Prevención y tratamiento de complicaciones postoperatorias en equinos: reflujo postoperatorio, endotoxemia, peritonitis, complicaciones incisionales y adhesiones

David E. Freeman
University of Florida, freemand@ufl.edu

Jair Pérez Osorio
Universidad de La Salle, Bogotá

Prevention and Treatment of Postoperative Complications in Equines: Postoperative Reflux, Endotoxemia, Peritonitis, Incisional Complications and Adhesions *

David E. Freeman[1] / Jair Pérez Osorio[2]

Abstract

Colic surgery is one of the most expensive procedures in equine clinics throughout the world. Although costs of surgery and anesthesia can be standardized to some extent, the cost of aftercare is less predictable. It can be altered considerably by the development of complications, such as surgical site infection, postoperative ileus, and formation of postoperative hernias, among others. Colic surgery places enormous demands on personnel, time, and resources. Nevertheless, it is a life-saving procedure. Complications increase cost through prolonged nursing care, technician salaries, extended treatment with antibiotics and other drugs, repeated laboratory analysis, and high-volume fluid therapy. Additional surgery, such as repeat celiotomy or repair of incisional complications, increases the costs considerably. Because none of these can be anticipated in most cases, a critical part of case management is a complete evaluation of expected and probable unexpected costs for the owner.

Keywords: Postoperative complications, postoperative reflux, endotoxemia, peritonitis, incisional complications, adhesions

Prevención y tratamiento de complicaciones postoperatorias en equinos: reflujo postoperatorio, endotoxemia, peritonitis, complicaciones incisionales y adhesiones

Resumen

La cirugía de cólicos es uno de los procedimientos más costosos en la clínica de equinos en todo el mundo. Aunque los costos de la cirugía y la anestesia se pueden estandarizar hasta cierta medida, el costo de cuidado posterior es menos predecible y se puede alterar considerablemente mediante el desarrollo de complicaciones, tales como infección del sitio quirúrgico, íleus postoperatorio y formación de hernias postoperatorias, entre otros. La cirugía de cólicos le trae exigencias enormes al personal y requiere tiempo y recursos. Sin embargo, es un procedimiento que salva vidas. Las complicaciones aumentan el costo debido a que el cuidado de enfermería se prolonga, hay que pagar salarios a los técnicos, se amplía el tratamiento con antibióticos y otros medicamentos, hay que repetir análisis de laboratorio y se requiere terapia de fluidos con altos volúmenes. La cirugía adicional, como una celiotomía repetida o reparación de las complicaciones incisionales, aumenta los costos considerablemente. Como ninguno en la mayoría de los

casos no se puede prever ninguna de estas cosas, una parte crítica del manejo de casos es la evaluación completa de los costos esperados y los probables no-esperados que cubrirá el propietario.

Palabras clave: complicaciones postoperatorias, reflujo postoperatorio, endotoxemia, peritonitis, complicaciones incisionales, adhesiones

Prevenção e tratamento de complicações pós-operatórias em equinos: refluxo pós-operatório, endotoxemia, peritonite, complicações incisionais e adesões

Resumo

A cirurgia de cólica é um dos mais custosos procedimentos clínicas equinas ao redor do mundo. No entanto, os custos de cirurgia e anestesia possam ser padronizados até certo ponto, o custo dos cuidados posteriores é menos previsível e pode se alterar consideravelmente a causa de complicações, tais como infecção do local cirúrgico, íleo pós-operatório e formação de hérnias pós-operatórias, entre outras. A cirurgia de cólica impõe uma enorme demanda de pessoal, tempo e recursos, toda vez que é um procedimento que salva vidas. As complicações aumentam o custo por meio de cuidados prolongados de enfermagem, salários dos técnicos, tratamento prolongado com antibióticos e outros medicamentos, análises laboratoriais repetidas e fluidoterapia de alto volume. Cirurgias adicionais, como repetição de celiotomia ou reparo de complicações incisionais, aumentam consideravelmente os custos. Como nada disso pode ser previsto na maioria dos casos, uma parte crítica do gerenciamento de casos é a avaliação completa dos custos esperados e prováveis inesperados para o proprietário.

