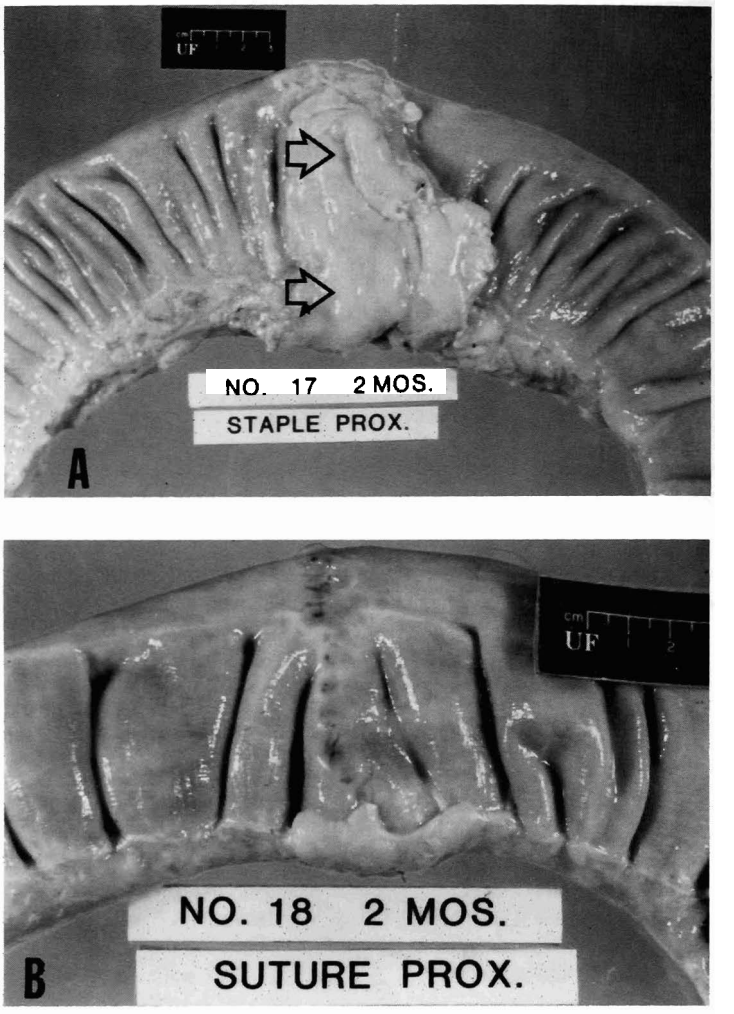


Fig 2—Section of stapled and sutured anastomoses at 2 months.
A—Extensive adhesion formation (horse 3) along stapled anastomosis (arrows).
B—Adhesions are not seen along sutured anastomosis (horse 4).

colon. Adhesions were not associated with the sutured anastomosis after the 2-week evaluation. The stapled anastomoses, however, had as many adhesions at 2 months (68% of anastomotic circumference; Fig 2) and 6 months (58% of anastomotic circumference) as were found at 2 weeks (52% of anastomotic circumference).

Moderate full-thickness inversion of the nontaenial portion of the stapled anastomosis was found at 2 weeks. Minimal to no inversion of the anastomotic line was found at 2 and 6 months. Mucosal depressions had developed in areas where staples had migrated from anastomotic sites. At 6 months, horse 2 had multiple areas of intestinal wall thinning associated with staple loss. Complications were not evident at the inverting/everting intersections of the stapled anastomoses.

For the sutured anastomoses, tissues were accurately aligned at all evaluation periods. The anastomotic site could be determined only by the presence of suture granulomas.

