Colonic displacements and uterine artery hemorrhage in two postpartum mares

Briony Bray,[a,b] Viviane Gomes,[a] Jonuel Cruz-Sanabria,[a] Lindsay Knott,[a,c] Mustajab Mirza,[a]
Charles McCauley,[a] Britta Leise,[a] Jennifer Sones[a]
[a]Veterinary Clinical Sciences, School of Veterinary Medicine, Louisiana State University, LA
[b]Goulburn Valley Equine Hospital, Congupna, Victoria, Australia
[c]Large Animal Clinical Sciences, College of Veterinary Medicine, Michigan State University, MI

Abstract

Although parturition, even unattended, may proceed without difficulty, acute postpartum complications in mares can be life threatening. Timely attention to complicated postpartum cases is crucial for mare's survival, especially first 24 hours after foaling. These mares may present with adverse clinical signs, due to gastrointestinal and/or urogenital system disorders, such as displacements and hemorrhage, respectively, which can have substantial effects on health and fertility. This case report discusses 2 mares referred to the same hospital for signs of colic within 24 hours postpartum: 1) large colon volvulus and broad ligament hematoma; and 2) right dorsal colonic displacement with uterine artery rupture. This report emphasizes concomitant occurrence of 2 disease processes, which may be omitted when assessed individually. Therefore, it is imperative that postpartum mare is fully assessed, as foaling associated hemorrhage may be masked by alimentary anomalies or vice versa.

Keywords: Parturition, postpartum, colic, hematoma, uterus, colon

Background

Broodmares are at an increased risk of developing abdominal disease, such as gastrointestinal pathology and uterine artery hemorrhage[1] in the peripartum period.[2] In part, this was attributed to changes in dietary composition,[3] violent movement of foal's extremities during parturition,[4] decompression and movement of internal organs post foaling,[5] and/or inflammatory responses related to stress. A large study reviewed 163 postpartum hospital referrals and reported that ⅓ of these cases had gastrointestinal disease, with colon volvulus being responsible for 16.6% of those cases.[2] Uterine arterial hemorrhage was responsible for approximately 40% of fatalities reported in postpartum mares, with majority occurring in the immediate postpartum period.[2] Cases described herein provide a topical and relevant review of complications frequently seen in a postpartum mare with signs of colic. Clinical presentations of these conditions can pose a diagnostic dilemma, due to difficulty in differentiating them[6] and treatment for gastrointestinal displacements/volvulus can be different than that for uterine artery associated hemorrhage.[4] It is necessary for clinicians to consider that these concurrent issues may be present.

Case 1 presentation

A 10 year old primiparous, 502 kg Thoroughbred mare delivered a live colt foal on the farm with vaginal assistance. Mare demonstrated mild abdominal discomfort and retained fetal membranes. Fetal membranes were removed manually by referring veterinarian after 12 hours, following ecbolic therapy. However, mare continued to display persistent signs of abdominal discomfort despite analgesics (Detomidine hydrochloride at 0.01 mg/kg IV; Dormosedan®, Zoetis, Kalamazoo, MI) and butorphanol tartrate (0.01 mg/kg IV; Torbugesic, Zoetis), and was referred 16 hours after foaling for signs of colic.

On presentation, mare was quiet, alert, and responsive but tachycardic at 60 beats per minute (bpm), pink mucous membranes with capillary refill time (CRT) of < 2 seconds with decreased borborygmi on abdominal auscultation. Reminder of mare's physical examination findings were within limits. Nasogastric intubation yielded no net reflux and transrectal palpation in addition to transabdominal ultrasonography (2 - 3.5 MHz convex transducer) revealed no significant findings.

A complete blood count revealed a normal packed cell volume (PCV) of 35% (reference range: 30 - 46%) and total protein (TP) of 8 g/dl (reference range: 5.8 - 8.7 g/dl), with a mild neutrophilia of 13 x 10^3/µl (reference range: 2.6 - 6.8 x 10^3/µl) that was consistent with potential inflammation, infection or stress. Although peripheral blood lactate was very mildly increased (2.13 mmol/l, reference range: < 2

mmol/l), no abdominocentesis was performed, precluding a comparison between these 2 values. A markedly increased concentration of creatine kinase (2,715 U/L, reference range: 119 - 287 U/L) and aspartate aminotransferase (AST 538 U/L, reference range: 168 - 494 U/L) were noted on the serum chemistry. Combined plasma muscle enzymes concentrations were used as prognostic indicators in colic cases and substantially associated with nonsurvival and intestinal ischemia cases. However, further research is indicated to understand the etiology of increased activity and relevance as a true preoperative indicator of severity and prognosis.[7]

