Use of a hand-assisted laparoscopic surgical technique for closure of an extensive mesojejunal rent in a horse

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EQUINE

Case Description—A 7-year-old 573-kg (1,261-lb) Swiss Warmblood gelding was evaluated because of signs of acute abdominal pain.

Clinical Findings—Physical examination revealed a markedly distended abdomen with subjectively reduced borborygmi in all abdominal quadrants. A large, gas-distended viscus was present at the pelvic brim preventing complete palpation of the abdomen per rectum. Ultrasonographic evaluation could not be safely performed in the initial evaluation because of severe signs of abdominal pain.

Treatment and Outcome—Ventral midline celiotomy was performed, and right dorsal displacement of the ascending colon was corrected. Progressive signs of abdominal pain after surgery prompted repeat ventral midline celiotomy, and small intestinal incarceration in a large, radial mesojejunal rent was detected. The incarceration was reduced, but the defect was not fully accessible for repair via the celiotomy. Repair of the mesenteric defect was not attempted, and conservative management was planned after surgery; however, signs of colic returned. A standard laparoscopic approach was attempted from both flanks in the standing patient, but the small intestine could not be adequately mobilized for full evaluation of the rent. Hand-assisted laparoscopic surgery (HALS) allowed identification and reduction of jejunal incarceration and repair of the mesenteric rent. Although minor ventral midline incisional complications were encountered, the horse recovered fully.

Clinical Relevance—HALS techniques should be considered for repair of mesenteric rents in horses. In the horse of this report, HALS facilitated identification, evaluation, and repair of a large radial mesenteric rent that was not accessible from a ventral median celiotomy. (*J Am Vet Med Assoc* 2013;243:1166–1169)

A 7-year-old Swiss Warmblood gelding weighing 573 kg (1,261 lb) was evaluated because of signs of acute abdominal pain (ie, colic). The horse was reported to have moderate signs of colic for 8 hours prior to examination. During the initial evaluation, the horse had a heart rate of 80 beats/min and was sweating profusely; rectal temperature was within the reference range, and the patient's mucous membranes were mildly hyperemic with a slightly prolonged capillary refill time (3 seconds). Resistance was encountered during attempts to place a nasogastric tube, which could not be definitively positioned into the stomach. The abdomen appeared markedly distended, with subjectively reduced borborygmi evident on auscultation of all abdominal quadrants. A large, gas-distended viscus was present at the pelvic brim preventing complete palpation of the abdomen per rectum. Ultrasonographic evaluation could not be safely performed because of severe signs of abdominal pain. No significant abnormalities were detected on hematologic and biochemical profiles. The horse was not considered to respond adequately to analgesic drug administration, including metamizole[a] (dipyrone; 50 mg/kg [22.7 mg/lb], IV), flunixin meglumine[b] (1.1 mg/kg [0.50 mg/lb], IV), and xylazine hydrochloride[c] (0.5 mg/kg [0.23 mg/lb], IV; 4 doses). On the basis of a presumptive diagnosis of displacement of the ascending colon, the decision was made to undertake exploratory celiotomy.

Abbreviation

HALS Hand-assisted laparoscopic surgery

Prior to induction of anesthesia, 7.2% sodium chloride solution (4.0 mL/kg [1.82 mL/lb]), penicillin sodium[d] (22,000 U/kg [10,000 U/lb]), and gentamicin sulfate[e] (6.6 mg/kg [3.0 mg/lb]) were administered IV. The horse was sedated with romifidine (0.05 mg/kg [0.023 mg/lb], IV) and L-methadone (0.05 mg/kg, IV), and general anesthesia was induced with guaifenesin to effect (approx 100 mL of 15% solution, IV), ketamine hydrochloride (2.5 mg/kg [1.14 mg/lb], IV), and diazepam (0.05 mg/kg, IV). The horse was positioned in dorsal recumbency.

