Role of Laparoscopy in Diagnosis and Management of Equine Colic

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KEYWORDS

• Laparoscopy • Horse • Colic • Diagnosis • Treatment • Nephrosplenic • Adhesion

KEY POINTS

- Laparoscopy is most commonly used for diagnosis and treatment of chronic recurrent colic in horses.
- Laparoscopy can be performed in standing and recumbent horses depending on the area of interest.
- Preventative measures such as closure of anatomic spaces, as well as treatment of some acute causes of colic, and taking biopsies for further diagnostic testing can be performed.

INTRODUCTION

Laparoscopy in horses was first described in 1970 in mares for characterization of reproductive events.[1,2] The first description of laparoscopy on horses with abdominal abnormalities was published in 1986 by Fischer and colleagues.[3] Since then laparoscopy has become a frequently used diagnostic and surgical tool in equine medicine.[4] Presently, equine laparoscopy is most commonly used for the diagnosis and treatment of disorders of the urogenital tract, with the two most common procedures being laparoscopic ovariectomy and cryptorchidectomy. Nevertheless, laparoscopy has also found its place in the broad field of diagnosis, treatment, and prevention of several gastrointestinal disorders causing colic in horses.

Horses with acute abdominal pain are generally poor patients for laparoscopic exploration and treatment, as they are often too painful to be restrained in stocks for standing laparoscopy. Moreover, horses with acute abdominal pain typically have distended intestines, which preclude good visualization of the abdomen and increase the chance of inadvertent intestinal puncture when introducing a trocar. Therefore, laparoscopy is most commonly performed in horses with chronic recurrent colic to establish a diagnosis, take biopsies, or if possible, perform a treatment. Globally,

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the diagnostic sensitivity of laparoscopy for recurrent colic and or weight loss was 63% to 66%, whereas the diagnostic specificity was low (17%–25%), meaning that the cause of colic or weight loss can often be missed.[5,6]

SYSTEMATIC LAPAROSCOPIC VISUALIZATION OF THE EQUINE ABDOMEN

Laparoscopy can be performed in the standing or recumbent horse. The left flank and right flank approaches in the standing horse as well as the ventral approach in the dorsally recumbent horse have different indications and offer a different view and approach to the abdominal structures. For either procedure, it is strongly advised to withhold feed for at least 12 hours before surgery to facilitate safe access to the abdomen and maximize visualization of the abdominal organs.[5] The authors prefer a fasting period of 24 to 36 hours in which horses are also walked to encourage defecation. Water should not be withheld.

Standing Laparoscopy

Laparoscopy is most frequently performed in the standing, sedated horse with infiltration of the flank region with local anesthetic. This approach has the advantage of avoiding the risks of general anesthesia and providing a good view and access to several abdominal organs that can be involved in pathology causing colic (eg, nephrosplenic space, epiploic foramen (EF), inguinal rings, and diaphragm). Moreover, standing laparoscopy is also more suitable for horses in which general anesthesia seems undesirable due to old age, weakness due to chronic diseases, or severe lameness.

Depending on the region of interest and procedure planned, the left or right flank is approached by making a stab incision through the skin just dorsal to the crus of the internal abdominal oblique muscle, halfway between the tuber coxae and the last rib.[5] In general, it is considered safer to make this portal on the left side of the abdomen due to the risk of inadvertently puncturing the cecum on the right side.[7] Palpation per rectum can be used to check for cecal distention before making a portal on the right side. Overall, the authors consider the risks of intestinal damage minimal if the correct technique and appropriate instrumentation are used for a first portal on the right side. A cannula with conical obturator is introduced through the abdominal muscles aiming toward the opposite coxofemoral joint. After removal of the trocar, air is allowed to spontaneously enter the abdomen by introducing a slim instrument into the outer opening of the cannula. Then, a laparoscope is introduced into the cannula, and the abdomen is insufflated with carbon dioxide to a pressure of approximately 15 mm Hg. Instrument portals are made under direct vision in the locations needed for the planned procedure. Typically, one portal is made between the 17th and 18th rib and the laparoscope is switched to that portal to allow free instrument manipulation through several flank portals.

