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ORIGINAL ARTICLE

Use of flank laparoscopy in the standing horse as a diagnostic aid in horses with chronic abdominal pain

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Summary

Background: Reaching a specific diagnosis in horses with chronic or recurrent abdominal pain may be challenging and elusive.

Objectives: The aim of this study was to report indications, findings and outcomes of equine exploratory laparoscopy in a case series to support its diagnostic value and identify potential limitations.

Study design: Retrospective cases series.

Methods: Sixty-nine client-owned horses underwent laparoscopic exploration of the abdomen due to chronic colic symptoms. All horses were operated standing while sedated and under local anaesthesia. Diagnosis, follow-up, surgical or medical interventions, as well as intra- and postoperative complications were recorded.

Results: A definitive diagnosis could be made by laparoscopy in 61 horses. However, no abnormal findings were found by laparoscopic exploration of the abdominal cavity in eight horses. Overall, the sensitivity of diagnostic laparoscopy in the standing horse in our study was 88% and its specificity was 15%. No severe intra- or postoperative complications occurred. Exploratory flank laparoscopy in the standing horse can be a valuable diagnostic tool for chronic abdominal pain.

Main limitations: The limitations of the present study are its retrospective nature, missing some details in the reports. In addition, no long-term follow-up was available for the horses which underwent surgical intervention, and whether the colic signs reoccurred after a period of time or complications occurred in the long-term postoperative period are not known. No confirmation of the laparoscopic diagnosis was available in some horses, and a post-mortem examination or histology of a biopsy sample would have been beneficial.

Conclusions: Exploratory flank laparoscopy in the standing horse can be considered in horses with chronic abdominal pain in view of the high sensitivity and low complication rate of this study.

KEYWORDS
horse, colic, diagnostic tool, laparoscopy, minimal invasive surgery

INTRODUCTION

Abdominal pain in horses can be caused by various pathological conditions of the digestive tract, urogenital organs or liver. Additionally, peritonitis, adhesion formation, thromboembolism and neoplasia may cause signs of abdominal discomfort (Mair & Hillyer, 1997). If a routine examination in horses is inconclusive, exploring the abdomen surgically may be indicated (Mair & Hillyer, 1997).

Exploratory laparoscopy is a well-established, minimally invasive diagnostic tool in horses, and has been described in horses with chronic (Fischer et al., 1986), or, in rare occasions, acute abdominal pain (Klohnen, 2012).

Indications are chronic weight loss (Fischer et al., 1986), masses in the abdominal cavity (Fischer et al., 1986; Fulton et al., 1990; Göbel & Koene, 1995; Sponton et al., 2009) or intra-abdominal adhesion formation, evaluation of peritonitis (Embertson & Bramlage, 1992), rectal tears (Embertson & Bramlage, 1992; Fischer et al., 1986), rupture of the mesocolon after rectal prolapse (Ragle et al., 1997), and evaluation of urogenital disorders (Straticò et al., 2020), such as ovarian and uterine disorders (Hassel & Ragle, 1994) as well as the oviducts (Arnold & Love, 2013; Kollmann et al., 2011). In addition, it is useful in horses of suspected cryptorchidism to verify the presence of abdominal testis (Göbel & Koene, 1995; Wilson, 1989) or for the examination of intersex animals (Selders et al., 2001).

The visibility of abdominal organs during laparoscopy depends on the specific approach used. Besides the visual inspection of the organs, biopsies of some organs can be taken, if needed, under direct visual control (Fischer et al., 1986).

The value of diagnostic laparoscopy has been highlighted in a few studies to date (Rijkenhuizen & Van Dijk, 2002; Walmsley, 1999). The sensitivity of the laparoscopy was reported to be 63% with a specificity of 17% in 54 horses with recurrent colic and an overall sensitivity of laparoscopy of 75% with a specificity of 18% (Walmsley, 1999). In another study, a diagnosis was made in 17 out 26 horses with chronic abdominal pain (Rijkenhuizen & Van Dijk, 2002).

The aim of this study was to report the indications, findings, outcomes and limitations of equine exploratory laparoscopy in horses with chronic/recurrent colic.

MATERIALS AND METHODS

Horses

The medical records of all patients that underwent diagnostic laparoscopy between January 2017 and May 2023 were reviewed in this retrospective case study. Inclusion criteria were recurrent colic signs without a definitive diagnosis reached after extensive clinical examinations. Patient case detail data (age, sex, weight and breed) were recorded. All intraoperative findings during laparoscopy and if a ventral midline laparotomy was performed were recorded. Details of the therapeutic interventions whether performed laparoscopically, via a ventral midline laparotomy or medically were obtained. In addition, all intra- and post-operative complications as well as histological results or post-mortem examinations were noted. The postoperative period recorded was considered from surgery to discharge from the hospital or euthanasia.

Surgical procedure

All procedures were performed in the standing, sedated horse using a 57 cm long rigid laparoscope with a diameter of 10 mm and 30° optical lens (Karl Storz).

In preparation for surgery, food intake was reduced for 36 h, followed by 12 h fasting with only water accessible before surgery. If possible, the horses were exercised on the lunge line at the trot, 2–3 times a day for 10–15 min at a time for 2–3 days prior to surgery to decrease the bowel content and prevent gas accumulation in the intestine. Horses underwent a transrectal palpation immediately prior to surgery to determine any changes of abdominal contents.

All horses were restrained in stocks with the tail tied up and fixed to themselves. Sedation was carried out using detomidine hydrochloride (Cepesedan®, CP-Pharma) 0.01 mg/kg bwt (10 mg/mL) and butorphanol tartrate (Butorgesic®, CP-Pharma) 0.01 mg/kg bwt (10 mg/mL) intravenously as the initial bolus followed by a continuous rate infusion of detomidine hydrochloride (0.03 mg/kg bwt/h) with butorphanol tartrate (0.03 mg/kg bwt/h). If indicated, horses received acepromazine maleate (Tranquisol® P, WDT) 0.03 mg/kg bwt (10 mg/mL) intramuscularly around 30 min prior to surgery.

