Ultrasound of the Equine Acute Abdomen

Sarah le Jeune, DVM*, Mary Beth Whitcomb, DVM, MBA

KEYWORDS

• Acute abdomen • Ultrasound • Colic

KEY POINTS

- Ultrasound can be a quick, noninvasive tool in formulating the accurate diagnosis of horses presenting with acute colic, leading to successful treatment and outcome.
- Transcutaneous ultrasound gives immediate information on the volume and type of peritoneal effusion, gastric dilatation and contents; small intestinal contents, motility, wall thickness, and diameter; and large intestinal contents and wall thickness.
- Ultrasound can be useful in distinguishing between strangulating and nonstrangulating small intestinal lesions and can help determine whether a horse should have surgery.
- A low-frequency (2–5 MHz) curvilinear transducer is the transducer of choice for equine transcutaneous abdominal ultrasonography because of its ability to image up to 27 to 30 cm of depth.

INTRODUCTION AND CLINICAL INDICATIONS

Transcutaneous abdominal ultrasonography has become an integral part of the diagnostic workup for the acute abdomen in many equine clinics. A quick and accurate assessment of horses with acute abdominal pain is essential for the formulation of the correct diagnosis, prognosis, and treatment, particularly as it pertains to the initial decision of either medical or surgical management. Abdominal ultrasound is a relatively easy, noninvasive tool to evaluate the anatomic location, wall thickness, motility, and contents of the intestine. Transcutaneous ultrasound is of particular value in patients that cannot undergo rectal palpation due to size (foals or miniature horses), lack of adequate restraint, safe facilities, excessive straining, history of a rectal tear, or where rectal palpation is limited because of advanced pregnancy. Despite limitations caused by the large depth and size of the abdominal cavity of the horse, the presence of osseous ribs encasing the cranial viscera, and varying amounts of gaseous

The authors have nothing to disclose.
Department of Surgical and Radiological Sciences, University of California, 1 Shields Avenue, Davis, CA 95616, USA
* Corresponding author.
E-mail address: sslejeune@ucdavis.edu

Vet Clin Equine 30 (2014) 353–381
http://dx.doi.org/10.1016/j.cveq.2014.04.011 **vetequine.theclinics.com**
0749-0739/14/$ – see front matter Published by Elsevier Inc.

distension, ultrasound provides valuable information that could not be obtained by other diagnostic methods.[1–3]

Transcutaneous ultrasound examination is a noninvasive method that gives immediate information on the volume and type of peritoneal effusion; gastric dilatation and contents; small intestinal contents, motility, wall thickness, and diameter; and large intestinal contents and wall thickness.[1–7] Ultrasonography has been shown to be a reliable method for the evaluation of normal intestinal wall thickness in horses and ponies[4,8,9] as well as for assessment of strangulating small intestinal lesions[3,6,10–12] and strangulating large colon lesions[10,13,14] as compared with histologic sections.[15]

Originally, the use of abdominal ultrasonography as a diagnostic tool in colic patients was evaluated prospectively in 226 colics.[6] In this study, horses with primary small intestinal lesions had a small intestine (SI) wall thickness of 0.2 to 1.8 cm and a diameter of 3.6 to 13.5 cm without evidence of motility. Horses with peritonitis showed SI motility, wall thickness measurements of 0.5 to 1.3 cm, and diameters of 2 to 5.1 cm. Horses with primary large colon lesions or small colon impactions had ultrasonographic evidence of small intestinal motility, normal SI wall thicknesses, and diameters of 3 to 7.1 cm. More importantly, if distended and amotile SI was detected by ultrasonographic evaluation, the sensitivity, specificity, and positive and negative predictive values for SI strangulation obstructions were 100%. In contrast, detection of abnormal SI via transrectal palpation yielded a sensitivity of only 50%, specificity of 98%, and a positive and negative predictive value of 89% for small intestine strangulation obstructions. This study showed that the use of abdominal ultrasonography in horses with signs of colic is accurate in detecting SI strangulation obstructions.

A recent retrospective study investigated the correlation between abdominal ultrasonographic findings and disease categories that cause abdominal pain requiring surgery in 158 horses.[10] In this study, abdominal ultrasound was performed to assess for free peritoneal fluid, visibility of the left kidney, gastric distention, the appearance and motility of the duodenum, the appearance, motility, and thickness of SI loops, and the appearance and motility of the colon. The most significant findings of this study were that the presence of distended and nonmotile small intestinal loops was associated with strangulating small intestinal obstructions; that increased free peritoneal fluid and distended and thickened SI loops with abnormal motility were associated with a definitive diagnosis involving the SI, that failure to visualize the left kidney was associated with nephrosplenic entrapment, and that thickened large colon was associated with large colon strangulating volvulus. This finding indicates that ultrasound is a useful diagnostic tool to aid in determining whether a horse needs colic surgery.

A protocol for fast, localized abdominal ultrasonography of horses (FLASH) has been recently described.[11] In this protocol, the horse's abdomen is divided into 7 regions (described below under technique) and assessed using alcohol saturation and without clipping. This protocol was evaluated by inexperienced clinicians in 36 horses with colic. In this study, the FLASH examination was completed within approximately 10 minutes and was able to show free peritoneal fluid and abnormal intestinal loops. Thirteen horses were considered surgical colics. Sensitivity, specificity, and positive and negative predictive values for dilated small intestinal loops as an indicator of small intestinal obstruction were similar to that reported by Klohnen and colleagues.[6] These results support the use of the FLASH technique by experienced and inexperienced veterinarians to detect important abdominal abnormalities in equine colic patients.

Technique and Equipment

Although the type of ultrasound machine is often thought to be the most important factor to obtain quality ultrasonographic images, the value of abdominal ultrasound is

more heavily influenced by the following factors: patient preparation, individual horse-to-horse variation, availability of ultrasound transducers, technique, experience level of the examiner, and complexity of the abdominal disorder.

