Case Report

Hand-assisted laparoscopic adhesiolysis of extensive small intestinal adhesions in a mare after breeding injury

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Summary

In this article we report the course of disease in a mare following severe vaginal injury during natural cover. Although the genital injury healed completely, the mare developed extensive intra-abdominal intestinal adhesions causing complete small intestinal obstruction 2 years after the incident. The adhesion was not accessible during initial emergency laparotomy and a standing, hand-assisted laparoscopic adhesiolysis and jejuno-jejunal end-to-end anastomosis were subsequently performed. The mare was subjected to euthanasia 10 weeks after surgery due to recurrence of abdominal pain. The pertaining literature is discussed in regards to this case.

Introduction

Vaginal injury is a rare incident during natural service. Injuries involving mucosa or submucosa most often heal adequately without any specific treatment. However, full thickness tears entering the peritoneal cavity present a life threatening problem and warrant immediate attention. If possible, the tear should be closed and nonsteroidal anti-inflammatory and antimicrobial medication given to prevent peritonitis (Blue 1985; Tulleners et al. 1985). If lacerations become infected, they may subsequently result in abscess or fistula formation (Hooper et al. 1994).

Intra-abdominal adhesions in general, and of small intestine in particular, are known complications after abdominal surgery in horses (Southwood et al. 1997). Treatment modalities include mechanical adhesiolysis via laparotomy (Baxter et al. 1989) or laparoscopy (Bleyaert et al. 1997; Bourd et al. 1998; Walmsley 1999; Fischer 2002; Röcken et al. 2002; Bartmann et al. 2006).

In this report we describe our experience using a standing, hand-assisted laparoscopic technique to transect the adherent tissue.

Case history

A 14-year-old, 600 kg, multiparous (7 foals) Warmblood mare was presented to the Large Animal Clinic for Surgery with a history of vaginal wall injury during natural cover 12 days before admission. The mare had been treated inconsistently with enrofloxacin, but was referred to our hospital because of continued fever, tachycardia, reduced appetite and prolonged recumbency.

Initial presentation

On initial evaluation, the mare was depressed, had a heart rate of 60 beats/min and body temperature of 38.1°C. During rectal examination, a firm mass with a diameter of 15 cm was palpated ventro-laterally on the right hand side to the rectum. The mass was located just at the cranial border of the bony pelvic ring and felt firmly attached to the surrounding soft tissue. Vaginal examination revealed white, odorous discharge. On the right-dorsal vaginal vault (12 to 2 o’clock), close to the cervix, the vaginal mucosa was swollen and inflamed and a small opening was palpable and visible from which white, mucous material was leaking. Subsequent bacterial culture revealed *Streptococcus equi* ssp. *zooepidemicus* and *Streptococcus dysgalactiae* ssp. *equisimilis*, both sensitive to cefquinome. The mare had a leucocytosis (19.0 ¥ 10⁹/l, reference range [rr] < 5 ¥ 10⁹/l) with a left shift (2% band neutrophils). Transcutaneous abdominal ultrasonography revealed a large increase of abdominal fluid. Results of the abdominal fluid evaluation revealed an increase in total white blood cells (13.1 ¥ 10⁹/l, rr<5 ¥ 10⁹/l), increase of total protein (52.2 g/l, rr<25 g/l), but no bacteria were seen on a Gram stain. Rectal ultrasound revealed that the fluid had a thick capsule and anechoic, loculated content (Fig 1). The remaining parts of the genital tract were normal.

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A diagnosis of vaginal wall injury with subsequent intra-abdominal abscess and fistula formation, and generalised peritonitis was made. The mare was placed on 1 mg/kg bwt i.v. cefquinome (Cobactan)\(^1\) and 1 mg/kg bwt flunixin meglumine (Flunidol RP)\(^2\); 2 l mineral oil (Paraffinum perliquidum)\(^3\) were given via nasogastric tube and she was placed on 2.0 ml/kg bwt/h i.v. Ringer’s solution (Ringer)\(^4\). Within 12 h, the mare became severely tachycardic (80 beats/min), developed gastric reflux (6–15 l q. 6 h), was completely inappetent and became recumbent.