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The ventral abdomen was clipped and prepared for ventral median celiotomy via aseptic techniques, and a 30-cm ventral midline incision was made cranial to the umbilicus. A right dorsal displacement of the ascending colon was identified; the colon was exteriorized and returned to the abdomen in the correct orientation. Decompression of the ascending colon via a pelvic flexure enterotomy was not deemed necessary. Difficulty was encountered in exteriorizing several sections of the small intestine, which appeared moderately distended segmentally with fluid and gas. No areas of small intestinal edema, subserosal hemorrhage, or ischemia were identified, and no strangulation or incarceration of intestine could be found. The stomach, duodenum, descending colon, and cranial aspect of the abdomen were examined prior to closure, with no abnormalities detected. The linea alba was closed in a simple continuous pattern by use of size 3 polyglactin 910.[f] Subcutaneous tissues were apposed in a simple continuous pattern with 2-0 polyglecaprone 25,[g] and the skin was closed with stainless steel skin staples.[h]

Postoperatively, routine medical management was initiated. Feed was withheld, and the horse had free access to water; a balanced electrolyte solution was administered IV (90 mL/kg/d [40.9 mL/lb/d]). Lidocaine (loading dose, 1.3 mg/kg [0.59 mg/lb], IV; 0.05 mg/kg/min via constant rate infusion thereafter) was also administered. In addition, the patient received flunixin meglumine (1.1 mg/kg, IV, q 12 h), gentamicin sulfate (6.6 mg/kg, IV, q 24 h), and penicillin sodium (22,000 U/kg, IV, q 6 h). Eight hours after recovery from surgery, the horse's heart rate was high (80 beats/min), and increasingly severe signs of colic were detected. Mucous membrane color was subjectively normal, and capillary refill time, total protein concentration, and Hct remained within the respective reference ranges. The signs of colic did not respond to administration of analgesics, including flunixin meglumine and repeated doses of xylazine hydrochloride as previously described. Results of abdominal palpation per rectum and abdominal ultrasonography revealed several distended loops of small intestine. No net nasogastric reflux was present on nasogastric intubation. Because of the signs of progressive abdominal pain and failure to respond to analgesic treatment, repeat laparotomy was performed.

Anesthesia was induced, and the horse was positioned in dorsal recumbency and prepared for ventral midline celiotomy as previously described. The previous midline incision was reopened, and preliminary exploration of the abdomen revealed normal ascending colon orientation. Exteriorization of the small intestine proved more difficult than expected, with diffuse resistance to mobilization. Close evaluation of the small intestinal mesentery revealed a 30-cm-long, radial mesenteric rent at the midpoint of the jejunum. The ventralmost extent of the defect could be exteriorized to the level of the body wall incision, but the dorsalmost extent could not be observed directly. Attempts to exteriorize the defect enough to enable closure were unsuccessful. The small intestine did not appear hyperemic or edematous and was decompressed into the cecum. Decompression of the ascending colon via a pelvic flexure enterotomy did not improve access to the dorsalmost extent of the defect. The rent was found to lie immediately adjacent at its oral border to the radial mesenteric blood vessels, the jejunal artery and vein, precluding blind closure of the dorsal extent of the rent. For these reasons, the defect was not closed. The initial postoperative plan was to manage the horse conservatively, with standing laparoscopic repair as previously described[1] considered an option if clinical signs returned.

The horse recovered uneventfully from anesthesia, and postoperative treatments were initiated as previously described. The patient remained free of signs of colic until 48 hours after surgery, when signs of mild abdominal pain were identified. Laparoscopic surgery was elected immediately because recurrent small intestinal incarceration was suspected and to avoid progressive distension and worsening of colic signs, which may later have precluded standing surgery. The horse was sedated with detomidine hydrochloride (0.01 mg/kg [0.0045 mg/lb], IV) and butorphanol tartrate (0.025 mg/kg [0.01 mg/lb], IV) and placed in standing stocks. Sedation was maintained with a constant rate IV infusion of detomidine hydrochloride (approx 1.87 µg/kg/min [0.85 µg/kg/min]).

Both flanks were clipped and prepared for aseptic surgery in a standard manner. The skin was desensitized by direct infiltration of mepivicaine hydrochloride (total volume, 10 mL) at the proposed incision sites before the flanks were draped. A stab incision was made in the skin with a No.10 scalpel blade at a location just dorsal to the crus of the internal abdominal oblique muscle, midway between the tuber coxae and the last rib on the left side. A Veress needle was inserted through the stab incision into the peritoneal cavity, and the abdomen was insufflated with CO_2 and maintained at a pressure of 10 cm H_2O. A 10-mm blunt trocar-cannula unit[i] was inserted through the same incision in a caudoventral direction toward the contralateral stifle joint. A 10-mm-diameter telescope[i] with a 57-cm, 30° viewing angle was inserted for observation of the caudal and cranial aspects of the left side of the abdomen.