Patient preparation

Alcohol saturation is sufficient for imaging the acute abdomen in most instances. In heavily coated or obese horses, clipping the hair with no. 40 blades is often necessary to obtain diagnostic images. Ponies, donkeys, and certain breeds with thick skin and heavy fat deposition, such as Friesians, draft breeds, and Icelandic horses, are notoriously challenging to image and thus often require clipping.

Transducers and ultrasound machines

A low-frequency (2–5 MHz) curvilinear transducer is preferable for abdominal imaging; however, a rectal transducer can provide useful information to aid in the decision-making process for surgical referral. Visibility with a rectal transducer is limited to structures close to the skin surface because of its maximal scanning depth of 10 to 12 cm. Fortunately, abnormal SI is heavy and falls to the dependent portion of the abdomen, usually adjacent to the body wall where it may be detected with a rectal transducer. A rectal transducer can also identify ventral peritoneal fluid accumulations to assist with abdominocentesis. Transrectal ultrasound may be performed with either a traditional linear rectal transducer or a small curvilinear (microconvex) transducer. The latter transducer is quite small and can be readily manipulated within the rectum.

A low-frequency (2–5 MHz) curvilinear transducer is the transducer of choice for equine transcutaneous abdominal ultrasonography because of its ability to image up to 27 to 30 cm of depth. Curvilinear transducers are available for nearly all of today's ultrasound machines and are capable of producing high-quality, diagnostic images in the ambulatory and hospital setting. In addition, the curvilinear arrangement of ultrasound crystals produces a sector-shaped image regardless of scanning depth, resulting in a wider field of view when compared with linear transducers. In contrast, the rectal transducer (a linear transducer) produces a progressively narrower image as the scanning depth is increased.

Scanning technique

Techniques for abdominal ultrasound can roughly be broken down into 3 general categories: the limited examination, the FLASH technique, and the full examination. Variations of these techniques abound, depending on examiner preferences and experience.[4,6,11,16]

Limited examination The limited examination often focuses on the caudoventral abdomen and left caudal intercostal spaces (ICS) in colicking horses. The primary goal is to detect evidence of nephrosplenic entrapment from the renosplenic window and strangulating small intestinal lesions from the ventral abdomen. This examination can be quickly performed in the ambulatory setting to help determine whether surgical referral is indicated. The limited examination is appropriate for beginning and novice abdominal imagers to prevent becoming overwhelmed by the more thorough examinations described below.

FLASH technique The recently described FLASH technique is based in part on FAST (focused assessment with sonography in trauma) techniques used in human emergency clinics.[11] The FLASH technique has been met enthusiastically by practitioners, in part because of its catchy name, but also because it expands beyond the limited examination. The FLASH technique is performed using alcohol saturation in the unclipped horse and divides the horse's abdomen into 7 topographic locations: ventral

abdomen, gastric window, splenorenal window, left middle third of the abdomen, duodenal window, right middle third of the abdomen, and thoracic window.

Full examination The full examination divides each side of the abdomen into 3 general regions: (1) paralumbar fossa/flank region from the level of the tuber coxae to the stifle; (2) ICS (5–17th) from the ventral lung margins to costochondral junctions; (3) ventrum from sternum to inguinal region (cranial to caudal) and costochondral junctions to midline (left to right). Each region is thoroughly evaluated in systematic fashion, rather than dividing the abdomen into specific windows as with the FLASH technique. In addition, each ICS is evaluated from the ventral lung margin to the costochondral junctions to ensure imaging of all abdominal structures *and* the ventral thorax to detect pleural/pulmonary abnormalities that can mask as colic. Although this examination can initially seem extensive, it can be performed quickly in colic patients.

Machine settings

Regardless of the technique used, image quality should be optimized by altering frequency settings, time-gain compensation controls, depth settings, and overall gain. Settings will depend on the individual situation. In general, larger horses will require a lower frequency setting for adequate penetration than a foal or young, fit Thoroughbred racehorse, whereby a higher frequency setting of 5 MHz often produces the best image quality. In general, it is best to scan with the highest frequency setting that will result in adequate penetration. Depth settings should be adjusted frequently, depending on the location of the structure of interest. Shallow depth settings (6–12 cm) will give better detail of superficial structures but will not be adequate to visualize deeper abdominal structures. In contrast, scanning with a constant depth setting of 20 to 30 cm will result in subtle findings being overlooked in those structures located close to the skin surface.

Examiner experience and diagnostic complexity

There is little question that ultrasound is highly operator dependent, in both image acquisition and interpretation. Fortunately, the basic questions to be answered with abdominal ultrasound (evidence of strangulating obstructions, nephrosplenic entrapment, peritoneal effusion) in many colicking horses are fairly straightforward. In contrast, less common disorders, such as obstructive cholelithiasis, dissecting aortic root aneurysms, and neoplasia, generally require much more experience to detect and recognize. Findings consistent with colon torsion or right dorsal displacement are more common, but also require more than basic ultrasound skills. In addition, findings such as severe colonic thickening may represent both surgical and medical disorders, colon torsion, or colitis, respectively.[14,17] Interpretation must always consider the clinical picture of the horse, which may not be as straightforward as one might anticipate.

Normal Ultrasonographic Anatomy of the Equine Abdomen

Briefly, the cecum, cecal mesentery, right kidney, right liver lobe, duodenum, and right dorsal colon are evaluated from the right side of the abdomen, and the left kidney, spleen, stomach, and left liver lobe are evaluated from the left side of the horse. The left dorsal colon and ventral colon are seen predominantly in the left ventral abdomen, and the right ventral colon is visualized primarily from the right ventral abdomen. Differentiation between cecum and colon segments is primarily based on location rather than the presence and size of sacculations.[18] Jejunum is most often seen in the ventral abdomen, but may be visible in multiple locations throughout the abdomen.[9]