The following morning the mare was placed in stocks and sedated using 0.06 mg/kg bwt romifidine (Sedivet)\(^5\) and 0.02 mg/kg bwt butorphanol (Torbugesic)\(^6\). The small opening into the abscess was blindly enlarged to a length of about 5 cm using a No. 22 scalpel blade. The abscess cavity was lavaged with large amounts of tap water and a 10\(\times\)1 cm piece of polyurethane sponge (Ligasano)\(^7\), soaked in streptomycin and penicillin (Streptocombin)\(^8\), was placed into the cavity.

Over the next 7 days, the abscess cavity was lavaged with tap water and the sponge soaked in antibiotic solution was replaced daily. The mare’s general condition, body temperature, heart rate and haematological parameters returned to normal limits within 3 days. The antibiotics and nonsteroidal drugs were discontinued on Day 5 after admission. At the time of discharge, 7 days after admission, the abscess cavity had decreased in size.

The mare was returned to the clinic one week later for re-evaluation. Heart rate, body temperature and haematological parameters were within normal limits. On vaginal examination a minimal amount of brown, odorous discharge was found. A 2 fingers wide opening was palpable at the site of vaginal wall injury and the cavity was again lavaged.

One month later (6 weeks after initial presentation), the mare was presented again because of continuous brown, odorous vaginal discharge. The mass had decreased in size but was still palpable on rectal examination. An opening from the vaginal vault into the abscess was also still palpable. The remaining parts of the genital tract were normal. Bacteriological evaluation of the abscess cavity and a uterine swab revealed *Streptococcus equi* ssp. *zooepidemicus*, *Prevotella oris* and *E. coli*, all sensitive to cefquinome. The mare was placed on cefquinome for 5 days. The opening into the abscess cavity was enlarged digitally and lavaged daily with diluted iodine solution. She was discharged 3 weeks later. At that time, a mass with a diameter of 5 cm could be palpated rectally and no abnormalities were found on vaginal evaluation. Swabs taken for bacterial culture were all negative at that time.

The mare was completely normal during the next 12 months and was rebred using artificial insemination the following year.

### Second course of disease

#### Clinical findings, diagnosis, treatment and outcome

Exactly 2 years later, the mare was presented to our hospital again with acute signs of severe colic. The mare had an unassisted parturition 48 h earlier and had delivered a live male foal. Treatment by the referring veterinarian included 30 ml butylscopolamin/metamizol (Buscopan compositum)\(^5\).

On admission, her heart rate was 80 beats/min, respiratory rate 28 breaths/min and mucous membranes were pale. Haematology revealed a mild haemoconcentration (40%). Ionised calcium was slightly decreased (1.17 mmol/l), chloride was slightly decreased (92 mmol/l) and the mare had a base excess of 9.6 mmol/l. Dilated small intestinal loops were visible on transcutaneous abdominal ultrasonography and were palpable during rectal examination. Twenty litres of reflux were removed via nasogastric tube. On the basis of our clinical findings, a decision was made to perform immediate exploratory laparotomy.

Treatment initiated included 20,000 iu/kg bwt i.v. penicillin sodium (Infectocillin)\(^9\), 6.6 mg/kg bwt gentamicin (Genta 100)\(^2\), 1.1 mg/kg bwt flunixin and a bolus of 5 l Ringer’s solution. The mare was premedicated with i.v. 0.05 mg/kg bwt romifidine and 0.03 mg/kg bwt butorphanol. General anaesthesia was induced using i.v. 0.07 mg/kg bwt diazepam (Diazepam-Lipura)\(^6\) and 3.5 mg/kg bwt ketamine (Ursotamin)\(^10\) and maintained on isoflurane (Isoflurane)\(^7\) in 100% oxygen. Further treatments during

