Evaluation of the Colic in Horses: Decision for Referral

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KEYWORDS

• Horse • Colic • Diagnostic tests • Evaluation

KEY POINTS

- A thorough evaluation of the horse with colic allows early identification of cases that need referral for intensive medical or surgical intervention.
- Early referral improves the horse's prognosis and reduces client cost by allowing intervention while the horse is systemically stable.
- Evaluation should start with a detailed history, thorough physical examination, rectal examination, and passage of a nasogastric tube.
- More advanced diagnostics, including transabdominal ultrasonography, abdominocentesis, and point-of-care measurement of lactate and glucose, can aid in the decision for referral.

INTRODUCTION: NATURE OF THE PROBLEM

Colic is the most common emergency in equine practice with approximately 4 out of every 100 horses having an episode of colic each year.[1] Of the horses that are evaluated by a veterinarian in private practice, approximately 7% to 10% have a lesion that requires surgical correction.[2] Although this may be obvious with severe, acute strangulating obstructions, most colic cases are not quite as black and white. Early identification and referral of horses with a surgical lesion is critical to obtain a successful outcome. Early referral allows general anesthesia and surgery to occur while the horse is systemically stable and intestinal damage is mild, and this decreases postoperative morbidity and mortality and reduces client cost. Many owners would consider taking their horse to a referral hospital for evaluation of colic, and with the excellent success in treatment of geriatric horses with colic,[3] age should not be considered a negative factor in the decision to refer.

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The veterinary practitioner should thoroughly assess the horse on the first visit and appropriately analyze the findings and offer treatment options. This analysis includes obtaining the signalment of the patient, a thorough history, a complete physical examination including transrectal palpation and nasogastric intubation, and performance of appropriate diagnostic tests and procedures. Accumulation of this information will provide the tools to dictate whether referral to a center with surgical capabilities is appropriate. Referral is necessary not only for surgical intervention but also for advanced intensive medical management such as 24-hour monitoring, antiendotoxic therapies, advanced fluid therapy administration, trocarization, or for a second opinion before euthanasia.

PATIENT HISTORY AND SIGNALMENT

Although patient history in itself does not indicate the need for referral, a thorough history and consideration of patient signalment can provide key information toward identifying the specific cause of colic. This knowledge could lead to a more expedited referral in horses with surgical conditions and likely an improved outcome.

Use of a standardized colic history form is recommended to ensure important historical information is not omitted and to streamline the history-taking process. Important components of the history that should be included are the following:

- Duration, nature of onset, and severity of colic signs
- Current diet and recent dietary changes
- Appetite, water intake, and access to water
- Fecal and urine output and consistency
- Reproductive status
- Whether the horse has had prior colic episodes
- History of diarrhea, laminitis, or other medical conditions
- Medications administered
- Vaccination and deworming status and protocol
- Dental care
- Prior surgeries
- Presence of sand or dirt access
- Primary use of the horse
- Current housing and recent changes in management
- Whether other horses on the property have clinical signs of illness
- Whether the horse is a cribber or windsucker
- Locations the horse has lived and recent travel history

There are several specific historical findings that may lead the clinician to consider particular diagnoses. The characteristic signs the patient has demonstrated are one of the most useful components of the history to assist with diagnosis. Did the patient display acute, severe signs initially? If the onset of colic was not observed, is there physical evidence of severe signs of colic such as skin abrasions over prominent points over the head or hips (**Fig. 1**)? This acute onset of severe pain most commonly is associated with a strangulating obstruction. Once the intestine becomes devitalized, the signs of pain may also abate to some degree, making the determination of the need for surgery more difficult. Stoic, aged horses presenting this way with strangulating small intestinal obstructions may be misdiagnosed with duodenitis/proximal jejunitis until progression of disease ensues. Delays in surgical treatment may lead to a poorer prognosis from advanced systemic disease resulting from the presence of necrotic bowel.

Fig. 1. Horse showing evidence of severe prior colic with abrasions over prominent points on the head.

