

New Perspectives in Postoperative Complications After Abdominal Surgery

Andreas Klohnen, DVM

KEYWORDS

- Colic surgery • Postoperative incisional complications
- Postoperative ileus • Postoperative signs of colic

Abdominal exploratory surgeries are one of the most commonly performed surgeries in equine practice. Although most cases of equine abdominal pain resolve either spontaneously or with medical treatment, some cases would be fatal if surgical intervention was not pursued.¹ As a result of our better understanding of the causes of colic, improved diagnostic modalities to pinpoint the cause of colic, improved anesthesia techniques, improved surgeons skills, and much improved postoperative care and detection of complications earlier, survival rates have been improving vastly over the last 15–20 years.¹ Despite the increase in surgical case survival rates and vast improvements in postoperative care, equine abdominal surgery for gastrointestinal (GI) diseases carries a high mortality rate and complication rate.

This article focuses on postoperative complications after equine abdominal surgery, new ways to prevent complications, and treatment methods. A more general review of postoperative complications was completed by Mair and colleagues,¹ Dukti and White,² and Hackett and Hassel.³ The most common postoperative complications after equine colic surgery are listed in **Box 1**.

CATHETER-RELATED THROMBOPHLEBITIS

Thrombophlebitis is an unpopular secondary complication to intravenous catheterization. Thrombophlebitis is defined as thrombosis of a vein with inflammation of the vessel wall. Septic thrombophlebitis is defined as an infected thrombus. Clinical signs related to vein thrombophlebitis include soft tissue swelling around the catheter entry site, pain upon soft tissue palpation around the catheter site, secondary entry wound catheter site discharge, firm swelling of the catheterized vein, fever spikes, head swelling, and lower limb swelling as a result of the complete vein occlusion.

Chino Valley Equine Hospital, 2945 English Place, Chino Hills, CA 91709, USA
E-mail address: topgun96@att.net

Vet Clin Equine 25 (2009) 341–350

doi:10.1016/j.cveq.2009.05.003

vetequine.theclinics.com

0749-0739/09/\$ – see front matter © 2009 Elsevier Inc. All rights reserved.

Box 1**Postoperative complications in horses undergoing abdominal surgery**

Jugular vein thrombophlebitis

Incisional infection during the hospitalization stay, acute hernia formation during the initial hospitalization versus hernia formation after an incisional infection has healed and the body wall formed a hernia, and acute dehiscence of the abdominal wall during the recovery period or the initial hospitalization

Postoperative pneumonia

Postoperative signs of intestinal ileus

Repeated signs of colic during the initial hospitalization or after discharge from the hospital

Signs of colitis or diarrhea³

Peritonitis (secondary to intestinal necrosis or leakage of an enterotomy site and leakage of an anastomosis)²

Intra-abdominal hemorrhage²

Ultrasonographic evaluation of the surrounding soft tissue and the catheterized vein can be used to confirm thrombophlebitis and monitor the extend of the thrombophlebitis.⁴ Lateral thoracic veins and cephalic veins appear to thrombose at a higher and faster rate compared to jugular veins. Lateral thoracic veins and cephalic veins catheters and their skin entry sites need to be protected by bandages. It is believed that the bandages increase the risk of venous stasis, which increases the risk of a potential thrombus formation. In a recent private practice review of cases that had multiple different vein catheterizations (jugular vein, cephalic vein, and lateral thoracic vein), it was determined that 65% of the cephalic veins and 85% of the lateral thoracic veins thrombosed.⁵

In a recent review of short term complications in horses undergoing colic surgery, 21 of 252 had evidence of jugular vein thrombosis.⁶ In this case series, horses with signs of postoperative abdominal pain and horses that developed signs of postoperative shock had a significantly higher rate of jugular vein thrombosis.⁶

In another review of short term complications after colic surgery, 15 of 747 horses had evidence of varying degrees of jugular vein thrombosis.⁷ Horses with signs of postoperative ileus appeared to have a higher rate of jugular vein thrombosis. In a separate review of each of the years in the 3-year study, horses in the third year appeared to have a higher rate of jugular vein thrombosis. In this case series, the single most effective way to prevent jugular vein thrombosis or to decrease the incidence of jugular vein thrombosis appeared to be that all horse handlers started to wear surgical gloves.