Palavras-chave: Complicações Pós-operatórias, refluxo pós-operatório, endotoxemia, peritonite, complicações incisionais, adesões

COMPLICATIONS OF SMALL INTESTINAL SURGERY

The most common complications of small intestinal surgery, such as anastomotic obstructions, postoperative ileus (POI), and adhesions, can be the result of the small intestine's poor tolerance for technical errors (1,2). At times the last resort post-medical treatment of certain diseases ends up in the operating room, despite its complication always maintaining the patients' wellbeing first. Strangulating disease of the small intestines, (e.g., strangulating lipoma, epiploic foramen entrapment), large colon (e.g., large colon volvulus), and small colon (e.g., strangulating lipoma or intraluminal distension resulting in pressure necrosis) can only be corrected surgically (24). In a study on 74 horses that recovered from general anesthesia after small intestinal surgery, technical errors were responsible for 8 of 14 repetitions of celiotomies 57 % and 7 of 11 deaths during hospitalization 64 % (3). Although some of these errors were mistakes in judgment, most were avoidable technical errors made by inexperienced surgeons (1).

Postoperative complications such as postoperative ileus and adhesion formation after jejunocecal anastomosis have a higher incidence compared with a jejunojejunostomy. They can create a new sharp transition between intestinal segments of dissimilar functions and histologic characteristics after jejunocecostomy (3). The jejunum must overcome intracecal pressure to be able to

empty its content without the coordinating mechanism of the ileum and the ileocecal valve in order to keep its physiological movement and avoid ileus (1). Also, based on evidence that viable small intestine proximal to an obstruction is subjected to enough distention to delay the return of function, a jejunocecostomy could be at a distinct disadvantage compared with a jejunojejunostomy (1). If the same length of jejunum is resected in two horses and one requires a midjejunal jejunojejunostomy and the others require jejunocecostomy, no more than half the remaining small intestine was distended preoperatively in the former, compared with almost all the remaining small intestine in the latter (1). Also, the small intestine proximal to the anastomosis is continuous with the intestine of similar function in the jejunojejunostomy (1). Despite problems experienced in the short-term with jejunocecostomy, long-term results were similar to those for jejunojejunostomy, possibly because the fixed position of the stoma might make it less sensitive to distortion from adhesions (3).

Some horses can develop large intestinal colics during the first few months after a jejunocecostomy, possibly caused by altered delivery and composition of digesta delivered from the small intestine in the absence of an ileocecal sphincter (1).

Anastomotic Obstruction

The clinical distinction between anastomotic obstructions and postoperative ileus (POI) is difficult, and each can contribute to the pathogenesis of the other (1). The first causes greater and more persistent signs of abdominal pain (1). Mechanical obstruction of a small intestinal anastomosis by anastomotic impaction, hematoma, or constriction, arises from errors in technique (1). In an overzealous attempt to prevent leakage, some surgeons invert intestinal edges excessively or apply more than one layer (1). Stromas of marginal size are prone to obstruction because they are further reduced by post-anastomotic edema (1). Small intestinal volvulus may develop in distended jejunum and at points of small intestinal fixation, such as at a jejunocecal anastomosis (1). Risk of this complication is increased in a jejunoce-

cal anastomosis by failure to decompress intestine during surgery (1).

The most important point for surgeons to consider is that true POI is rare after abdominal surgery and that most horses with postoperative reflux have a surgical complication that reduces small intestinal function (1,4). The diagnosis of POI is made in horses largely based on reflux through a nasogastric tube. Therefore, postoperative reflux is a clinical finding and should be regarded as such in each horse until a cause is established, rather than simply labeling it as POI. Often overlooked in discussions of POI in horses is the contribution from mechanical factors, such as anastomotic obstruction or stenosis, delayed transit through an anastomosis because of motility derangement or interruption across the anastomosis, or failure to adequately decompress distended small intestine during surgery.

In one study, postoperative ileus was purely a function of the type of anastomosis and did not appear to correlate with other findings (3). Of the 16 horses that had gastric reflux after small intestinal surgery, 9 (56%) had a mechanical obstruction that required repeat celiotomy and/or euthanasia (3). The remaining 7 of 16 (44%) were diagnosed as having a functional POI 10% of total (3). Of these 7 horses, 5 had a jejunocecostomy, 1 had no resection, and 1 had a jejunoileostomy. No horse that had a jejunojejunostomy had POI, despite similar clinical presentations and lesions as horses that had a jejunocecostomy (3).