Another component of the history that is useful in decision making is noting what medications have previously been administered by the owner or trainer. Consider the presence of these medications when observing the horse's degree of pain as it is likely the presence of drugs such as flunixin meglumine will attenuate the clinical signs.

Table 1 contains historical variables that may be associated with particular diagnoses and that may have an impact on the decision for surgery.

Signalment of the patient (age, breed, and sex) can also provide important clues to what type of process should be on the differential list of the clinician. A list of differential diagnoses that should be taken into account based on specifics of patient signalment is provided in Table 2.

Horses at increased risk for a surgical condition based on history, signalment, and physical examination findings should be transported to a facility with surgical capabilities at the earliest possible time point.

PHYSICAL EXAMINATION

The basic physical examination, when combined with signalment and history, will often provide the information needed to determine whether surgery is needed in a given colic case. Key components of the physical examination for the colic include

- Pain assessment and general appearance
- Heart rate
- Temperature
- Respiratory rate

Table 1
Patient historical variables that may be associated with particular diagnoses and may aid in the decision for early referral

Historical Variable	Diagnosis Association
Acute onset, severe colic	Strangulating obstruction
Insidious onset colic of several days duration	Nonstrangulating obstruction/displacement
History of recurrent colic episodes	Sand colic; enterolithiasis; gastric or colonic ulcers; impaction; gas colic
Limited access to water/absent or concentrated urine output	Large colon impaction
Feces: diarrhea observed early on followed by progressive colic[35]	Small colon impaction
Feces: persistent soft or watery feces	Colitis
Dull mentation and inappetance	Colitis; non-GI origin systemic diseases
Variable pain followed by signs of shock (sweating, muscle fasciculations and reluctance to move)[4]	GI rupture
Mild to moderate colic followed by severe colic	Secondary LC displacement or LC volvulus
Colic minimally/unresponsive to alpha-2 agonists	Strangulating obstruction
Changes in feed type or quantity of consumption[36,37]:	
Feeding of coastal Bermuda grass hay (East coast)	Ileal impaction
Change to lower-quality fibrous feed	Colon or cecal impaction
Increase in feeding of concentrates	Proximal enteritis[38] or large colon displacement/volvulus from gas production
Alfalfa hay as predominant forage source[39]	Enterolithiasis
Access to moldy hay or grain	Proximal enteritis/gastritis/enterocolitis
History of gradual weight loss and intermittent soft stool	Sand impaction
Feeding on the ground or access to sandy soil	Sand impaction
Recent anthelmintic administration in a young horse[40]	Ascarid impaction
History of chronic NSAID use for musculoskeletal problems[41]	Right dorsal colitis/gastric ulceration
Geographic location—current or recent:	
California	Enterolithiasis
Arizona, Florida, or regions with sandy soils	Sand colic
UK, Northern Mainland Europe, or South America[42]	Equine grass sickness
History of prior colic surgery	Recurrence of original problem/adhesions

Abbreviations: GI, gastrointestinal; NSAID, nonsteroidal antiinflammatory drug.

- Auscultation of gastrointestinal motility
- Perfusion indices (mucous membrane color and capillary refill, jugular refill, extremity temperature)
- Hydration indices (mucous membrane moisture, skin turgor)
- Palpation of digital pulses (pulse strength and temperature of lower limb/hoof)

Table 2
Differential diagnoses to be considered relative to patient signalment

Signalment	Differential Diagnoses
Age: neonate (0–30 d)	Meconium impaction (0–2 d); clostridial enteritis/enterocolitis; strangulating obstruction (small intestinal [SI] volvulus, scrotal hernia); atresias
Age: <2 y of age	Foreign body obstruction[43]; ascarid impaction[44]; intussusception[45]
Age: aged (>12 y)	SI strangulating lipoma; fecalith or large colon impaction
Breed: Arabian/Morgan	Enterolithiasis[39]
Breed: American miniature	Fecalith[46]; sand impaction; enterolithiasis[39,46,47]
Breed: Standardbred/Andalusian draft	Inguinal hernia (stallions)[48–50]
Sex: stallion	Inguinal hernia[49]
Sex: mare—pregnant	Uterine torsion; uterine artery rupture (peri-partum)[51]
Sex: mare—post-partum	Colonic volvulus; uterine artery rupture; mesenteric hematoma/rent

- Rectal palpation
- Passage of nasogastric tube for detection of gastric reflux

Key components of the physical examination to be discussed in greater detail that play strong roles in the decision for surgery include pain assessment with general appearance, heart rate, temperature, gastrointestinal motility, rectal palpation, and presence of gastric reflux.

