Evaluation of a Novel Method of Jejunal Anastomosis in Horses using a Hyaluronate Membrane

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A single-layer, appositional, end-to-end anastomosis covered by a bioresorbable, hyaluronate membrane is an effective method for small intestinal anastomosis in horses. This technique provides a larger stomal diameter and reduced surgery times as compared to standard inverting anastomotic techniques, and minimizes the incidence of intra-abdominal adhesion formation. Authors' addresses: Departments of Pathology (Harmon) and Large Animal Medicine (Eggleston, Mueller, Neuwirth), College of Veterinary Medicine, University of Georgia, Athens, GA 30602-7385. Department of Clinical Sciences, University of California, College of Veterinary Medicine, Davis, CA 95616. © 2000 AAEP.

1. Introduction

Diseases of the small intestine requiring surgical intervention remain significant problems in horses admitted to referral hospitals for acute abdominal disease. Postoperative complications most commonly reported which contribute to the poor survival rate of horses with small intestinal disease include intra-abdominal adhesions, anastomotic leakage, ileus, and peritonitis.

Numerous anastomotic techniques have been described for small intestinal anastomoses in horses. Hand-sewn end-to-end anastomoses result in the most anatomically correct alignment of intestinal segments and commonly consist of a simple continuous pattern in the mucosa, oversewn with a continuous Cushing's or Lembert pattern in the seromuscular layer. The hand-sewn, end-to-end, inverting anastomosis provides a tight seal and low incidence of adhesion formation as compared to described appositional anastomoses. Appositional anastomotic techniques including the Gambee, simple interrupted, and Crushing suture patterns result in a greater stomal diameter and more accurate tissue alignment; however, they have been associated with a greater than 50% incidence of intra-abdominal adhesion formation due to exposed mucosa and suture.

Intra-abdominal adhesions are a significant cause of postoperative intestinal obstruction in horses undergoing abdominal surgery and intestinal resection and anastomosis for small intestinal diseases. Adhesions become a clinical problem when they compress or anatomically distort the intestine. This may lead to intestinal constriction, incarceration, or volvulus, predisposing the patient to intestinal obstruction and signs of abdominal
pain, often requiring repeat celiotomy or euthanasia. Numerous clinical trials and laboratory investigations have been devoted to determining methods of minimizing the formation of postoperative intra-abdominal adhesions. Broad spectrum antibiotics, non-steroidal anti-inflammatory agents, heparin, intra-peritoneal administration of high molecular weight solutions, temporary protective barrier agents, omentectomy, and postoperative peritoneal lavage have all been advocated to minimize adhesion formation.3

A commercially available bioresorbable hyaluronate membrane (HA-membrane) developed to reduce postoperative adhesion formation in humans has recently been shown to significantly reduce postoperative adhesion formation in horses.3 Furthermore, use of the HA-membrane caused no adverse effects on intestinal or peritoneal healing.4 The HA-membrane is placed on the serosal surface of the intestine or parietal peritoneum, forming a temporary protective barrier against serosal-serosal or serosal-peritoneal adhesion formation during the early postoperative healing period.3,4

Identification of anastomotic methods that maximize stomal diameter and minimize adhesion formation may be beneficial in reducing the morbidity and mortality associated with abdominal diseases in horses. The purpose of this study was to compare a double-layer inverting anastomosis, a single-layer appositional anastomosis, and a single-layer appositional anastomosis covered by an HA-membrane in the small intestine of horses with respect to adhesion formation, stomal diameter, and surgery time.

2. Materials and Methods
Eighteen healthy adult horses were utilized in the study. Experimental procedures and animal care were approved by the University Animal Care and Use Committee. Horses (n = 6 per group) were randomly assigned to one of three groups determined by the type of anastomoses performed: double-layer inverting anastomoses (DIA), single-layer appositional anastomoses (SAA), and single-layer appositional anastomoses covered by a hyaluronate membrane (SAA + HA-membrane). Whole blood and serum samples were obtained from each horse for hematologic and biochemical evaluation.

Food was withheld for 12 hr before surgery. One hr before induction of anesthesia, administration of potassium penicillin G (22,000 IU/kg IV q 6 h), gentamicin sulfate (6.6 mg/kg IV q 24 h) and flunixin meglumine (1.1 mg/kg IV q 12 h) was initiated. Each horse was anesthetized with xylazine hydrochloride (1.1 mg/kg of body weight IV) followed by ketamine hydrochloride (2.2 mg/kg of body weight IV) and anesthesia was maintained with sevoflurane in oxygen in a semiclosed system. Lactated Ringer’s solution (10 ml/kg/hr IV) was administered during the surgical procedure. Horses were positioned in dorsal recumbency and prepared for aseptic abdominal surgery.