Treatment

Initial management to attempt to stabilize the patient included: IV fluid therapy (lactated Ringer's solution at 1.5 liters/hour, supplemented with 29 grams calcium gluconate and 20 milliequivalents of potassium chloride per liter) and n-butylscopolammonium bromide (0.3 mg/kg IV; Buscopan®, Boehringer Ingelheim, St Joseph, MO) as a spasmolytic. However, mare's mentation continued to decline and persistent signs of colic were displayed, despite 2 more repeated administrations of xylazine (0.25 mg/kg IV; Xylamed™, Vetone®, Boise, ID) and butorphanol tartrate (0.01 mg/kg IV). Due to her worsening clinical status, exploratory celiotomy was recommended. Perioperative treatment included: penicillin G potassium (22,000 IU/kg IV, every 6 hours; Sandoz, Princeton, NJ), gentamicin sulfate (6.6 mg/kg IV once daily; Vetone®, Boise, ID) and flunixin meglumine (1.1 mg/kg IV, once daily; Prevail™, Vetone®, Boise, ID). Intraoperatively, a 180 degree volvulus of ascending colon was identified and corrected. Both small and large intestines were determined to be viable; however, an ~ 23 cm long, hematoma on the dorsal aspect of left broad ligament was also discovered. Care was taken during surgical correction of volvulus to limit manipulation within the caudal abdomen so as not to disrupt the hematoma within broad ligament.

Mare recovered without complication from surgery and general anesthesia. Except for mild tachycardia 24 hours postsurgery, mare's postoperative physical examination parameters and the hematology findings returned to normal. Postfoaling reproductive tract examination was performed 24 hours following surgery. On transrectal ultrasonography (linear 5 - 10.0 MHz transducer) examination, revealed normal ovaries and large pendulous and involuting uterus with intraluminal fluid accumulation (10 x 11 cm in depth; Figure 1). A low dose of oxytocin treatment was initiated (2 IU IM; Oxytocin, Vetone®, Boise, ID) as an ecbolic therapy, every 2 hours for 24 hours, then, every 4 hours, for 3 days. Authors prefer smaller more frequent doses of oxytocin (compared to accepted 20 IU) to have reduced exacerbation of colic signs. In addition to exogenous supply of oxytocin, mare releases oxytocin from posterior pituitary gland during nursing and bonding to facilitate uterine involution that incidentally has an endogenous effect on uterine contractility.[8] Reproductive tract transrectal examination, 2 days following treatment, revealed substantial reduction in the amount of intraluminal uterine fluid to a 1 x 3 cm pocket (Figure 2).

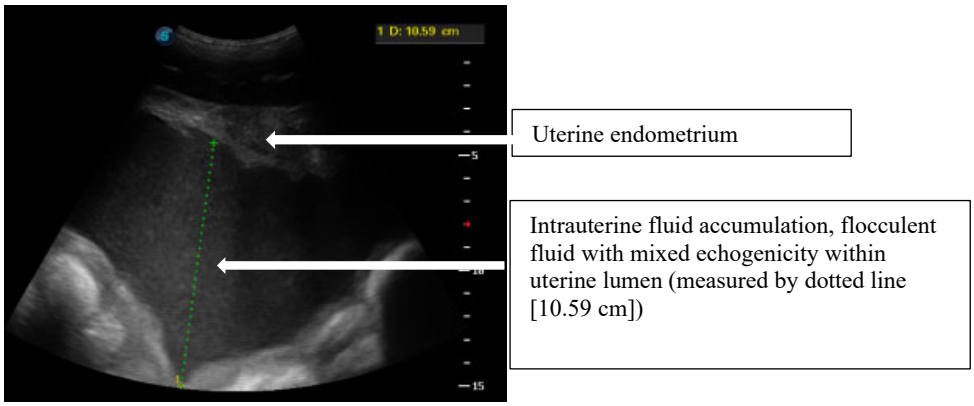

Figure 1. Transrectal ultrasonogram showing intrauterine fluid accumulation (3 days postpartum).

