Update on Recent Advances in Equine Abdominal Surgery

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- Equine • Surgery • Colic • Complications • Prognosis

In recent years important advancements in colic surgery have led to improved prediction of survival rates, better survival rates, and decreased complication rates. This article describes several modalities to combat and prevent incisional hernia and intestinal adhesion formation in horses undergoing colic surgery. These modalities have had a positive impact on reducing complications in horses after surgery.

LACTATE

Prognostication in horses with strangulating large colon volvulus (LCV) can be difficult even during abdominal exploration. This severe, peracute-type colic can result in rapid colonic devitalization; therefore, a better grasp of prognosis preoperatively can be helpful. A recent study by Johnston and colleagues[1] found plasma lactate concentration to be highly accurate in predicting survival of horses with LCV. Plasma lactate less than 6 mmol/L had a positive predictive value of 96%, and no horses with lactate greater than 10 mmol/L survived. Stall-side portable lactate sampling is simple and quick and is proven to be a reliable technique for measuring plasma and peritoneal fluid lactate.[2] For LCV, specifically, plasma lactate is an accurate and invaluable preoperative prognostic tool. For other gastrointestinal lesions, plasma lactate is valuable; however, peritoneal fluid lactate has a better correlation with survival rates, and neither plasma nor peritoneal fluid lactate values predict survival once the lesion is not strangulating.[2] Because determining the strangulating nature of the lesion is often impossible preoperatively in small intestinal lesions, one must use caution when using lactate to predict survival in horses that seem to have small intestinal lesions. Peritoneal lactate can be a useful tool, however, to predict the need for surgery by determining the strangulating nature of the lesion in any horse presenting for colic.[3]

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ADHESION PREVENTION

Intestinal adhesions are one of the most common complications that limit survival rates after abdominal surgery in horses (**Fig. 1**), and the primary mode of prevention is an atraumatic surgical technique.[4] Recently, several studies have addressed the issue and found support for preoperative intravenous treatments, including dimethyl sulfoxide (20 mg/kg), potassium penicillin (22,000 IU/kg), and flunixin meglumine (Banamine, 1.1 mg/kg), and for intraoperative treatments, including intraperitoneal unfractionated heparin administration (20,000 IU) and the use of sodium carboxymethylcellulose (SCMC 7 mL/kg).[5–7] In addition, an omentectomy has been shown to significantly decrease the rate of adhesion formation according to one study,[8] and in a more recent study by Mair and Smith[6] the same trend was noted. Santschi and colleagues[9] reported an 8% rate of adhesions after colic surgery in more than 200 juvenile horses, and they attributed their relatively low adhesion rate to the routine performance of omentectomies. Several recent studies have found that adhesions involving the omentum are a significant cause for colic and for repeat celiotomy,[4,10,11] and this is consistent with our clinical experience. In addition, incarcerations of the intestine through the greater omentum have been reported.[12,13] Peritoneal lavage has been shown to decrease adhesion formation in horses.[14] Omentectomy greatly facilitates peritoneal dialysis[15] by preventing catheter occlusion, which is one of the most common complications with peritoneal lavage;[16] thus, omentectomy may also enhance the efficacy of postoperative peritoneal lavage. Removal of the omentum has multiple advantages, and it is an additional sensible, quick, and simple technique to reduce postoperative complications following equine abdominal surgery.

Highly viscous solutions, such as SCMC, have two antiadhesive properties: they act as lubricants to decrease bowel handling trauma and as surface barriers, separating serosal surfaces. Intraoperative use of SCMC has been previously shown not to interfere with healing of either small intestinal anastomosis or the abdominal incision.[5,17] In contrast to previous theories and experimental studies, clinically, adhesions seem to involve any region of the intestine (**Fig. 2**) without predilection for anastomosis or enterotomy sites, and thus the use of pan-abdominal adhesion preventative
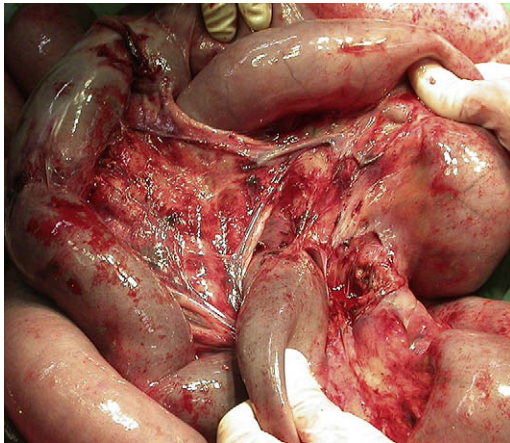