POSTOPERATIVE INCISIONAL COMPLICATIONS

In equine GI surgery, the abdominal closure is one of the most important components of the surgical procedure and can contribute to possible postoperative complications that could influence the overall outcome. Several different types of suture material and suture patterns for closure of the linea alba or sheath of the rectus muscle have been investigated.⁸ One study suggested that closure of the linea alba with a simple continuous suture pattern is superior in bursting strength when compared to an inverted cruciate suture pattern.⁹ Another study investigated biomechanical properties of the equine adult linea alba in regards to tissue bite size and type of suture material.¹⁰

The study concluded that the optimal tissue bite size in adult horses is 15 mm from the edge of the linea alba.¹⁰

Postoperative incisional complications include incisional swelling, local infection, suture sinus formation, hematoma formation, incisional drainage, incisional dehiscence, and hernia formation. Overall, incisional complications can develop in 40% of horses that have intestinal surgery,¹¹ with incisional drainage reported in 32% to 36% of horses, dehiscence in 3% to 5%, and hernia formation in 6% to 17%.^{11–13} Another recently published study demonstrated that horses with incisional infections are 62.5 times more likely to develop an incisional hernia compared to horses without incisional problems.¹⁴

Many different factors associated with incisional complications have been identified and include the age of the horse, size (weight) of the horse, type of incision, type of suture material, method of closure, degree of surgical trauma, length of surgery, and possible difficulties associated with anesthetic recovery.^{15–18} A more recent study by Mair and Smith found significant differences in rates of incisional complications in relation to total plasma protein concentration and gut sounds at admission, administration of intraperitoneal heparin, dissection of the linea alba prior to closure, and application of wound coverage (stent bandage or incise drape).⁶

Surgical site infections can be a substantial cause of morbidity in the post-surgical period in horses that have undergone an exploratory celiotomy. The financial implications associated with an extended period of hospitalization for treatment of ventral midline incisional problems and the use of a newly designed abdominal bandage¹⁹ can significantly contribute to hospital charges.

The possible role of surgical sutures in the cause of surgical site infection has been researched extensively, because bacterial contamination of suture material within a surgical wound may increase the virulence of a surgical site infection.²⁰ The prevention and treatment of surgical site infections is one of the main surgical challenges, and antibacterial-coated suture material may play a role in the prevention of post-surgical infection. Zone of inhibition assays showed that antibacterial (triclosan) coated 2-0 polyglactin 910 sutures provide an antimicrobial effect sufficient to prevent *in vitro* colonization by *Staphylococcus aureus* and *Staphylococcus epidermis*.²¹ Several other *in vitro* and *in vivo* studies have evaluated the efficacy of antibacterial coated suture material.²²

A recently completed study in horses evaluated the clinical effect of antibacterial (triclosan) coated 2-0 polyglactin 910 suture material on the likelihood of incisional complications following ventral midline exploratory celiotomies in 100 horses with abdominal pain.²² In this study, it was hypothesized that the antibacterial effect of triclosan may decrease the likelihood of incisional complications following ventral midline exploratory celiotomy.²² The results of this study revealed that antibacterial (triclosan) coated 2-0 polyglactin 910 did not decrease the likelihood of incisional complications in this horse population.²² Furthermore, there was a slight increased incidence of incisional edema when triclosan coated 2-0 polyglactin 910 was used.²² Peri-incisional edema may affect local tissue oxygen tension at the incisional site and may result in delayed wound healing, suppression of local immune function and provide an optimal environment for bacterial growth.²² Thus the clinical relevance and benefits of antibacterial suture material in equine ventral midline closure remains questionable and there may potentially be adverse effects when using triclosan coated suture material.²²