Lumen diameter—Lumen diameters for all anastomoses were smaller than control lumen diameters at 2 weeks, but were larger than control lumen diameters at 2 months and 6 months (Table 2). The anastomotic lumen

TABLE 2—Lumen diameters at stapled and sutured anastomoses

Horse No.	Time after surgery	Lumen diameter (mm)			
		Stapled anastomosis	Control	Sutured anastomosis	Control
1	6 Mo	73.5	71.4	84.4	75.9
2	6 Mo	80.9	73.9	84.1	75.2
3	2 Mo	68.6	70.3	85.4	86
4	2 Mo	64.4	71	75.9	74.7
5	2 Wk	50.4	70.1	55.6	70.2
6	2 Wk	62.2	77.3	60.9	76.8

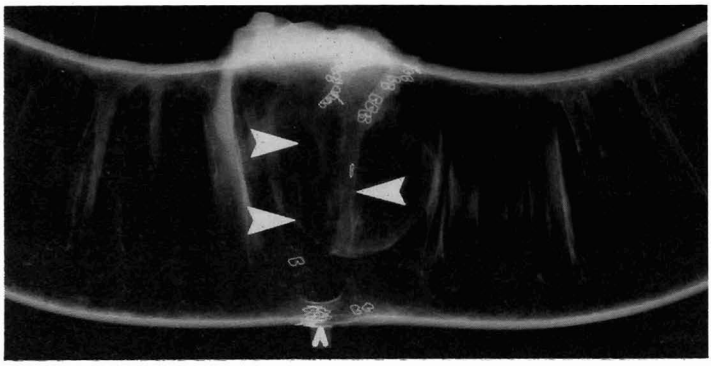


Fig 3—Radiograph of stapled anastomosis at 6 months (horse 2). Notice missing staples in the everted nontaenial portion of the small colon (arrowheads).

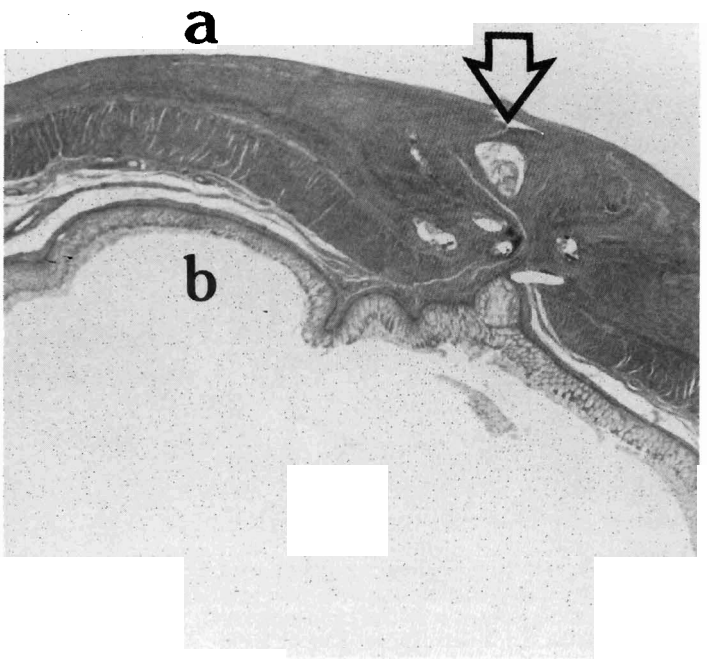


Fig 4—Photomicrograph of section from stapled anastomosis at 2 weeks (horse 5). Notice eversion of mucosa (arrow) between apposed muscular bundles; a = serosal surface, b = mucosal surface. Holes in tissue indicate where staples had been applied. Masson Trichrome stain; × 5.5

diameters increased at 2 months and 6 months postoperatively, whereas there was no significant change in control lumen diameters (Table 2). For the entire evaluation period, the lumen diameter at the sutured anastomosis was an average of 6 mm greater than that at the stapled anastomoses ($P \leq 0.05$).

Radiography revealed that staples were missing from the anastomotic site as early as 2 weeks (7% of anastomosic circumference), but no defects in staple "B" formation were evident in the remaining staples. A higher percentage of staples was missing along the anastomotic line in horses evaluated > 2 weeks (av, 11% and 33% of anastomotic circumference at 2 and 6 months, respectively). Although staples were missing from both the inverting and everting staple lines, a higher percentage of staples were missing from the everted nontaenial portion (66% of anastomotic circumference) than from the inverting period (17% of anastomotic circumference) of the small colon (Fig 3).