The anatomy visible on laparoscopy has been thoroughly described. From the left flank, parts of the diaphragm, liver, stomach, spleen, left kidney and segments of jejunum, descending and ascending colon as well as the urinary bladder, rectum, ovary, and uterus in mares and vaginal ring in males are visible. From the right flank parts of the liver including its caudate process, the stomach including the pylorus, the EF and omental bursa, the duodenum, the base of the cecum, the right dorsal colon, segments of the jejunum, descending, and ascending colon, urinary bladder and right reproductive organs as well as the rectum can be evaluated.[7]

Recumbent Laparoscopy

As mentioned above, standing laparoscopy is unsuitable for acute colic in most cases. The need for the horse to remain still and standing is alleviated during recumbent

laparoscopy. However, many clinicians prefer an open approach to the abdomen for easier manipulation of the intestines. Colic-related interventions described using a recumbent laparoscopic approach include adhesiolysis and colopexy,[6] but this approach could also be used to obtain intestinal biopsies.

In the dorsally recumbent horse, the ventral part of the abdomen can be inspected laparoscopically. For access to the abdomen, a ventral portal is made at the caudal extend of the umbilical depression.[6] A cannula with a blunt obturator is introduced into the abdomen. Care must be taken to avoid penetration of the intestines and lifting the abdominal wall using Backhaus towel clamps placed on the linea alba close to the stab incision can help to prevent this. Alternatively, a teat cannula can be used for safe abdominal access. The following steps are identical to the approach for standing laparoscopy including introduction of the laparoscope and insufflation of the abdominal cavity. Further portals are created as needed for the respective procedure. In the cranial region of the abdomen, the following structures can be found: ventral surface of the diaphragm, falciform ligament and round ligaments of the liver, ventral portion of the liver, spleen, right and left ventral colons, sternal flexure of the ascending colon, apex of the cecum, and stomach.[8] Good visualization of the caudal region of the abdomen is facilitated by positioning the horse in Trendelenburg position (elevation of the caudal portion of the body up to 30°, ensuring that the horse is fixed to the table well). Structures that can be observed in the caudal abdomen are the urinary bladder, mesorchium and ductus deferens (left and right), vaginal ring (left and right), insertion of the prepubic tendon, various segments of jejunum and descending colon, pelvic flexure of the ascending colon, body of the cecum, and cecocolic fold.

INTESTINAL BIOPSY AND TREATMENT OF SMALL INTESTINAL LESIONS

As mentioned, laparoscopy is often used for the minimally invasive diagnosis of causes of chronic weight loss and recurrent colic. Inflammatory bowel disease, grass sickness, and neoplasia are common causes and can be diagnosed by taking biopsies of the small intestine with the aid of laparoscopy. To identify the appropriate section for sampling, the small intestine must be evaluated in its entirety. To achieve the maximum visibility, a right flank approach should be used. According to Schambourg and Marcoux, this allows for 15 to 20 cm of the duodenum and about 40 cm more of the ileum to be viewed compared with a standard ventral midline laparotomy.[9] The exploration of the small intestine starts at the level of the duodenum. Its short mesentery keeps it in place, and minimal manipulation is necessary. The long mesentery of the jejunum, however, makes running of the small intestine imperative. This is readily performed using two atraumatic clamps to pass the intestine from the one to the other (**Fig. 1**, Video 1). Schambourg and Marcoux state that Babcock clamps provide inadequate purchase and recommend the use of Kelly or atraumatic intestinal forceps.[9]

Once the appropriate segment of the small intestine for biopsy is identified, the surgeon can chose between two different techniques: one involves intracorporeal suturing or stapling and the other one relies on exteriorization of the small intestinal segment of which the biopsies are taken. The latter technique is the most straightforward to perform in the authors' experience.