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anaesthesia included 15 mg/kg bwt vitamin C (Vitamin C forte)\textsuperscript{11}, 2 ml/kg bwt 7.5% sodium chloride solution [Hypertonie Natriumchlorid-Lösung]\textsuperscript{4} and, to effect, hydroxyethyl starch [Tetraspan 6%]\textsuperscript{4} besides Ringer’s solution. A standard preumbilical, midline laparotomy incision of 20 cm length was performed. Multiple distended loops of small intestine were found. Starting at the ileum and tracing the small intestine proximally, an adhesion of the mid-jejunum to the very caudal aspect of the pelvic cavity was found. The adhesion included the entire circumference of about 30 cm small intestine. The prestenotic intestine was severely fluid-distended and the serosal surface was pink. Initial attempts to break down the adhesions were unsuccessful. Only very little intestinal content was massaged past that adhesion. To decompress the distended intestine, a 5 cm long, longitudinal enterotomy along the antimesenteric aspect of the jejunum was made. It was closed in layers using a 3 m polyglyactin 910 (Vicryl)\textsuperscript{12} suture in a simple continuous pattern for the mucosal layer and continuous Lembert pattern for the seromuscular layer. During further manipulation on the adhesion side, it was not possible to safely break down more than a few tissue strands. The abdomen was lavaged with sterile solution and the laparotomy incision closed using a double stranded (looped) 5 metric glycolide/lactide copolymer (Polysorb)\textsuperscript{13} suture in a simple continuous pattern for the linea alba, a 3 m polyglyactin 910 suture in simple continuous pattern for the subcutaneous tissue and 4 m polyamid (Supramid)\textsuperscript{4} suture in a horizontal mattress pattern for the skin. Total anaesthesia time was 200 min.

The mare was maintained on gentamicin (6.6 mg/kg bwt q. 24 h, i.v.), penicillin sodium (20,000 iu/kg bwt q. 8 h, i.v.), flunixin (1.1 mg/kg bwt q. 24 h, i.v.), Ringer’s solution (2.5 ml/kg bwt/h) and vitamin C (15 mg/kg bwt q. 24 h, i.v.) after surgery. Additionally, she was placed on 0.05 mg/kg bwt/min lidocaine (Lidocain hydrochlorid 2%)\textsuperscript{14}. An abdominal bandage was applied. Heart rate, body temperature and haematological parameters returned to, or stayed within, normal limits within 24 h after surgery. She was completely held off food but slowly reintroduced to free choice of water.

To break down the adhesion, a standing right flank laparoscopy using digital assistance was performed 2.5 days after the initial laparotomy. The mare was placed in stocks and the right flank prepared and draped for aseptic surgery. Sedation and analgesia were provided using repeated boluses of i.v. romifidine and butorphanol (total dose 0.16 mg/kg bwt and 0.11 mg/kg bwt, respectively). A combination of 0.17 mg/kg bwt lidocaine, 0.13 mg/kg bwt xylocaine (Xylazin 2%)\textsuperscript{15}, 0.17 mg/kg bwt ketamine and 0.02 mg/kg bwt butorphanol were administered epidurally (total volume 11 ml). A paravertebral block desensitising the last thoracic and the first 2 lumbar spinal nerves using 1.8 mg/kg bwt lidocaine was performed. Due to incomplete desensitisation, infiltration of the surgical sites with 1 mg/kg bwt lidocaine was also performed. A 12 mm skin incision was made midway between the last rib and the tuber coxae, dorsal to the crus of the internal abdominal oblique muscle. The 11 mm laparoscopic trocar-cannula assembly (Trinox Trocar systems shielded trocars)\textsuperscript{16} was introduced into the abdomen and the cannula replaced by a 52 cm, 30° telescope (Telescope Hopkins)\textsuperscript{17}. Insufflation with CO\textsubscript{2} was started and maintained during the first part of the surgery at about 12 mmHg (Endoflator 26411020)\textsuperscript{17}. Broad adhesions of a small intestinal loop to the abdominal wall, the uterine body and mesocolon of the descending colon were visible in the right caudal pelvic cavity. A distal laparoscopic portal was created about 8 cm ventrally and slightly caudally to the first portal. Straight laparoscopic scissors (Laparoscopic scissors)\textsuperscript{17} were introduced into that portal. However, manipulation of the adhesion site was not possible. Therefore, the distal portal was converted into a laparotomy by sharp vertical transection of the abdominal wall dorsally and ventrally to the portal to a total length of about 15 cm. The surgeon’s right hand was introduced into the laparoscopic field and some adhesions broken down manually under visual control. The newly formed tissue was very extensive, thick and firm. For further sharp transection, laparoscopic scissors were introduced ventrally into the laparotomy incision and operated by the surgeon’s left hand. Under digital guidance and control, the adhered tissue was either tensioned for scissors application or placed digitally within the branches of the scissors (Fig 2). Using these techniques, incising the uterus or intestine was avoided and a large vessel within the small intestinal mesentery was identified prior to transection. This vessel was divided using a vessel sealing system (handswitching laparoscopic sealer/divider LigaSure)\textsuperscript{18} (Fig 3). The freed small intestine was exteriorised through
the flank laparotomy (Fig 4). A hole in the mesentery and a mass of fibrous tissue on the intestinal serosa became visible. About 30 cm of affected small intestine were removed by resection and end-to-end anastomosis. A 3 m polyglactin 910 suture in a simple continuous pattern was used for the mucosal layer and a continuous Lembert pattern used for the seromuscular layer. Both suture layers were interrupted at 180° of the entire circumference to avoid a purse string effect. The defect in the mesentery was closed using a 3 m polyglactin 910 suture in a simple continuous pattern. The intestine was replaced and the abdominal incisions closed. The peritoneum of the laparotomy incision was sutured using a 3 m polyglactin 910 suture in a simple continuous pattern, the 3 muscular layers were closed individually using a 4 m polyglactin 910 suture (Vicryl)\textsuperscript{12} in a simple continuous pattern, the subcutaneous layer was closed using a 3 m polyglactin 910 suture in simple continuous pattern and the skin closed using a 3.5 m polyamid suture (Ethilon II)\textsuperscript{12} in a simple interrupted pattern. The laparoscopic portal was closed using a 4 m polyglactin 910 suture to close the muscular tissue and subcutaneous tissue in a single layer and the skin was closed using a 3.5 m polyamid suture in a simple interrupted pattern. Before closing the laparoscopic portal, 10 l Ringer’s solution were applied into the abdomen. Total time of sedation was 240 min.