Bursting strength—Twenty-four segments of small colon (6 stapled, 6 sutured anastomoses, and 12 normal segments) were evaluated for bursting strength. Of the 12 anastomotic segments, 11 burst at the mesenteric taenial band at a distance from the anastomotic line. One stapled anastomosis (horse 5 at 2 weeks) had burst at the inverting portion of the staple line where an adhesion from the mesocolon had attached. Overall strength of each anastomosis could not be evaluated, since 11 of the anastomoses burst elsewhere along the small colon segment. An analysis of variance, however, was done to determine whether differences could be detected in small colon strength across time or due to type of treatment (staple, suture, or normal). The data failed to present sufficient evidence to conclude such differences existed.

Histopathologic findings—At 2 weeks, all anastomotic lines were apposed, but the mucosa did not bridge the anastomosis. There was obvious inversion into the lumen at the inverted mesenteric stapled edge. The remaining stapled edges were completely everted, with protrusion of the mucosa between the apposed muscle bundles (Fig 4). Thickened serosa blended into adhesions along the everted portions. The sutured anastomoses were apposed with plugs of fibrin, inflammatory cells, and maturing granulation tissue, which extended between apposed incisional edges. Inflammation was greater around sutures than around staples and consisted of macrophages, neutrophils, and eosinophils (Fig 5).

At 2 months, the mucosa was intact, bridging the sutured anastomoses. The stapled anastomoses still had sections not covered with mucosa, especially along the inverted edges. Although a dense but narrow band of connective tissue held all anastomotic sites together, healing did not appear to be complete. Connective tissue bridged wide gaps between adjoining muscle layers along the everting stapled anastomoses where staple migration or loss had occurred. Other sites of both types of anastomoses had connective tissue bridging the gaps that was in the form of nodular plugs and that caused some focal thickening of the wall.

At 6 months, all anastomotic sites were healed with dense fibrous connective tissue, and mucosal covering was complete. Portions of the everted stapled line where staple migration had occurred had a wide, thin band of connective tissue between cut ends of muscle layer, resulting in poor apposition (Fig 6). The suturing technique resulted in better apposition of the muscle layers (Fig 7). Suture material was contained in granulomatous and eosinophilic inflammation. Radiographic evaluation of the stapled anastomotic segments revealed that staples were missing along the everted nontaenial part of the anas-

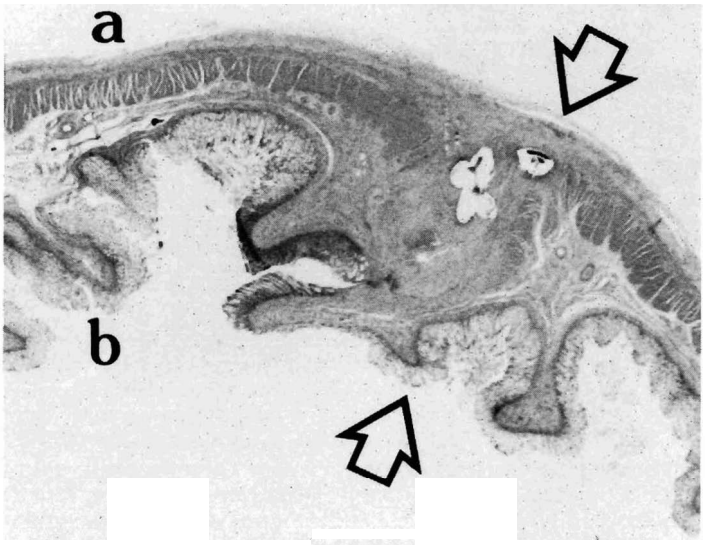


Fig 5—Photomicrograph of section from sutured anastomosis (between arrows) at 2 weeks (horse 5). Although inflammation is greater than the stapled anastomosis in Figure 4, there is good apposition of all tissue layers; a = serosal surface, b = mucosal surface. Holes in tissue indicate where sutures had been applied. Hematoxylin and eosin stain; × 5.5

tomosis where thinning of the tissues was evident (Fig 8).