The intracorporeal technique comes with two options. Schambourg and Marcoux describe a two-step biopsy procedure during which first only serosa and muscularis are removed with laparoscopic scissors. The incision is then partially closed with a Lembert pattern, ensuring that the submucosa and mucosa are everted through the non-sutured part of the incision. Kelly clamps are used to keep traction on the submucosa and mucosa, which are then resected using scissors before closing the incision

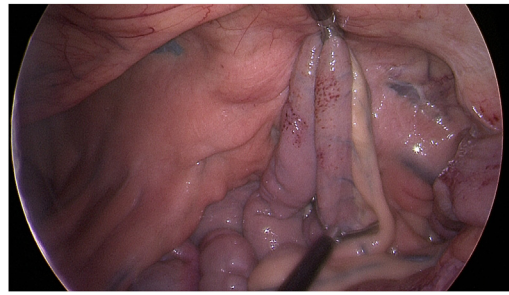

Fig. 1. Running the small intestine: a section of jejunum is held with Babcock forceps, whereas another atraumatic intestinal forceps is used to grasp a more aboral section. There is light serosal hemorrhage due to manipulation of the small intestine.

with the last suture.[9] Bracamonte and colleagues describe the use of a 45-mm endoscopic articulating linear stapler (ELS) with a 440-mm shaft: The ELS is applied to the small intestine at a 10-degree angle to the antimesenteric border. The ELS is then reapplied crossing the first cut in a 120-degree angle. This created a V-shaped segment that is safely removed. Bracamonte and colleagues then compared the ELS-technique to a double-layer hand-sewn technique via a laparotomy approach. They found that the segments closed with the ELS had a higher bursting strength and a smaller reduction in luminal diameter than the double-layer hand sewn segments.[10]

For the extracorporeal biopsy technique, the abdomen is first examined laparoscopically. Then, a 10-cm grid flank laparotomy incision is made through which the small intestine can be exteriorized. In order to choose the appropriate segment, the length of the accessible intestine can either be manipulated intra-abdominally with the aid of two atraumatic laparoscopic forceps or be exteriorized and repositioned with hand assistance through the grid incision. The flank incision can be protected with a plastic sleeve (**Fig. 2**A, B, Video 2) to facilitate the atraumatic exteriorization of the intestinal loop and to decrease the risk of incisional infection.[11] A routine biopsy can then be taking using conventional techniques.

Acute small intestinal lesions are typically treated via a ventral midline laparotomy, should medical treatment not be sufficient. However, Klohnen describes the laparoscopic removal of a lipoma in a standing horse.[12] The small intestine had not been compromised in this case. Similarly, Klohnen describes the laparoscopic removal of a lipoma obstructing the small colon.[12] Coomer and colleagues describe the use of laparoscopy for a small intestinal resection by exteriorizing the affected part of the small intestine as described in the previous paragraph. However, the resection only comprised a small section of the small intestine including a small adenocarcinoma.[13]

NEPHROSPLENIC ENTRAPMENT OF THE ASCENDING COLON AND CLOSURE OF THE NEPHROSPLENIC SPACE

Nephrosplenic entrapment of the large colon is a common cause of colic in horses with an incidence rate of 2.5% to 11%.[14] Although acute cases are most commonly treated either conservatively or surgically via a midline laparotomy, Munoz described the laparoscopic treatment of a left dorsal displacement: in a case series of 12 horses the displacement was first corrected in the standing horse using a modified grid laparotomy, after which the nephrosplenic space was closed laparoscopically. The authors first introduced a laparoscope through a 4 to 5 cm long flank incision to