Fig. 1. Diffused small intestinal adhesions 3 months after surgery for correction of a severe large colon impaction. The adhesions in this horse were so extensive that the horse was euthanized on the table.
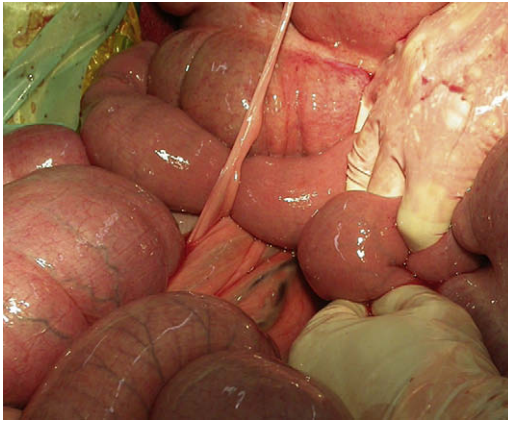
Fig. 2. Single, long stalked adhesion involving the large colon. The adhesion in this horse did not cause any obstruction and seemed to be an incidental finding on abdominal exploration.

measures, such as SCMC, is advocated in all abdominal surgeries in the horse.[4] Recently Fogle and colleagues[18] presented the strongest and most up-to-date evidence supporting routine use of SCMC by demonstrating that horses that received intraoperative SCMC were twice as likely to survive as horses not receiving SCMC. To summarize, as opposed to other techniques we commonly implement in equine surgery, the routine use of SCMC in abdominal surgeries has a strong clinical evidence basis.

ABDOMINAL BANDAGE

Incisional complications are common in equine abdominal surgery; they significantly increase the morbidity and expenses associated with the procedure and occasionally can be fatal.[19] Edema, drainage, infection, hernia formation, and dehiscence are the typical complications in decreased order of frequency. A recent study by Mair and Smith[6] has shown that an iodophor-impregnated adhesive drape (Ioban, 3M USA, St. Paul, Minnesota) applied to the incision at the end of surgery and removed once the horse recovers from general anesthesia is more effective than a sutured stent in preventing incisional complications. Edema formation can predispose the horse to further incisional complications, such as hernia.[20,21] Recently, a study by Smith and colleagues[22] found that applying an abdominal bandage immediately after recovery from abdominal surgery and maintaining it for 2 weeks post discharge significantly decreased incisional complications. In a recent study by Nieto and colleagues,[16] decreased incisional complications were attributed to in-hospital use of postoperative abdominal bandages. Two studies compiling 142 cases concluded that use of a commercially available abdominal bandage (CM Hernia Belt, CM Equine Products, Norco, California) after a complicated ventral midline incision and after a paramedian abdominal incision markedly decreased the incidence of incisional hernia formation.[23,24] Overall, abundant evidence in recent literature suggests that the use of an abdominal bandage to prevent and treat incisional complications is beneficial. Our experience parallels that; we found that the use of the same commercially available abdominal bandage (**Fig. 3**) as part of routine postoperative case management is

Fig. 3. Postoperative use of a commercial multiuse abdominal bandage (CM Hernia Belt, CM Equine Products, Norco, California).

highly effective in preventing edema and minimizing incisional complications, and its use is simple and economically worthwhile.

SMALL INTESTINAL ANASTOMOSIS

Small intestinal lesions are typically strangulating and often necessitate resection and anastomosis. It is interesting that although the ileum represents only about 5% of the small intestine, it is involved in about 50% of common cases of small intestinal incarceration, such as inguinal hernia and epiploic foramen entrapment.[25,26] Jejunocecostomy (JC) was the recommended procedure in cases in which the ileum was involved; connecting the jejunum to the ileum was considered undesirable because of differences in wall thickness and concerns about uncoordinated motility. Recently, multiple studies including a large number of horses have shown that JC is more likely to result in postoperative complications, including a higher rate of repeat celiotomy and an increase in mortality risk compared with jejunojejunostomy (JJ).[13,27] In addition several recent studies have shown that jejunoileostomy (JI) is highly successful[28] and results in a success rate equal to that of end-to-end JJ.[10,29] According to current information, whenever possible, creating an anastomosis between the jejunum and the ileum is definitively preferable to JC. JC remains a viable, often life-saving option, however, when not enough ileum is available for anastomosis. JC and JJ can be performed successfully hand sewn and with the aid of stapling devices. Using stapling devices can decrease surgery times, thus decreasing anesthesia and recovery-related complications. In addition, using the stapling technique may substantially decrease intraoperative contamination and decrease chances of postoperative infection.[30] All this correlates well with our recent clinical experience in having good results with stapled, closed, one-stage functional end-to-end[31] JI in all recent relevant clinical cases.