Both paralumbar fossae were clipped and aseptically prepared. A local infiltration of 10–20 mL of mepivacaine hydrochloride 2% (Mepidor®, WDT) was used for local anaesthesia at the sites of portal placement. A combination of butylscopolamine (0.2 mg/kg bwt) and metamizole (25 mg/kg bwt; Buscopan compositum®, Boehringer Ingelheim) was administered intravenously to decrease the intestinal activity before the first cannula-trocar unit was placed. The portals were created by a sharp incision of the skin, followed by blunt dissection of the subcutaneous tissue, using straight Mayo scissors. Finally, a 10 mm diameter safety trocar-cannula unit (Karl Storz) was advanced into the abdomen. After a capnoperitoneum for abdominal distention was created, the left abdomen was inspected and additional portals were made under direct visualisation if necessary. The localisation of the portals was routinely created as previously described (Fischer, 1991; Fischer et al., 1986; Hendrickson, 2012), unless a previously performed transrectal palpation indicated a variation of these locations due to anatomic restrictions or conditions related to the pathology. All horses underwent a bilateral laparoscopic systematic examination starting on the left side. If required, the intestine was mobilised carefully either with blunt grasping forceps or by transrectal palpation (Silva et al., 2008). The portal sites were closed in two layers with simple interrupted suture patterns. The preparation time and surgical time were recorded.

Statistical analyses

Descriptive statistical analyses were performed using IBM SPSS Statistics 28. The data were evaluated for normality by visual evaluation of QQ-Plots. *p*-values of <0.05 were considered significant.

Calculation of sensitivity was performed by the formula true positive cases/true positive cases + false negative cases. Specificity was evaluated by true negative cases/true negative cases + false positive cases. True positive results were considered if the laparoscopic diagnosis was confirmed by laparotomy, post-mortem examination and cytology or by clear, definite laparoscopic findings, such as an adhesion formation or anatomic abnormality. A false positive result was defined when abnormal findings were found but their clinical significance was not confirmed. A false negative outcome occurred when the pathology could not be diagnosed by laparoscopy but was then found at laparotomy or necropsy. A true negative result showed no abnormalities in laparoscopy, laparotomy or during post-mortem examination, or the horses no longer showed any signs of colic.

RESULTS

Horses data

Exploratory laparoscopy was performed in 69 horses with chronic abdominal pain. The median age was 10 years (range 2–26 years). Most of the horses were geldings ($n=41$), followed by mares ($n=24$), and the remaining horses were stallions ($n=4$). Most of the horses were warmblood horses ($n=39$), followed by 7 ponies, 5 Icelandic Horses, 5 Spanish type horses, 3 Friesians, 2 Quarter Horses, 2 Appaloosas, 2 Cobs, 1 Paint, 1 Haflinger, 1 Standardbred, and 1 Thoroughbred. The median weight of the horses was 492.5 kg (range 267–684 kg).

The specific indications which led to performing a diagnostic laparoscopy were a suspected inflammatory process with local or generalised peritonitis in 7 horses, mass formation (neoplasia or abscess formation without peritonitis) in 11 horses, disorders of the urogenital tract were assumed in 4 horses, and a primary intestinal disease was considered in 46 horses. One remaining horse had non-specific findings in the previous examination, which led to a lack of a suspected specific pathology.

Surgical findings

A diagnosis was made by laparoscopy in 61 out of 69 horses (Figure 1). The median time for the preparation of the patients was 35 min (range 20–55 min). The median surgical time for laparoscopy was 45 min (range 20–85 min).

The diagnoses found laparoscopically included right dorsal displacement of the large colon ($n=12$; Figure 2) and colon displacement into the nephrosplenic space or between body wall and spleen ($n=4$). Signs of recurrent displacement of the large colon, such as fibrinous attachments on the serosa of the large colon and in the nephrosplenic space or with adhesion formation were found in six horses ($n=6$; Figure 3). Inflammatory diseases of the small intestine were diagnosed in eight horses (Figure 4). Pathology of the caecum included caecal inflammation and hypertrophy of the wall ($n=4$) and one excrescence of the caecum. Other findings

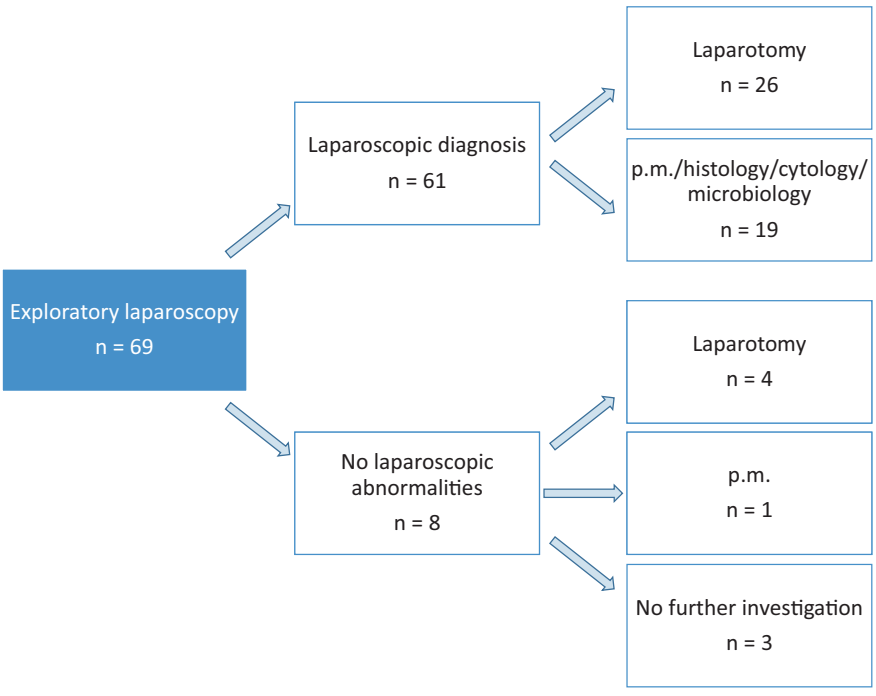

FIGURE 1 Flow chart of the horses undergoing exploratory laparoscopy and further examinations.

