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Ultrasound of the Nonacute Abdomen: Gastrointestinal Tract

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1. Introduction

Ultrasonography is invaluable in the diagnosis of a wide variety of gastrointestinal diseases in horses and determining if the horse has a medical or surgical lesion. The quick evaluation of the abdomen in horses with severe colic (FLASH examination) is an examination of selected high-yield areas of the abdomen that can be done in the emergency setting in less than 15 minutes by individuals who are not extensively trained in diagnostic ultrasound. The windows for the FLASH scan of the emergency abdomen include the left middle third of the abdomen, the renosplenic window, the gastric window, the ventral abdomen, the duodenal window, the right middle third of the abdomen, and the right cranioventral thorax. In postoperative ponies, bowel handling during exploratory celiotomy caused minimal changes in bowel wall thickness, contractility, amount of distention, luminal contents, and peritoneal fluid. Therefore, abnormal gastrointestinal motility, size or contents; bowel wall thickness, and/or changes in the quantity or echogenicity of the peritoneal fluid are clinically significant in a postoperative patient. A complete sonographic examination is also very useful in evaluating the horse with chronic colic, chronic weight loss, or when other abdominal disease is suspected. Sonographic evaluation of the abdomen is also valuable for following the clinical progress in horses with a wide variety of gastrointestinal diseases.

The sonographic examination of the gastrointestinal tract can be performed with a microconvex transducer, a high-frequency linear transducer for evaluation of bowel wall thickness close to the body wall, and a transrectal transducer for evaluating any abnormalities detected on rectal examination. A large lower-frequency convex transducer is useful for the FLASH examination, in which time is of the essence in making the diagnosis and the subtleties of the image are less important, or for evaluating gastrointestinal structures that are further away from the transducer. The standard linear transrectal transducer can be used and placed over any structure that is abnormal on rectal palpation to further define the abnormality but is limited by the depth of penetration of the transducer and the ability to place the transducer directly over the abnormality. A small microconvex transducer can also be used transrectally and has the advantage of a wide field of view and being able to direct the transducer towards the abnormality without having to place the transducer directly over the abnormality.
2. Normal Ultrasonographic Findings in the Equine Gastrointestinal Tract

The large intestinal echoes are recognized by their large semicurved, sacculated appearance, except for the right dorsal colon which has a smoother nonsacculated appearance and is imaged consistently in the right 11th and 12th intercostal spaces in both normal horses and horses with right dorsal colitis. The large intestinal wall is hypoechoic to echogenic with a hyperechoic mucosal gas echo and measures ≤3.5 mm in the adult horse. Peristaltic activity is normally visualized. The cecum has larger contractions and a trend towards smaller sacculations compared with the large colon in normal horses. The small intestine has a small tubular and circular appearance with a hypoechoic to echogenic wall that usually measures ≤3 mm in the equine adult. Peristaltic waves are also normally visualized. The duodenum is imaged around the caudal pole of the right kidney and medial to the right liver lobe. It appears small and circular with a hypoechoic to echogenic wall, also measures ≤3 mm, and appears partially collapsed with its peristaltic motion easily visualized. The jejunal, cecal, and colonic motility is decreased with fasting. The gastric fundic echo is visualized in the left 9th to 12th intercostal space and is imaged as a large semicircular structure medial to the spleen at the level of the splenic vein. The gastric wall is hyperechoic to echogenic with a hyperechoic gas echo from the mucosal surface and normally measures ≤7.5 mm. All the wall thicknesses in normal adult ponies are significantly thinner than in the normal adult horse.

Large intestinal motility was significantly reduced (most marked in the aboral left ventral colon) in stabled horses compared with pastured horses. Xylazine in fasted horses decreased jejunal and cecal motility. Romifidine has been shown to result in decreased motility (nonpropulsive contractions) of the jejunum, cecum, and left ventral colon. Both feeding status and sedation need to be considered when evaluating GI motility in horses.