Only one previously completed study evaluated the potential problem associated with intraoperative culturing of abdominal incisions during colic surgeries and postoperative incisional infections, and it did not find a significant association.¹⁴ Another

recently completed study²³ tried to evaluate the exact time frame when these abdominal incision infections are contracted and what type of bacteria (whether acquired from the horse or being nosocomial in origin) is responsible for postoperative incisional infections.²³ In this study, the surgical procedures had been classified as clean if no enterotomy was performed or clean-contaminated if an intestinal lumen was exposed. The results of this study indicate that pre-surgical and intra-surgical cultures rarely yielded any significant growth, indicating appropriate abdominal preparation and maintenance of aseptic technique during surgery.²³ However, infections tended to occur in horses that had significant bacterial growth after recovery and 24 hours after surgery.²³ The results of the study suggest that the period of time for acquiring infections occurs after abdominal closure.²³ This study indicates the need for the continuation of appropriate asepsis and protection of the surgical site in the immediate post-surgical period.²³ However, the duration of postoperative protection needed to significantly reduce surgical site infections is uncertain, but it seems prudent to maintain sterility in the area for the 24-hour period immediately after surgery. It appears that routine application of an antimicrobial incise drape is not sufficient in preventing contamination of the surgical site during recovery. A second study is currently underway, evaluating the use of a more aseptic incisional support during the recovery room period and postoperative period.²⁴ A previous study evaluated the use of a postoperative abdominal bandage and showed a decrease in incisional problems in the postoperative period.²⁵

Once a horse has an incisional infection, treatment options for ventral midline and paramedian skin incision complications have been documented previously in literature.⁸ As previously reported, horses with incisional drainage are much more likely to develop incisional hernias or to acutely disrupt all layers of the abdominal wall. In one study, the single most important risk factor for herniation was an incisional infection. An incisional infection increased the risk for future herniation by 17.8 times.¹³ In another study, the risk of future incisional hernia formation increased by 62.5 times after having an incisional infection.¹⁴

If a postoperative incisional infection can not be prevented, it is imperative to avoid a future suture line hernia. A recently completed study evaluated the use of a newly designed postoperative hernia belt/abdominal bandage in horses with postoperative incisional complications (Fig. 1).²⁶ The results of this study compare favorably to the reported literature numbers. In this study, only 85 of 993 (8%) horses had evidence



Fig. 1. Contents of the newly designed abdominal bandage package.

of incisional complications.²⁶ The hernia formation rate in this study was 6% of horses with incisional complications and 0.5% of all horses undergoing an exploratory celiotomy in the study period.²⁶ All horses were individually measured for a custom newly designed abdominal bandage, and three measurements are required for the newly designed abdominal bandage (**Fig. 2**).

The first measurement is around the girth, just caudal (5–10 cm caudal) to the withers. The second measurement is taken around the largest or widest part of the abdomen (it is recommended to add 2 inches to the measured length for a pad, and the pad should be at least 1 inch thick). The third measurement involves measuring the length of the abdominal incision.

The newly designed abdominal bandage allows for daily wound care and daily inspection of the abdominal incisions.²⁶ As a result of the edema reduction and the firm and even pressure on the healing ventral midline skin incision or healing paramedian skin incision, abdominal hernias can be prevented.²⁶ Overall, this study demonstrated that the use of the newly designed abdominal bandage reduced the length of time each horse with incisional drainage needed to be treated and that the incidence of incisional hernia formation, despite incisional drainage, is reduced to very low numbers compared to published literature reports.^{1,2,26}

Dehiscence of the body wall, with or without exposure of the abdominal content, is the most serious wound complication after an exploratory celiotomy. Many different causes and factors have been described in the literature that lead to possible body wall failures. Once a body wall fails or any other secondary closure of the body wall is necessary, an abdominal wire repair is needed.²⁷ A horse with secondary abdominal wire repair should be wearing the newly designed abdominal bandage for daily wound care. In a previous study, one horse that acutely disrupted the body wall layers healed with small dimples along the ventral midline skin incision and very small dimples in the paramedian stab incisions for the wire placement.²⁶

POSTOPERATIVE PNEUMONIA

Abdominal exploratory surgeries are performed as a potential life saving procedure. One of the most serious postoperative complications can be the development of postoperative pneumonia. There are several reports on horses with pleuropneumonia after shipping or exercise.²⁸ Only one case report describes the outcome of a thoroughbred