Discussion

Stapling instrumentation continues to be used in gastrointestinal surgery with increasing frequency. Stapled anastomoses have been shown to be as safe as hand-sewn anastomoses in prospective clinical trials in human surgery.[23-28] Controversy continues, however, as to whether stapling decreases operative time or results in more ideal anastomotic healing.[29,30] Caution must be exercised in correlating the success of stapling in human surgery to that in equine surgery. Differences in bowel diameter and thickness, as well as diet, limit the selection of equipment, location, and methods for which it may be used. Triangulation of the descending colon in human surgery results in minimal complications,[11,31,32] but extensive adhesion formation, with postoperative ileus and anastomotic strictures, has been reported with a similar method in the equine small intestine.[13]

Resection and anastomosis of the small colon must provide immediate mechanical strength, minimal deviation in the lumen diameter, and an impervious seal, given the immediate demand for passage of firm feces through an already reduced lumen diameter. Any technique that would decrease tissue trauma would reduce imbalances in collagen lysis and synthesis, resulting in less anastomotic complications and faster healing.[33-36]

The suturing technique we used was a modification of a method previously reported for small colon anastomosis in the horse.[8] Mucosa was excluded from the suture bites to minimize mucosal eversion between sutures, to promote a more physiologic apposition of the bowel, and to decrease anastomotic bead formation.

The stapling technique was chosen over other end-to-end stapling techniques, because the thickness of small colon was excessive for 2-layer inverting mechanical stapling devices.[i] Although the stapling was faster to perform, it was technically demanding and created special problems dealing with the thick taenial bands. Full-thickness inversion of the mesenteric side of the anastomosis was the most difficult to achieve because of the mesenteric blood vessels and the closely associated mesenteric taenial band. Careful triangulation to align the taenial bands and multiple clamps or stay sutures on the inverted edge was needed before this first critical staple row could be applied. The 2 inverting/everting junctional edges of the triangulated anastomosis created no special clinical complications. Persistent oozing of blood along the anastomotic line was a problem in all horses that required electrocoagulation or, in more severe cases, isolation with a suture to stop hemorrhage. This is a major complication of the technique and, if not properly controlled, can result in postoperative hemorrhage necessitating reexploration of the abdomen.[32] Other than the

[i] GIA, United States Surgical Corporation, Norwalk, Conn.