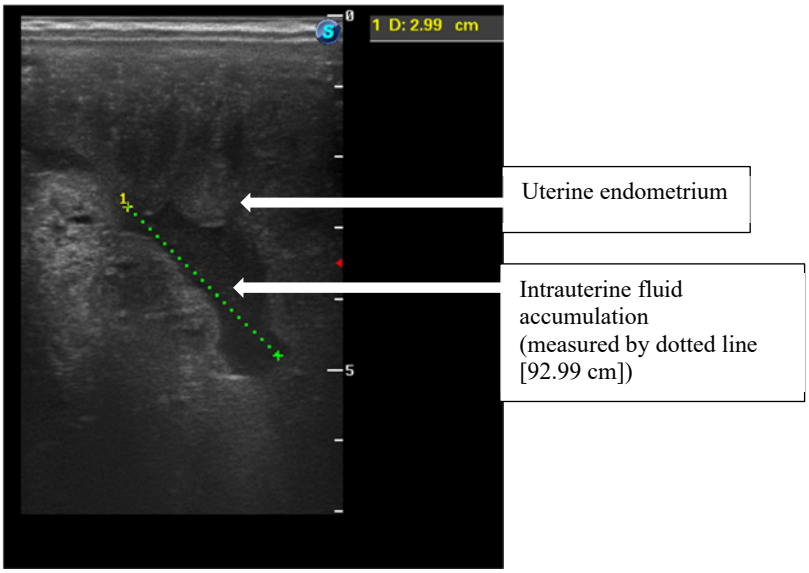

Figure 2. Transrectal ultrasonogram (5 days postpartum, 2 days after ecbolic therapy initiation) showing decreased intrauterine anechoic fluid accumulation.

Outcome

Mare and foal were discharged 9 days after surgery with following treatment regimen: trimethoprim sulfamethoxazole (20 mg/kg, every 12 hours orally; Rising health, Saddlebrook, IN) for 7 days and phenylbutazone (1 gram, every 12 hours orally; Vetone®, Boise, ID) for 3 days. Foal was normal at 3 months physical examination and the owners elected to delay breeding for financial reasons.

Case 2 presentation

A 17 year old multiparous, 418 kg Thoroughbred mare, that delivered a live colt foal unassisted (born at 366 days of pregnancy), had fetal membrane expulsion within 2 hours, was presented for acute signs of colic. Mare was reluctant to stand at 3 hours postpartum. Mare was referred following treatment with 10 liters of IV bolus, flunixin meglumine (1.1 mg/kg IV, once daily), butorphanol tartrate (0.01 mg/kg IV) and a sedative dose of detomidine hydrochloride (0.01 mg/kg IV). Mare had a history of a previous surgically corrected large colon displacement 3 years prior to this event. This was followed 1 year later with hospitalization also in our facilities for an unknown cause of abdominal discomfort that was treated medically.

On presentation, mare appeared was and depressed with tachycardia (80 bpm), had pale and dry mucous membranes with a CRT of 2 seconds, decreased borborygmi, and was continually trying to lie in lateral recumbency. Remainder of her vitals were within normal limits. Nasogastric intubation yielded no net reflux, and transrectal palpation findings were within normal limits for a < 24 hour postpartum mare. Transabdominal ultrasonography revealed swirling free fluid with mixed echogenicity surrounding intestine within the peritoneal cavity, indicative of a hemoabdomen (Figure 3). Abdominocentesis confirmed the presence of hemorrhagic fluid with a marked elevation in lactate at 10.2 mmol/l (reference range: < 2 mmol/l) and total protein of 5.2 g/dl (reference range: > 4 g/dl). The abnormalities from the mare's CBC revealed an anemia with a PCV of 24% (reference range: 30 - 46%), hypoproteinemia; total protein 4 g/dl (reference range: 5.8 - 8.7 g/dl) and hyperlactatemia 7.9 mmol/l (reference range: < 2 mmol/l), as well as a leukocytosis 12.1 x 10^3/µl (reference range: 5 - 11.6 x 10^3/µl) with a mature neutrophilia 9.7 x 10^3/µl (reference range: 2.6 - 6.8 x 10^3/µl).