Postoperative reflux can develop after handsewn anastomosis if the surgeon tries so hard to get a leakproof anastomosis that the lumen becomes constricted, especially if a continuous pattern or more than one layer of tissue is used (2). Even slight luminal constriction is poorly tolerated in equine small intestine, and can increase resistance to flow (2). Although most horses probably do develop some degree of postoperative small intestinal paralysis or POI, the tendency to focus on functional disturbances and treat them with prokinetic drugs runs the risk of overlooking other potential causes (5). The most common cause of reflux after

small intestinal surgery in the author's experience is a failure to decompress all distended small intestine at surgery (2). Decompression is accomplished by stripping the fluid contents through the strangulated bowel into a bucket (and not into the cecum) (2). Horses are very sensitive to small intestinal distention, and the concerns about handling the bowel during decompression and causing reflex POI are not valid, provided that good technique is used (2).

If postoperative reflux develops, the patient should enter controlled fasting, a nasogastric tube should pass as needed, and the content received should be evaluated. Disturbances in acid-base balance, hydration, and electrolytes are treated through parenteral hydration, and a prokinetic agent is given (Table 1) (2). Response to prokinetic agents and IV lidocaine is inconsistent, and the author does not use these agents routinely after small intestinal surgery (3,4).

Adhesions

Horses are not particularly prone to adhesion formation but are extremely sensitive to them (1). Foals between the ages of 15 days and 6 months are more likely than weanlings or yearlings for developing adhesions requiring surgical intervention (23). Adhesions usually cause problems in the first 2 months after surgery. Although they can develop at any time, are more likely after small intestinal resection and anastomosis than other procedures, and are unlikely to develop after large intestinal surgery (1). Factors that could contribute to adhesions are postoperative ileus, ischemia, violations of Halstead's principles of surgery, foreign material, serosal abrasion by towels, and use of large suture material (1). After experimental ischemia-reperfusion of the small intestine in foals, gross adhesions were prevented by treatment with a combination of gentamicin and flunixin meglumine or by systemic administration of dimethyl sulfoxide (23). In one study 1, prevalence of confirmed adhesions was 6%, although inclusion of deaths from colic yielded an estimated prevalence of 13% (3). Prevention by intraabdominal instillation of sodium carboxymethylcellulose (SCMC) (6), or application of a membrane of SCMC and hyaluronic acid holds promise (7), but clinical trials are inconclusive (4).

Miscellaneous Complications of Small Intestinal Surgery

Other reported complications are anastomotic kinks, persistent distention, and pain from failure to decompress distended bowel, anastomotic stricture, mesenteric rents, anastomotic ischemia, and bleeding from mesenteric vessels (4,8). Anastomotic dehiscence and peritonitis are rare and usually caused by postoperative ischemia and technical error (1). Failure to effectively ligate mesenteric vessels can lead to postoperative hemorrhage (1). Fatal hemorrhage can be caused by tearing of the portal vein during the extraction of strangulated bowel from the epiploic foramen (1), and this can be prevented by withdrawing the strangulated bowel gently through the plain of the opening rather than upwards against the edge of the portal vein (2). Other techniques are also available such as decompression of the entrapped loop, with or without transection on the proximal side, and then oversewing the blind ends. The decompressed oversewn blind end is easy to pull through the foramen (2). Life-threatening intraluminal hemorrhage is a rare complication of jejunocecostomy, characterized by the passage of tarry feces and declining PCV. It is possibly caused by a large bleeding vessel on the cecal side (1). A rare complication of jejunocecostomy is obstruction of the cecocolic orifice by an ileal stump that has intussuscepted into the cecum and progressed into the right ventral colon (9). The risk of this complication can be reduced by making a short ileal stump (2).

Repeated Celiotomy

Repeated celiotomy is a lifesaving procedure and can be required for 19 % of small intestinal diseases (3). Although the distinction between postoperative ileus and mechanical obstruction can be difficult, horses with the latter usually demonstrate a greater amount of pain and have a progressive increase in heart rate (1). The disadvantages of a second exploration of the abdomen are the expense and risk of incisional site infection, having as a

matter of consideration that the patient's immune system is compromised after any surgical procedure, which diminishes the effects of antibiotics and other drugs such as NSAIDs (1). However, survival after a repeated celiotomy can reach 64 %, and the benefits of this procedure can outweigh the risks and disadvantages (1).