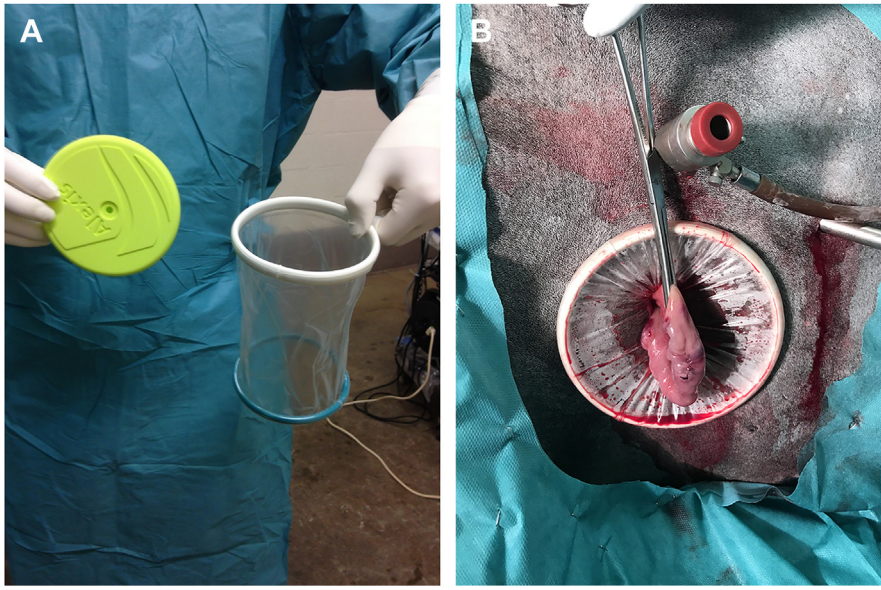

Fig. 2. Use of a plastic sleeve (Alexis O Wound Protector-Retractor, Applied Medical Resources Corporation, Rancho Santa Margarita, USA) for extracorporeal biopsy technique: (*A*) Alexis O protector-retractor with two rings that are connected by a plastic sleeve and a cap to avoid the loss of insufflation of the abdomen when using the ring as a portal and (*B*) the blue ring is placed intra-abdominally, whereas the white retraction ring remains on the skin. The white ring is gently grasped at 10 and 2 o'clock and pulled up until the green ring sits tightly against the peritoneal layer. It is then flipped inward or outward until the desired retraction is achieved. A piece of jejunum has been exteriorized and a biopsy has been taken.

explore the abdomen. After creation of a second portal between the 17th and 18th intercostal space, the first incision was enlarged to exteriorize the colon and allow for decompression and later manual replacement into the ventral abdomen, as well as repositioning of the spleen dorsally to close the nephrosplenic space. The closure of the nephrosplenic space was performed laparoscopically without manual assistance. Eight horses developed minor complications after surgery, 10 horses returned to their intended purpose, whereas the other two were retired or euthanized due to unrelated problems.[15]

Closure of the nephrosplenic space to prevent recurrence of a nephrosplenic entrapment of the large colon is reported in literature. Many different techniques and materials are described to close the space: these include simple suture material, barbed sutures and various implants.[14,16,17] A standard left laparoscopic approach allows for visualization of the nephrosplenic space. A large diameter (25–30 mm) cannula is introduced through the most dorsal left flank portal to allow for direct vision of the nephrosplenic space and to facilitate suturing. Suture material is used as per the surgeon's preference, however, a needle size that just fits through the large diameter cannula while fixed on the needle holder is recommended, as it avoids the challenges of intracorporeal needle repositioning. Barbed suture makes an extracorporeal starting knot redundant and obviates the need to keep the suture tight in between the bites, as the suture cannot glide back through the tissue. The space is closed from cranial to caudal, suturing the perirenal fascia to the splenic capsule (**Fig. 3**A, B, Video 3).

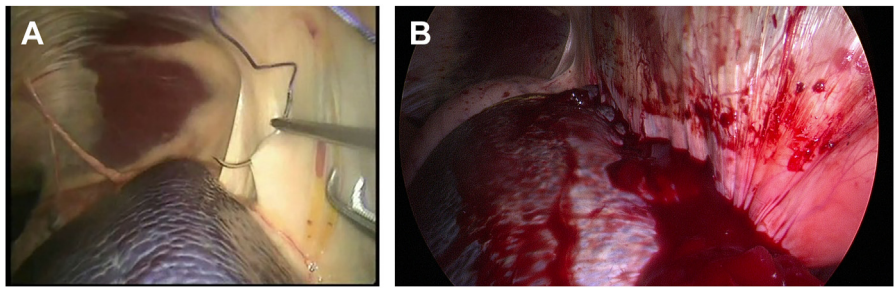

Fig. 3. Closure of the nephrosplenic space, the laparoscope is placed through a portal in the last intercostal space on the left side. A 25 to 30 mm diameter cannula is used for insertion of the needle holder and fixed needle. At this point, there is no gas insufflation of the abdomen. (*A*) The first bite is taken through the renal fascia and splenic capsule. (*B*) Appearance after closure of the nephrosplenic space.