The mesenteric defect could not be visualized through the portal created, so the stab incision was temporarily occluded with a Backhaus penetrating towel clamp to maintain pneumoperitoneum. Next, the right side of the abdomen was explored via a portal created in the right flank; the incision was created in the same location relative to anatomic landmarks as described for the left flank. An instrument portal was created just ventral to the endoscopy portal to allow manipulation of the small intestine by means of a pair of 10-mm-diameter, 32-cm-long Babcock tissue forceps.[i] The small intestine was difficult to manipulate via standard laparoscopic techniques, and therefore, a laparotomy incision was made in the right flank to allow hand-assisted laparoscopic exploration of the abdomen.

The flank incision was created by extending the original instrument portal by approximately 15 cm in a ventral direction. The surgical approach was completed in a modified grid pattern, incising the external abdominal oblique muscle vertically and then dividing the internal abdominal oblique and transversus abdominis muscles parallel to the muscle fibers before bluntly penetrating the peritoneum. The surgeon's dominant

right hand was inserted to manually explore the abdomen. A portal device was not used to maintain insufflation, and the loss of insufflation did not seem to be of detriment to the available working space. Abdominal exploration confirmed incarceration of a 50-cm length of small intestine through the mesenteric rent; the intestine was manually removed from the rent, and the full extent of the mesenteric defect was defined. The rent was confirmed to extend radially all the way to the mesenteric root. Under laparoscopic guidance, the rent was closed with size 3 polyglactin 910 in a simple continuous pattern. This large size of suture material was chosen to avoid the material cutting through the mesentery and for ease of manipulation with 1 hand. The strand of suture was passed through a loop knot to start the suture line near the mesenteric root. The closure incorporated the mesenteric vessels at the cranial border of the rent because it was impossible to exclude them. Hemorrhage was not encountered. Apposition of the defect edges was achieved successfully, and suture tension was minimized to avoid compromise to the vascular supply. After closure of the rent, the bilateral body wall incisions were closed with simple continuous patterns in 3 layers; size 3 polyglactin 910 was used for the muscle layers, and 2-0 polyglecaprone 25 was used for the subcutaneous layers and skin.

The horse recovered uneventfully from sedation and had no further clinical signs of colic up to discharge from the clinic 3 weeks later. Penicillin and gentamicin were continued as described for a total of 8 days. Feed was reintroduced at approximately 12 hours after surgery, when no further colic signs were noted. Mild to moderate drainage and eventual partial dehiscence of the ventral midline celiotomy incision were evident starting 1 week after the second ventral exploratory surgery. This was managed routinely with supportive abdominal bandages and wound treatment measures of regular cleansing and lavage. Treatment with metronidazole (15 mg/kg [6.8 mg/lb], PO, q 8 h for 20 days) and cefquinome (1.0 mg/kg [0.45 mg/lb], IV, q 24 h for 4 days] was started when penicillin and gentamicin were discontinued. At the time of discharge, all incisions were healing satisfactorily. Discharge instructions advised regular wound cleaning with chlorhexidine solution and 12 weeks of restricted exercise (4 weeks of stall confinement followed by 4 weeks of small paddock turnout and 4 weeks of regular turnout with no ridden exercise).

Verbal follow-up was undertaken with the owner 3 years after discharge from the clinic, and at that time, the horse was alive and still belonged to the same owner. The owner indicated that, during the first month after surgery, the horse had several mild episodes of colic that were managed conservatively and ultimately attributed to gastric ulcers identified via gastroscopy. No further colic signs were seen after gastric ulcer treatment was initiated. Herniation had developed over the middle portion of the ventral celiotomy incision; this herniation was managed with supportive abdominal bandages and resolved completely over the duration of the controlled exercise program. The laparoscopy and flank laparotomy incisions healed routinely with no complications, and the owner considered the cosmetic outcome to be good. The horse subsequently returned to the same level of dressage activity, including competition, as it was involved in prior to surgery.