Left abdomen

The spleen is the predominant feature of the left abdomen, including the ICS and ventrum, and often extends to or slightly to the right of midline (**Fig. 1**). The spleen is homogenously echogenic and should appear hyperechoic to the liver and kidneys. The splenic vein is visible in nearly all horses near the gastrosplenic space. The left kidney is visible deep to the spleen in the left paralumbar fossa region and caudal (15–17th) ICS. The stomach is located dorsal to the spleen and ventral to the lung in the left 10th to 15th ICS. Evaluation is primarily limited to its greater curvature. Gastric contents are not typically visible, unless there are increased luminal fluid contents.[19] The left liver lobe is imaged cranial to the stomach in the left 6th to 10th ICS. The left liver lobe may be situated lateral or medial to the spleen, but should always be hypoechoic to the spleen. Visibility of the left liver lobe is somewhat variable and may not be seen in some horses. Large colon should be visible deep to the spleen. Collapsed to mildly dilated SI loops are often detectable between the spleen and large colon and occasionally in the gastrosplenic space.[9]

Right abdomen

The cecum is visualized from the upper right paralumbar fossa and flank region with its apex extending to the ventral abdomen (**Fig. 2**). The cecal mesentery and lateral cecal artery and vein can be evaluated along this same path,[20] but may not be of particular interest when evaluating the acute abdomen. The right kidney is seen in the caudal

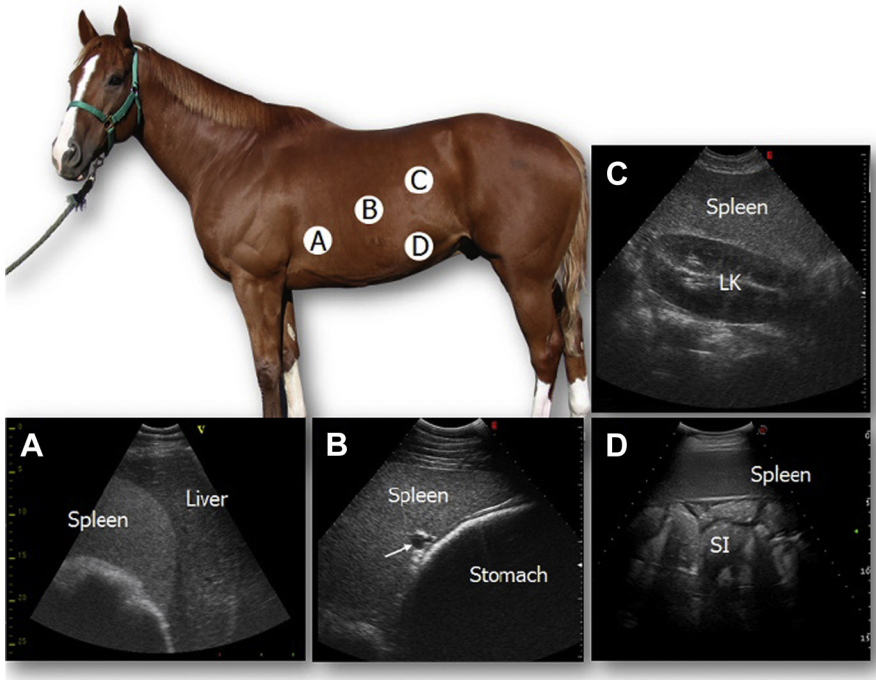


Fig. 1. Reference ultrasound images from the left abdomen. (*A*) The spleen and left liver lobe are seen in the left cranial (6–10th) ICS. (*B*) Gastrosplenic window. The spleen, splenic vein (*arrow*), and stomach are seen in the left mid-ICS. (*C*) Renosplenic window. The left kidney (LK) is seen deep to the spleen in the left paralumbar fossa region and caudal ICS (15–17th). (*D*) SI loops are often identified deep to the spleen in the left caudoventral abdomen.

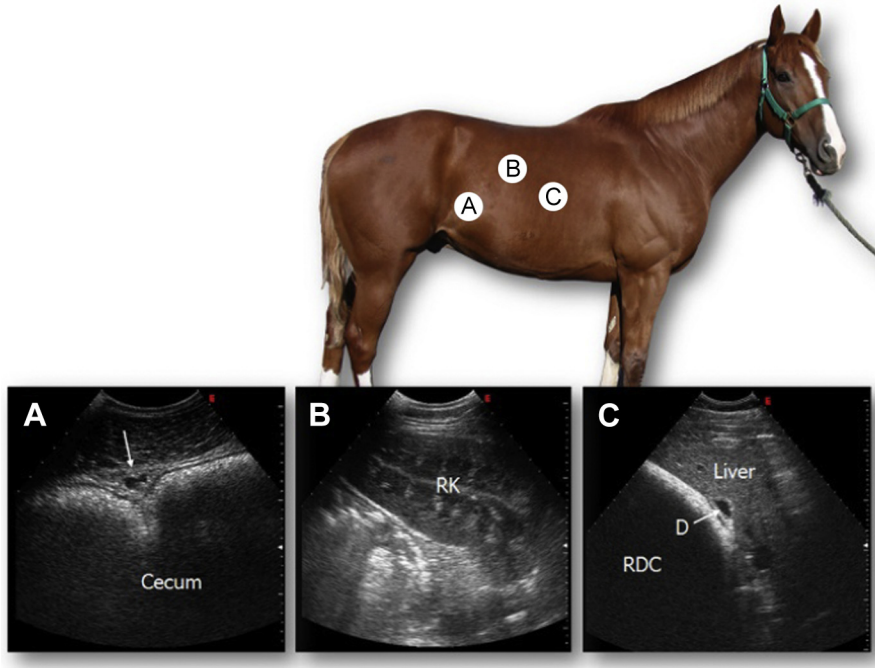


Fig. 2. Reference ultrasound images from the right abdomen: (*A*) The lateral cecal artery and vein are seen within the cecal mesentery (*arrow*). The mesentery can often be followed from this location to the cecal apex. (*B*) The right kidney (RK) is visualized adjacent to the body wall in the right 14th to 17th ICS. (*C*) The right liver lobe is seen ventral to the lung in the right 10th to 15th ICS in many horses. The duodenum (D) and right dorsal colon (RDC) are visible deep to the right liver lobe. The RDC shows a characteristic large radius of curvature.