COMPLICATIONS OF LARGE INTESTINAL SURGERY

Complications of large intestinal surgery are different from those of the small intestine and are usually related to the original lesion (1). For example, adhesions and postoperative obstruction are well-known complications of small intestinal surgery but are rare after large intestinal surgery (1). Recurrence of the original lesion, the continued deterioration of ischemic bowel, endotoxemia, enterocolitis, and peritonitis are rare after small intestinal surgery but more likely after large intestinal surgery (1).

Recurrence of Original Disease

Right dorsal colon displacement and entrapment over the renosplenic ligament can be treated by surgical and non-surgical methods, and have low morbidity and mortality rates, but can be recurrent (1). Renosplenic entrapment can have a recurrence rate of approximately 8 %, which is low, but readily prevented by laparoscopic closure of the renosplenic space (2). Large colon volvulus has a high rate of recurrence, especially in broodmares (10), which has significant importance due to the high mortality associated with this disease (1). Colopexy of the ventral colon to the body wall is designed to prevent the recurrence of colon displacements (11), and the same goal is achieved by resection of most of the colon in horses that have a large colon volvulus and compromised colon (10). Open or laparoscopic closure of the renosplenic space can be used to prevent the recurrence of colon entrapment in this structure (1).

Cecal impaction can be treated medically or surgically, the latter by typhlotomy alone or combined with il-

eocolostomy to bypass the cecum completely (with ileal transection) or incompletely (without ileal transection to preserve some ileocecal flow) (1). This disease has a high rate of recurrence and carries the danger of cecal rupture, which explains why some surgeons instead use a bypass procedure (1).

Endotoxemia

Large colon volvulus can rapidly cause ischemia and extensive colon necrosis (1). If resection is not performed, as in a colon that has suffered a mild enough ischemic insult to survive, progressive mucosal damage after surgery can result from continued vascular occlusion and reperfusion injury (1). If the colon is resected, all affected tissue might not be accessible to allow anastomosis, and any remaining mucosa that sloughs postoperatively can cause endotoxemia, anastomotic leakage leading to peritonitis (1). Removal of as much strangulated colon as possible could reduce endotoxin access to the circulation by reducing transmural leakage across a large bulk of necrotic mucosa (1).

Endotoxemia is treated with intravenous fluids and flunixin meglumine, but additional treatment is often warranted (12). Such treatment includes Endoserum (Immvac, Inc, Columbia, Mo), a hyperimmune serum from horses vaccinated with *Salmonella typhimurium* Re mutant (1). Polymixin B is a cationic polypeptide antibiotic that can bind and neutralize endotoxins and is given to horses for this purpose at a dose of 1000 to 6000 IU/kg body weight intravenously every 8 to 12 hours (1). At doses of greater than 6000 U/kg, polymyxin B can cause toxic owing to its ability to disrupt phospholipid membranes (26). The risk of kidney damage with this drug could be increased by existing damage or dehydration (1). Although a crystalloid fluid, such as lactated Ringer's solution, Plasmalyte A, or Normosol-R, is the mainstay of treatment for fluid and electrolyte deficits caused by endotoxemia, plasma or Hetastarch might be required to increase colloid oncotic pressure in horses with total plasma protein concentrations below 5g/dl (1). Complications of endotoxemia are laminitis, disseminated vascular coagulopathy, catheter-related

sepsis and thrombosis, renal disease, abortion, respiratory disease and myocarditis (12).

Peritonitis

Peritonitis is very rare after colic surgery, but the leakage of an anastomosis in the non-viable colon after resection for large colon volvulus is one of the more common causes (1). Equine peritoneum can handle intraoperative contamination that is removed at surgery, but even slight leakage from a suture line is poorly tolerated (1). The most common reported pathogens isolated from horses with peritonitis include E. coli, Staphylococcus, Streptococcus, Rhodococcus, Bacteroides, Clostridium, and Fusobacterium spp (25). Enterotomies are often indicated for large colon diseases, such as removal of enteroliths, impacted foreign materials, and feed impactions, but dehiscence of the suture line is extremely rare and usually results from a surgical error (1). Intraoperative contamination during surgery is usually well contained and removed by copious lavage, and even severe contamination of exteriorized bowel rarely causes peritonitis (1). Rectal tears that extend through the mucosa and remaining layers, with or without penetration of the serosa or mesentery, can cause severe peritonitis and even fecal contamination of the abdomen (1). Although not a direct complication of surgery, it can result from preoperative rectal palpation, and should always be considered as a possible cause of peritonitis in the postoperative period (1).