Discussion

In the horse of this report, HALS was used successfully for treatment of an extensive, radial, mesojejunal mesenteric defect, which was not accessible for safe closure via ventral midline celiotomy and had caused intestinal incarceration and severe signs of colic. Mesenteric rents have been reported in 4.8% to 13.4% of horses undergoing surgical treatment of colic associated with the small intestine[2–5] and can be life threatening if bowel, particularly small intestine, becomes incarcerated and strangulated. Treatment involves reduction of any bowel incarceration, treatment of bowel compromise as necessary, and closure of the defect, where possible.[6]

Previous reports[7] suggest that large mesenteric defects may be less likely to cause strangulation than small defects. Therefore, conservative management was initially attempted in this case when complete closure via midline celiotomy was deemed unsafe and considered to carry a high risk of intestinal damage or hemorrhage. However, when colic signs recurred and small intestinal incarceration was identified, complete closure of the rent was elected.

The origin of the mesenteric rent in the horse of this report was unknown. It is possible that it was present at the time of the first exploratory celiotomy, considering that the small intestine was found to be difficult to exteriorize at that time, similar to the second surgery, in which the defect was definitively identified. Although iatrogenic injury to the mesentery during the first exploration of the abdomen was possible, it is the authors' opinion that this was unlikely because of the large size of the lesion and the absence of mesenteric hemorrhage during the first surgery.

Mesenteric defects that cannot be accessed or closed completely via ventral midline celiotomy may be approached via laparoscopy.[1,8] Laparoscopic techniques represent an excellent means of thorough evaluation and definitive treatment of such lesions. However, manipulation of intestine, especially when distended, and the difficulties of intracorporeal approximation of tissue edges make its application for large defects more challenging.

In the HALS technique, a surgeon introduces a hand into the surgical field through a laparotomy incision with laparoscopic guidance. This approach significantly enhances the dexterity of the surgeon, by allowing for direct manipulation of the viscera. The use of HALS techniques maintains many of the advantages of standard laparoscopy, such as improved visual detection of lesions, smaller surgical incisions compared with conventional open techniques, and the ability to perform procedures in a standing patient. In addition, HALS allows direct tactile sensation and improves coordination. Dissection, traction, and exposure may all be performed more smoothly, and unexpected or difficult situations such as hemorrhage or the handling of a large or heavy structure, as in the horse of this report,

are facilitated, thus improving surgical efficiency.[9] In humans, procedures performed with HALS techniques include esophagectomy, fundoplication, gastrectomy, gastroplasty, pancreatectomy, splenectomy, adrenalectomy, nephrectomy, vertebral fusion, gastric bypass, adhesiolysis, hepatectomy, and pancreatoduodenectomy.[9] In horses, HALS approaches to ovariectomy, nephrectomy, partial hysterectomy, and treatment of left dorsal displacement of the ascending colon with closure of the nephrosplenic space have been described.[10–15]

Tissue approximation during minimally invasive surgery can be achieved by a variety of methods, including clips, staples, and adhesives intended to reduce surgical times. The use of clips and staples can substantially reduce operative time but was not suitable in this case because of the defect's proximity to regional blood vessels. Sutures are commonly used for accurate tissue apposition, but intracorporeal suturing remains technically challenging.[16] The use of a looped suture to start the closure in the patient described in this report, in combination with HALS techniques, resulted in a fast and accurate repair.

In the horse of this report, the mesenteric defect was not identified when traditional laparoscopic techniques were used, most likely because of the inability to manipulate the distended small intestine incarcerated in the rent. However, direct manipulation of intestine, facilitated by HALS, allowed for identification and correction of the lesion. Direct visual inspection was vital to surgical success, since it ensured adequate examination and avoidance of the regional blood vessels. The radial mesenteric vessels cranial to the defect were incorporated into the closure because of the close proximity of the margins of the mesentery to these vessels. Apposition was achieved without tension on the suture, to potentially allow for continued normal blood flow to the adjacent intestine. The authors suspect that collateral circulation may be capable of accommodating for disturbances in local blood supply in healthy jejunum not requiring resection and anastomosis; however, to our knowledge, this has not been established.