right ICS (14–17th) adjacent to the body wall. The right liver lobe is visible in the right ICS, usually the 10th to 15th ICS. Margins should be sharp and not extend to or beyond the costochondral junctions. The descending duodenum has a fixed location and is visible in most horses ventral to the right kidney and deep to the right liver lobe in the right 11th to 17th ICS.[9,21] Visibility in the more cranial ICS is highly variable, as the duodenum becomes deeper as it extends to the stomach. The ascending duodenum cannot be visualized with ultrasound. The right dorsal colon is located deep to the right liver lobe in the right ICS and shows a large, smooth radius of curvature. The mixture of luminal feed and gas precludes visualization of the lumen and the far wall of the colon and cecum. Colonic or cecal wall thickness is often difficult to measure in normal horses. The hyperechoic gas/feed contents should not erroneously be included when acquiring wall thickness measurements. Normal colon and cecal wall thickness measurements are somewhat variable between reports, but measurements greater than 3 to 4 mm are generally considered thickened.[8,9,16,18] Interpretation of measurements should consider the degree and distribution of thickening (focal vs diffuse) as well as the detail provided by the image to obtain accurate wall thickness measurements.

Ventrum

The large colon is the dominant feature of the ventral abdomen. Although jejunum can be found in multiple sites throughout the abdomen, common locations for visualization

of small intestinal loops include the inguinal regions, deep to the spleen and occasionally in the gastrosplenic space.[9] SI visibility may be increased in fasted horses.[22] The bladder may be seen caudally in the inguinal region in some horses. Urine may appear variably echoic due to the presence of mucus and crystals. Care should be taken not to confuse a bladder containing echogenic urine for an abdominal abscess. It should be emphasized that evaluation of the entire ventral abdomen is an important part of the ultrasound examination in the acute abdomen, as many abnormalities described in this article are frequently identified in the ventral abdomen.

Gastric Abnormalities

Ultrasonographic evidence of gastric distention in equine colic patients is most often secondary to primary small intestinal lesions and occasionally large intestine disorders (**Fig. 3**). Primary gastric disorders are infrequent and include gastric impaction and gastric neoplasia, such as squamous cell carcinoma (addressed later in this article).[23] In horses with gastric distention due to excess feed or fluid accumulation, the stomach will become visible over a larger number of ICS. Although some authors suggest that gastric visibility over more than 5 ICS is consistent with gastric distention,[16] this is seen routinely during ultrasound examinations in noncolic patients by one author (M.B.W.). Dorsocaudal displacement of the stomach wall is considered ultrasonographic evidence of gastric distension. Due to considerable variability between horses, it is important to obtain a baseline assessment of gastric position to use for comparison during subsequent examinations. This information can then be used to estimate gastric volume and base the need for nasogastric intubation and decompression.[19] Gastric contents are not typically visible in horses with gastric feed impaction, but increased gastric fluid contents may be seen in horses with gastric reflux due to enteritis or other small intestinal disorders. An enlarged radius of curvature may also be noted.

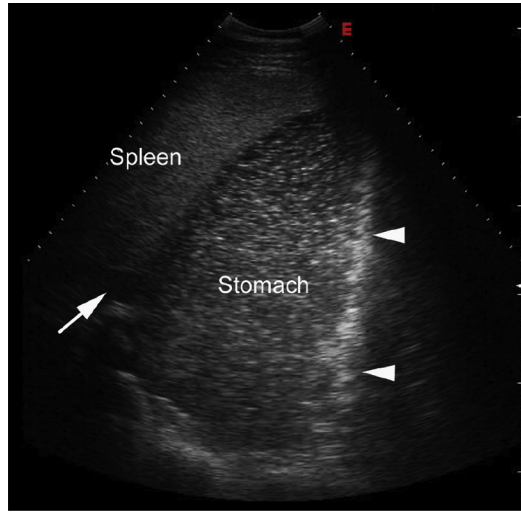


Fig. 3. Ultrasound image of gastric distention in a 31-year-old Thoroughbred gelding admitted for colic due to proximal enteritis. The stomach was visible from the left 8th through 14th ICS and showed an enlarged radius of curvature and a large ventral fluid accumulation with a visible gas-fluid interface (*arrowheads*). Splenic vein (*arrow*). Dorsal is to the right.

Small Intestinal Abnormalities

Abdominal ultrasonography can be very useful in distinguishing between small intestinal distension due to nonsurgical conditions, such as ileus or enteritis, and surgical lesions, such as small intestinal strangulation. Most small intestinal abnormalities and some large intestinal abnormalities create visible small intestinal distention. The increased weight created by the distention causes abnormal loops to migrate to the ventrum (in standing horses) or the dependent portion of the abdomen (in recumbent patients). Small intestinal distension can be seen on transcutaneous ultrasound before being palpated by rectum.[2,24] Small intestinal distension has been defined as a luminal diameter greater than or equal to 5 cm. Increased small intestinal wall thickness is considered greater than or equal to 3 mm.[6,10,12] It should be mentioned that small intestinal distention can also be found in horses with primary large intestine abnormalities.

Small intestinal strangulating obstructions

As mentioned previously, visualization of distended and amotile loops of SI is highly associated with small intestinal strangulating lesions (**Fig. 4**).[2,10,12] Careful evaluation of the ventral abdomen is important in all patients because strangulated loops tend to fall to the dependent portion of the abdomen. Affected loops are often round in shape, as opposed to compressed or triangular in shape, as can be seen in horses with enteritis or ileus. The presence of both distended and collapsed small intestinal loops can also be seen. Wall thickness measurements can be normal or increased, sometimes in the same horse, especially when imaging the strangulated portion of bowel (thickened) rather than the dilated loops proximal to the obstruction (nonthickened) (**Fig. 5**).

Intussusception

Small intestinal intussusceptions can occasionally be diagnosed in foals and rarely in adult horses.[25,26] Cross-sectional ultrasonography through the intussusception often reveals a typical bull's-eye or target appearance (**Fig. 6**).[25] Abdominal



Fig. 4. Ultrasound image from the left ventral flank region showing marked small intestinal thickening and distention (*arrows*) in a 2-year-old Warmblood gelding with small intestinal volvulus found at surgery. Although wall thickness is not shown, a measurement of 1 to 1.5 cm can be extrapolated from the depth scale on the right side of the image. (*Courtesy of* Dr Erin Byrne, Alamo Pintado Equine Medical Center, Los Olivos, CA.)