Ventral midline celiotomy and systematic exploration of the abdominal cavity was performed. The jejunum was exteriorized and examined from the ileocecal orifice to the duodenocolic ligament. Sterile saline solution (0.9% NaCl) was used to lubricate the intestine during manipulation. In all horses an end-to-end jejunal anastomosis was performed 10 m proximal to the ileocecal orifice. In DIA horses, a two-layer, end-to-end inverting anastomosis was performed. The mucosa was apposed with 3-0 Polydioxanone in a simple continuous pattern. The seromuscular layer was inverted with 3-0 Polydioxanone using a continuous Cushing’s pattern. Each suture line was interrupted and tied at the mesenteric and anti-mesenteric borders to prevent a purse string affect.

In SAA horses, a single-layer, end-to-end, appositional anastomosis was performed. The mucosa and seromuscular layers were apposed in a simple continuous suture pattern with 3-0 Polydioxanone. The mucosa was meticulously folded below the seromuscular layer with each throw to minimize mucosal exposure. The suture line was interrupted and tied at the mesenteric and anti-mesenteric borders.

In SAA + HA-membrane horses, a single-layer, end-to-end, appositional anastomosis was performed as in SAA horses. Once the anastomosis was complete it was liberally lavaged with sterile saline and then patted dry with a sterile gauze sponge. A one-half sheet of the HA-membrane (6.35 × 7.6 cm) was then applied to the jejunum to completely cover the anastomosis and adjacent mesentery. Surgery times were recorded for each anastomosis. Transection of the jejunum marked the start surgery time, and tying of the last knot of the anastomosis (DIA and SAA) or complete application of the HA-membrane (SAA + HA-membrane) marked the end surgery time. The linea alba was closed with #3 Polylactin 910 in a simple continuous suture pattern and the subcutaneous tissues and skin apposed with 2-0 PDS in a continuous subcuticular suture pattern.

Horses in all groups were euthanatized with an overdose of pentobarbital sodium solution 21 d after surgery. The abdominal incision, peritoneal cavity, anastomoses, and all abdominal organs were evaluated. Adhesions were recorded according to location and severity. Each anastomosis including 20 cm of jejunum proximal and distal to the anastomosis was harvested for determination of stomal diameter and evaluation of anastomatic healing. Jejunal segments were distended with lactated Ringers solution to an intraluminal pressure of 20 mmHg (27.2 cm H2O). Ultrasonographic images were acquired in the transverse plane from each intestinal segment 10 cm proximal and distal to the anastomosis, and at the anastomosis using a 10 MHz linear transducer. The proximal and distal diameters were measured and averaged to serve as controls. Luminal circumferences were obtained using an internal ellipse function, fit to the internal
mucosal margin. The stomal diameter and area were calculated internally from the ellipse function measurements. Images were taken in triplicate and data were recorded on radiographic film. The stomal diameter of each anastomosis was expressed as a mean percentage ± standard deviation of the control.

The variables of horse age and weight were compared using an ANOVA. A 3 × 2 contingency table of surgical procedure vs. adhesion (yes/no) was analyzed using Fisher’s Exact test. A one-way ANOVA was used to determine the effects of the three surgical procedures with respect to the percent reduction of stomal diameter and surgery time. Orthogonal contrasts were used for those instances where there were statistically significant differences among the surgical procedures. Statistical significance was set at p < 0.05.

3. Results

Preoperative hematologic and biochemical values for all horses were similar to values established as normal in our laboratory. All horses recovered from surgery without complications. There were no statistically significant differences in age or weight among the surgical procedure groups (p = 0.8515 and 0.4364, respectively). One horse from each the SAA and SAA + HA membrane group demonstrated signs of mild abdominal pain two and five days post-operatively, respectively. Both horses responded well to medical management consisting of nasogastric intubation, intravenous fluids, and a single dose of flunixin meglumine (500 mg IV). One horse in the DIA group developed a 1-cm adhesion from the anastomosis to the adjacent mesentery. The adhesion did not result in stricture of the jejunal lumen. Five horses in the SAA group developed adhesions to the anastomosis involving 60–80% of the anastomotic circumference. These adhesions were to the adjacent mesentery and omentum. One adhesion formed a mesenteric band, creating a potential space for intestinal incarceration. In three horses, the adhesions caused a reduction in jejunal luminal diameter that was evident at gross necropsy. One horse in the SAA + HA-membrane group developed a 1-cm adhesion to the adjacent mesentery. The adhesion did not result in stricture of the jejunal lumen. There were significantly more adhesions associated with the anastomoses in the SAA group as compared to the DIA or SAA + HA membrane groups (p = 0.039). Horses in the SAA group were 25 times more likely to develop adhesions associated with the anastomosis than horses in the DIA or SAA + HA-membrane groups.

The percent reduction in stomal diameters for the DIA, SAA, and SAA + HA-membrane groups were 44.0 ± 9.6%, 35.6 ± 6.3%, and 28.0 ± 8.5% respectively. The DIA anastomotic technique causes a significantly greater reduction in intestinal luminal diameter as compared to the SAA or SAA + HA-membrane anastomotic techniques (p = 0.007).