A trocar with incorporated light emitting diode (LED) light (eg, Trocar Large Animal GR®, GR Vet Innovation, Saint Saturnin, 72, France) allows for direct visualization of the nephrosplenic space, making a laparoscope redundant.[18] Yet, when laparoscopic instruments are available, this device does not offer additional benefit.

Alternatively, a polypropylene mesh can be applied to the nephrosplenic space. The mesh needs to be 2 to 4 cm wider than the distance between the perirenal fascia and the spleen. It is draped over the dorsolateral edge of the spleen making sure that the space is sufficiently covered and the mesh lays cranial to the caudal border of the spleen to avoid intestinal adhesions. It is first attached to the renal fascia and then to the splenic capsule using laparoscopic staples or tacking devices.[16,19] Gialletti and colleagues compared the use of mesh and barbed suture for nephrosplenic space ablation and concluded that the suture was faster, more cost-efficient and caused fewer complications.[16] Spagnolo and colleagues described the use of homologous pericardium implants harvested from horses euthanized for orthopedic disease. The study included six Arabian horses without previous related abdominal disease. The complete closure of the nephrosplenic space was achieved in all horses without signs of colic for the 36-month follow-up period.[14]

The reported recurrence rates of nephrosplenic entrapment in horses after laparoscopic closure of the nephrosplenic space are low: Röcken and Nelson reported 0% to 3% recurrence after closure versus 21% to 23% in the control groups.[17,20] Rodriguez described a recurrence of colic of unspecified cause in 19% of horses undergoing closure versus 42% in the control group.[21] In the study by Burke and Parente, none of the horses treated by mesh obliteration showed recurrence of nephrosplenic entrapment. However, 38% of them showed signs of colic within a year after mesh obliteration. This included 15% of horses that had a surgically confirmed diagnosis of nephrosplenic entrapment versus 50% of horses in which the diagnosis was made based on palpation per rectum only. This difference was attributed to the possibility of additional causes of colic that were unrecognized at the time of treatment or an incorrect diagnosis made at presentation.[19] Reasons for recurrence of colic are most commonly other types of displacements or volvulus of the large colon as well as other causes of mild colic or displacement of the colon between the spleen and the body wall.[17,21] In the authors' experience, true nephrosplenic entrapment of the large colon after ablation of the nephrosplenic space only occurs after failure of the mesh or suture.

EPIPLOIC FORAMEN ENTRAPMENT AND PREVENTIVE CLOSURE OF THE FORAMEN

Just like the nephrosplenic space, the EF can be closed to prevent colic associated with intestinal EF entrapment (EFE). Recent work has demonstrated the funnel-like shape of the omental vestibule with two openings: a smaller one on the right side of the median plane, which is the EF, and a large one on the left side, which is the opening from the omental vestibule to the caudal recess of the omental bursa.[22,23] It has been suggested that the funnel-like shape of the equine omental vestibule, as it tapers toward the EF, acts as a trap that allows intestines to enter the wide opening of the omental vestibule, and then move through it from the left to the right toward the smaller EF, where intestines become entrapped.[24] Main risk factors are crib-biting and wind-sucking as well as height and a previous history of colic.[25] Compared with other strangulating small intestinal lesions, EFE has been identified as having a worse prognosis for long-term survival.[26] Recurrence of EFE has been described in 2% to 14% of cases.[23] To prevent entrapment, the EF can be closed laparoscopically through a standing right flank approach. A long (58 cm) 30° laparoscope is advanced cranially between the caudate process of the liver and the duodenum until the EF can be visualized between the base of the caudate process and the hepatoduodenal ligament. The first described technique uses titanium helical coils to staple the gastropancreatic fold to the right lobe of the liver.[27] This resulted in complete closure of the EF in five of the six horses on which this procedure was performed, albeit with a relatively thin fold. The technique described by van Bergen and colleagues uses a self-folded diabolo-shaped polypropylene implant (**Fig. 4**) which is introduced through a stainless steel applicator tube into the EF. The implant is self-retaining and positioned with its smallest part at the level of the portal vein (Video 4). In their study, van Bergen and colleagues successfully closed all EFs of the six horses enrolled.[28] In a further study evaluating this laparoscopic procedure, including 34 horses that had colic surgery due to EFE, the EF had closed spontaneously in 32% of cases, most likely caused by the local inflammation after entrapment of the intestines. In the remaining 23 horses, the EF was obliterated using the diabolo-mesh technique without major complications.[29]