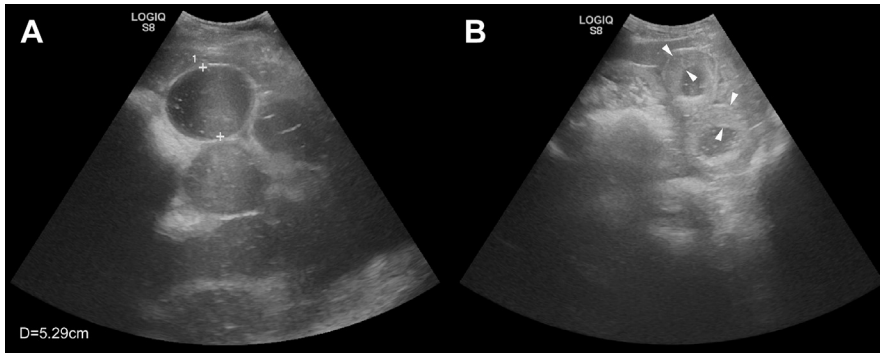


Fig. 5. Ultrasound images from an adult horse with a strangulating lipoma. (*A*) Marked small intestinal distention is noted (luminal diameter = 5.29 cm). (*B*) In the same horse, severe SI wall thickening of up to 1.5 cm (*arrowheads*) is also evident, which likely represents the strangulated portion of bowel. Twenty-seven feet of jejunum were resected at surgery. (*Courtesy of* Dr Erin Byrne, Alamo Pintado Equine Medical Center, Los Olivos, CA.)

ultrasonography in foals may improve the recognition of these surgical lesions and improve the potential for successful treatment. Similar to most small intestinal lesions, small intestinal intussusceptions are typically edematous and fluid-filled and fall to the most dependent portion of the abdomen, which should be a consideration when performing ultrasound on a recumbent foal.

Proximal enteritis

Horses with ileus due to enteritis show varying degrees of small intestinal and gastric distention (**Fig. 7**). Small intestinal motility is reduced but usually not absent; however, affected horses with large numbers of turgid and amotile small intestinal loops have been reported.[11] In such cases, differentiation between surgical and nonsurgical lesions can be challenging. A positive response to repeated decompression via

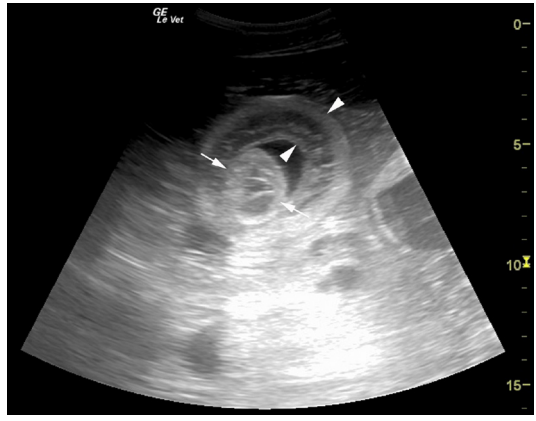


Fig. 6. Ultrasound image of a jejuno-jejunal intussusception in a 12-year-old Arab gelding with a 36-hour history of colic. This image was obtained from the ventral abdomen and shows the characteristic bull's-eye appearance created by the intussusceptum (*arrows*) within the severely thickened intussuscipiens (*arrowheads*).

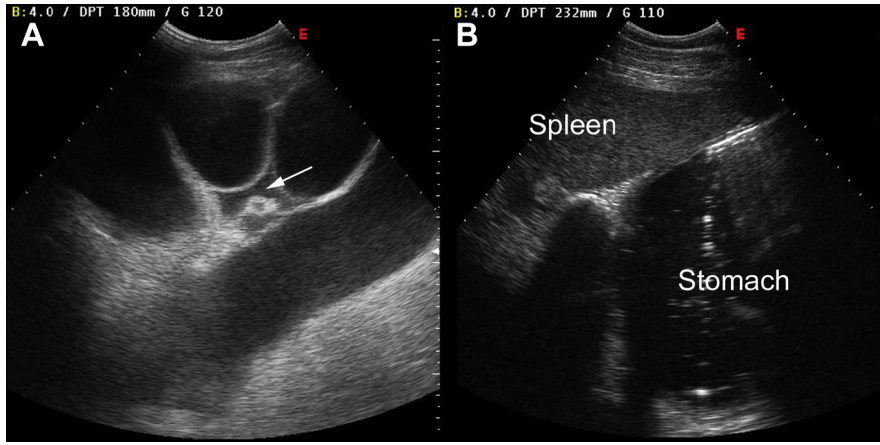


Fig. 7. Ultrasound images from a horse with proximal enteritis. (*A*) Prominently dilated and hypomotile small intestinal loops are seen throughout the ventral abdomen. Pockets of anechoic peritoneal fluid (*arrow*) are also visible. (*B*) Gastric distention due to increased fluid contents was present in this horse and is a common feature of proximal enteritis. Both findings can also be seen in horses with strangulating lesions, making differentiation between conditions challenging.

nasogastric intubation may point to a diagnosis of proximal enteritis. Wall thickness may be thickened or normal in affected horses.

Other small intestinal lesions

Small intestinal thickening is not an uncommon finding in colic patients with other nonstrangulating small intestinal lesions. Possible diagnoses include inflammatory bowel disease (IBD), hypertrophy due to distal obstruction, and less commonly, idiopathic muscular hypertrophy or neoplasia (addressed later in this article). All may present with a previous history of colic episodes. Differentiation between conditions is challenging, especially in the emergency setting, unless a mass or abscess is also found in conjunction with SI thickening. Luminal, mural, or extramural masses can all cause proximal distention and mural thickening. Thickening may involve all layers or only the muscular layer. Horses with idiopathic muscular hypertrophy show severe thickening that is limited to the muscularis layer of the SI (**Fig. 8**A).[27,28] Horses with IBD may show segmental or diffuse SI thickening (see **Fig. 8**B). Some IBD horses may also show cecal lymphadenopathy; however, this finding is not pathognomonic for this condition.[20] Diagnosis may rely on a positive response to corticosteroids in nonsurgical cases or via surgical biopsy/resection.