Pain Assessment and General Appearance

General appearance assessment should include pain assessment, degree of abdominal distension, stance, and body condition scoring. As described earlier in patient history, physical evidence of a prior severe painful episode or observed severe uncontrolled pain is often associated with a strangulating obstruction. A "shocky" or "depressed" appearance following an episode of colic along with reluctance to walk is often associated with intestinal rupture[4] or is observed in stoic horses with strangulating lesions of the small intestine. Degree of abdominal distention has been shown to be an effective discriminating variable for medical versus surgical management of colic.[5] Similarly, the need to administer more than one analgesic treatment to control pain has been associated with the need for surgery.[6] When a specific diagnosis has not been made, lack of response to analgesic administration or resumption of colic after analgesic administration should be considered as a need for surgery.[6] Body condition evaluation may also provide clues as to underlying cause of the colic episode. Horses with sand accumulation tend to have lower body condition scores,[7] and horses with enterolithiasis on an alfalfa-rich diet tend to have higher body condition scores. A poor body condition may also indicate underlying disease processes, inadequate nutrition, or poor dentition.

Heart Rate

Elevation in heart rate, along with other abnormalities in cardiovascular parameters, has been found to be predictive of mortality in several studies evaluating prognosis

in colic.[8–10] However, caution should be used in relying on heart rate alone to predict outcome, particularly in horses with normal heart rates, because wide variations exist in between individuals in tolerance to pain and a normal heart rate may exist in the presence of severe gastrointestinal disease. When combined with other physical examination parameters, elevation in heart rate is a useful tool for judging the severity of a disease process because it often indicates severe pain or circulatory compromise. Horses with colic combined with cardiovascular compromise and hypovolemia need aggressive treatment and should have ready access to a referral center. Signs of hypovolemia include tachycardia heart rate (HR>60), cool extremities, delayed jugular refill, variable mucous membrane color, delayed capillary refill time (>2 sec), and diminished peripheral pulse quality.

Temperature

It is important to obtain the body temperature in a horse with colic because this may provide insight into the underlying cause. An exception to this would be the violent, uncontrolled colic that is clearly in need of surgical exploration. Because pneumorectum will often result in a falsely low temperature, body temperature should always be obtained before performing a rectal palpation. Rectal temperature is most often normal or subnormal in the surgical colic case. Subnormal temperatures may be associated with cardiovascular compromise. It is rare to perform surgery for colic on a febrile horse. Exceptions to this may be septic peritonitis and some horses with sand impaction may have low-grade fevers likely as a consequence of chronic mucosal inflammation and bacterial translocation. Although many sand impactions may be treated successfully medically, concurrent colonic displacement often dictates the need for surgical intervention. Horses with concurrent signs of colic with a fever often have an inflammatory or infectious condition such as colitis or duodenitis/proximal jejunitis (DPJ). Similarly, horses with internal abscesses and concurrent peritonitis may be febrile and show signs of colic if adhesions of bowel to the abscess result in gastrointestinal obstruction. In general, be wary of surgical intervention of the febrile horse until further diagnostic tests can help elucidate the underlying cause.