3. Gastrointestinal Diseases

Right Dorsal Displacement of the Large Colon

Abnormal positioning of the gastrointestinal viscera is difficult to diagnose ultrasonographically, unless the viscera are displaced into the scrotum, thoracic cavity or into an umbilical hernia. Right dorsal displacements have traditionally been difficult to definitively diagnose. Horses with a colonic displacement and an elevated gamma-glutamyl transferase (GGT) are most likely to have a right dorsal displacement of the large colon (RDDLC). The success of treating horses with right dorsal displacements has been reported to be 64% in a recent study. In this study, right dorsal displacement was diagnosed by the identification of a gas distended colon oriented horizontally across the abdomen on rectal palpation and the sonographic finding of a large gas filled large colon. The detection of abnormally located large colon mesenteric vessels, distinct from cecal vessels, along the right lateral abdomen, dorsal to the costochondral junction in at least 2 intercostal spaces (between intercostal space 10 to 16) is consistent with a surgical diagnosis of right dorsal displacement of the large colon (Fig. 1). This finding was not seen by these investigators in other types of surgical colics. Although these investigators did not see these abnormally located mesenteric vessels in the right lower abdominal area in horses with a large colon volvulus, this remains a possibility.

Colon/Cecal Impaction

The reduction in motility in the aboral portion of the left ventral colon detected in stabled horses compared with pastured horses may provide insight into the reason for the most common impaction at the pelvic flexure. An impaction can often be imaged from the flank for side of the abdomen in horses with cecal or large colon impactions. The impacted viscus is enlarged and may appear flattened, or round to oval (Fig. 2). The distended large colon will occupy a much larger area in the abdomen than normal, often measuring 20 to 30 cm or more, and the sacculations are reduced or not visible. The bowel wall may be normal thickness or may be thicker than normal, and there is a large acoustic shadow cast from the impacted ingesta. The hyperechoic echo from impacted ingesta appears as a long flat thick hyperechoic line in an enlarged elongated viscus. Little to no motility of the affected portion of the intestinal tract will also be imaged. Small colon impactions may be imaged transrectally as echogenic intraluminal masses.

Intussusceptions

Intussusceptions have a characteristic target or bull’s eye sign in the affected portion of intestine.
With intussusceptions involving the large bowel, the affected segments are markedly thickened, diminishing the typical sacculated appearance of the large colon and cecum. The outer intussuscipiens has an echoic pattern within the wall typical of large bowel and a somewhat sacculated appearance. The inner intussusceptum is thick-walled, hypoechoic to echoic with loss of bowel wall layering and surrounded by fluid and/or fibrin. The majority of intussusceptions imaged in adult horses are imaged from the right ventral abdomen. The cecocolic intussusceptions have a more oval appearance than the cececal intussusceptions.

Small Intestinal Masses

Masses within the intestinal wall are thickened areas, often compromising the lumen of the affected portion of intestine, which may be anechoic to echogenic, depending on their etiology. Intramural hemorrhage has been reported in horses causing small intestinal obstruction (Fig. 4). Hemorrhage in the lumen of the intestine often appears as echogenic clots or echoic swirling fluid. Areas of mural stricture have been imaged in several horses with chronic colic.

Idiopathic Muscular Hypertrophy of the Small Intestine

Marked symmetrical annular thickening of the muscular layer of the small intestine has been reported in horses with idiopathic muscular hypertrophy of the small intestine, resulting in reduction of the luminal diameter during peristalsis (Fig. 5). The ileum is the most commonly affected. Severely thickened loops may be present adjacent to mildly thickened loops of small intestine. A significant reduction in intestinal motility occurs in those severely thickened loops which appear tubular and noncompressible.

Inflammatory Bowel Disease

The wall of the affected portion of the intestine is usually thickened with an abnormal pattern of echogenicity in the bowel wall (Fig. 6). Increased or decreased echogenicity in one or more layers of the bowel wall, usually the submucosa, is usually present. The visualization of abnormal echogenicity with persistence of the bowel wall layering is more consistent with inflammatory bowel disease (IBD).
than neoplasia. Thickening of the bowel wall with increased vascularity is indicative of active IBD. Power Doppler and color Doppler ultrasound can be used to assess vascularity of the gastrointestinal tract in horses with suspected IBD. Although usually diffuse, focal eosinophilic enteritis causing small intestinal obstruction has been described in some horses. A segmental mural lesion in the left dorsal colon, causing partial obstruction of the large colon, has also been reported. Circumferential mural bands have been detected in both the small and large intestine at surgery in some horses with IBD.

**Necrotizing Enterocolitis**

Sonography can characterize the peritoneal fluid, identify intramural gas (pneumatosis intestinalis), portal venous gas, intraperitoneal gas, bowel wall thickening, and bowel wall perfusion in foals and adults with necrotizing enterocolitis. Pneumatosis intestinalis is the detection of hyperechoic echoes consistent with free gas in the intestinal wall (Fig. 7). Thinning of the bowel wall and lack of bowel wall perfusion are indicative of nonviable intestine and possible impending perforation.