Duodenal abnormalities

Although duodenal abnormalities are uncommon primary causes of colic, the duodenum should be evaluated for distention, thickening, or alterations in motility. Visualization of the normal duodenum may not be practical in the emergency setting, because it may be collapsed and visibility may require waiting for peristalsis. In horses with enteritis or other jejunal disorders, the duodenum may appear persistently or intermittently distended and hypomotile.[10,11] Severe distention should prompt closer evaluation for a duodenal mass or other obstruction (**Fig. 9**A). Severe duodenal thickening has been seen in foals and horses with duodenitis and duodenal ulceration. Duodenoscopy may be beneficial in such cases (see **Fig. 9**B).

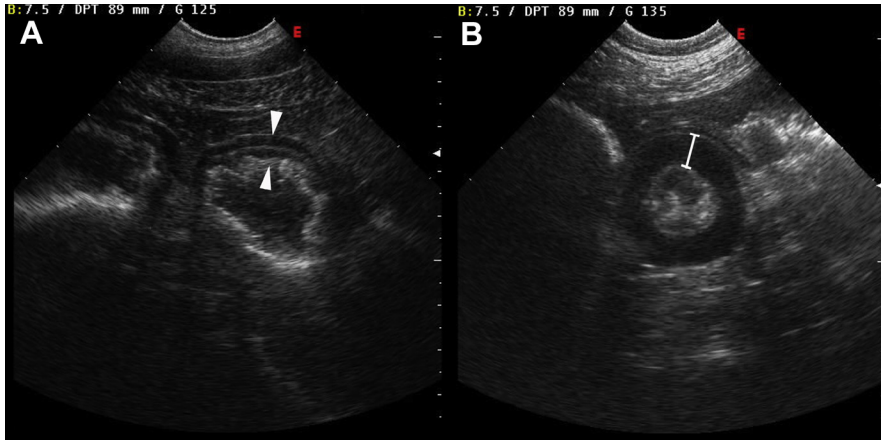


Fig. 8. Ultrasound images of severe small intestinal thickening from 2 different horses. (*A*) Severe diffuse thickening involving all SI layers (*arrowheads*) in a horse with recurrent colic bouts due to IBD, later diagnosed as eosinophilic-lymphoplasmacytic enterocolitis. (*B*) Severe thickening of the muscularis layer (*bracket*) in an adult miniature horse due to idiopathic muscular hypertrophy. Mucosal and submucosal thickening are also present. Approximately 15 feet of affected SI were resected at surgery, after which the colic bouts resolved.

Large Intestinal Abnormalities

Left dorsal displacement

Left dorsal displacement of the large colon (LDDLC) or nephrosplenic entrapment of the large colon is a cause of acute colic in horses, particularly in large Warmblood breeds. Even though the colon can be palpated by rectum as it courses laterally to the spleen into the nephrosplenic space, transcutaneous ultrasound can be used to confirm the diagnosis. LDDLC is typically diagnosed ultrasonographically when a

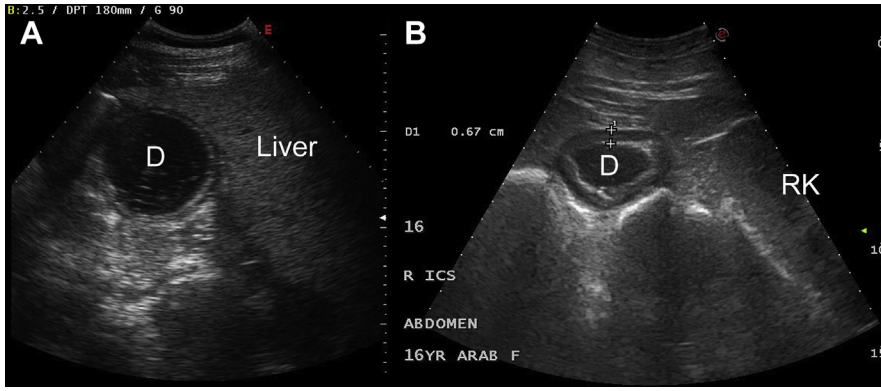


Fig. 9. Ultrasound images of the descending duodenum (D) from 2 different horses with colic. Images were obtained from the right 15th and 16th ICS, respectively. Dorsal is to the right. (*A*) Duodenal distention and hypomotility are present in this 23-year-old Morgan gelding diagnosed with splenic B-cell lymphoma at necropsy. A definitive reason for the duodenal findings was not identified. (*B*) Moderate duodenal thickening (6.7 mm) is seen in this 16-year-old Arab mare with multiple recurrent episodes of colic. Diffuse thickening was also noted of small intestinal loops throughout the ventral abdomen. RK, right kidney.

gas echo is identified dorsal to the spleen and obliterating the dorsal splenic border and left kidney, or when the colon is observed laterally to the spleen (Fig. 10). In the original study investigating the use of ultrasound to diagnose and to monitor the nonsurgical correction of LDDLC, ultrasound was found to be a very reliable aid in the diagnosis of LDDLC and in confirming correction of the displacement after a nonsurgical rolling procedure.[29] Ultrasound has since been integrated into standard practice in the management of this condition.[30,31] In the original report, no false positives and few false negatives were identified, indicating a high specificity with a lower sensitivity to diagnose LDDLC with ultrasound.[29] It is the authors' experience that unaffected horses, horses with other displacements of the large colon, and even large colon torsions can potentially have a similar appearance on ultrasound, particularly in obliterating the left kidney. This obliteration has been reported in other studies, including one where only 2 of 7 horses without a visible left kidney were found to have LDDLC and another study that reported 18 of 143 false positive examinations.[10,11] Therefore, nonvisualization of the left kidney on ultrasound should not be used as the sole indicator of LDDLC. Additional ultrasonographic findings consistent with LDDLC include splenic enlargement and ventral displacement, often extending past the ventral midline.