Mare was stabilized with following intravenous medications: 1 liter of frozen plasma (Protein Volume Replacement 7100, Mg Biologics, St. Ames, IA), lactated Ringers solution (1.5 liters/hour), and

aminocaproic acid (40 mg/kg, Hospira, Lake Forest, IL) in 1 liter of 0.9% hypertonic saline given slowly. Aminocaproic acid inhibits fibrinolysis by inhibiting plasminogen activation and increasing alpha-2-antiplasmin activity, helping to maintain clot formation once it has occurred.[9]

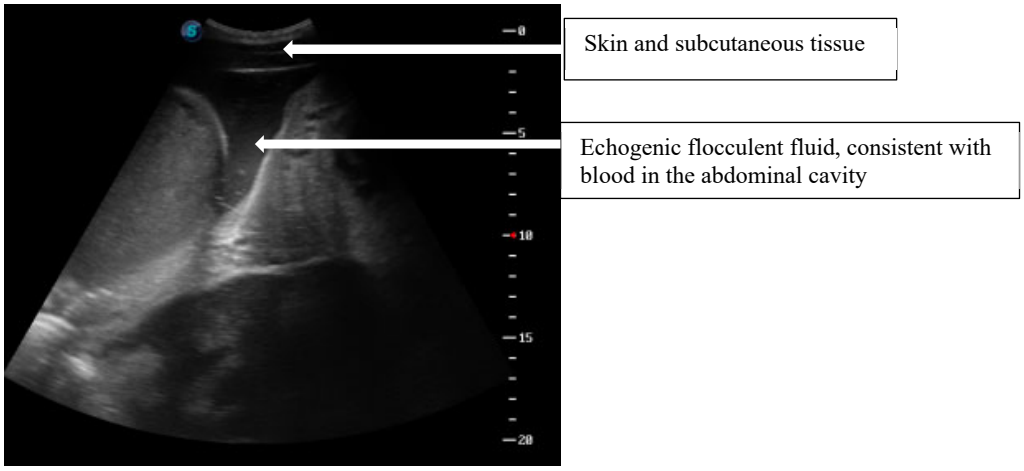

Figure 3. Transabdominal ultrasonogram on admission revealing echogenic swirling free fluid, consistent with blood, in ventral abdomen (bottom arrow).

Treatment

Within 6 hours after admission, mare's clinical presentation continued to decline, including a decrease in PCV to 15% and abdominal discomfort that did not improve despite an additional 2 doses of xylazine (0.25 mg/kg IV) and butorphanol tartrate (0.01 mg/kg IV). A presumptive diagnosis of uterine rupture or uterine-associated arterial hemorrhage was made; however, gastrointestinal causes of colic could not be ruled out.

Decision was made to perform an exploratory celiotomy. Perioperative treatment included: penicillin G potassium (22,000 IU/kg IV, every 6 hours), gentamicin sulfate (6.6 mg/kg IV, once daily), flunixin meglumine (1.1 mg/kg IV, once daily), and a tetanus toxoid (1 ml IM; Zoetis, Kalamazoo, MI). During surgical preparation, 2 liters of 6% Hetastarch (Hospira, Lake Forest, IL)
IV and 6 l of whole blood was collected from a hospital donor and administered. At exploratory celiotomy, a right dorsal colon displacement and a 32 x 25 x 9 cm hematoma within right broad ligament (occupying most of the pelvic canal and extended cranially beyond the pelvic inlet) was identified. Significant contusions and bruising to the nongravid uterine horn were also noted (Figure 4). Manipulation of the caudal abdomen was minimized as much as possible to avoid any potential disruption of the hematoma. Colonic displacement was corrected and, due to the mare's previous history, a colopexy was performed.