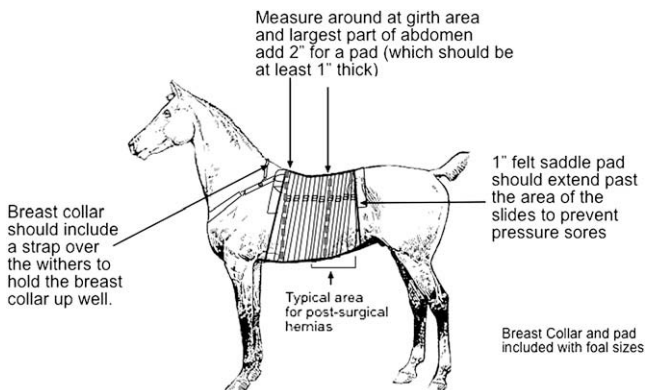


Fig. 2. How to measure for the newly designed abdominal bandage. (Courtesy of CM Equine Products, Norco, CA; with permission.)

racehorse who developed postoperative hematogenic pleuropneumonia and died.²⁹ In a recent short-term complication review of 300 horses undergoing colic surgery, none of the horses undergoing one celiotomy developed signs of postoperative pneumonia.⁶ A second study evaluated short-term complications in a group of 747 horses undergoing exploratory celiotomies for signs of abdominal pain.⁷ In this group, 4 of 747 horses developed postoperative hemorrhagic pneumonia.⁷ Two of the horses had enteroliths removed during surgery, and the other two horses had small intestinal strangulation obstructions as their primary surgical lesions. All four horses had varying degrees of intra-operative naso-gastric reflux. Two of the horses developed postoperative signs of thrombophlebitis, and all four horses developed high fevers (103.5°–106°F) between 5–8 days postoperatively. In all four horses, a trans-tracheal wash was performed, and several resistant bacteria were identified. All four horses were treated with antimicrobials, and the two horses with enteroliths as the primary diagnosis survived to discharge from the hospital and are doing well. The two horses with small intestinal strangulation obstructions as their primary diagnosis were euthanized as a result of complications caused by the hemorrhagic pneumonia.

POSTOPERATIVE SIGNS OF ABDOMINAL PAIN

Abdominal exploratory surgeries for signs of colic are one of the most frequently performed emergency surgeries. The decision to performed surgery is based mainly on physical examination, abdominal ultrasonography findings, abdominal radiography findings, and ultimately response to pain medication. Most horses undergoing an emergency exploratory celiotomy do not show any further signs of abdominal pain after surgery. Signs of abdominal pain after surgery (lying down for an excessive time period, restlessness, flank watching, stretching out, kicking at the abdomen, pawing, and rolling) are all considered abnormal and not desirable. The origin of postoperative pain in horses can be multi factorial, and every effort should be made to determine the cause of postoperative abdominal pain. In a recent review by Mair and Smith,⁶ 64 of 227 horses (28.2%) showed signs of abdominal pain after a single laparotomy. In another large case study by Klohnen,⁷ 209 of 747 horses showed signs of postoperative abdominal pain. Most of the horses with signs of postoperative abdominal pain respond to medical therapy, especially if the cause of abdominal pain was attributed to postoperative ileus. One hundred ninety of the seven hundred forty seven horses were diagnosed with signs of postoperative ileus^{7,35} and treated with intravenous lidocaine. A small percentage of horses will not respond to medical therapy and will require a second exploratory celiotomy.^{1–3}

Mair and colleagues¹ summarized many different published studies on evidence based medicine in regards to the decision making process on when to pursue a second laparotomy. In one report, the decision to pursue a second laparotomy was made within 24 hours after the first surgery.³⁰ The primary reason for the repeat laparotomy was an initial surgical error. Typically, in a private practice setting, horses are taken back to surgery if medical therapy is unsuccessful.⁷ Forty six of seven hundred forty seven horses required a second laparotomy, and none of the horses were taken back to surgery within the first 24 hours after the first surgery. There are many other reasons (besides signs of postoperative ileus) that may contribute to postoperative signs of colic.³

POSTOPERATIVE ILEUS

Postoperative ileus is an important cause of morbidity and mortality in the postsurgical period for horses with colic. The diagnosis has classically been made on the basis of

postoperative reflux obtained through nasogastric intubation and possible postoperative signs of abdominal pain in conjunction with reflux. According to veterinary literature, postoperative ileus mainly has been defined by the volume of reflux that is recovered from a horse during a 24 hour period.^{6,30-32} This is neither a definitive nor accurate method of diagnosing postoperative ileus.