**Right Dorsal Colitis**

Right dorsal colitis associated with nonsteroidal anti-inflammatory drug toxicity can be diagnosed ultrasonographically by detecting a thickened right dorsal colon ventral to the liver in the right 10th to 14th intercostal spaces. The right dorsal colon can consistently be imaged in the right 11th and 12th intercostal spaces in all horses with right dorsal colitis and in the 13th intercostal space in most affected horses. The wall of the right dorsal colon is usually thickened (2 to 3 times normal) and is significantly greater than the thickness of the right ventral colon measured in the 12th intercostal space in affected horses. An abnormal pattern of echogenicity of the right dorsal colon is detected sonographically when compared with control horses. In affected horses, a hypoechoic layer was detected in the thickened right dorsal colon, surrounded on each side by a hyperechoic mucosal and serosal surface (Fig. 8). The hypoechoic layer was less echoic than the adjacent liver. In this study, the hypoechoic layer detected in the wall of the right dorsal colon in all horses with right dorsal colitis appeared to correspond to submucosal edema, inflammatory cell infiltrates, and granulation tissue that were subsequently observed on postmortem examination. Thinning of the wall of the right dorsal colon was reported in one horse treated successfully for right dorsal colitis, as well as in one horse that had a rupture of the right dorsal colon. The sensitivity and specificity of the ultrasonographic detection of...
right dorsal colitis remains to be determined, as does its usefulness in monitoring the response of horses to treatment. Affected areas of the right dorsal colon may not be accessible ultrasonographically, and mural thickness may be within the normal range in horses with severe ulceration of the right dorsal colon.3

**Verminous Arteritis**

Verminous arteritis can be imaged if the affected vessel is imageable transrectally. The affected vessel wall is thickened and large plaque-like or mass lesions can be imaged along the intimal surface of the vessel, invading the arterial lumen.

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4. **Gastritis/Gastric Ulceration/Gastric Impaction/Gastric Rupture**

Irregular thickening of the gastric wall with prominent rugal folds may be detected in some horses with gastritis. Gastric ulcers cannot usually be imaged ultrasonographically but have been seen by the author in one yearling with a severe gastric impaction. Gastric impactions appear as a markedly enlarged stomach that is imageable over many intercostal spaces with ventral and caudal displacement of the spleen (Fig. 9).22,23 Horses with gastric rupture have an increased amount of flocculent peritoneal fluid with large particulate matter and free gas within (Fig. 10). The defect in the gastric wall with thickened curled edges has been detected ultrasonographically.

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**Fig. 8.** Sonogram of the right 13th intercostal space in a horse with right dorsal colitis. Notice the marked thickening of the ventral aspect of the right dorsal colon (large arrows) with the increased echogenicity and thickening of the submucosal layer (small arrows).

**Fig. 9.** Sonogram of the left ventral abdomen in a horse with severe gastric impaction. Notice the marked enlargement and flattening of the normally circular gastric echo. The stomach extended over 10 intercostal spaces and was displacing the lung dorsally, the spleen ventrally and occupied the area from the mid ventral abdomen to the dorsal portion of the left side of the abdomen.

**Fig. 10.** Sonogram of the left 13th intercostal space in a horse with a gastric rupture. Notice the hyperechoic pinpoint echoes representing free gas (small arrows) adjacent to the stomach in the echoic peritoneal fluid. There is also a pneumoperitoneum (large arrow).

**Fig. 11.** Sonogram of the left 12th intercostal space in a horse with a gastric myxosarcoma. Notice the large size of the gastric neoplasm (18.93 × 21.43 cm).
Gastric Neoplasia

By the time that the horse exhibits clinical signs associated with gastric neoplasia, the mass is usually large enough to be easily imaged ultrasonographically. In 3 of 4 horses with squamous cell carcinoma in which an ultrasonographic examination was performed, the mass was large and visible ultrasonographically. In the one horse in which the mass was not detected ultrasonographically, the squamous cell carcinoma was small (2.6 by 4.2 cm).24 The masses are usually large and heterogeneous (Fig. 11). Metastatic neoplasia is common in horses with gastric neoplasia. Involvement of the adjacent liver and spleen commonly occurs with larger neoplasms. Intra-abdominal masses were imaged in all 5 horses in one study with gastric neoplasia in which an abdominal ultrasound examination had been performed.24 Squamous cell carcinoma is the common gastric neoplasm found in horses and is usually located in the nonglandular portion of the stomach.24 A gastric myxosarcoma seen by the author had a more homogeneous discrete sonographic appearance.