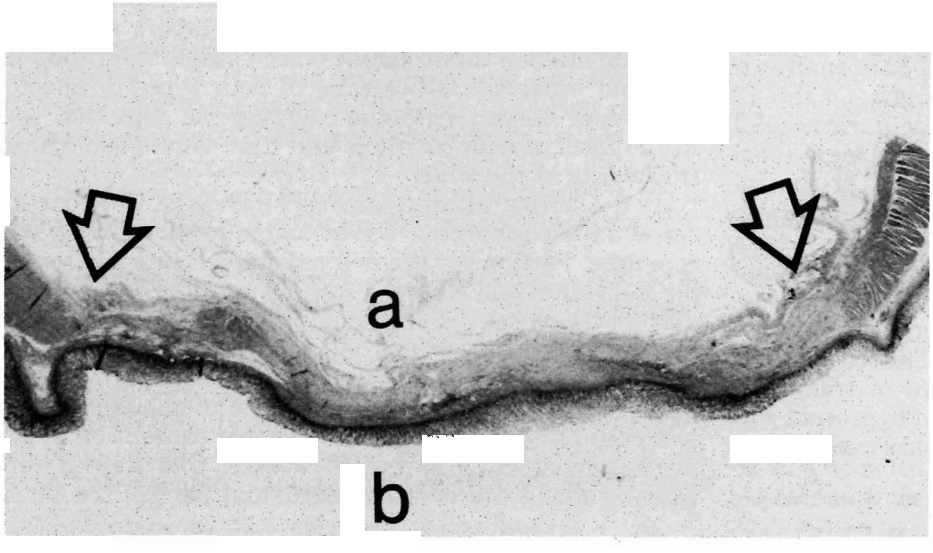


Fig 6—Photomicrograph of section from stapled anastomosis at 6 months (horse 2). Extensive deposition of connective tissue (between arrows) has resulted in poor apposition of the muscular and submucosal layers; a = serosal surface, b = mucosal surface. Hematoxylin and eosin stain; × 5.5.

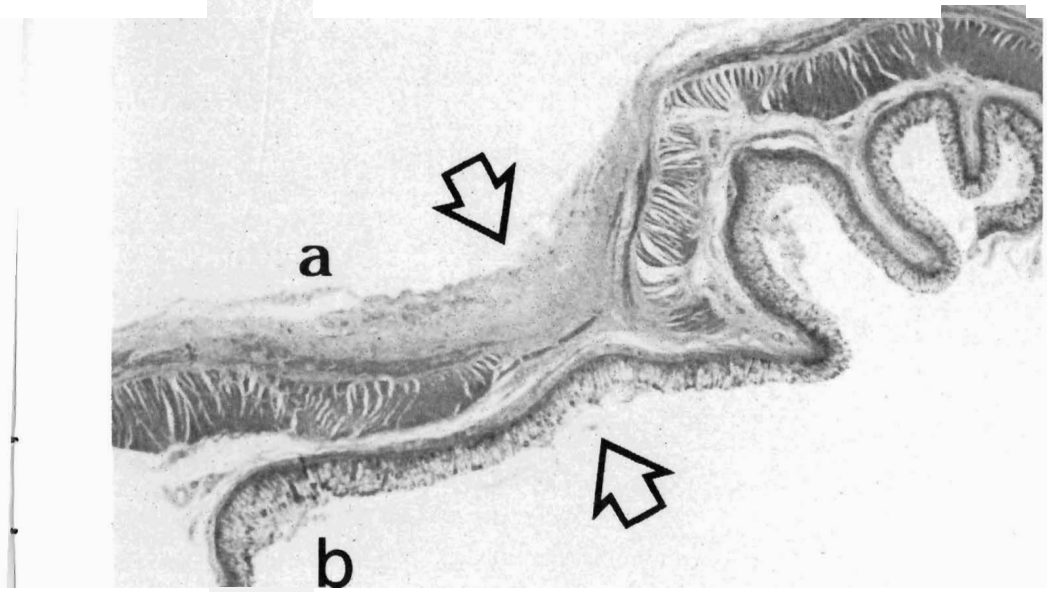


Fig 7—Photomicrograph of section from sutured anastomosis (horse 2) at 6 months. Minimal thinning with good apposition of the bowel segments is evident (arrows); a = serosal surface, b = mucosal surface. Hematoxylin and eosin stain; × 5.5.

transient passage of bloody feces (horses 2 and 6) and transient hemoperitoneum (horses 1 and 3), clinical complications were not noted.

Eversion of two thirds of the anastomotic line with the stapling technique resulted in more postoperative adhesion formation than did the suturing technique. The adhesions probably were the result of mucosal eversion, as previously described in horses.[13] Although adhesions were extensive along the anastomotic line, they did not interfere with the longitudinal anatomy of the small colon. In horse 1, a 3- × 12-cm foramen developed at the stapled anastomosis site by the mesocolon attaching to the antimesenteric taenial surface. This foramen was a potential site for intestinal incarceration.