After surgery the mare was maintained on i.v. antibiotics, flunixin, Ringer’s solution and lidocaine as described after the first surgery. Lidocaine was discontinued the following day. Food and water were slowly reintroduced. Heart rate and body temperature stayed within normal limits. The mare developed a pitting oedema and mucopurulent discharge from the ventral laparotomy incision 3 days after the second surgery, but not from the incisions in the right flank. Treatment included hydrotherapy with warm water twice daily. Antibiotics and flunixin were discontinued 5 days after the second surgery. The mare and foal were discharged one week later.

According to the owner, the incisional infection healed without any further complication. However, the mare intermittently showed signs of abdominal discomfort and occasionally fever. She was treated by the local veterinarian with NSAIDs. The mare was subjected to euthanasia 10 weeks after discharge following one of the colic episodes. No post mortem evaluation was performed.

**Discussion**

Trauma to the caudal birth canal occurs commonly during parturition (Blanchard and MacPherson 2007) but genital injuries of mares caused by mating are seldom reported. The most common location for such injuries is the cranial vaginal vault, dorsolateral to the cervix (Blue 1985; Tulleners et al. 1985). They have been attributed to relative oversize of the stallion’s penis and may be prevented by using a
beyond the submucosa can be sutured per vaginum (Blanchard and MacPherson 2007). Alternatively, complete healing by second intention is reported to occur within 7–10 days (Blue 1985; Tulleners et al. 1985). A possible complication is intestinal prolapse through the vaginal rent (Blue 1985; Tulleners et al. 1985). Intra-vaginal transluminal adhesion formation is also possible and is prevented by frequent local medication and manipulation. The depth of laceration in the present case was not known. A deep or even complete laceration was suspected based on subsequent large abscess formation and peritonitis. Our treatment was successful in resolving the peritonitis and the abscess as well as restoring complete breeding soundness in this mare. However, an additional extensive intra-abdominal adhesion had formed unnoticed during that time and caused severe clinical problems 2 years later. It is also possible that the mare had acquired this adhesion during one of the 7 previous pregnancies, but there were no known complications during any of the previous breedings or deliveries.