The surgical procedure that carries the highest risk of peritonitis is colotomy in the right ventral colon for reduction of a cecocolic intussusception, whether or not the necrotic cecum is resected through the colostomy (1). The severe contamination from this procedure can be difficult to contain during surgery but can be prevented through careful isolation of the colotomy site by drapes or a sterile plastic sheet sutured around the proposed incision (1).

A focal small colon impaction with an enterolith or dehydrated feed material can cause transmural pressure necrosis (1). Although the vascular changes at the impaction site are recognizable, it is not unusual for the impacting material to have undergone repeated impaction and spontaneous correction at more proximal segments of the small colon (1). These sites can progress to full-thickness mural necrosis after surgery and cause peritonitis (1). Therefore, a careful intraoperative inspection of the prestenotic segment of the small colon is recommended to prevent this mishap (1).

Miscellaneous Complications of Large Intestinal Surgery

Complications of enterotomy are very rare, but the most common is hemorrhage from the incision edges, which can be severe enough to cause melena and hemorrhagic shock (1). There is some evidence that an enterotomy, but not a small intestinal resection and anastomosis, can increase the risk of postoperative incisional infections and other incisional problems in the body wall (13). Possibly, the high bacterial burden in the colon increases the chances of contamination to the edges of the body wall incision (1). Obstruction of an enterotomy is possible if the lumen is reduced by excessive inversion, which is why the author places a pelvic flexure enterotomy in the widest part, closer to the left ventral colon (1).

COMPLICATIONS IN THE ABDOMINAL INCISION

Complications can develop in the abdominal incision in 40 % of horses (14), with incisional drainage in 32 to 36 %, dehiscence in 3 to 5 %, and hernia formation in 6 to 17 % (15).

Incisional Swelling

Postoperative edema, usually in large plaques to both sides of the midline, is usually most evident at 5 to 7 days after surgery (1). Although severe cases signify a slowly developing infection, edema alone could be harmful by decreasing local oxygen tension in the incision (16), putting tension on suture lines, weakening the tissues,

reducing blood supply, and separating any bacteria in the incision from the immune system (1).

Incisional Infection

Focal drainage of serum, fibrin strands, or mucopurulent material from an incision, with or without fever, is evidence of incisional infection (14). The mean time to incisional drainage is 17 days after surgery (16). Ultrasonography should be used for early diagnosis because it is sensitive and can be used to evaluate the integrity of the infected body wall and to locate abscesses (1). Risk factors for incisional infection and related complications are horses older than 1 year and that weigh more than 300 kg (14), enterotomy, increased fibrinogen concentration in the peritoneal fluid, use of polyglactin 910 to close the linea alba (13), use of a U suture pattern in the linea alba (17), incisional contamination in the recovery stall, high numbers of bacterial CFU obtained after anesthetic recovery, poor intraoperative drape adherence, high numbers of CFU obtained from surgery room contamination, preexisting dermatitis (16). Surgical site infection is a common and important complication that occurs in 7.4 % to 37 % of horses undergoing abdominal surgery for acute gastrointestinal disease (25). Treatment of infection involves removing some skin sutures to establish drainage, and cleaning the incision as often as needed with a dilute antiseptic soap, with or without systemic antibiotics selected by culture and sensitivity testing of exudate (1). An abdominal bandage and topical antibiotics can be applied if the infection is extensive, but the bandage must be replaced frequently (1). There is some evidence that an abdominal bandage applied routinely after surgery might reduce the prevalence of incisional infection (18), but this is expensive and not used by the author. Short surgery times, attention to proper technique and asepsis, short incisions, and application of a protective adhesive barrier over gauze sponges before placement in the recovery stall can prevent infection (15). Recent clinical trials have demonstrated that right ventral paramedian incision is at least comparable to and possibly better than a ventral midline approach for colic surgery (19), that skin staples increase the risk of incisional infection (20),

and that horses that develop incisional infections usually culture bacteria from the incision within 12 hours of surgery that are resistant to many commonly used antibiotics (15).