Although staples were missing from the anastomoses as early as 2 weeks after surgery, clinical complications were not encountered. Many staples were missing from the everted nontaenial portion of the small colon, perhaps because of poor tissue compression or necrosis of the everted mucosa between the staples. At 2 and 6 months, areas of the stapled anastomoses that had lost staples had poor apposition of the muscular layers and a wide but thin collagen scar between the muscle layers (Fig 6 and 8). This defect was not as severe where the staple line was intact. The suturing technique had minimal deposition of fibrous tissue at the anastomosis, compared with the stapling technique. The taenial bands at the suture anastomoses did not heal with more collagen deposition than were seen in the nontaenial saccular portions.

Bursting pressures were chosen as strength indicators of the anastomotic site in this and similar experiments, because the applied pressure represents a constant stress applied evenly to the anastomotic site.[8,17-21,37,38] The small colon burst distant from the anastomotic line in all but 1 specimen. As a result, the bursting pressures did not accurately evaluate the anastomotic strength. Normal colon segments burst at pressures and locations similar to those for the anastomotic segments. The limited value of bursting pressures in evaluation of equine small colon strengths has been reported.[8] We considered tensile testing of a representative fixed width of bowel harvested across the anastomotic line for evaluating bowel strength. However, the choice of taenial or nontaenial bowel wall and the random distribution of strengthening adhesions and weaker inflamed areas would have complicated assessment of bowel strength by this method.

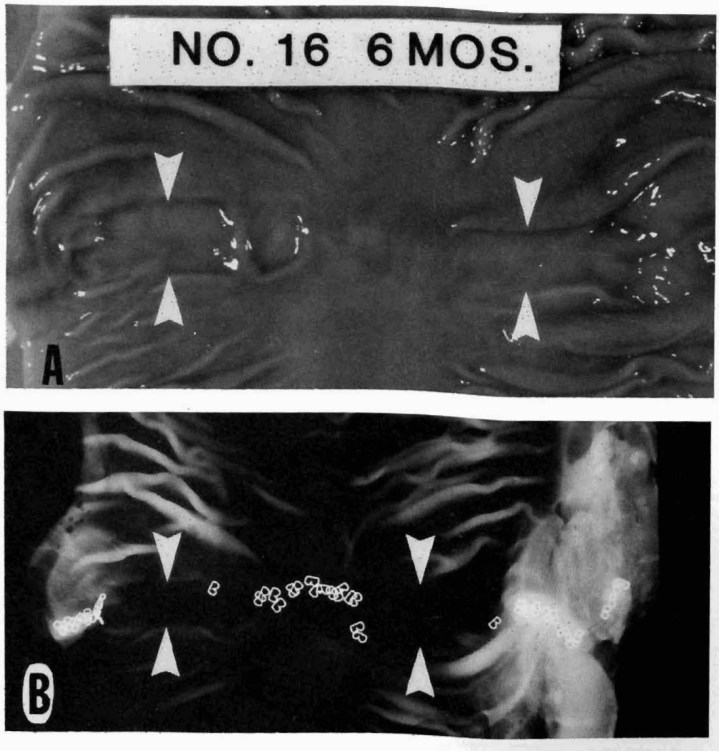


Fig 8—Photograph (A) and radiograph (B) of stapled anastomosis (horse 2) at 6 months. The small colon has been opened along the mesentery. Notice poor apposition of bowel tissue (arrowheads) where staples are missing from the everting nontaenial portion of the anastomosis.

A direct comparison of the 2 anastomoses in each horse provided greater sensitivity by eliminating variability among horses from the comparison. A potentially impor-

tant variable with this experimental model was the proximal vs distal position for anastomosis. In human surgery, there is a higher frequency of anastomotic failure with high, rather than low, large bowel anastomoses.[36,39-42] In our study, this difference was obviated by alternating the types of anastomoses between the proximal and distal positions.

The purpose of this study was to compare the healing response of 2 surgical techniques for resection and anastomosis of the small colon. As a result, the feces were softened prior to surgery to minimize the variability between horses. In the clinical situation, where preoperative softening of the feces is not possible, we would recommend that all ingesta in the large colon be removed via pelvic flexure enterotomy to minimize undue stresses on the small colon for the immediate postoperative period.

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