Gastrointestinal Motility

Gastrointestinal motility may be increased in horses with spasmodic colic or phases of colitis and these most often may be managed effectively with medical therapy. Decreased or absent borborygmi is more commonly associated with mechanical obstruction (strangulating or nonstrangulating) or conditions resulting in the systemic inflammatory response syndrome and may be exacerbated by dehydration, electrolyte imbalances, or cardiovascular compromise. Horses with decreased or absent borborygmi have significantly increased odds of requiring surgery compared with horses with normal intestinal sounds.[6] If a horse with colic is demonstrating evidence of progressive intestinal motility as evidenced by both auscultation and passage of feces, surgical intervention is often not required.

Rectal Palpation

The rectal examination is the most useful diagnostic component of the physical examination because, in experienced hands, it can often provide a diagnosis and the degree of distention of bowel can readily be recognized. Commonly diagnosed conditions identified during transrectal palpation include nephrosplenic entrapment (left dorsal displacement of the colon), right dorsal displacement of the colon, cecal impaction, pelvic flexure impaction, colonic volvulus, inguinal herniation, small colon impaction, abdominal masses, gastrointestinal rupture, and detection of small

intestinal distention. Serial rectal palpation, particularly in a colicky horse that has minimal abnormalities on its first rectal palpation, is an essential means of assessing progression of disease and the need for surgical intervention.

A systematic approach to transrectal palpation is recommended, ensuring that adequate restraint has been applied. Horses that object to palpation should be restrained with the combination of an alpha2-agonist (xylazine hydrochloride) and an opioid (butorphanol). If straining is present, use of low-dose N-butylscopolammonium bromide (NBB; Buscopan, Boehringer Ingelhiem Vetmedica Inc, St Joseph, Mo.) (0.1–0.15 mg/kg) and use of topical lidocaine in the rectum can be helpful in both improving reach to palpable structures and reducing the risk for iatrogenic rectal tears. The use of NBB will result in an increase in heart rate for up to an hour[11] and will substantially change the way the bowel feels. What once felt moderately to severely gas distended may feel much more compressible and less severely distended when NBB is administered.

Key features to assess for when performing rectal palpation include evidence of any form of distension or displacement along with the location (cecum, large colon, small colon, or small intestine) and type (gas, fluid, or impaction) of distension. Presence of edema within the wall of the palpated intestine should also be noted. Rectal examination findings that often indicate the need for surgical intervention include distention of the small intestine, distended and displaced large colon, severe distention or impaction of any viscus that cannot be resolved with medical therapy, or presence of a palpable foreign body. Older horses with wounds that indicate a severe episode of colic (see **Fig. 1**) with a palpable impaction often have strangulating small intestinal disease. Differentiating between a “dehydrated colon” and a true colonic impaction is essential in these cases. True colonic impactions tend to be “taut” or distended with an absence of undulations from colonic haustra on the surface of the bowel and will typically be larger in diameter than a colon containing dry, firm, dehydrated ingesta from lack of fluid content from the small intestine.

The ability to routinely identify normal visceral anatomy, including the descending colon containing fecal balls, the large colon and pelvic flexure, the caudal border of the spleen, the left kidney, the nephrosplenic ligament, the vertically oriented ventral band of the cecum, the urinary bladder, and the female reproductive tract, will prove useful when abnormalities are present. For example, when the ventral band of the cecum is displaced medially and the ventral colon with its characteristic taenia (bands) and haustra (sacculations) is palpable to the right of the ventral band of the cecum, a right dorsal displacement is present. Ultrasonographic examination of the right lateral body wall can confirm these rectal palpation findings.

Presence of Gastric Reflux

Passage of a nasogastric tube is an essential component of a colic examination, particularly in horses showing signs of severe abdominal pain. A key feature of an overly distended stomach is the inability to pass a nasogastric tube through the cardiac sphincter into the stomach. Access to the stomach is most critical in these cases, yet can be very difficult. Confirmation that an enlarged stomach is present is made by visualizing the stomach extending beyond the 13th intercostal space on ultrasound examination of the left lateral abdomen. Methods that may be used to facilitate passage of the tube include small volume fluid infusion while applying constant pressure and lidocaine infusion into the tube or administration of NBB (Buscopan) to promote relaxation of the cardia.