Although the exact causes of postoperative ileus are not fully understood, it has been postulated that an imbalance of sympathetic and parasympathetic inputs to the GI tract results in a reduction in propulsive motility, contributing to or causing signs of ileus.⁸ Abdominal ultrasonography is a proven diagnostic modality in the preoperative diagnosis of small intestinal lesions and is potentially a useful diagnostic imaging technique to assess distention, contractility, wall edema, and motility of small intestine postoperatively.^{33,34}

In a recently completed study, postoperative intestinal ileus was defined by the presence of multiple ($n > 3$) distended loops of small intestine with decreased intestinal contractility and motility.³⁵ It was the study hypothesis that routine ultrasonographic examination of the postsurgical abdomen would allow for a more definitive and accurate detection of decreased small intestinal motility, indicating a diagnosis of postoperative ileus. Furthermore, a comparison was made between signs of postoperative ileus observed with abdominal ultrasound and naso-gastric reflux.³⁵

The results of the study demonstrate that abdominal ultrasound is a reliable method for the diagnosis and monitoring of postoperative signs of intestinal ileus and is potentially a more useful technique than the current analysis of gastric reflux volume.³⁵ In addition, the study demonstrated that both small intestinal and large intestinal lesions can contribute to postoperative ileus of the small intestine. Interestingly, 88% of the small intestinal ileus cases were associated with a strangulating obstruction,³⁵ supporting the view that ischemia and intestinal stress at surgery may contribute to intestinal ileus.³⁰ However, it is also interesting to note that 41% of postoperative ileus cases were diagnosed as having a primary large intestinal lesion.³⁵ The study further concluded that abdominal ultrasonography appeared to be more accurate in the detection and diagnosis of postoperative intestinal ileus compared to reflux obtained by way of a naso-gastric tube.³⁵

POSTOPERATIVE ADHESIONS

Abdominal exploratory celiotomies for signs of acute or chronic colic episodes are one of the most common surgeries performed in equine practice. Postoperative adhesions are one of the possible postoperative complications that can be encountered. Most adhesions are formed in the early postoperative period (30 days after surgery).³⁶ The extent and exact location of the adhesions will determine if they are a clinical problem or will remain "silent."³⁶ Adhesions become a clinical problem when they form constrictive bands or when they either compress or anatomically distort the intestines.

Despite numerous research and clinical investigations, postoperative adhesions after exploratory celiotomies continue to present clinical complications and challenges to equine surgeons. In human abdominal surgery, the most common method used for adhesion prevention is the use of high molecular weight polymers and application of physical barriers to focal lesions to prevent adhesion formation between serosal surfaces.

The use of a high molecular weight hydrophilic polymer solution (sodium carboxymethylcellulose [SCMC]) has been shown to reduce the adhesion formation rate and severity of experimentally induced adhesions in ponies³⁷ and horses.³⁸ In

a more recent clinical study, it was advocated that the use of SCMC improved survival in colic patients.³⁹

It was the author's hypothesis in a recently completed study³⁶ that horses in which 1% SCMC was used intraoperatively would have a lower incidence of adhesion compared to horses without the use of SCMC. Once the initial SCMC results became available, two other groups of horses were evaluated (before and after the use of SCMC).³⁶ The results of this study³⁶ did not support the findings that had been previously outlined during the research studies.^{37,38} Overall, 644 horses had an exploratory celiotomy over a 4-year period with an adhesion rate of 7.3%.³⁶

To the best of the author's knowledge, the Chino Valley Equine Hospital postoperative adhesion rate prior to and after the use of SCMC was 3.6% and 3.8%, respectively.³⁶ These numbers are in contrast to a confirmed adhesion rate during the use of SCMC that had increased to 24.6%.³⁶ After careful evaluation of all three study groups, it was determined that no other variables had changed besides the use of the SCMC.³⁶ The overall results of this study³⁶ were surprising, and further investigations are underway to determine why the horses in the SCMC group had a higher adhesion rate compared to the non SCMC group of horses. Currently, the use of 1% SCMC is not recommended in clinical cases.³⁶