LARGE COLON RESECTION AND ANASTOMOSIS

Large colon resection and anastomosis (LCRA) has been considered a salvage procedure with poor prognosis for survival. Early studies on LCRA reported high survival rates; however, these studies included only a few cases.[32] Two recent reports, including one on a large number of horses, suggest that the prognosis for LCRA may not be as poor as once believed.[33,34] In one study including 73 horses treated

with LCRA for strangulated large colon volvulus, 74% of the horses survived to discharge,[34] and in another study partially overlapping the previous one, from the same clinic, 80% short-term survival was found for horses with LCV treated with LCRA.[35] This latter study included in the survival analysis only horses recovered successfully from surgery, which artificially increased the success rate because it omitted cases that were euthanized or died during surgery and those that had catastrophic recovery. As suggested by the authors, the high survival rate in this study can be in part attributed to the short duration of clinical signs before presentation due to the close proximity of the breeding farms to the clinic.[35] In another study, Driscoll and colleagues[33] reported a similar survival rate for LCRA; however, the survival rate in these horses was less than 50% when only strangulated lesions were included, and horses with a strangulated lesion were four times less likely to survive. Heart rate (HR) at 24 hours after surgery was significantly associated with survival. Short-term survivors had a median HR of 48 beats per minute (bpm), whereas the nonsurvivors had a median HR of 80 bpm. Colonic luminal pressure was found to be an inaccurate prognostic indicator.[35] Intraoperative gross assessment of colonic viability is prone to error because of the high level of subjectivity in values such as serosal color and arterial pulse strength; however, histologic evaluation of fresh frozen sections of the pelvic flexure was found to be accurate in predicting survival in horses with large colon volvulus.[32] Unfortunately, this technique is not available in most equine surgical facilities and thus subjective assessment of colonic viability remains the mainstay method to determine if resection is indicated. Serum lactate can serve as an accurate predictor of survivability of horses with LCV,[1] but we do not have information regarding its usefulness to predict survivability following resection of a compromised colon. It is encouraging that in one study, all horses that were discharged survived at least 1 year,[33] although more than 50% of them experienced complications, of which the most common were colic and weight loss. The procedure of LCRA has been advocated not just as a treatment of LCV with a nonviable colon but also as a preventative measure against recurrence of LCV.[36] Despite the recently reported good results for LCRA, complication rates are high and occasionally may prove fatal. For this reason we believe LCRA, as a preventative measure, should be reserved for "repeat offenders" that have an athletic career. Colopexy is less invasive and carries good results as a preventative measure against LCV and displacement.[37] The procedure can be performed as an open surgery or through laparoscopy; however, it has not been proven safe for an athletic horse.[37,38] Different techniques for LCRA have been reported, and the ones recently reported to yield good results involve end-to-end anastomosis with or without the aid of staples for extending the stoma and for ligating the mesocolon.[33,39] Overall, LCRA is a viable treatment option for several large colon lesions, especially LCV, and the procedure has been recently shown to carry reasonable prognosis. Because of the high risk for complications, however, LCRA should be performed only when clinically deemed absolutely necessary.

HAND-ASSISTED LAPAROSCOPY

In recent years laparoscopy has gained much popularity in the equine world as a less invasive method for diagnostic and surgical purposes. The technique of hand-assisted laparoscopy (HAL) has been used successfully in several clinical cases lately. The procedures performed using HAL include left and right nephrectomies, splenectomy, and removal of ovarian and uterine tumors.[40–43] The technique was adopted from human medicine and adapted for use in horses under general anesthesia and under standing sedation. HAL is advantageous over open surgery and laparoscopy because

it combines the excellent visibility achieved by laparoscopy with the tactile sensation, tissue handling, and maneuverability capabilities enabled by having a hand in the abdomen, while being only moderately invasive. As the procedure gains in popularity, it is reasonable to assume that additional procedures currently performed in horses by laparoscopy or open surgery, such nephrosplenic space obliteration and adhesiolysis, will also be adapted to HAL because the procedure has significant advantages over both approaches in many cases. Another option, to incorporate the visual advantage of laparoscopy, is to use it for initial assessment and exteriorization and then perform a procedure in an open fashion. Röcken and colleagues[44] reported on cystic calculi removal in this manner, and the technique combines the advantages of open surgery and laparoscopy in an elegant way. Overall, HAL seems to have an important place in the future of equine abdominal surgery.