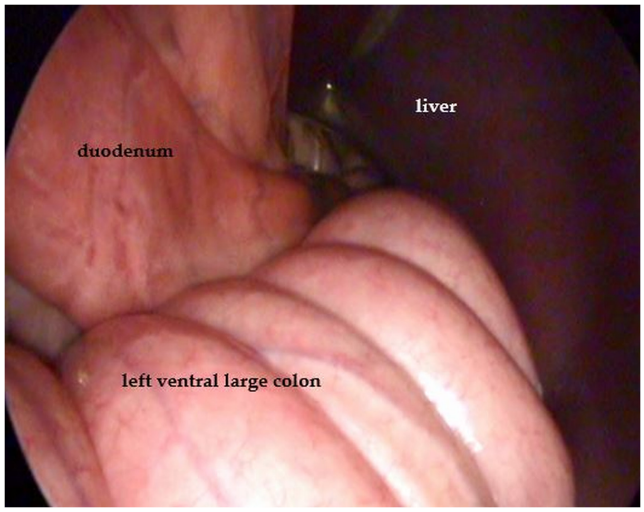

FIGURE 2 Laparoscopic view from the right side: The left ventral colon is visible on the right dorsal aspect. Diagnosis: Right dorsal displacement of the large colon.

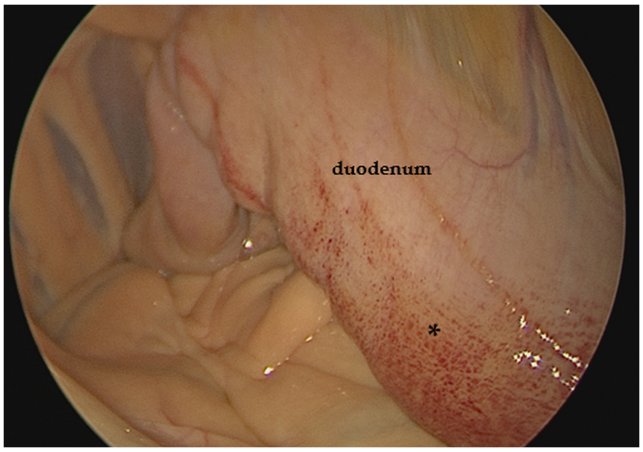

FIGURE 4 Laparoscopic view from the right side: The duodenum is slightly thickened and shows towards the oral side petechiae on the serosa as a sign of inflammation. Diagnosis: Duodenitis (*).

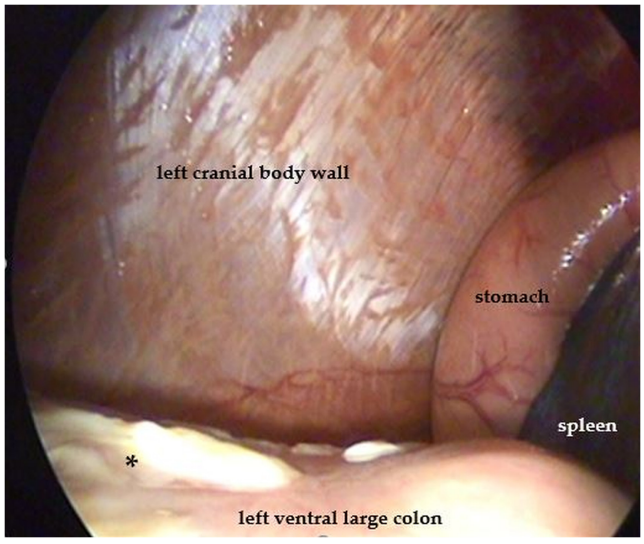

FIGURE 3 Laparoscopic view from the left side: Fibrous attachments on the left ventral large colon (*), which is displaced to the left side between the body wall and spleen. The fibrous attachments were found in horses with recurrent displacement of the large colon.

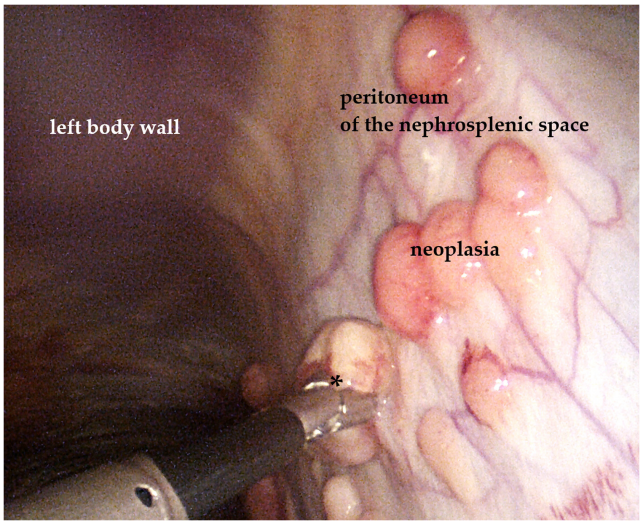

FIGURE 5 Laparoscopic view from the left side: Sampling biopsy (*) from neoplastic masses in the nephrosplenic space with laparoscopic biopsy forceps. The histopathology revealed a malignant lymphoma in this horse.

included neoplasia ($n = 7$) (Figure 5), adhesion formation ($n = 4$), peritonitis with or without adhesion formation ($n = 6$), abscess formation ($n = 4$) and extended funiculitis with adhesion formation ($n = 1$) (Figure 6). A total of three gastric diseases (dilatation and one anatomic malformation of the dorsal gastric attachments) were found. A severe dilated urinary bladder was present in one horse.