Once a tube has successfully been passed into the stomach, the nature of the gastric content can provide important clues toward cause of the disease. Large

volumes of gastric reflux (>4 L) often indicate a more severe disease process, and referral should be considered. An increased pH of the gastric secretions (>5) is suggestive of a small intestinal origin to the fluid accumulation, whereas orange to red color with a strong foul odor may be associated with some form of proximal enteritis (DPJ). Wide variations exist in appearance of reflux with DPJ. DPJ can result in large volumes of gastric reflux and may create a diagnostic dilemma. It is difficult to differentiate DPJ from strangulating or nonstrangulating small intestinal obstructions in some cases. It is important to try to differentiate DPJ from other surgical small intestinal diseases, because prognosis is likely to be affected if delays in surgical intervention occur with strangulating diseases of the small intestine. Surgical intervention for treatment of DPJ is contraindicated however because it is associated with decreased survival and increased complications.[12] A thorough discussion of history in combination with adjunctive diagnostics including a complete blood count, abdominal ultrasound, and an enzyme-linked immunosorbent assay for *Clostridium difficile* toxins on gastric reflux may provide the necessary clues to help differentiate DPJ from other forms of small intestinal obstruction.

In summary, physical examination findings that often indicate the need for referral and surgical intervention include one or more of the following:

- Severe abdominal discomfort requiring repeated analgesic administration
- Gross and progressive abdominal distention
- Tachycardia (HR>60) and/or signs of hypovolemia
- Absence of auscultable intestinal motility
- Abnormal rectal palpation findings: severe progressive distention of a viscus; displaced large colon; distended small intestine; edematous walls of the large colon; extremely firm or extensive impactions of the large colon, small colon, or ileum; or a palpable foreign body, enterolith or fecalith.
- Gastric reflux volume exceeding 4 L

Caution should be exercised when considering surgery in horses with an absence of abdominal pain or distension, an elevated body temperature greater than 102°F, or significant abnormalities in their blood consistent with an inflammatory intestinal condition (marked leukocytosis or neutropenia).

IMAGING AND ADDITIONAL TESTING

Additional diagnostic tests can provide information that may guide the veterinarian in determining if referral is required. However, none of these tests should be considered in isolation. Instead, the entire evaluation, including a through physical examination, should be considered when making the decision for referral.

Transabdominal Ultrasound

Transabdominal ultrasound has revolutionized the veterinarian's ability to detect gastrointestinal disease in the last 15 years and is becoming an essential part of the colic workup, even in the field. A 3 to 5 mHz curvilinear probe is ideal for evaluation of the equine abdomen; however information can be gained even when a higher frequency probe (such as a linear probe) is used. Imaging can be achieved with alcohol as the coupling agent, and clipping the hair is usually unnecessary. When attempting to determine the presence of a surgical lesion, focused abdominal ultrasound evaluating specific areas can be performed. A protocol for fast localized abdominal sonography of horses has been developed, which is easy to learn, quick to perform, and highly sensitive and specific for a small intestinal obstruction.[13] In this protocol, 7 sites

are evaluated; however, the authors use a slightly modified protocol as described in Table 3.

An in-depth review on ultrasonography of the equine acute abdomen is found in the preceding article.

Abdominocentesis

The composition of the peritoneal fluid changes rapidly in response to pathophysiologic changes in the abdominal viscera. Therefore, obtaining a sample of the peritoneal fluid provides an easy and sensitive method to evaluate pathology in the

Table 3
Sites for performing a rapid focused abdominal ultrasound evaluation of horses with colic