Intestinal Neoplasia

Neoplasms affecting the wall of the gastrointestinal tract may be visualized on transabdominal ultrasonographic examination of the abdomen. If abnormal loops of bowel are palpable rectally, rectal ultrasonographic examination would enable further characterization of the mass invading the intestinal wall.

The sonographic identification of a wide variety of intestinal neoplasia has been described.25 The most common primary gastrointestinal neoplasia includes intestinal adenocarcinoma, GIST (gastrointestinal stromal tumors), leiomyoma/myxosarcoma, and alimentary lymphosarcoma. The GIST masses that have been seen ultrasonographically may be round to oval or multilobular with a heterogeneous sonographic appearance (Fig. 12). Hypoechoic to anechoic areas of necrosis may be imaged within the gastrointestinal mass. Intestinal adenocarcinoma has been imaged sonographically as a solid homogeneous or heterogeneous intraluminal 3–9 cm mass. In some horses with intestinal adenocarcinoma, only increased wall thickness of the large colon, an omen-

Fig. 12. Sonogram of the left ventral abdomen in a horse with a GIST. Notice the large heterogeneous intestinal mass (arrows).

Fig. 13. Sonograms of the abdomen in a horse with alimentary and splenic lymphosarcoma. Notice the diffuse thickening of the small intestine and the loss of the bowel wall layering (arrows) consistent with cellular infiltration of the bowel wall (A), the enlargement and heterogeneity (arrows) of the mesenteric lymph nodes (B), and the hypoechoic mass (arrow) in the spleen (C).
tal mass or lymphadenopathy were detected sonographically. Thickening of the gastrointestinal wall, most frequently the small intestine, with an echoic homogeneous cellular infiltrate is consistent with alimentary lymphosarcoma (Fig. 13), although inflammatory bowel disease must be included in the differential list. Loss of the layering of the bowel wall is more indicative of neoplasia, but may also be simply a consequence of the resolution of the sonographic image. Large solitary mostly homogeneous mural masses are also occasionally imaged in horses with lymphosarcoma. Hypoechoic homogeneous enlarged mesenteric lymph nodes are commonly detected in horses with lymphosarcoma (Fig. 13). Hepatic and splenic involvement may also be detected (Fig. 13). Hemangiosarcoma can occasionally be detected in the wall of the gastrointestinal tract and mimics the sonographic appearance of a mural hematoma (Fig 14).

Abdominal Abscess
Abdominal abscesses may be anechoic, hypoechoic, or filled with echoic material and may be loculated (Fig. 15). Hyperechoic echoes representing free gas may be detected suggesting concurrent anaerobic infection. Mixed homogeneously hypoechoic or heterogeneous encapsulated abscesses are common in horses with mesenteric abscesses associated with Streptococcus equi spp. equi.26 Abdominal abscesses associated with Streptococcus equi spp. equi were visualized via transcutaneous and/or transrectal ultrasonography in all horses.26 Abscesses were identified throughout the caudal abdomen (ventral to the left kidney, in the dorsocaudal abdomen, in the ventrocaudal abdomen ventral to the rectum, caudal to the left kidney, and within the spleen). A number of these horses had a moderate increase in the amount of peritoneal fluid imaged.26 Thickening of the small intestine or dilated small intestinal loops may also be imaged. Large and/or small intestine may be adhered to the wall of the abscess and its motion restricted. Serial ultrasonographic evaluation was also useful to monitor the horse’s response to treatment.26 Occasionally, mesenteric abscessation can also occur with Corynebacterium pseudotuberculosis.27

Peritonitis
The detection of an increased amount of hypoechoic or echogenic, flocculent, composite fluid, fibrin, and/or adhesions between the serosal surfaces of the intestine and the abdominal wall is compatible with peritonitis (Fig. 16). The abdomen and associated gastrointestinal and abdominal viscera should be thoroughly scanned for the source of the peritonitis such as an abdominal abscess or devitalized area of bowel. The appearance of the peritoneal fluid in
Peritoneal Neoplasia

Carcinomatosis appears as multiple hypoechoic to echogenic homogeneous or heterogeneous masses that line the peritoneal cavity and involve the mesentery as well as metastasizing to other abdominal organs and lymph nodes. Hemoperitoneum is often seen in horses with carcinomatosis and was reported in 35% of horses with hemoperitoneum. The peritoneal mesotheliomas also often have a homogeneous sonographic appearance with multiple masses lining the peritoneal surfaces (Fig. 18).

References