No pathologic findings were found in eight horses. Four of these horses underwent an exploratory laparotomy and one a post-mortem examination. The results were: segmental malformation of the large colon, caecal impaction probably due to motor dysfunction, nonstrangulating, large mesenteric lipoma, chronic ileal hypertrophy and, in one case, no gross pathology was found, therefore, a dysfunctional problem was suspected. The remaining three horses did not undergo further investigations due to owner refusal.

The sensitivity of exploratory laparoscopy was 88% in horses with chronic abdominal pain while the specificity was 15%. Table 1 shows the allocation of the horses for the calculation of the sensitivity and specificity. Two horses with no diagnostic findings were excluded from the analyses because no further investigation was performed, and in the third horse, the signs resolved without further examinations. Two horses with a laparoscopic diagnosis were counted as false negative because the true underlying cause of the pathology was found during ventral midline laparotomy.

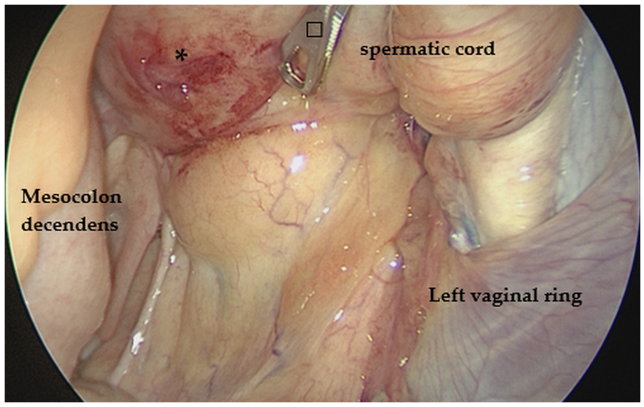

FIGURE 6 Laparoscopic view from the left side: extensive funiculitis of the left spermatic cord with adhesion formation (*). Manipulation by atraumatic laparoscopic Babcock forceps (□) indicated adhesion formation with urinary bladder and descending colon (not visible in the picture).

TABLE 1 Horses with or without confirmed diagnosis.

	Cases in total	Laparoscopic diagnosis	No laparoscopic diagnosis
	69	61	8
True positive		48	
False positive		11	
True negative			2
False negative		2	4

Surgical intervention and further treatment

Direct laparoscopic intervention was performed in 15 horses. Laparoscopic adhesiolysis ($n=7$), laparoscopic closure of the nephrosplenic space ($n=5$), abdominal lavage through the laparoscopic cannula, and an egress exit was made via a Foley-catheter placed in the ventral midline ($n=4$), and intra-abdominal abscess formation were either drained extra abdominally or injected with antimicrobial drugs ($n=2$). Following laparoscopy, a conversion to general anaesthesia for treatment or further diagnostics via midline laparotomy was performed in 26 horses. Twenty horses received additional medical treatment of the standard antimicrobial and analgesia.

Intra- and postoperative complications

Complications during laparoscopic surgery did not occur. However, it was not possible to evaluate the complete abdomen laparoscopically in a safe manner in one horse due to its behaviour.

Ten horses underwent immediate euthanasia following surgery at the owner's request due to a poor prognosis. Laparoscopy showed no abnormal findings in two of these horses. Post-mortem examination revealed a malformation of the colon in one of these horses and in the other horse, a motor dysfunction was suspected. Intestinal neoplasia ($n=4$), severe adhesions ($n=2$), a caecal diverticulum ($n=1$), and an undefined intestinal mass ($n=1$) were the intraoperative findings, which led to euthanasia. All other horses recovered well from the general anaesthesia.

TABLE 2 Horses subjected to postoperative euthanasia.

Cases	Diagnosis	Clinical Signs
2 horses	Intra-abdominal abscess formation	Severe systemic inflammatory response syndrome
2 horses	Caecal thickening and dysfunction	Caecal rupture
2 horses	Malignant intestinal lymphoma	Euthanasia after histological confirmation
1 horse	Malignant adenocarcinoma of the jejunum	Postoperative colic and reflux after resection
1 horse	Grass sickness	Postoperative colic and reflux
1 horse	Suspected dysfunction of the intestine	Recurrent colic signs
1 horse	Right dorsal displacement of the large colon	Recurrent severe colic and displacement

Post laparoscopic complications included a mild swelling of the surgical side ($n=6$), subcutaneous emphysema at the portal sites ($n=7$), mild serous discharge ($n=1$), transient postoperative fever ($n=7$) and mild colic signs ($n=5$). Furthermore, six horses showed leukopenia (2.7–4.5 G/L; reference range: 5.0–10.0 G/L) after the laparoscopic procedure, while three horses had transient leucocytosis (12.3–14.5 G/L).

Ten horses were subjected to euthanasia within a period of 2 weeks. Details can be found in Table 2. The remaining 49 horses survived to hospital discharge.