Location	Description of Site	Normal Structures and Possible Abnormalities Identified
Ventral abdomen	Caudal to the xiphoid and at the most dependent part of the abdomen	Abdominal fluid Volume is usually minimal and any increase is considered abnormal Determination of large colon wall thickness ≥9 mm indicates a large colon volvulus[52]
Gastric window	Left 8–10th ICS, midway up the abdomen	Stomach Extension caudal to the 10th ICS indicates distention
Splenorenal window	Left 17th ICS in the top to middle third of the abdomen	Left kidney and spleen Gas shadowing by the colon preventing imaging of the kidney is suggestive of a nephrosplenic entrapment
Left and right inguinal areas	Lateral to sheath or mammary gland	Small intestine, colon, cecum (R). Small intestine >5 cm diameter indicates strangulation. Small intestine wall thickness >4 mm is suggestive of enteritis[53]
Duodenal window	Right side at 14–15th intercostals space on a line between the tuber coxae and elbow	Duodenum. Should contract completely Fluid distention and failure to contract is suggestive of aboral small intestinal obstruction
Right middle third	Right side, midway up the caudal abdomen	Small intestine, colon, and cecum Imaging colonic mesenteric vasculature is specific for a large colon displacement[54]
Cranial ventral thorax	Caudal to triceps muscle on left and right side	Lung Presence of free fluid indicates pleuritis

Abbreviation: ICS, Intercostal space.

Adapted from Busoni V, De Busscher V, Lopez D, et al. Evaluation of a protocol for fast localised abdominal sonography of horses (FLASH) admitted for colic. Vet J 2011;188:78; with permission.

abdomen. The fluid sample can be obtained with either a spinal needle or a blunt ended catheter such as a bitch catheter or teat cannula.

The technique is as follows:

- Clip an approximately 3″×3″ area one hand's breadth behind the xiphoid and slightly to the right of midline just caudal to the superficial pectoral muscles. This site is usually cranial to the most dependent part of the abdomen and is more cranial than the site first described for abdominocentesis.[14]
- Aseptically prepare the area and then don sterile gloves.
- Needle technique: using an 18G 5″ spinal needle insert the needle perpendicular to midline and advance it slowly. Once the needle is situated, the stylet should be removed and the needle advanced slowly and rotated until fluid is obtained. Jerky movements of the needle indicate contact with intestinal serosa, and the needle should be withdrawn slightly and redirected.
- Cannula technique: 2 mL of local anesthetic is injected into the skin and body wall in the center of the prepared area. A #15 scalpel blade is used to create a stab incision through the skin and external rectus sheath in a transverse direction. By using this orientation a kick from the horse is less likely to accidentally result in a large cranial to caudal laceration. It is essential that the scalpel blade penetrate the external rectus sheath. Push the cannula through a sterile gauze to collect blood dripping along the outside of the cannula and prevent contamination of the sample. Push the cannula through the body wall at a perpendicular angle. After passing through the external rectus sheath, 2 "pops" should be felt, the first as the cannula penetrates the internal rectus sheath and the second as it penetrates the peritoneum. The cannula should be advanced and rotated until fluid is obtained.
- Fluid should be collected in Ethylenediaminetetraacetic acid (EDTA) and serum Vacutainer (Becton, Dickson and Company, Franklin lakes, NJ) by free catch.

Complications are rare[15] with the biggest risk being enterocentesis. Many clinicians feel that enterocentesis is more likely to occur when using a needle than a cannula. However, one study found no significant difference between the 2 techniques, with an incidence of 5.7% when a needle was used compared with 3.1% with a cannula.[16] Regardless, enterocentesis is usually inconsequential in adult horses as the hole in the bowel is small and rapidly reseals. However, enterocentesis should not be overlooked in foals because ongoing leakage from the puncture can occur, resulting in septic peritonitis. Therefore, before performing abdominocentesis in a foal it should be sedated to minimize movement during the procedure. Additionally, it is advisable to place local anesthetic at the proposed site, even when a needle is used, to minimize the likelihood of the foal reacting. Because of the risk of enterocentesis, many clinicians prefer to use a teat cannula in a foal; however, this frequently results in omentum herniating through the small stab incision in the body wall. If enterocentesis does occur in a foal, it should not be ignored and the foal should receive systemic antibiotics for 7 to 10 days to prevent septic peritonitis.

Sample analysis: changes in the peritoneal fluid occur rapidly because of the close association with the viscera. Therefore, if the results are to be meaningful and guide the decision for referral, analysis of peritoneal fluid is best performed immediately. If an abdominal fluid sample is obtained, which is abnormal based on color and/or total protein concentration, referral should be strongly considered.