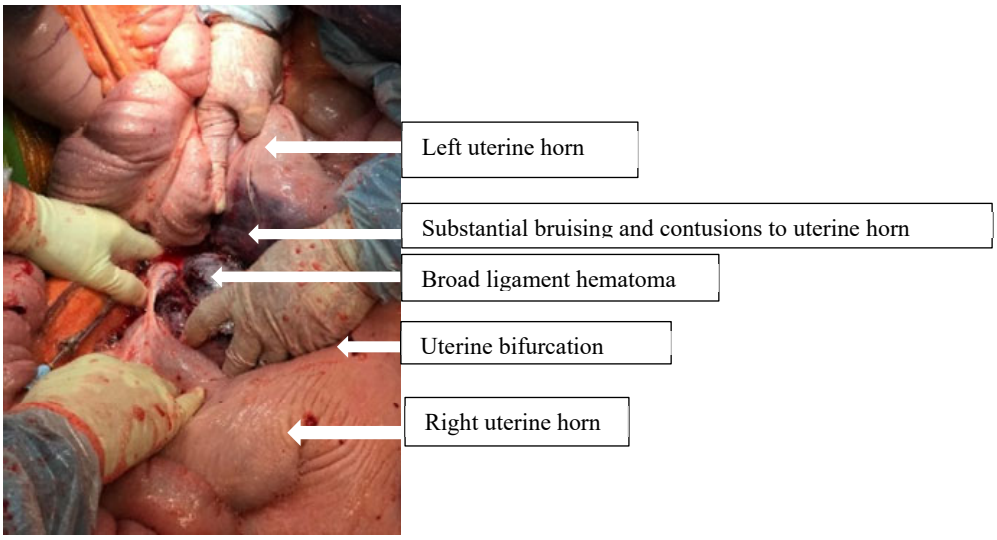

Figure 4. Case 2 intraoperative image of the uterus demonstrating hemorrhagic clot and substantial contusions and bruising to the nongravid horn of the uterus

Recovery from surgery and anesthesia was unremarkable and the foal was reunited with mare. However, concern of continuing hemorrhage remained presumably from the original insult and a second dose of aminocaproic acid (40 mg/kg slowly IV in 1.0 l of 7.2 % hypertonic saline) and Yunnan Baiyao, a Chinese herbal medication, (13 mg/kg, every 12 hours orally, Yunnan Baiyao Group, Yunnan, China) was administered. Yunnan Baiyao had no effects on hemostatic function in healthy horses;[10] however, it decreased surgical blood loss in human patients, apparently by increased expression of platelet surface receptors[11] and in ponies.[12]

Mare was stable after 24 hours and physical examination findings were within normal limits. PCV stabilized and increased to 25% at 72 hours. Postoperative transrectal ultrasonographic examination (linear 5 - 10 MHz transducer) revealed a moderate volume of grade 3 intrauterine fluid, therefore, an ecbolic regime (oxytocin 2 IU, every 4 hours, IM for 3 days) was implemented. It was noted that foal was not gaining weight appropriately so offerings of milk replacer via bucket feeding was initiated. Foal's nutrition was maintained during the remainder of hospitalization. Daily transrectal and transabdominal ultrasonographic findings revealed less free fluid in uterus than before (small volume and grade 4), and a more organized hematoma structure formation in broad ligament suggesting resolution of active uterine artery bleed.

Mare's colic signs returned within 48 hours postsurgery. Despite medical management and analgesics treatment, colic signs of tachycardia, tachypnea, flank watching, and laying in lateral recumbency persisted. A repeat celiotomy through initial ventral midline incision was performed, and a large colon impaction was diagnosed. An enterotomy was performed, the large colon was evacuated and the colopexy was reversed. Mare continued on perioperative antibiotics, flunixin meglumine, IV fluid therapy and was administered lidocaine hydrochloride (CRI 0.05 mg/kg/min IV; Lidocaine 2%, Vetone®, Boise, ID) for pain and the prevention of postoperative ileus. Although mare remained comfortable, showing no signs of abdominal pain, sudden copious purulent serosanguineous drainage from the abdominal incision occurred 24 hours after second surgery. Ultrasonographic evaluation of incision suggested partial incisional dehiscence. Mare returned to surgery where abdominal cavity lavage and drain placement was followed by an incisional revision. Mare was managed postoperatively with an abdominal bandage and twice daily abdominal lavage with 10 l of sterile saline through a drain. Metronidazole (15 mg/kg, every 8 hours orally; Alembie, Bridgewater, NJ) was added to antibiotic treatment regimen, as abdominal fluid findings were consistent with peritonitis. Although no further complications were noted with the incision, mare began to display intermittent mild colic signs, predominantly tachycardia and laying in lateral recumbency 5 days following drain placement (11 days from initial presentation). Mare was unresponsive to aggressive pain management (CRI of lidocaine [0.05

mg/kg], ketamine hydrochloride [0.6 mg/kg/hr, Zetamine™, Vet one®, Boise, ID], and detomidine hydrochloride [0.0044 mg/kg/hour]), along with butorphanol tartrate (0.01 mg/kg IM, every 4 hours) and flunixin meglumine (1.1 mg/kg, IV, every 12 hours). After 36 hours of therapy, owner elected for euthanasia.