Right dorsal displacement

Ultrasonographic findings associated with right dorsal displacement include dilated mesenteric vessels on the right side of the abdomen, reported as near the costochondral junctions in 1 to 2 ICS.[32,33] In the authors' experience, abnormally distended vessels are most often found in the right 10th to 12th ICS and are oriented *parallel* with the ribs.[34] This nearly vertical orientation is almost perpendicular to the horizontal orientation of the large colon and its mesenteric vasculature in the normal horse (Fig. 11). Although surgical intervention is recommended in such cases, it is interesting that some horses without a surgical option have resolved with only supportive treatment. It is important not to confuse this finding with the normal appearance of the lateral cecal artery and vein. Cecal vessels are oriented somewhat vertically but are located further caudally in the abdomen, extending from the paralumbar fossa/flank region to the ventral abdomen.

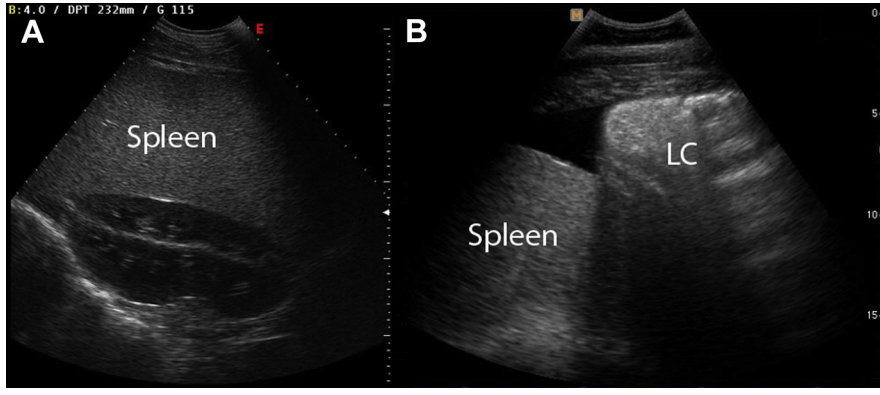


Fig. 10. (*A*) Normal renosplenic window. The left kidney is visible deep to the spleen in the caudal ICS. (*B*) In this horse with nephrosplenic entrapment, the left kidney is obscured by large colon (LC), which has migrated lateral and dorsal to the spleen. Peritoneal effusion is also present in this image. Dorsal is to the right in both images.

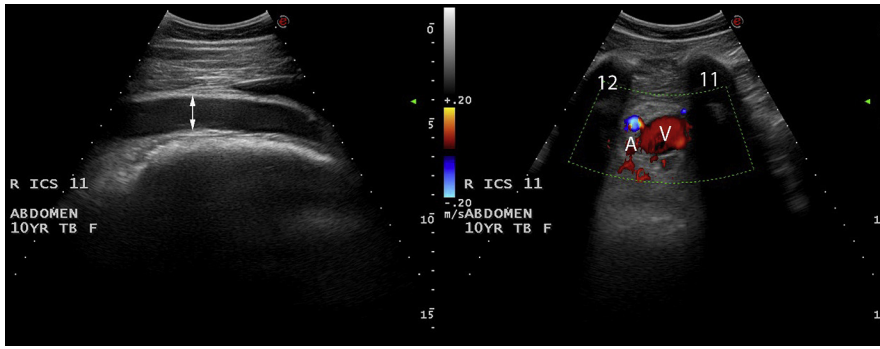


Fig. 11. Longitudinal (*left*) and transverse (*right*) ultrasound images of a severely distended mesenteric vein (*double headed arrows*, V) in a horse with right dorsal displacement. Both images were obtained from the right 11th ICS with the transducer oriented parallel to the ribs in the left image and perpendicular to ribs 11 and 12 in the right image. Venous blood flow was visible with both B-mode and color Doppler imaging. The smaller artery (A) is visible adjacent to the dilated vein on the transverse image.

Colon torsion

Large colon torsion is a common cause of severe colic in horses and ultrasound is typically not essential in establishing the correct diagnosis and treatment plan. However, in atypical cases where the colon is not completely strangulated and pain is not severe, ultrasound can be a useful diagnostic tool for this condition. Abutarbush[13] described a technique wherein the identification of nonsacculated large colon in the left ventral portion of the abdomen indicated a large colon volvulus, and the degree and location of the volvulus could be accurately estimated by ultrasound.[13] In a prospective study conducted by Pease and colleagues,[14] a colon wall thickness greater than or equal to 9 mm accurately predicted strangulating large colon torsion (**Fig. 12**) with a 100% specificity and 67% sensitivity using a ventral abdominal window.

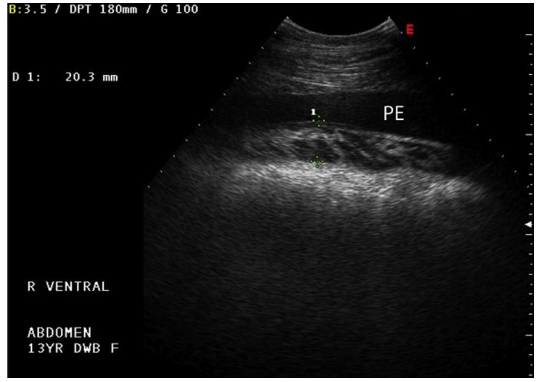


Fig. 12. Severe colonic thickening in a 13-year-old broodmare that presented for tachycardia (up to 120 bpm) and lying down at 4 days postpartum. Although this image was obtained from the right ventral abdomen, similar thickening was present throughout the right abdomen and left ventral abdomen. Peritoneal effusion (PE) is also visible. A 360° colon torsion was found and corrected at surgery.