SUMMARY

This article summarizes several new aspects of postoperative complications in horses after abdominal surgery. A more extensive review may be found in the articles by Mair and colleagues,¹ Dutki and White,² and Hackett and Hassel.³

REFERENCES

1. Mair TS, Smith LJ, Sherlock CE. Evidence-based gastrointestinal surgery in horses. *Vet Clin North Am Equine Pract* 2007;23:267–92.
2. Dutki S, White N. Surgical complications of colic surgery. *Vet Clin North Am Vet Equine Pract* 2008;24:513–34.
3. Hackett ES, Hassel DM. Colic: nonsurgical complications. *Vet Clin North Am Equine Pract* 2008;24:535–55.
4. Gardner SY, Reef VB, Spender PA. Ultrasonographic evaluation of horses with thrombophlebitis of the jugular vein: 46 cases (1985–1988). *Jam Vet Med Assoc* 1991;199(3):370–3.
5. Klohnen A. Private practice case review of vein thrombosis. *J Am Vet Med Assoc*, submitted for publication.
6. Mair TS, Smith LJ. Survival and complication rates in 300 horses undergoing surgical treatment of colic: short-term complications. *EVJ* 2005;37(4):303–9.
7. Klohnen A. A 3 year review of horses undergoing exploratory celiotomies for acute and chronic signs of abdominal pain: short term survival rates and short term complication rates in 747 horses. *Vet Surg*, submitted for publication.
8. Hardy J, Rakestraw PC. Postoperative care and complications associated with abdominal surgery. In: Auer JA, Stick JA, editors. *Equine surgery*. 3rd edition. St. Louis (MO): Saunders Elsevier; 2006. p. 506–9.
9. Magee AA, Galupo LD. Comparison of incisional bursting strength of simple continuous and inverted cruciate patterns in the equine linea alba. *Vet Surg* 1999;28:442–7.
10. Trostle SS, Wilson DG, Stone WC, et al. A study of the biomechanical properties of the adult equine linea alba: relationship of tissue bite size and suture material to breaking strength. *Vet Surg* 1994;23:435–41.