DISCUSSION

This study shows a sensitivity of 88% and a specificity of 15% of laparoscopy as a diagnostic tool in horses with chronic abdominal pain. The sensitivity was higher compared to previously reported data of 63% (Walmsley, 1999). However, the specificity is fractionally lower than the earlier data of 17% (Walmsley, 1999). The previous report was published in the early days of equine laparoscopy and, since then, laparoscopy has evolved considerably and improved its ability as a diagnostic tool probably combined with advances made in case selection. Nowadays, better laparoscopic equipment is available, for example, more powerful LED light sources help to increase vison within the abdominal cavity, which increases the success rate of this procedure. Additionally, experience and training in laparoscopic surgery is crucial for a good outcome (Smith et al., 2005). One surgeon with 30 years of experience in this field performed all the laparoscopies in the current study. It is possible that a less experienced surgeon may not have achieved similar results. It has

been shown in simulated laparoscopies in human medicine that experienced surgeons perform consistently better than those with less experience (Eriksen & Grantcharov, 2005). The preoperative workup, including improved abdominal ultrasound, has increased the ability to refine the case selection. In order to optimise the results, appropriate patient preparation is of the utmost importance to facilitate abdominal exploration. An adequate reduction of the intestinal contents is facilitated by reducing intake and exercising the horse daily for several days prior to surgery (Scheunert, 1905). Patients in our study which were not daily exercised due to orthopaedic diseases were found to have markedly more bowel content and, therefore, the visualisation was impaired as was the facility to move the intestine.

Our results are not completely comparable to the previously reported numbers because the criteria applied to classify the horses into true positive cases were more stringent: a confirmation of the finding via laparotomy, post-mortem or histology was necessary for inclusion as true positive. In contrast to the previous data, we also considered cases as true positive when the pathology was visually seen, such as a displacement of the colon to the left, significant adhesion formation or gross anatomic changes of the organs. When the therapy was performed laparoscopically, a laparotomy was not reasonable and sampling biopsies might not always be justifiable due to the adherent risks and, therefore, not performed in every case. When applying these more stringent criteria to the current study population, the sensitivity would be 85% and the specificity would decrease to 7%.

The reason for the recurrent colic signs could be found in the majority of the horses in the current study. Laparoscopy in the standing horse offers the possibility to access anatomical structures, which are not visible or approachable by midline laparotomy, such as most of the dorsal aspect of the abdomen, duodenum, epiploic foramen, liver, and stomach (Marshall & Blikslager, 2018). Therefore, the anatomic area of the suspected underlying pathology is one of the most crucial factors to determine whether diagnostic laparoscopy could be successful as a diagnostic tool and a good presurgical examination is very important to achieve a good result. It is known that the visualisation of the ventral aspects might be partially or fully impaired by the overlaying intestine in standing laparoscopy (Fischer et al., 1986). A ventral midline laparotomy might be a better option in horses where pathology is suspected in the ventral abdomen. On the other hand, exteriorisation and inspection of the oral end of the jejunum, duodenum and the aboral end of the ileum is not possible during ventral midline laparotomy (Marshall & Blikslager, 2018). These regions can be accessed via laparoscopy allowing a diagnosis such as duodenitis (Göbel & Koene, 1995) and permitting visualisation of the ileocaecal junction in 60% of the horses (Jones et al., 2017). Exploring the small intestine by using two atraumatic laparoscopic Babcock forceps for visual exploration is a method which has been reported (Bracamonte et al., 2008; Schambourg & Marcoux, 2006) with no severe adverse side effects (Jones et al., 2017). The nature and behaviour of the horses is also an important consideration, as was shown in our experience with a case where chronic ileal hypertrophy was diagnosed by laparotomy. This case had to be anaesthetised due to its uncooperative behaviour, resulting in an inability to complete the entire inspection of the small intestine. Laparoscopic biopsy techniques had been described for further investigations of the nature of small intestine pathologies (Bracamonte et al., 2008; Schambourg & Marcoux, 2006). In addition, even therapeutic interventions via hand-assisted laparoscopic surgery (HALS) are possible and should be considered in small intestinal diseases (Coomer et al., 2016).

Among the diagnoses found in this case series were many horses with large colon displacements to either the right or left side, which are usually diagnosed prior to a surgical intervention. Displacement of the large colon can provoke different degrees of colic signs. The positioning of the displaced colon determines the severity of the signs (Hardy, 2017). The horses in the present study did not display any signs of abdominal discomfort at the time of laparoscopic examination. The horses with left or right displacements of the ascending colon in our study showed chronic and only mild to moderate signs, probably due to the positions of the colon, lesser gas content of the bowel and the absence of concurrent impaction. This is probably also the reason why the preoperative examinations with transrectal palpation and abdominal ultrasound were inconclusive. During the transrectal examination, the pelvic flexure was not palpable but no taenia were felt due to the decreased content of the bowl. The typical sonographic signs, such as the presence of vessel structures of the large colon at the right body wall, could have been missed because of the position of the colon in those horses (Hardy, 2017; Manso-Díaz et al., 2020).

Recurrence of the left dorsal displacement of the large colon was highly suspected in nine of our horses due to the presence of adhesions or filamentous reaction of the serous membranes of the intestine, nephrosplenic space and body wall. Left dorsal displacement of the ascending colon is known to have a reoccurrence rate of up to 21% (Röcken et al., 2005). A transrectal diagnosis was made prior to the laparoscopic surgery in horses with a currently displaced colon to the left, but the intraoperative findings of fibrous attachments or adhesion formation in this area led to the conclusion that this displacement was recurrent and, therefore, the cause of the chronic colic signs. Other horses with left dorsal displacement of the large colon without these additional findings were not included in this case series, because the diagnosis was made prior to surgery.

Laparoscopy was not only diagnostic in horses with a left dorsal displacement of the large colon, but also offered the possibility to correct the displacement, perform adhesiolysis, if needed, and closure of the nephrosplenic space. Laparoscopic adhesiolysis was performed in 8 of 12 horses. These adhesions were suspected to be the cause of the recurrent colic; however, long-term follow-up or a second-look laparoscopy was not available. It is known that the prevalence of adhesion formation after laparoscopy in human medicine is decreased compared to conventional laparotomy (Schäfer et al., 1998). This could also be proven in dogs (Schippers et al., 1998). No data are available comparing both techniques in equids, but it might be suspected that adhesion occurrence after

laparoscopy is less likely in horses as well (Bouré et al., 2002). Even though a HALS was thoroughly described to be used successfully (Muñoz & Bussy, 2013) in none of the horses in the current study a flank laparotomy was needed for correction of the displacement or for closure of the nephrosplenic space. A flank laparotomy is more invasive and considerably associated with more complications than the insertion of a 30 mm cannula-trocar unit, which was used for placing suture material into the abdomen in a technique described by Mariën et al. (2001). On the other hand, a laparotomy approach offers the advantage of direct tactile examination of the abdominal cavity by palpation and, therefore, might have additional diagnostic potential (Graham & Freeman, 2014). No beneficial diagnostic value of HALS was considered in our population.