Dehiscence of Body Wall Incision

Dehiscence of the body wall, with or without eventration, is the most serious wound complication following an exploratory celiotomy (15). The main reasons for wound dehiscence include loss of strength in absorbable sutures, breakage of sutures, knot failure, and tissue failure (15). Good surgical technique, decompression of all distended bowel, and smooth anesthetic recovery can reduce the risk of partial or complete wound disruption (15). Severe incisional infections can delay healing and cause tissue necrosis and dehiscence in as little as 5-7 days following surgery (14,18). Delayed disruption of a ventral midline incision (3 to 8 days after surgery) is usually preceded by copious drainage of peritoneal fluid and gap formation in the linea alba, followed by prolapse of omentum or bowel (15). In such cases, the horse should be anesthetized; all suture material removed, and the incision repaired by secondary closure (15). Acute dehiscence in the recovery stall is more catastrophic because there is little warning, the horse is not easily controlled, and a large amount of bowel is usually prolapsed (15). Despite the extensive contamination, intestinal bruising, and venous congestion associated with evisceration, resection is rarely needed and the prognosis for full recovery is good, provided self-inflicted trauma is prevented (15). However, extensive self-inflicted damage to bowel and disruption of mesentery can require resection and anastomosis or euthanasia (15).

Hernia Formation

Horses with incisional complications have an increased risk of developing hernias, especially those incisions that become infected (15). Hernias may appear weeks to months after the initial surgery (15). Hernia repair should be postponed for approximately 3 to 4 months after the first surgery to allow inflammation and infec-

tion to resolve fully and for the hernial ring to become firm and well organized (15). Large hernias can be repaired by suture closure or by mesh (15).

Miscellaneous Postoperative Complications

Postanesthetic rhabdomyolysis, long bone fracture during recovery, colitis, laminitis, and septic jugular thrombophlebitis are other life-threatening complications of colic surgery (1). Laminitis and septic jugular thrombophlebitis can be secondary to endotoxemia (1). Gastric ulcers are rarer than expected after colic surgery (21, 22). Some minor weight loss is not unusual for weeks after colic surgery, but chronic weight loss is rare, except after excessive small intestinal resection (>70% of small intestine removed) (3,4). Reduced appetite and liver disease can contribute to this complication (1).

References

1. Chuit P, Kuffer A and S. Montavon, Freeman DE. Abdominal Surgery: Complications and Costs. In: 8ème Congrès de médecine et chirurgie équine - 8. Kongress für Pferdemedezin und -chirurgie - 8th Congress on Equine Medicine and Surgery; New York 2003 Nov 16. New York: College of Veterinary Medicine, University of Illinois, Urbana, IL, USA. Available on: International Veterinary Information Service (www.ivis.org)

2. Freeman DE. Surgery of the small intestine. Vet Clin North Am Equine Pract. 1997; 13(2): 261-301. https://doi.org/10.1016/s0749-0739(17)30240-7

3. Freeman DE, Hammock P, Baker GJ, Goetz T, Foreman JH, Schaeffer DJ et al. Short- and long-term survival and prevalence of postoperative ileus after small intestinal surgery in the horse. Equine Vet J Suppl. 2000; 32 (S32): 42-51. https://doi.org/10.1111/j.2042-3306.2000.tb05333.x

4. Freeman DE, Schaeffer DJ. Clinical comparison between a continuous Lembert pattern wrapped in a carboxymethylcellulose and hyaluronate membrane with an interrupted Lembert pattern for one-layer jejunoje-junostomy in horses. Equine Vet J. 2011; 43(3): 708-13. https://doi.org/10.1111/j.2042-3306.2010.00340.x

5. Freeman DE. Post-operative ileus (POI): Another perspective. Equine Vet J. 2008; 40(4): 297-298. https://doi.org/10.2746/042516408X302528

6. Moll HD, Schumacher J, Wright JC, Spano JS. Evaluation of sodium carboxymethylcellulose for prevention of experimentally induced abdominal adhesions in ponies. Am J Vet Res. 1991; 52(1): 88-91. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/2021260

7. Eggleston RB, Mueller E, Quandt JE, Neuwirth L, Harmon BG, Waguespack WR, Rainbow ME. Use of a hyaluronate membrane for jejunal anastomosis in horses. Am J Vet Res. 2001; 62(8): 1314-9. https://doi.org/10.2460/ajvr.2001.62.1314

8. Vachon AM, Fischer AT. Small-intestinal herniation through the epiploic foramen: 53 cases (1987-1993). Equine Vet J. 1995; 27(5): 373-80. https://doi.org/10.1111/j.2042-3306.1995.tb04073.x

9. Schumacher J, Hanrahan L. Ileocecocolic intussusception as a sequel to jejunocecostomy in a mare. J Am Vet Med Assoc. 1987; 190: 303-304.