Mean surgery times for the DIA, SAA, and SAA + HA-membrane groups were 32.8 ± 3.6 min, 25.0 ± 1.3 min, and 27.3 ± 3.7 min, respectively. The DIA anastomotic technique took significantly longer to perform as compared to the SAA or SAA + HA-membrane anastomotic techniques (p = 0.012).

4. Discussion

Technological advances in anesthesia and surgery have made surgical treatment of small intestinal diseases in horses more common. Despite improvements in diagnostic, anesthetic, and surgical techniques, long-term survival rates for horses with small intestinal diseases requiring surgery only approach 50–60%. Numerous anastomotic techniques have been described for small intestinal anastomoses in horses.1,2 The ideal small intestinal anastomosis for use in the horse would provide a maximal stomal diameter without increasing the incidence of perianastomotic adhesions, and be relatively simple and quick to perform. In the present study, a single-layer appositional suture pattern used in combination with a HA-membrane resulted in an effective technique for small intestinal anastomoses in horses. The single-layer appositional pattern allowed for maximal luminal diameter and minimal surgery time, while application of the HA-membrane prevented the formation of perianastomotic adhesions usually associated with appositional anastomoses.

Previous studies have demonstrated that inverting intestinal anastomoses results in decreased perianastomotic adhesion formation because inversion of the serosa minimizes peritoneal exposure of bacteria laden mucosa and suture material.1 In contrast, the use of single layer appositional anastomoses in horses has been associated with an unacceptably high incidence of adhesion formation.1 Adhesions formation associated with intestinal anastomoses predispose to intestinal stricture or volvulus with intestinal obstruction as a common sequela. The recurrent signs of abdominal pain associated with these adhesions often necessitate repeat celiotomy or euthanasia. The findings of the present study are similar to previous studies, in that only one horse in the DIA group developed adhesions, while five horses in the SAA group developed adhesions associated with the anastomoses. Adhesions in SAA horses formed to the adjacent intestinal mesentery and distant omentum. However, when a HA-membrane was used in conjunction with a SAA anastomosis, only one horse developed one adhesion to the adjacent mesentery. Application of HA-membranes to SAA anastomoses significantly decreased the incidence of adhesions as compared to performing SAA anastomoses alone.

While standard, two-layer, inverting small intestinal anastomoses provide a tight serosal seal, the
internal mucosal cuff produced as a result of tissue inversion markedly decreases intestinal luminal diameter. This decrease in luminal diameter may predispose to intestinal obstruction and recurrent signs of abdominal pain. Single-layer appositional suture patterns, including the Gambee, simple continuous, and simple interrupted suture patterns result in maximal intestinal luminal diameters due to more accurate tissue alignment and absence of the internal mucosal cuff. Previous studies reported a greater than 40% reduction in stomal diameter with two-layer inverting anastomoses compared to less than 33% reduction in stomal diameter with single-layer appositional anastomoses. In the present study, the intestinal segments were distended to an intraluminal pressure of 20 mmHg during stomal diameter measurements in an attempt to accurately represent the clinical situation. Anastomoses from the SAA and SAA + HA-membrane groups demonstrated significantly less reduction in stomal diameter as compared to anastomoses in the DIA group. Although not statistically significant, the SAA anastomosis resulted in a greater reduction in stomal diameter than the SAA + HA-membrane anastomosis. At necropsy, adhesion formation and fibrosis causing intestinal distortion and stricture was apparent in three of the anastomoses in the SAA group. This may have accounted for the greater mean reduction in stomal diameter observed in the SAA group.

Decreasing surgery and anesthesia time in horses is important to minimize the incidence of such postoperative complications as hypotension, hypothermia, myositis, and peripheral neuropathies. Horses with severe small intestinal lesions requiring intestinal resection and anastomosis may require excessively long surgery times. Any reduction in the duration of anesthesia may reduce the incidence of postoperative complications and morbidity. In the present study the SAA and SAA + HA-membrane anastomoses required significantly less time to perform than the DIA anastomoses.

In conclusion, the use of a continuous single layer appositional suture pattern in combination with a bioresorbable HA-membrane resulted in an effective alternative for small intestinal anastomoses in horses. This technique provides a larger stomal diameter and reduced surgery times as compared to conventional, two-layer, inverting anastomoses, and minimizes the incidence of perianastomotic adhesion formation. In horses, the use of a single layer appositional anastomosis combined with a HA-membrane may reduce the morbidity and mortality associated with small intestinal diseases requiring intestinal resection and anastomosis.

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References and Notes

*Seprafilm*, Genzyme Corporation, Surgical Division, One Kendall Square, Cambridge, MA 02139 (1-800-261-1570).
*Sevoflurane*, Abbott Laboratories, North Chicago, IL 60064.
PDS, Ethicon Inc., Somerville, NJ 08876.
Vicryl, Ethicon Inc., Somerville, NJ 08876.
HDI® 3000, ATL Ultrasound, Bothell, Washington 98041.