11. Wilson DA, Baker GJ, Boero MJ. Complications of celiotomy incisions in horses. *Vet Surg* 1995;24:506–14.
12. Kobluk CN, Ducharme NG, Lumsden JH, et al. Factors affecting incisional complications rates associated with colic surgery in horses: 78 cases (1983–1985). *J Am Vet Med Assoc* 1989;195:639–42.
13. Gibson KT, Curtis CR, Turner AS, et al. Incisional hernias in the horse. Incidence and predisposing factors. *Vet Surg* 1989;18:360–6.
14. Ingle-Fehr JE, Baxter GM, Howard RD, et al. Bacterial culturing of ventral median celiotomies for prediction of postoperative incisional complications in horses. *Vet Surg* 1997;26:7–13.
15. Honnas CM, Cohen ND. Risk factors for wound infection following celiotomies in horses. *J Am Vet Med Assoc* 1997;210:78–81.
16. Galuppo LD, Pasco JR, Jang SS, et al. Evaluation of iodophor skin preparation techniques and factors influencing drainage from ventral midline incisions in horses. *J Am Vet Med Assoc* 1999;215:963–9.
17. Stone WC, Lindsay WA, Mason DA, et al. Factors associated with acute wound dehiscence following equine abdominal surgery. *Proceedings of the Fourth Equine Colic Research Symposium* 1991(52).
18. French NP, Smith J, Edwards GB, et al. Equine surgical colic: risk factors for post-operative complications. *Equine Vet J* 2002;34:444–9.
19. Klohnen A, Lores M. Management of post-operative abdominal incisional complications with a hernia belt: 85 horses (2001–2005). *American College of Veterinary Surgeons Symposium*. Chicago (IL), 2007.
20. Edmiston CE, Seabrook GR, Goheen MP, et al. Bacterial adherence to surgical sutures: can antibacterial-coated sutures reduce the risk of microbial contamination? *J Am Coll Surg* 2006;203:481–9.
21. Rothenburger S, Spangler D, Bhende S, et al. In vitro antimicrobial evaluation of Coated VICRYL* Plus Antibacterial Suture (coated polyglactin 910 with triclosan) using zone of inhibition assays. *Surg Infect (Larchmt)* 2002;3(Suppl 1):S79–87.
22. Klohnen A, Brauer T, Bischofberger A, et al. Incisional complications following exploratory celiotomies: does antimicrobial (triclosan) coated suture material decrease the likelihood of incisional infection? Presented at the 17th Annual Scientific Meeting, European College of Veterinary Surgeons. Basel, 2008.
23. Klohnen A, Biedrzycki A. A new approach to the detection of incisional site infections after colic surgeries. *Vet Surg*, submitted for publication.
24. Klohnen A. Comparison of post-operative incisional infection rate in horses undergoing exploratory celiotomies being protected by either an loban bandage or an extensive abdominal bandage in the recovery room. *Vet Surg*, submitted for publication.
25. Smith LJ, Mellor DJ, Marr CM, et al. Incisional complications following exploratory celiotomy: does an abdominal bandage reduce the risk? *Equine Vet J* 2007;39:277–83.
26. Klohnen A, Lores M. Management of post-operative abdominal incisional complications with a newly designed abdominal hernia belt: 85 horses (2001–2005). Presented at the 17th Annual Scientific Meeting, European College of Veterinary Surgeons. Basel, 2008.
27. Tulleners EP, Donawick WJ. Secondary closure of infected abdominal incisions in cattle and horses. *J Am Vet Med Assoc* 1983;182:1377–9.
28. Mair TS, Lane JG. Pneumonia, lung abscesses and pleuritis in adult horses: a review of 51 cases. *Equine Vet J* 1989;21:175–80.

29. Seung-ho R, Joon-gyu K, Ung-bok B. A hematogenic pleuropneumonia caused by postoperative septic thrombophlebitis in a thoroughbred gelding. *J Vet Sci* 2004;5:75–7.
30. Freeman DE, Hammock P, Baker P, et al. Short- and long-term survival and prevalence of postoperative ileus after small intestinal surgery in the horse. *Equine Vet Suppl* 2000;32:42–51.
31. Merritt AM, Blickslager AT. Post-operative ileus: to be or not to be? *Equine Vet J* 2008;40:295–6.
32. Freeman DE. Postoperative ileus (POI): another perspective. *Equine Vet J* 2008; 40:297–8.
33. Klohnen A, Vachon A, Fischer AT. Use of diagnostic ultrasound in horses with signs of acute abdominal pain. *J Am Vet Med Assoc* 1996;209:1597–601.
34. Klohnen A. Abdominal ultrasonography in the equine colic patient: a validation of the technique. Presented at the 17th Annual Scientific Meeting, European College of Veterinary Surgeons. Basel, 2008.
35. Klohnen A, Biedrzycki A. Detection of postoperative ileus with the help of abdominal ultrasound in horses after colic surgery. *Equine Vet J*, submitted for publication.
36. Klohnen A, Rafetto J, Bischofberger A, et al. Adhesion formation rate after exploratory celiotomies in horses with and without intra-abdominal use sodium carboxymethylcellulose: a 4 year study. Presented at the American College of Veterinary Surgeons Symposium. San Diego, CA, 2008.
37. Moll H, Schumacher J, Wright J, et al. Evaluation of sodium carboxymethylcellulose for prevention of experimentally induced abdominal adhesions in ponies. *Am J Vet Res* 1991;52:88–91.
38. Hay WP, Mueller PO, Harmon BG, et al. Once percent carboxymethylcellulose prevents experimentally induced adhesions in horses. *Vet Surg* 2001;30:223–7.
39. Fogle CA, Mathew PG, Yvonne AE, et al. Analysis of sodium carboxymethylcellulose administration and related factors associated with postoperative colic and survival in horses with small intestinal disease. *Vet Surg* 2008;37:558–63.