Overall, a direct laparoscopic therapy was performed in 22% of our horses. The laparoscopic findings led to a conversion to ventral midline exploratory laparotomy under general anaesthesia to treat the pathologic condition found laparoscopically in 26 cases.

Diagnosis in some horses was made by laparoscopy correctly, but laparotomy revealed more details of the pathology, because the pathology was in the ventral large colon or not accessible due to adhesion formation. This shows that, in some instances, laparoscopy and laparotomy act as complementary diagnostic tools.

Masses could be detected by palpation with atraumatic Babcock laparoscopic forceps in some instances when not visible directly because of their anatomical localisation. This shows the value of palpating the intestine with atraumatic forceps as an additional diagnostic tool. It was possible in some instances to manoeuvre parts of the intestine with the atraumatic laparoscopic forceps or through transrectal palpation by an assistant, for example, by lifting the aboral end of the descending colon to increase the visualisation of the pelvic region.

Despite its minimally invasive nature, severe intraoperative complications can occur, such as inadvertently puncturing the intestine, the spleen or the circumflex iliac vessel while placing the trocar-cannula unit (Cerullo et al., 2022; Fischer, 1991; Fischer et al., 1986; Hendrickson, 2009; Ragle et al., 1996; Rijkenhuizen & Van Dijk, 2002; Shettko, 2000; Walmsley, 2007). Insufflation of the retroperitoneal space instead of the abdominal cavity has no serious consequences, but it increases the surgery time and reduces the visibility in the abdomen (Rijkenhuizen & Van Dijk, 2002; Shettko, 2000). None of these complications occurred in our case series but good practice measures, such as appropriate fasting, proper sedation, performing a transrectal examination prior to trocar introduction and gentle bowel manipulation, were important. We always started bilateral laparoscopy from the left side based on reduced risk of accidental caecal puncture compared to starting on the right (Fischer et al., 1986). Additionally, we used Mayo scissors for blunt dissection before entering with the safety trocar, which helped to prevent injury to the organs and avoided the separation of the peritoneum from the body wall. To the best of our knowledge, this method has not been mentioned previously. Another factor to avoid damage to the bowel was the use of intraoperative butylscopolamine, which reduces the mobility of the intestine.

Performing this procedure in the standing horse avoids general anaesthesia. The mortality rates due to sedation in the horse are reported to be as low as 0.2% (Gozalo-Marcilla et al., 2021). No negative side effects of the sedation could be observed in any of our 69 horses.

Mild postoperative complications, such as mild subcutaneous emphysema, mild incisional oedema and transient fever, found in our study have been described previously (Cerullo et al., 2022; Hendrickson, 2009; Rijkenhuizen & Van Dijk, 2002; Smith et al., 2005; Straticò et al., 2020) and could be managed satisfactorily. Some horses in our study population were observed with transient leukopenia or leucocytosis, which has not been described in horses previously. Of the three horses with leucocytosis, two underwent additional laparotomy and the third horse had extended funiculitis. The horses with leukopenia had different pathologies but all had an inflammatory nature. Three of six horses with leukopenia were euthanised. None of the horses showed signs of a developing colitis or pleuropneumonia. One study in a rat model of peritonitis demonstrated that the insufflation with carbon dioxide leads to a significant reduction in the total white cell count and circulating neutrophil (Araújo Filho et al., 2006). This might be a possible explanation for the leukopenia in our study.

The main limitations of the present study were due to its retrospective nature: some details were missing in the medical reports. In addition, no long-term follow-up was available to ascertain whether colic signs reoccurred after surgical intervention, or complications occurred in the long postoperative period. No confirmation of the laparoscopic diagnosis was available for some horses, and a post-mortem examination or histology of a biopsy sample would have been beneficial. The judgement whether the findings leading to the colic signs was influenced by the severity of the former and by the experience of the surgeon. This was subjective and could have led potentially to a false judgement overall. However, a confirmation was not always possible due to the chronic state of the disease, for example, in horses with recurrent displacement. Furthermore, the results of our study might have a bias because we considered 14 horses as true positive cases even when the unambiguous laparoscopic findings were not confirmed by post-mortem or laparotomy.

In conclusion, explorative laparoscopy in the standing horse is a valuable diagnostic tool for well-selected cases with chronic abdominal pain. It can be useful to determine treatment options including further laparoscopic intervention, midline laparotomy, medical treatment or euthanasia, as was also shown in our population (Embertson & Bramlage, 1992). A good knowledge of the anatomy and experience is important to explore the abdomen and for finding a correct diagnosis (Rijkenhuizen & Van Dijk, 2002; Selders et al., 2001) but the surgeon must consider that false negative results are possible. The results of our study support the use of explorative flank laparoscopy as a valuable modality in the cascade of diagnostics with a high

sensitivity. However, the specificity is low, meaning that a negative laparoscopy should encourage further investigations.

AUTHOR CONTRIBUTIONS

Tanja Pudert: Writing – original draft; data curation; investigation; conceptualization; methodology; formal analysis; visualization. **Antonio M. Cruz:** Conceptualization; investigation; writing – review and editing; methodology; validation; supervision; project administration. **Michael Röcken:** Writing – review and editing; conceptualization; investigation; methodology; validation; supervision; data curation; resources.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS STATEMENT

The owners of the horses were informed and signed an informed consent form. Animal welfare was respected throughout the hospital stay.