- Visualization: the easiest and most useful technique for evaluation of a sample of peritoneal fluid is simply to observe the color and clarity because this alone

provides extremely useful information. Normal peritoneal fluid should be yellow and transparent. A serosanguinous sample is 98% specific for a surgical lesion because red cells leach out of the devitalized bowel into the peritoneal fluid.[17] Care should be taken to ensure that this is an accurate representation of the peritoneal fluid and not merely blood contamination from the spleen or the stab incision. With blood contamination the blood will not appear to be uniformly distributed throughout the sample as it is collected.

- Total protein concentration: protein concentration can be easily read on a portable refractometer and does not require centrifugation first. The normal value is described as less than 2.5 g/dL; however, in most horses without intestinal pathology the concentration will be less than 1.5 g/dL. An elevation in protein concentration indicates an increase in the permeability of the viscera, which allows plasma protein to leak out of the circulation into the peritoneal fluid. Therefore, both medical (peritonitis) and surgical lesions can result in an elevation in protein concentration.
- Total nucleated cell count: determination of the total nucleated cell count in abdominal fluid cannot be performed immediately in the field but can be determined with simple equipment available in most practices. Nucleated cell counts in abdominal fluid are usually low at less than 5000 cells/mL. A cloudy sample is suggestive of an increased cell count. Cell counts have proved to be less reliable than color and total protein in differentiating medical and surgical colics.[17] Indeed, many surgical colic cases have nucleated cell counts in the normal range. However, rather than the total cell count, differential counts are more useful especially when performed on a cytospin smear.[18] The presence of band neutrophils or toxic changes indicates peritonitis,[18] and the sample is also inspected for the presence of bacteria or feed particles that could indicate intestinal leakage.
- Lactate: see separate section on lactate.
- Glucose: see separate section on glucose.

Lactate

High blood lactate concentrations have long been associated with a poor prognosis for colic.[9,19] Lactate can be measured in the field using small portable lactate meters, with results being obtained within 10 to 60 seconds. Several models are available (Lactate Scout, EKF Diagnostics, Accutrend, Roche, Lactate Pro 2, Arkray) and all have proved to accurately measure lactate in equine blood.[20–22] Because these lactate meters provide rapid, easy, and cheap methods to determine lactate concentration, measurement of blood and abdominal fluid lactate has become one of the most helpful techniques to determine the degree of circulatory and intestinal compromise in horses with colic.

Blood lactate concentration is usually less than 1.5 mmol/L. Physical exertion in horses with colic may result in elevations from 2 to 3 mmol based on the authors' experience. However, blood lactate concentrations greater than 3 mmol/L are usually associated with the presence of ischemic intestine. Blood lactate concentration may be particularly helpful in determining the potential prognosis in horses with large colon volvulus. Blood lactate at hospital admission in horses with large colon volvulus was compared to survival. If blood lactate was less than 6 mmol/L, 90% of horses survived compared with only 30% survival if lactate concentration was greater than 7 mmol/L.[23] Care should be taken when interpreting blood lactate concentration in ponies because lactate values are significantly higher, even in ponies with nonsurgical lesions, than in horses.[24]

For horses with a suspected small intestinal lesion, comparison of blood and peritoneal fluid lactate concentrations can help identify the presence of ischemic-injured intestine. In normal horses, peritoneal lactate is lower than plasma lactate at approximately 0.7 mmol/L. Horses with nonstrangulating obstructions have peritoneal fluid lactate values of approximately 2 mmol/L.[25] Ischemic segments of intestine rapidly leak small molecules such as lactate into the peritoneal fluid. This results in a rapid elevation in peritoneal fluid lactate, whereas blood lactate does not rise so rapidly while the horse is systemically stable. Therefore, an elevated peritoneal fluid lactate compared with blood lactate is a sensitive indicator for the presence of ischemic intestine[25] and the need for referral for emergency surgery. If the need for referral remains in doubt, a second abdominal fluid sample can be obtained 1 to 6 hours after the first and the results of the 2 samples compared. An elevation in peritoneal lactate compared with the first sample is highly suggestive of the progression of ischemia and the need for referral for surgery.[26]

A complete discussion on the utility of lactate in critically ill adults and neonates is found in the next article.