The decision for the most appropriate treatment during the emergency laparotomy was a challenge and possible alternative treatments had to be weighed against each other. One option is the separation of the adhesion under laparoscopic visualisation. This requires the Trendelenburg position and set-up of laparoscopy equipment. This option was dismissed due to the mare’s markedly compromised cardiovascular state and a head down position would have further intensified this. Secondly, visualisation would have been poor, or even impossible, due to minor haemorrhage caused by initial attempts to break up the adhesions and distended small and large intestine. Furthermore, setting up laparoscopy equipment with less well trained night staff would have unacceptably prolonged the surgery time. Another option is the transection of the pre- and post stenotic small intestine, creating a standard end-to-end anastomosis and leaving an isolated piece of intestine of approximately 1.5 m length within the abdomen. In this case, a complete closure of the mesentery is not possible. An alternative option is the creation of a side-to-side anastomosis of the pre- and post stenotic jejunum, incompletely bypassing the adhered intestine. This has previously been reported in 3 horses (Mair and Hillyer 1997). Considering the short lived success in this mare, this is probably the best alternative for the present case. It would have caused less overall trauma in the abdomen, thus decreasing the risk of new adhesion formation. Functionality of an incomplete bypass of approximately 1.5 m jejunum has not been previously documented in the literature.

Intra-abdominal adhesion formation in horses is a known complication, especially after abdominal surgery (Southwood et al. 1997). About 22% of horses develop clinical signs attributable to adhesions after colic surgery and the small intestine is particularly prone to adhere (Baxter et al. 1989; Gerhards 1990). Additionally, the genital tract was the most common adhesion site in 2 horse case series with chronic colic, with and without previous abdominal surgery (Röcken et al. 2002; Bartmann et al. 2006). In man, 16–35% of patients undergoing open or laparoscopic gynaecological surgery develop adhesion related problems including infertility, chronic pelvic pain or intestinal obstruction (Lower et al. 2000, 2004; Dubuisson et al. 2010). Of all open gynaecological operations, ovarian and fallopian tube surgeries carry the highest risk of forming adhesions after surgery (Lower et al. 2000). This was also found in horses undergoing laparoscopy due to chronic colic and no history of abdominal surgery. Here also adhesions to the ovaries were the most common location for adhesion formation in mares (Röcken et al. 2002).

After surgery, the mare showed no signs of small intestinal obstruction, yet she was not fed during these 48 h. The question remains whether it was necessary to reverse the adhesion. The adhesion was chronic and presumably only the acute change of intra-abdominal space available after parturition induced intestinal kinking at the adhesion side. Concerns were that a corrective surgery to resolve the adhesion may cause de novo tissue formation itself. Experimental and clinical studies in man suggest that laparoscopic adhesiolysis causes significantly fewer de novo adhesions than open surgery (Milingsos et al. 2000; Tittel et al. 2001). Our preferred therapeutic approach was therefore a laparoscopic adhesiolysis, potentially using digital support.

Hand-assisted laparoscopic surgery in horses has been described for left and right-sided nephrectomy (Keoughan et al. 2003; Cokelaere et al. 2007; Röcken et al. 2007; Romero et al. 2010), ovariohysterectomy (Goedlin et al. 2011), ovariohysterectomy (Delling et al. 2004) and partial hysterectomy (Janicek et al. 2004). The advantage of this technique is the combination of a minimally invasive approach and the use of the surgeon’s hand under laparoscopic visualisation. In the present case it was chosen because manual manipulation provided exact feedback about extent and thickness of the adhesion and was invaluable during tissue transection.

The method of adhesional transection is mainly influenced by thickness, tenacity and degree of vascularisation (Gutt et al. 2004). Newly formed, fibrinous tissue can be disrupted using blunt dissection with a cherry dissector (Bleyaert et al. 1997) and Kelly or Babcock forceps (Boureü et al. 1998). Fibrous tissue bands can be sharply separated using scalars or electrosurgical instruments (Walmsley 1999; Fischer 2002; Röcken et al. 2002; Bartmann et al. 2006). If a hollow organ is involved, a laparoscopic stapling instrument is more appropriate (Bartmann et al. 2006). Not all adhesions are amenable to laparoscopic surgery, even after conversion to standard laparotomy (Walmsley 1999).
The timing of the laparoscopy following the emergency laparotomy is an aspect to consider with regards to the potential risk of intra-abdominal or incisional infection. Results from animal studies suggest an increased risk of bacteremia and endotoxiaemia after pneumoperitoneum. However, no clinical trials have found any contraindication to perform laparoscopy even in case of beginning peritonitis (Neudecker et al. 2002).