DIAPHRAGMATIC HERNIA

Recent information suggests that diaphragmatic hernia (DH) as a cause of colic is not as rare as previously considered (**Fig. 4**). One recent review compiled 114 cases of DH, and another recent retrospective study included 44 additional cases.[45,46] An incidence of between 0.67% and 7.77% was estimated by compiling more than 1400 surgical colic cases in one study.[46] When these data are compared to two large retrospective studies including nearly 1000 surgical colic cases, this incidence level is on par with lesions such as small intestine incarceration in the gastrosplenic ligament, cecal impaction, and other lesions that are not considered that rare.[10,47] According to a recent review article, a good inquiry into the history of most cases of DH reveals a traumatic incident or other event, such as breeding, that increased the
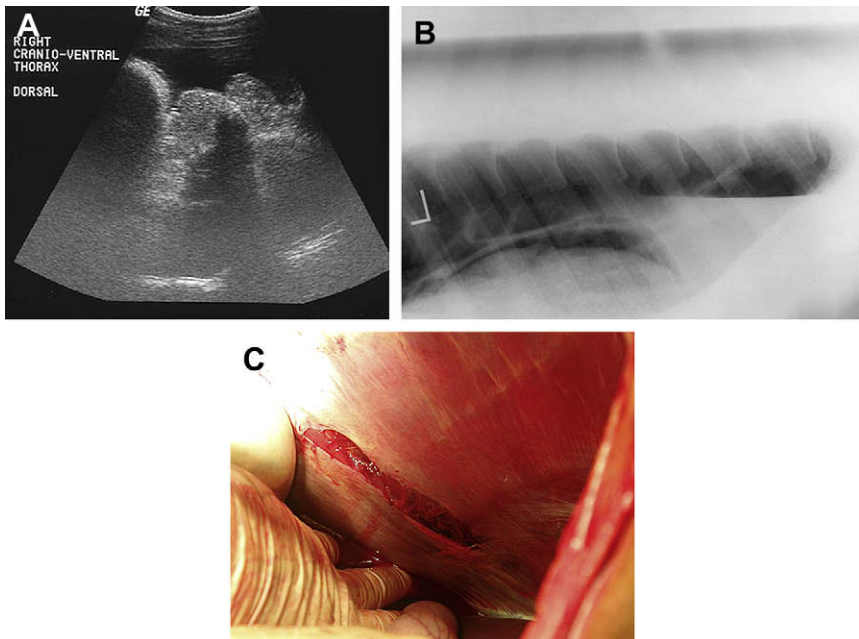

Fig. 4. (*A–C*) Diaphragmatic hernia in a weanling; after reduction of incarcerated small intestine a traumatic rent can be seen in the muscular portion of the diaphragm.

intra-abdominal pressure abruptly;[46] however, most horses in the mentioned retrospective study did not include such an event in their recorded history. Acquisition of a reliable and thorough history in each colic case cannot be overemphasized. Typically DH is diagnosed on abdominal exploration, but preoperative diagnosis, when achieved, has been established mainly using ultrasonography and radiography. Because DH is not that uncommon, it is important to include it in the differential diagnosis list in each case presenting for colic. By increasing our awareness of the problem we will improve chances of early diagnosis and a better outcome. Clinical signs accompanying DH are typically these of abdominal pain or colic, but they can also include respiratory compromise, such as tachypnea and dyspnea. According to these recent studies, most DHs, or diaphragmatic rents, are acquired, are more prevalent on the left side, and are dorsally located.[45,46] Some identical prognostic indicators were found in both recent studies; specifically, the more dorsal and larger the tear, the less likely the surgery is to succeed.[48] Diaphragmatic hernia, when presented with clinical signs, is a surgical lesion, but survival rate after surgical correction is low.[45] Although no breakthroughs were recently made in the treatment of DH, earlier diagnosis and HAL or thoracoscopy may offer an improved method to increase survival rates of DH.

INCISIONAL HERNIA—PREVENTION AND TREATMENT

An incisional hernia (**Fig. 5**) is a common complication of colic surgery in horses and, according to recent reports, occurs in 7% to 10% of cases.[6,49] Most hernias are preceded by surgical site drainage and infection (**Fig. 6**) in the first week after surgery.[50] Avoiding incisional infection substantially decreases the incidence of incisional hernia formation, and recent advances in this field were mentioned previously in the paragraph discussing abdominal bandage. Klohnen and colleagues[23,24] recently reported that once complications develop, use of an abdominal bandage (CM Hernia Belt) can effectively reduce the incidence of hernia formation after celiotomy by using ventral midline and right paramedian approaches. The same abdominal bandage may also be used effectively as a conservative treatment modality for small-to medium-sized incisional hernias, especially in the early stages of hernia formation when healing and fibrosis are still active. Large hernias are commonly repaired surgically and although most incisional hernias can be closed with sutures alone, multiple small hernias can often be palpated at the surgery site when healing is complete. In large hernia repair use of a synthetic mesh is recommended for added strength and better cosmetic results. Typically the mesh is placed external to the peritoneum