Outcome

Postmortem examination revealed previously discovered hematoma within broad ligament, now with a fibrinous adhesion to distal small colon. Fibrinous adhesion had created a 180 degree twist in small colon, partially occluding the lumen.

Discussion

Although largely based on anecdotal information, mare breed, age and parity may be predisposing factors for colic in postpartum mare.[4] As veterinarians, being aware of these potential factors, may be able to differentiate probable causes of abdominal pain in postfoaling period in a more timely manner. Attended parturition and regular postpartum monitoring, can result in earlier identification of signs indicative of postpartum complications. This allows veterinarian to institute aggressive therapies and/or rapid referral if necessary. Early identification of problems and rapid decision making in postpartum period can be critical to overall prognosis for survival. Poorer outcomes tend to be in cases where there is delayed diagnosis, often related to complications such as systemic compromise or gross abdominal contamination.[13]

Most common causes for referral in postpartum mare are large colon volvulus or displacement and urogenital hemorrhages.[13] Two cases presented in this report were determined to have conditions associated with both gastrointestinal and reproductive systems, yet each case presented in unique ways. A large US study illustrated that gastrointestinal disease accounted for > ⅓ of clinical cases within first 30 days postpartum, with nearly 17% being due to a large colon volvulus.[2] A UK study also demonstrated the increased prevalence of large colon volvulus in postpartum mares, which were 13 times more likely to be diagnosed as such.[5] While 88% of postpartum mares with gastrointestinal complications survived,[14] in locations where mares had increase distances to travel for referral treatment, prognosis can be much worse.

Although presenting signs are variable, majority mares, with either or both gastrointestinal or urogenital disease processes, will present similarly with moderate to severe abdominal discomfort unresponsive to analgesics. Further diagnostic evaluation such as transrectal palpation, transabdominal ultrasonography and abdominocentesis, can often be very helpful in providing further insight into severity and the nature of pathology, and provide suggestive information to help recommend next steps in treatment for a rewarding outcome.[13] Delayed referral or clinical decisions can ultimately lead to poorer prognosis and/or further complications.

Many theories were proposed for higher risk of postpartum mares developing a large colon displacement or volvulus compared to remainder of equine population. One possibility is large 'abandoned space' in caudal abdomen previously inhabited by fetus that permits more freedom for gastrointestinal organs to relocate or twist.[5] During Stages I and II of labor, foal may cause trauma to extrauterine organs with its limbs movements, despite protective covering over hooves and being encapsulated within uterus. Management changes often occur in late pregnancy and postpartum period for these mares, including altered and enhanced feeding practices, which is a consistent risk factor for colic.[3, 5] These diet changes can disturb normal gastrointestinal motility, and potentially change the microbiome and volatile organic compounds within large colon. A study reported that mares that did not experience colic, had very little change in their hindgut bacteria postfoaling; however, mares that displayed signs of colic postpartum had significant alterations in their microbiome, particularly associated with presence of Firmicute*s* and Proteobacteria.[15] These findings suggest that evaluation of fecal microbiome in postpartum mare could allow for identification of at risk mares, thereby allowing caretakers to change management practices, eliminate mare's fecal microbiota dysbiosis and possibly minimize chances of colic.