Glucose

Hyperglycemia is common in horses with colic and is associated with a poor prognosis. Conversely, hypoglycemia is rarely identified in adult horses with colic. Blood glucose concentration becomes dysregulated due to the action of endotoxin, which is absorbed across compromised intestinal mucosa and causes insulin resistance and hence an elevation in blood glucose concentration.[27] Blood glucose concentration is measured rapidly and easily in the field using a handheld glucometer. However, there is poor correlation in glucose concentration when testing whole blood with a human glucometer and plasma chemistry analyzer results for horses.[28] A veterinary glucometer (AlphaTRAK 2, Abbott Animal Health), which accounts for the higher percentage of glucose in the plasma of veterinary species, may be more accurate.[29] Care should be taken in interpreting glucose concentrations after an alpha-2 agonist has been administered because these sedatives cause hyperglycemia.[30]

Approximately 50% of horses with colic admitted to referral hospitals are hyperglycemic (>135 mg/dL).[31,32] Hyperglycemia in the horse with colic may indicate the presence of devitalized intestine and the need for referral. Extreme hyperglycemia (>180 mg/dL) in adult horses with colic has been associated with[31,32]

- Surgical colic
- Strangulating small intestinal lesions that require resection
- Decrease in hospital survival
- Decreased survival in the first 100 days after hospitalization

Glucose concentration can also be measured in peritoneal fluid with a glucometer. Blood and peritoneal fluid glucose concentrations are usually tightly correlated with peritoneal glucose concentrations being slightly higher than those in blood.[33] If bacteria are present in peritoneal fluid they use glucose and result in a lower glucose concentration in peritoneal fluid compared with blood. Therefore, peritoneal fluid glucose concentrations are low in horses with septic peritonitis, and this is a useful test to perform if the abdominal fluid is cloudy and hence there is a suspicion of peritonitis. Peritoneal fluid glucose concentrations less than 30 mg/dL are 100% specific for septic peritonitis.[34] Using the absolute value for peritoneal fluid glucose as the determining factor is not very sensitive, however, because some horses with septic peritonitis may have profound hyperglycemia and hence peritoneal glucose concentrations greater than 30 mg/dL. In such situations the specificity of this test is

increased further if the serum and peritoneal glucose concentrations are compared. If peritoneal fluid glucose concentration is greater than 50 mg/dL less than blood glucose concentration, a diagnosis of septic peritonitis can be made, even if the absolute concentration is greater than 30 mg/dL.

Overall the measurement of peritoneal fluid glucose concentration can be used as follows:

- Perform this test if peritoneal fluid is cloudy
- Concentration less than 30 mg/dL indicates septic peritonitis
- Concentration greater than 30 mg/dL should be compared with blood glucose concentration:
  - Blood glucose concentration greater than 50 mg/dL higher than peritoneal glucose concentration indicates septic peritonitis
  - Blood glucose concentration less than 50 mg/dL higher than peritoneal glucose concentration suggests nonseptic peritonitis
- Results are used to guide initial therapy; however, a full fluid cytology should be performed to confirm the diagnosis

SUMMARY

A thorough evaluation of the horse with colic is critical during the first visit to identify the small number of cases that would benefit from referral. Physical examination, including rectal examination and passage of a nasogastric tube to determine if there is gastric distention, are the foundation of this evaluation. More advanced diagnostic tests, including transabdominal ultrasound, abdominocentesis, and point-of-care measurement of lactate and glucose in blood and peritoneal fluid, can aid in determining if referral should be offered to the client. If doubt still exists, referral will allow further diagnostics to be performed along with around the clock monitoring to determine if advanced medical or surgical intervention is required.

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