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REFERENCES

Araújo Filho, I., Honorato Sobrinho, A.A., Rego, A.C.M.D., Garcia, A.C.M., Fernandes, D.P., Cruz, T.M. et al. (2006) Influence of laparoscopy and laparotomy on gasometry, leukocytes and cytokines in a rat abdominal sepsis model. *Acta Cirúrgica Brasileira*, 21, 74–79.

Arnold, C.E. & Love, C.C. (2013) Laparoscopic evaluation of oviductal patency in the standing mare. *Theriogenology*, 79, 905–910. Available from: https://doi.org/10.1016/j.theriogenology.2012.12.004

Bouré, L.P., Pearce, S.G., Kerr, C.L., Lansdowne, J.L., Martin, C.A., Hathway, A.L. et al. (2002) Evaluation of laparoscopic adhesiolysis for the treatment of experimentally induced adhesions in pony foals. *American Journal of Veterinary Research*, 63, 289–294. Available from: https://doi.org/10.2460/ajvr.2002.63.289

Bracamonte, J.L., Bouré, L.P., Geor, R.J., Runciman, J.R., Nykamp, S.G., Cruz, A.M. et al. (2008) Evaluation of laparoscopic technique for collection of serial fill-thickness small intestinal biopsy specimens in standing sedated horses. *American Journal of Veterinary Research*, 69, 431–439. Available from: https://doi.org/10.2460/ajvr.69.3.431

Cerullo, A., Ganddini, M. & Giusto, G. (2022) Occurence and definitions of intra and postoperative complications related to laparoscopy in equids: a scoping review. *Veterinary Science*, 9, 577. Available from: https://doi.org/10.3390/vetsci10010061

Coomer, R., McKane, S., Roberts, V., Gorvy, D. & Mair, T. (2016) Small intestinal biopsy and resection in standing sedated horses. *Equine Veterinary Education*, 28, 636–640. Available from: https://doi.org/10.1111/eve.12582

Embertson, R.M. & Bramlage, L.R. (1992) Clinical use of the laparoscope in general equine practice. *Proceedings of the American Association of Equine Practitioners*, 38, 165–169.

Eriksen, J.R. & Grantcharov, T. (2005) Objective assessment of laparoscopic skills using a virtual reality stimulator. *Surgical Endoscopy and Other Interventional Techniques*, 19, 1216–1219.

Fischer, A.T. (1991) Standing laparoscopic surgery. *Veterinary Clinics of North America: Equine Practice*, 7, 641–647. Available from: https://doi.org/10.1016/S0749-0739(17)30491-1

Fischer, A.T., Kent Lloyd, K.C., Carlson, G.P. & Madigan, J.E. (1986) Diagnostic laparoscopy in the horse. *Journal of the American Veterinary Medical Association*, 189, 289–292.

Fulton, I.C., Brown, C.M. & Yamini, B. (1990) Adenocarcinoma of intestinal origin in a horse: diagnosis by abdominocentesis and laparoscopy. *Equine Veterinary Journal*, 22, 447–448. Available from: https://doi.org/10.1111/j.2042-3306.1990.tb04314.x

Göbel, H. & Koene, M. (1995) Laparoskopische Untersuchung beim Pferd. *Der Praktische Tierarzt*, 5, 447–450.

Gozalo-Marcilla, M., Brettschart-Wolfensberger, R., Johnston, M., Taylor, P.M. & Redondo, J.I. (2021) Data collection for the fourth multicentre confidential enquiry into perioperative equine fatalities (CEPEF 4) study: new technology and preliminary results. *Animals*, 11, 2549. Available from: https://doi.org/10.3390/ani11092549

Graham, S. & Freeman, D. (2014) Standing diagnostic and therapeutic equine abdominal surgery. *Veterinary Clinics of North America: Equine Practice*, 30, 143–168. Available from: https://doi.org/10.1016/j.cveq.2013.11.010

Hardy, J. (2017) Specific diseased of the ascending colon. In: Blikslager, A.T., White, N.A., Moore, J.N. & Mair, T.S. (Eds.) *Equine Acute Abdomen*, 3rd edition. Hoboken, USA: Wiley-Blackwell, pp. 748–774.

Hassel, D.M. & Ragle, C.A. (1994) Laparoscopic diagnosis and conservative treatment of uterine tear in a mare. *Journal of the American Veterinary Medical Association*, 205, 1531–1533.

Hendrickson, D.A. (2009) Complications of laparoscopic surgery. *Veterinary Clinics of North America: Equine Practice*, 24, 557–571. Available from: https://doi.org/10.1016/j.cveq.2008.09.003

Hendrickson, D.A. (2012) Diagnostic Techniques. In: Ragle, C.A. (Ed.) *Advances in Equine Laparoscopy*, 1st edition. Ames, USA: Wiley-Blackwell, pp. 83–91.

Jones, A.R.E., Ragle, C.A., Anderson, D. & Scott, C. (2017) Laparoscopic evaluation of small intestine in the standing horse: technique and effects. *Veterinary Surgery*, 46, 812–820. Available from: https://doi.org/10.1111/vsu.12664

Klohnen, A. (2012) Evaluation of horses with signs of acute and chronic abdominal pain. In: Ragle, C.A. (Ed.) *Advances in Equine Laparoscopy*, 1st edition. Ames, USA: Wiley-Blackwell, pp. 93–118.