Fig. 5. Small incisional hernia in a mare 1 year after colic surgery for large colon displacement that was complicated by incisional infection.
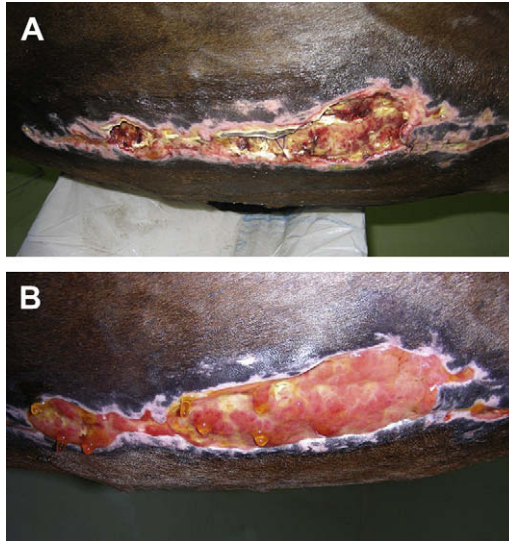
Fig. 6. Incisional infection in a gelding after surgical correction of a large colon volvulus. (*A*) The infection is progressing in the first postoperative week. (*B*) Two weeks after initial signs of infection with providing drainage and cleansing and the use of abdominal bandage the infection is resolving and healthy granulation tissue is seen.

(retroperitoneal) and the incidence of postoperative complications associated with retroperitoneal placement of mesh, such as tearing of the internal abdominal oblique muscle and incisional swelling and drainage, is relatively high.[51] Recently, an alternative technique was reported in which first the hernia ring was sutured closed with inversion of the hernia sac, and then a polypropylene mesh (Bard, Murray Hill, New Jersey) was implanted subcutaneously (**Fig. 7**).[52] Closing the hernial ring before
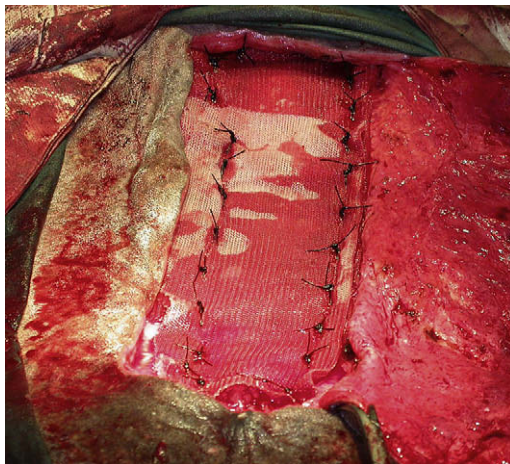

Fig. 7. Subcutaneous polypropylene mesh implantation, after suture herniorrhaphy, for repair of ventral abdominal incisional hernia in a horse.

implanting a mesh may strengthen the repair and improve postoperative appearance. Use of a hernia or kidney needle decreases the likelihood of penetrating a viscus during the repair. Based on our experience and that of others,[53] placing the mesh subcutaneously makes mesh repair less complicated, and concerns about development of subcutaneous infection around the mesh[54] seem to be unjustified. Recurrence of the hernia is a relatively common complication of herniorrhaphy and has been reported after using sutures alone[55] and after herniorrhaphy in which a mesh was implanted.[26] No hernias recurred using this combination technique on a large number of horses. Suture material used to secure the mesh should be absorbable so that if infection or an allergic reaction at the surgery site occurs, the mesh can be more easily removed. In summary, abdominal incisional hernias can be easily and successfully repaired by closing the hernia with sutures and implanting a mesh subcutaneously over the sutured hernial ring.

SUMMARY

Exciting advances have been made in certain areas of abdominal surgery in the horse. Recently developed methods to decrease the rate of complications, such as adhesions, incisional infections, and hernias, have proved effective. New approaches to abdominal surgery, such as HAL, have been adapted from human surgery and seem to show promise by decreasing morbidity and increasing the efficacy and feasibility of many procedures previously fraught with complications. Advances in supportive care and surgical techniques have brought increased success rates to small intestinal and large colon resection and anastomosis. Overall, significant advancements continue to improve the survival and decrease postoperative complication in colic surgery.

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