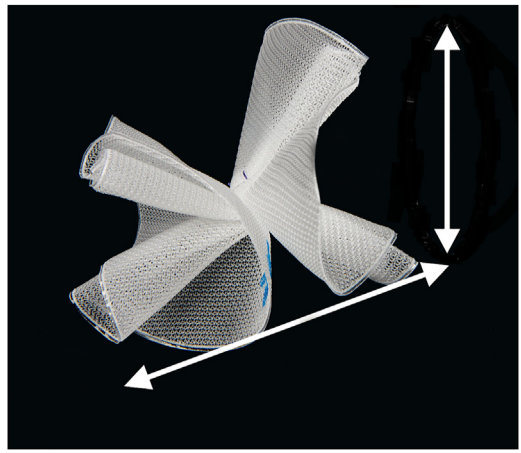

Fig. 4. Diabolo-shaped expandable mesh construct (diameter: 10 cm, length: 10 cm) used in horses for laparoscopic closure of the epiploic foramen. It is made of two preformed knitted polypropylene meshes (3DMax Mesh, BD, Franklin Lakes, New Jersey, USA) used for inguinal hernia repair in men.

ADHESIOLYSIS

Adhesions are one of the most common postoperative complications after laparotomy in the horse with a reported occurrence rate of 8% to 28%. In their study, Röcken and colleagues describe adhesions in 20 horses with chronic recurrent colic signs. Most of these adhesions (65%) involved abdominal reproductive organs and 17/20 could be successfully resolved laparsocopically.[30] In general, the adhesions that can be treated laparoscopically are clearly demarcated and a definite differentiation between adhesion and hollow organs is possible (**Fig. 5**). The use of sharp dissection, vessel sealing devices (Ligasure, Medtronic, Dublin, Ireland, Enseal, Johnson & Johnson, New Brunswick, New Jersey, USA), laser surgery, and high-frequency electrosurgery are described.[30] Furthermore, a stapling devise can be used to create a safe dissection; two lines of staples are placed on the transition of the adhesion to its origin. The staple line at the base of the adhesion closes the hollow organ or cavity, allowing the surgeon to cut between the two lines of staples without inadvertently opening any hollow structure.[30,31] In the authors' experience, converting to a hand-assisted laparoscopy is essential in those cases where a sharp delineation of the hollow organ and the adhesion is not possible. Hereby, one portal is enlarged to allow the surgeon's hand to enter the abdomen. This allows for tactile feedback as well as easier manipulation. Despite the encouraging success rates in the literature, extensive adhesions can seldomly be treated laparoscopically (Video 5).

SUTURE OF MESENTERIC RENTS

Some causes of acute colic can be treated with laparoscopy after the initial lesion has been corrected via a standard ventral midline laparotomy. One of those conditions is the laparoscopic closure of mesenteric rents or tears with or without entrapment of intestine through the opening. Even though the entrapment is usually not resolved laparoscopically, this technique provides surgical access to the most dorsal aspects of the mesentery, which are not accessible via ventral midline laparotomy. In all reports at hand, the acute colic was treated via laparotomy, during which the entrapment of the intestines was corrected, and further intraoperative interventions were effectuated as necessary. Laparoscopic closure of the mesenteric defect was then performed 24 hours to 18 days after laparotomy. In all cases, it had been impossible to close the tear during the celiotomy due to its dorsal extend. All authors used the standard laparoscopic approach to the abdominal cavity in standing horses described above.[32–35] In the authors' opinion, converting the standard laparoscopic approach to a hand-assisted procedure greatly facilitates both the visualization and the