Kollmann, M., Rötting, A., Heberling, A. & Sieme, H. (2011) Laparoscopic technique for investigating the equine oviduct. *Equine Veterinary Journal*, 43, 106–111. Available from: https://doi.org/10.1111/j.2042-3306.2010.00143.x

Mair, T.S. & Hillyer, M.H. (1997) Chronic colic in the mature horse: a retrospective review of 106 cases. *Equine Veterinary Journal*, 29, 415–420. Available from: https://doi.org/10.1111/j.2042-3306.1997.tb03151.x

Manso-Díaz, G., Bolt, D.M. & López-Sanromán, J. (2020) Ultrasonographic visualisation of the mesenteric vasculature in horses with large colon colic. *Veterinary Record*, 186, 491. Available from: https://doi.org/10.1136/vr.105468

Mariën, T., Adriaenssen, A., Hoeck, F.V. & Segers, L. (2001) Laparoscopic closure of the renosplenic space in standing horses. *Veterinary Surgery*, 30, 559–563. Available from: https://doi.org/10.1053/jvet.2001.28436

Marshall, J.F. & Blikslager, A.T. (2018) Colic: diagnosis, surgical decision, preoperative management, and surgical approaches to the abdomen. In: Auer, J.A., Stick, J.A., Kümmerle, J.M. & Prange, T. (Eds.) *Equine Surgery*, 5th edition. St. Louis: Elsevier, pp. 521–528.

Muñoz, J. & Bussy, C. (2013) Standing hand-assisted laparoscopic treatment of left dorsal displacement of the large colon and closure of the nephrosplenic space. *Veterinary Surgery*, 42, 595–599. Available from: https://doi.org/10.1111/j.1532-950X.2012.01050.x

Ragle, C.A., Schneider, R.K. & Southwood, L.L. (1996) Abdominal laparoscopy in horses. *Compendium: Continuing Education for Veterinarians*, 18, 1231–1239 (–1241).

Ragle, C.A., Southwood, L.L., Galuppo, L.D. & Howlett, M.R. (1997) Laparoscopic diagnosis of ischemic necrosis of the descending colon after rectal prolapse and rupture of the mesocolon in two postpartum mares. *Journal of the American Veterinary Medical Association*, 210, 1646–1648.

Rijkenhuizen, A.B.M. & Van Dijk, P. (2002) Diagnostic and therapeutic laparoscopy in the horse: experiences in 236 cases. *Pferdeheilkunde*, 18, 12–20.

Röcken, M., Schubert, C., Mosel, G. & Litzke, L.F. (2005) Indications, surgical technique, and long-term experience with laparoscopic closure of the nephrosplenic space in standing horses. *Veterinary Surgery*, 34, 637–641. Available from: https://doi.org/10.1111/j.1532-950X.2005.00098.x

Schäfer, M., Krähenbühl, L. & Büchler, M.W. (1998) Comparison of adhesion formation in open and laparoscopic surgery. *Digestive Surgery*, 15, 148–152. Available from: https://doi.org/10.1159/000018609

Schambourg, M.M. & Marcoux, M. (2006) Laparoscopic intestinal exploration and full-thickness intestinal biopsy in standing horses: a pilot study. *Veterinary Surgery*, 35, 689–696. Available from: https://doi.org/10.1111/j.1532-950X.2006.00210.x

Scheunert, A. (1905) Über den Einfluss der Körperbewegung auf die Verdauung und Nährstoffabsorption des Pferdes. *Archiv für Die Gesamte Physiologie Des Menschen und der Tiere*, 109, 145–198.

Schippers, E., Tittel, A., Ottinger, A. & Schumpelick, V. (1998) Laparoscopy versus laparotomy: comparison of adhesion-formation after bowel resection in a canine model. *Digestive Surgery*, 15, 145–147. Available from: https://doi.org/10.1159/000018608

Selders, C.G., Hendrickson, D.A., Bowling, A.T. & McCue, P.M. (2001) The use of laparoscopy to diagnose a case of equine intersex: a case report. *Journal of Equine Veterinary Science*, 21, 547–549. Available from: https://doi.org/10.1016/S0737-0806(01)70160-8

Shettko, D.L. (2000) Complications in laparoscopic surgery. *Veterinary Clinics of North America: Equine Practice*, 16, 377–383. Available from: https://doi.org/10.1016/S0749-0739(17)30112-8

Silva, L.C.L.C., Zoppa, A.L.V. & Hendrickson, D.A. (2008) Equine Diagnostic Laparoscopy. *Journal of Equine Veterinary Science*, 28, 247–254. Available from: https://doi.org/10.1016/j.jevs.2008.02.002

Smith, C.L., Dowling, B.A. & Dart, A.J. (2005) Recent advances in equine abdominal surgery. *Veterinary Journal*, 170, 41–51. Available from: https://doi.org/10.1016/j.tvjl.2004.03.019

Sponton, J.A., Mair, T.S. & Krudewig, C. (2009) Pancreatic adenocarcinoma in a donkey. Use of laparoscopy to aid the diagnosis. *Equine Veterinary Education*, 21, 19–24. Available from: https://doi.org/10.2746/095777308X382641

Straticò, P., Varasano, V., Guerri, G., Celani, G., Palozzo, A. & Petrizzi, L. (2020) A retrospective study of cryptorchidectomy in horses: diagnosis, treatment, outcome. *Animals*, 10, 2446. Available from: https://doi.org/10.3390/ani10122446

Walmsley, J.P. (1999) The sir Frederick hobday memorial lecture: review of equine laparoscopy and an analysis of 158 laparoscopies in the horse. *Equine Veterinary Journal*, 31, 456–464. Available from: https://doi.org/10.1111/j.2042-3306.1999.tb03851.x

Walmsley, J.P. (2007) Laparoscopy in horses with abdominal pain. *Equine Veterinary Education*, 19, 64–66. Available from: https://doi.org/10.2746/095777307X18193

Wilson, D.G. (1989) Laparoscopy as an aid in the surgical management of the equine hemicastrate. *Proceedings of the American Association of Equine Practitioners*, 35, 347–353.

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