Urogenital extrauterine hemorrhages are most frequently related to middle uterine, uteroovarian or external iliac arteries, with uterine artery being the most common.[13] Majority of literature suggests that risks substantially increase with age, with 78% of reported cases being mares 15 years of age or older.[1] This age predilection has been attributed to atrophy of smooth muscle cells in vessel wall, accompanied by arterial wall fibrosis.[2] Due to repeated loading and excessive fatigue of arterial wall from multiple pregnancies, 'elastica interna' is disrupted, thinned and can fragment, thereby also increasing chances of rupture.[6,16] Depending on vessel location, large volumes of blood can either be contained within uterine lumen, trapped between layers of broad ligament, or escape into abdominal cavity (hemoabdomen).[13] In severe cases of uterine artery rupture, there may be overt signs of hypovolemic shock, including pale mucous membranes and delayed CRT, and these cases can progress rapidly to acute fatalities. However, often, clinical signs observed with urogenital hemorrhages after 24 hours are dull mentation, tachycardia, and muscle fasciculations. When hemorrhage is contained within broad ligament, an organized hematoma can form, limiting blood loss. This is consistent with findings from a postmortem study in which hematomas in broad ligaments presumed to be from the uterine artery, were confirmed as the source of hemorrhage in
8 out of 11 mares.[17] Although there is no definite predilection to 1 particular side of uterus being more affected, it has been suggested the right side is more prone to such injury, attributable to displacement by cecum.[13] Management of mares with hemorrhage can vary depending on severity of blood loss and clinical signs. Supportive therapy such as IV fluids, blood transfusion, and medications such as aminocaproic acid to help improve blood clot stability can be important to utilize when managing these cases. Surgery may or may not be indicated, depending on diagnosed or suspected cause of the discomfort. Manipulation of uterus and surrounding structures during diagnostic examinations or intraoperatively should be minimized to limit potential disruption of organizing hematomas. Postsurgery oxytocin use in mares with hematomas is controversial and clinician dependent due to concern of uterine contraction disturbing a hematoma. Low dose oxytocin therapy, which was used in these cases, is reported to promote uterine involution and is indicated even in cases with suspected uterine lacerations, as long as the mare remains comfortable.[18,19] Administration of oxytocin, as compared to other ecbolics, has no effect on heart rate, blood pressure or hematological parameters in early postpartum mares.[18]

Both mares of this report displayed colic signs that are associated with gastrointestinal disease and had concurrent findings of broad ligament hematomas. As previously discussed, postpartum hemorrhage is widely considered to be age related, however probability also increases with each succeeding pregnancy beyond 10 years of age.[20] While diagnosis of a hemorrhagic event in Case 2 was based on physical examination and diagnostic findings, exact origin of hemorrhage could not be determined prior to surgery. Although her anesthetic risk increased due to a compromised cardiovascular state, surgery was deemed necessary due to uncontrolled pain and suspicion of a concurrent intestinal lesion. With this information in mind, it is important to remember that any mare is at potential risk of hemorrhage.[17]

Prognosis for survival is ultimately important for production of future offspring; however, fertility may be compromised by postpartum complications. Uterine laceration cases typically have an 80% chance of survival, whereas with colic, it can be as low as 40% after a large colon volvulus.[2,21] Therefore, there is a variable survival range and prognosis for postpartum complications, depending on the underlying cause. Postpartum conception rates are not affected in ~ 84% of mares, depending on the site and severity of hematoma.[13] In cases with severe hemorrhage into abdomen or uterus, there is a poorer prognosis for survival and therefore fertility.[22] Additionally, when hemorrhage is contained in broad ligament, it may take several weeks for hematoma to resolve,[13] potentially causing a mare to skip a breeding season or having a shorter broodmare career. This will depend on when insult occurred relative to timing of breeding season, size of hematoma and how owners are advised by veterinarian (for example live breeding may not be recommended, due to concern of clot disruption). However, during this peripartum period, coagulation reference ranges may be inappropriate, and there are ongoing studies to determine if they hinder diagnosis or treatment of a hemostatic disorders during pregnancy.[23] Mares that survive may still be fertile, and these mares are likely to become pregnant when rebred.[6] They are,

however, considered a high risk mare for potential hemorrhage at subsequent parturition, due to increased fibrosis and lost elasticity of vessels.[8] For mares, however, that present for colic, their prognosis for potential reproductive success should not be compromised, assuming the reproductive tract remains normal. Broodmares have had successful reproductive careers following surgical correction of large colon volvulus, even after multiple surgeries.[24] Recurrent colic, however, remains a hazard and techniques such as colopexy or large colon resection and anastomosis, should be considered in such cases.

Learning points

- Importance of obtaining a full and complete history, including signalment
- Reduced time to referral is critical in postpartum mares
- Any postpartum mare is at an increased risk of either urogenital hemorrhage or gastrointestinal disease

Conflict of interest

Authors have no conflicts of interest to declare.