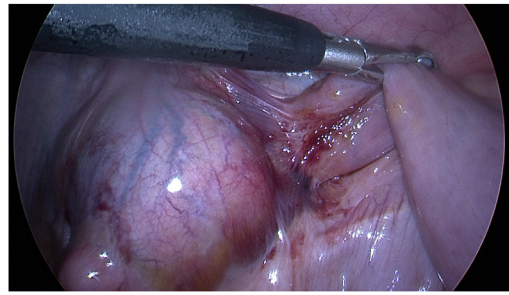

Fig. 5. Adhesions between a mass at the dorsal body wall and the duodenum seen from a portal in the 17th intercostal space on the right side.

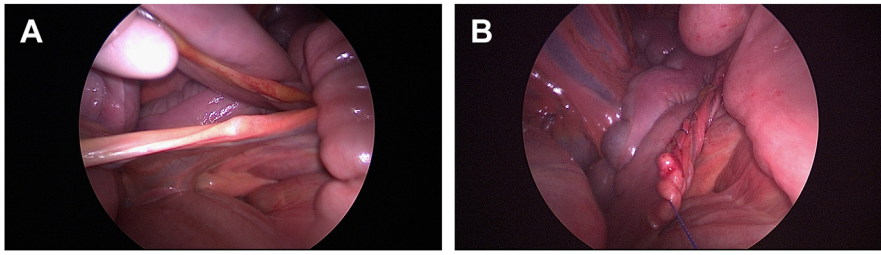

Fig. 6. Closure of a mesenteric rent: (*A*) depicting the hand-assisted approach to the large mesenteric rent and (*B*) showing the result after suturing the rent with barbed suture (Courtesy T. de Beauregard).

manipulations needed to identify and close of the defect (Fig. 6A, B). Mesenteric rents can be closed either with barbed suture, hemostatic staples or regular suture material. In the reports available, all horses recovered without complications.[32–35]

DIAPHRAGMATIC HERNIA

Another, arguably less common, cause of colic is diaphragmatic hernias. In their case report, Röcken and colleagues treated a horse with severe acute colic due to a diaphragmatic hernia with laparoscopic closure of the hernia 12 days after a standard ventral midline laparotomy. The horse presented with acute severe colic due to small intestinal strangulation. The diaphragmatic hernia was located dorsally to the nephrosplenic space, which had rendered a repair during the ventral midline laparotomy impossible. Laparoscopy was performed using standard left flank portals in the standing horse, revealing the defect in the tendinous part of the diaphragm. The defect was covered by the spleen and was deemed impossible to repair using flank portals. The repair was then finally performed a week later via thoracoscopy.[36] Klohnen also describes the laparoscopic closure of diaphragmatic hernias and mentions the use of a mesh if a tear in the muscular part cannot be fully closed.[12]

CLINICS CARE POINTS

- Feed should be withheld for at least 12 hours before laparoscopy to improve visualization and to avoid inadvertent puncture of the intestine when introducing a trocar.
- For standing laparoscopy, the horse has to be able to remain standing for the procedure which excludes most cases of acute colic.
- Transrectal palpation before the laparoscopy is advisable to identify distended intestines to avoid inadvertent puncture of the large intestine.
- Although laparoscopic visualization of the abdominal organs is typically good, manipulation is restricted. Conversion to a hand-assisted procedure can facilitate interventions.
- Intestinal biopsies are easiest to obtain using a laparoscopy-assisted extra-corporeal approach.

DISCLOSURE

The authors have no relevant financial or non-financial interests to disclose.

SUPPLEMENTARY DATA

Supplementary data related to this article can be found online at https://doi.org/10.1016/j.cveq.2023.03.003.

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