10. Hardy J, Minton M, Robertson JT, Beard WL, Beard LA. Nephrosplenic entrapment in the horse: a retrospective study of 174 cases. Equine Vet J Suppl. 2000; 32(S32): 95-7. https://doi.org/10.1111/j.2042-3306.2000.tb05342.x

11. Hughes FE, Slone DE. Large colon resection. Vet Clin N Am Equine Pract. 1997; 13:341-350.

12. Hance SR. Colopexy. Vet Clin N Am Equine Pract. 1997; 13(2): 351-8. https://doi.org/10.1016/s0749-0739(17)30244-4

13. Barton MH. Endotoxemia. In: Robinson NE (ed.). *Current Therapy in Equine Medicine*, vol. 5; 2003: 104-108.

14. Honnas CM, Cohen ND. Risk factors for wound infection following celiotomy in horses. J Am Vet Med Assoc. 1997; 210(1): 78-81. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/8977653

15. Wilson DA, Baker GJ, Boero MJ. Complications of celiotomy incisions in horses. Vet Surg. 1995; 24(6): 506-14. https://doi.org/10.1111/j.1532-950x.1995.tb01362.x

16. Freeman DE, Rötting AK, Inoue O. Abdominal closure and complications. Clin Tech Equine Pract. 2002;

1(3): 174-187. Retrieved from https://www.academia.edu/23205721/Abdominal_closure_and_complications

17. Galuppo LD, Pascoe JR, Jang SS, Willits NH, Greenman SL: Evaluation of iodophor skin preparation techniques and factors influencing drainage from ventral midline incisions in horses. J Am Vet Med Assoc. 1999; 215: 963–969.

18. Kobluk CN, Ducharme NG, Lumsden JH, et al. Factors affecting incisional complication rates associated with colic surgery in horses: 78 cases (1983-1985). J Am Vet Med Assoc. 1989; 195(5): 639-42. Retrieved from https://www.ncbi.nlm.nih.gov/pubmed/2777714

19. Smith LJ, Mellor DJ, Marr CM, Reid SW, Mair TS. Incisional complications following exploratory celiotomy: does an abdominal bandage reduce the risk? Equine Vet J. 2007; 39(3): 277-283. https://doi.org/10.2746/042516407x193963

20. Anderson SL, Vacek JR, Macharg MA, Holtkamp DJ. Occurrence of incisional complications and associated risk factors using a right ventral paramedian celiotomy in 159 horses. Vet Surg. 2011; 40(1): 82-9. https://doi.org/10.1111/j.1532-950X.2010.00750.x.

21. Torfs S, Levet T, Delesalle C, Dewulf J, Vlaminck L, Pille F. Risk factors for incisional complications after exploratory celiotomy in horses: do skin staples increase the risk? Vet Surg. 2010; 39(5): 616-20. https://doi.org/10.1111/j.1532-950X.2009.00636.x.

22. Dukti SA, Perkins S, Murphy J, Barr B, Boston R, Southwood L. Prevalence of gastric squamous ulceration in horses with abdominal pain. Equine Vet J. 2006; 38(4): 347-349. https://doi.org/10.2746/042516406777749164

23. Dukti S, White N. Surgical Complications of Colic Surgery. Vet Clin North Am Equine Pract 2008; 24(3): 515–534 https://doi.org/10.1016/j.cveq.2008.09.002

24. Gardner A, Dockery A, Quam V. Exploratory Celiotomy in the Horse Secondary to Acute Colic: A Review of Indications and Success Rates. Top in Companion Anim Med. 2019; 34: 1- 9 https://doi.org/10.1053/j.tcam.2018.11.00

25. Lopp C, Mochal-King C. Peritonitis, as a Result of a Retrograde Postoperative Incisional Infection. Journal of Equine Veterinary Science. 2015; 35(11-12): 966–72 https://doi.org/10.1016/j.jevs.2015.07.017

26. Burke M, Blikslager A. Advances in Diagnostics and Treatments in Horses with Acute Colic and Postoperative Ileus. Vet Clin North Am Equine Pract. 2018; 34(1): 81–96. https://doi.org/10.1016/j.cveq.2017.11.006