References

1. Williams B, Bryant U: Periparturient arterial rupture in mares: A postmortem study. J Equine Vet Sci 2012;32:281-284.
2. Dolente BA, Sullivan EK, Boston R, et al: Mares admitted to a referral hospital for post-partum emergencies: 163 cases (1992–2002). J Vet Emerg Crit Care 2005;15:193-200.
3. Hudson JM, Noah BS, Cohen D, et al: Feeding practices associated with colic in horses. J Am Vet Med Assoc 2001;219:1419-1425.
4. Turner RM: Post-partum problems: The top ten list. Proc Am Ass Equine Pract 2007; p. 305-319.
5. Suthers JM, Pinchbeck GL, Proudman CJ, et al: Risk factors for large colon volvulus in the UK. Equine Vet J 2012;45:558-563.
6. Frazer GS: Post-partum complications in the mare. Part 1: conditions affecting the uterus. Equine Vet Educ 2003;15:36-44.
7. Krueger CR, Ruple-Czerniak A, Hackett ES: Evaluation of plasma muscle enzyme activity as an indicator of lesion characteristics and prognosis in horses undergoing celiotomy for acute gastrointestinal pain. BMC Vet Res 2014;10:S7.
8. Knottenbelt DC, Pascoe RR, Lopate C, et al: Equine stud farm medicine and surgery. 1st edition, Edinburgh; Saunders: 2003. p. 282, 345.
9. Heidmann P, Tornquist SJ, Qu A, et al: Laboratory measures of hemostasis and fibrinolysis after intravenous administration of epsilon-aminocaproic acid in clinically normal horses and ponies. Am J Vet Res 2005;66: 313-318.
10. Ness SL, Frye AH, Divers TJ, et al: Randomized placebo-controlled study of the effects of Yunnan Baiyao on hemostasis in horses. Am J Vet Res 2017;78:969-976.
11. Tang ZL, Wang X, Yi B, et al: Effects of the preoperative administration of Yunnan Baiyao capsules on intraoperative blood loss in bimaxillary orthognathic surgery: a prospective, randomized, double-blind, placebo-controlled study. Int J Oral Maxillofac Surg 2009;38:261-266.
12. Graham L, Farnsworth K, Cary J: The effect of yunnan baiyao on the template bleeding time and activated clotting time in healthy halothane anesthetized ponies. J Vet Em Crit Care 2002;12:279.
13. Tibary A, Pearson LK: Medical problems in the immediate post-partum period. Proc Am Ass Equine Pract 2012; p. 362-369.
14. Hackett ES, Embertson RM, Hopper SA, et al: Duration of disease influences survival to discharge of Thoroughbred mares with surgically treated large colon volvulus. Equine Vet J 2015;47:650-654.
15. Weese JS, Holcombe SJ, Embertson RM, et al. Changes in the faecal microbiota of mares precede the development of post partum colic. Equine Vet J 2015;47:641-649.
16. Ueno T, Nambo Y, Tajima Y, et al: Pathology of lethal peripartum broad ligament haematoma in 31 Thoroughbred mares. Equine Vet J 2010;42:529-533.
17. Arnold CE, Payne M, Thompson JA, et al: Periparturient hemorrhage in mares: 73 cases (1998–2005). J Am Vet Med Assoc 2008;232:1345-1351.
18. Nagel C, Trenk L, Wulf M, et al: Oxytocin treatment does not change cardiovascular parameters, hematology and plasma electrolytes in parturient horse mares. Theriogenology 2017;91:69-76.
19. Canisso IF, Rodriguea JS: A Clinical Approach to the Diagnosis and Treatment of Retained Fetal Membranes with an Emphasis Placed on the Critically Ill Mare. J Equine Sci 2013;33:570-579.
20. Oikawa M, Nambo Y, Miyamoto M, et al: Post-partum massive hematoma within the broad ligament of the uterus in a broodmare possibly caused by rupture of the uterine artery. J Equine Sci 2009;20:41-46.

21. Santschi EM: Colic and Pregnant Mares. In: Blikslager AT, White NA, Moore JN et al: Editors. The Equine Acute Abdomen. 3rd Edition, Hoboken; John Wiley & Sons Inc.: 2017. p. 819-830.
22. Scoggin CF, McCue PM: How to assess and stabilize a mare suspected of periparturient hemorrhage in the field. Am Ass Equine Pract 2007; p. 342-348.
23. Bazzano M, Giannetto C, et al: Hemostatic profile during late pregnancy and early postpartum period in mares. Theriogenology 2014; 81:629-642
24. Leahy ER, Holcombe SJ, Hackett ES, et al: Reproductive careers of Thoroughbred broodmares before and after surgical correction of >/=360 degree large colon volvulus. Equine Vet J 2018;50:208-212.