Factors influencing adhesion formation after surgery include surgical approach (i.e., laparoscopy vs. laparotomy), surgical technique (i.e., tissue handling, method of haemostasis) and surgical adjuvants. The latter includes anticoagulants (i.e., heparin), fibrinolytic agents (i.e., urokinase), anti-inflammatory agents, antibiotics, mechanical separation (i.e., peritoneal instillates, barriers) and newer agents under research (Kamel 2010). Some of those adjuvants are part of the surgical routine in human and equine surgery, others are under controversial debate, but there is no single best or ideal strategy for adhesion prevention. Additionally, an individual predisposition is speculated in man (Kamel 2010). Measures to provide mechanical separation during the immediate post operative period are probably most commonly used by surgeons. This can be done by sterile fluid instillation into the abdomen to mechanically separate the injured serosal surfaces until healing is completed. Lavage can be extended into the post operative period through an indwelling catheter (Nieto et al. 2003). A significant decrease in adhesion formation was reported by using this technique after twice daily abdominal lavage for 2 days post surgery (Hague et al. 1998). The downside of this technique is the purported decrease of the local immune competence (Dunn et al. 1984), additional weight placed on the ventral abdominal incision and catheter related problems (Hague et al. 1998). Sodium carboxymethylcellulose acts as a mechanical barrier and is placed into the abdomen during or at the end of surgery. It has been shown to decrease adhesion formation in equine experimental studies (Hay et al. 2001). Hyaluronic acid alone, or in combination with carboxymethylcellulose in liquid form (Eggleston et al. 2004), or as a thin membrane (Eggleston et al. 2001), has also significantly decreased the incidence of experimentally induced intra-abdominal adhesion formation in horses. None of these products was available at the time of surgery in this mare. In human surgery, specifically during laparoscopic gynaecological surgeries, newer barrier adjuvants have now entered the clinical stage and might be of interest to the equine surgeon as well. One of them is SprayShield Adhesion Barrier System (Covidien)13, a polyethylene glycol ester. It is a 2 component sprayable barrier, which adheres to the tissue and is absorbed via hydrolysis within 7 days after application (Ferland and Campbell 2009). Finally, frequent rectal manipulation is also described to address de novo adhesion formation (Bouré et al. 1998).

The mare developed abdominal pain again within weeks after surgery. It is thought that new adhesion formation at the previous adhesion site or on the surgical incisions, or anastomosis-related problems were the most likely cause for these clinical signs. In man it is reported that thick, organised vascular adhesions disrupted during second-look laparoscopy in women after a gynaecological laparotomy were least amenable to intervention with no subsequent decrease in adhesion score at a third-look laparoscopy (Perez 1991).

The case of the horse presented here highlights that intra-abdominal adhesion formation should be considered in mares following severe vaginal trauma. Suitable preventative measures should be initiated at that time if an abdominal involvement is suspected. A second important finding is that hand-assisted laparoscopic adhesiolysis in a standing horse is technically feasible and can be performed effectively and safely. However, considering the de novo adhesion rate and short-lived success in this mare, adhesiolysis of extensive organised fibrous tissue should be evaluated critically.

Authors’ declaration of interests

No conflicts of interest have been declared.

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4B.Braun, Melsungen, Germany.
5Boehringer Ingelheim, Ingelheim, Germany.
6Fort Dodge Veterinär, Würselen, Germany.
7Igamed medical Produkte, Cadoziburg, Germany.
8Aibrech, Auendorf, Germany.
9Infecopharm, Heppenheim, Germany.
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11Vetoquinol, Ravensburg, Germany.
12Ethicon, Norderstedt, Germany.
13Covidien, Neustadt an der Donau, Germany.
14Bela-pharm, Vechta, Germany.
15Ceva Tiergesundheit, Düsseldorf, Germany.
16Xion medical, Berlin, Germany.
17Karl Storz Endoskope, Tuttingen, Germany.
18Valleylab, Boulder, Colorado, USA.

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