This report illustrates that a standing flank approach with HALS techniques can be used successfully for manipulation of distended and incarcerated small intestine and closure of a large mesenteric defect extending to the mesenteric root in a horse. This method supplements conventional laparoscopy by allowing for direct visual inspection and safe handling of damaged tissues in the dorsal aspect of the abdomen that are inaccessible with conventional laparotomy under general anesthesia.

a. Vetalgin N, Intervet Deutschland GmbH, Unterschleißheim, Germany.
b. Flunixine, Biokema SA, Crissier, Switzerland.
c. Xylasol, Graeub AG, Bern, Switzerland.
d. Streuli Pharma AG, Uznach, Switzerland.
e. Pargenta-50, Graeub AG, Bern, Switzerland.
f. Vicryl, Ethicon, Johnson and Johnson Medical Ltd, Livingston, Scotland.
g. Monocryl, Ethicon, Johnson and Johnson Medical Ltd, Livingston, Scotland.
h. Autosuture Royal skin stapler 35W, Covidien, Mansfield, Mass.
i. Karl Storz Veterinary Endoscopy, Goleta, Calif.

References

1. Sutter WW, Hardy J. Laparoscopic repair of a small intestinal mesenteric rent in a broodmare. *Vet Surg* 2004;33:92–95.
2. Huskamp D. Diagnosis and treatment of acute abdominal conditions in the horse: various types and frequency as seen at the animal hospital in Hochmoor, in *Proceedings*. Equine Colic Res Symp 1982;1:261–272.
3. Tennant B. Intestinal obstruction in the horse: some aspects of differential diagnosis in equine colic, in *Proceedings*. 21st Annu Meet Am Assoc Equine Pract 1975;426–438..
4. Phillips TJ, Walmsley JP. Retrospective analysis of the results of 151 exploratory laparotomies in horses with gastrointestinal disease. *Equine Vet J* 1993;25:427.
5. Edwards GB. Obstruction of the ileum—a common indication for surgery, in *Proceedings*. 14th Bain-Fallon Mem Lect 1992;143–150.
6. Freeman DE. Small intestine. In: Auer J, Stick JA, eds. *Equine surgery.* 4th ed. St Louis: Elsevier, 2012;434.
7. Gayle JM, Bliklslager AT, Bowman KF. Mesenteric rents as a source of small intestinal strangulation in horses: 15 cases (1990–1997). *J Am Vet Med Assoc* 2000;216:1446–1449.
8. Galuppo LD, Snyder JR, Pascoe JR. Laparoscopic anatomy of the equine abdomen. *Am J Vet Res* 1995;56:518–531.
9. Targarona EM, Gracia E, Rodriguez M, et al. Hand-assisted laparoscopic surgery. *Arch Surg* 2003;138:133–141.
10. Keoughan CG, Rodgerson DH, Brown MP. Hand-assisted laparoscopic left nephrectomy in standing horses. *Vet Surg* 2003;32:206–212.
11. Romero A, Rodgerson DH, Fontaine GL. Hand-assisted laparoscopic removal of a nephroblastoma in a horse. *Can Vet J* 2010;51:637–639.
12. Rodgerson DH, Brown MP, Watt BC, et al. Hand-assisted laparoscopic technique for removal of ovarian tumors in standing mares (Erratum published in *J Am Vet Med Assoc* 2002;221:272). *J Am Vet Med Assoc* 2002;220:1503–1507.
13. Goodin JT, Rodgerson DH, Gomez JH. Standing hand-assisted laparoscopic ovariectomy in 65 mares. *Vet Surg* 2011;40:90–92.
14. Janicek JC, Rodgerson DH, Boone BL. Use of a hand-assisted laparoscopic technique for removal of a uterine leiomyoma in a standing mare. *J Am Vet Med Assoc* 2004;225:911–914.
15. Muñoz J, Bussy C. Standing hand-assisted laparoscopic treatment of left dorsal displacement of the large colon and closure of the nephrosplenic space. *Vet Surg* 2013;42:595–599.
16. Larsson A. Intracorporeal suturing and knot tying in surgical simulation. *Stud Health Technol Inform* 2001;81:266–271.