Colitis

The term colitis may apply to multiple conditions that cause colonic inflammation. Right dorsal colitis is a common concern among equine veterinarians, and its clinical and ultrasonographic features have been described in multiple reports.[35–37] The ultrasound focus of these reports was on the right dorsal colon; however, colonic thickening consistent with colitis can be found throughout the colon in affected horses.[17] In the authors' experience, thickening is infrequently isolated to the right dorsal colon (**Fig. 13**). As such, examination should extend beyond the right dorsal colon in all suspect cases to more fully document the extent of involvement. Horses with acute infectious or inflammatory colitis may demonstrate similar ultrasonographic findings. Differentiation often relies on patient history and other clinical features.

Intussusception

Intussusceptions involving the large intestine include cecocecal, cecocolic, colocolic, ileocecal, and ileocecocolic intussusceptions. Ultrasound findings include a target sign similar to that seen with small intestinal intussusceptions, but because of their larger size, luminal fluid can be seen within the concentric rings of the intussusception.[38–40] Preoperative differentiation of the specific anatomic structures involved is challenging in large intestinal intussusceptions. In some horses, a masslike appearance may be present, especially if scanning immediately adjacent to the intussusception.[34] A closer look will often reveal the presence of an intussusceptum and intussuscepiens (**Fig. 14**). Because most large colon intussusceptions involve the cecum, identification requires imaging on the right side of the abdomen, including the right flank, paralumbar fossa, and ICS, regions that tend to be less frequently evaluated in colic patients. In one study of cecal intussusceptions, ultrasound was used to diagnose 3 of 37 ileocecal intussusceptions, 3 of 5 cecocecal intussusceptions, and 12 of 19 cecocolic intussusceptions; however, ultrasound was not performed in all cases.[41] These findings are similar to other studies on large intestinal intussusceptions where ultrasound was used to diagnose only 2 of 30 cases[42] and 2 of 8 cases,[43]

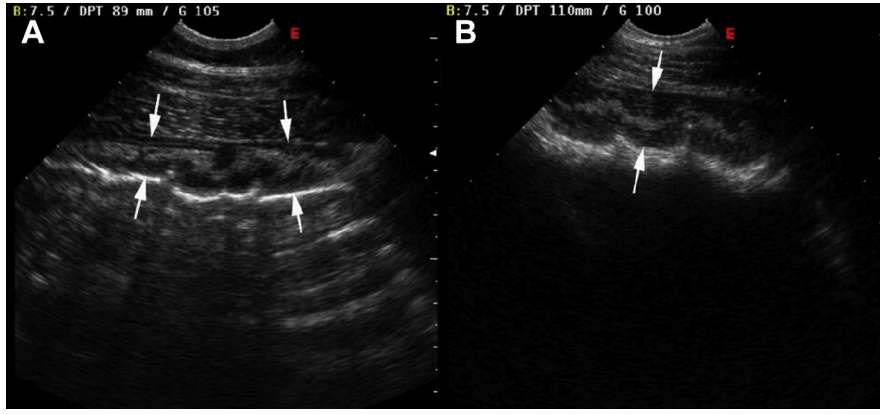


Fig. 13. Severe colonic thickening in a 15-year-old Thoroughbred mare with colic. (*A*) The right dorsal colon is severely thickened and shows an edematous, layered appearance (*arrows*). (*B*) Severe colonic thickening (*arrows*) was also seen throughout the abdomen, including the cranioventral abdomen as shown in this image. Wall thickness measurements ranged from 9.4 to 15 mm and involved nearly all visible portions of the colon. The horse recovered with conservative treatment.

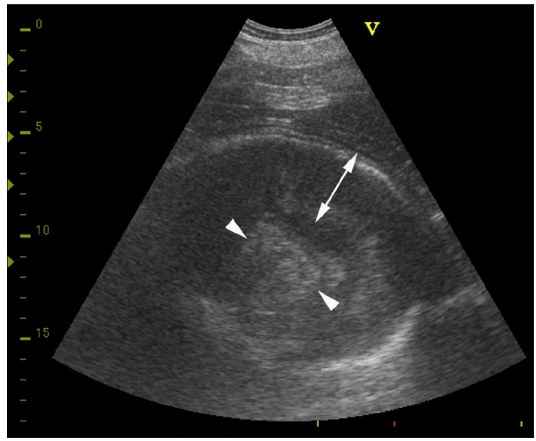


Fig. 14. Ultrasound image of a colocolic intussusception in a 17-year-old Tennessee Walker mare with a 2-week history of mild colic. The inner intussusceptum is seen (*arrowheads*) within the severely thickened and edematous outer intussuscipiens (*double headed arrow*). The intussusception was visible from the right 11th to 13th ICS. Surgical reduction was unsuccessful, and the horse was euthanized after the owner declined large colon resection.

respectively. Admittedly, both studies included years wherein the use of abdominal ultrasound was not yet embraced in colic patients.

Sand/Enteroliths

Sand accumulations within the large colon and enterolithiasis are typically diagnosed with abdominal radiographs as they cannot be imaged adequately with ultrasound. However, a Finnish group investigated the correlation of radiographic with ultrasonographic findings (large intestinal motility and localization relative to the ventral abdominal wall) in horses with sand accumulations.[44] In that study, the specificity of ultrasonography in detecting ventrally located sand accumulations was 87.5% and the sensitivity was 87.5%, but small and more dorsally located accumulations were difficult to detect. The authors were able to identify ultrasonographically the ventral aspect of sand accumulations as a hyperechoic line, allowing for an estimation of the length of the accumulation, but not the height, and the large intestine had decreased or absent motility. A weakness of the study was the lack of blinding of the ultrasonographers to the radiographic findings; it is the authors' experience that sand accumulations are not reliably identified on ultrasound.

Peritoneal Fluid

Ultrasound is helpful to determine the location of peritoneal fluid for abdominocentesis and to assess the quantity and character of fluid in horses with peritoneal effusions. Peritoneal fluid is not typically visible, but a few small pockets of anechoic fluid may be found in normal horses.[9] Although the ventral abdomen is the most common location to visualize peritoneal fluid, it is not unusual to detect fluid dorsal to the spleen in the gastrosplenic window and dorsal to the spleen and left kidney in the left caudal ICS (renosplenic window) in some horses (**Fig. 15**). Visualization of fluid in the latter location should not be overinterpreted as evidence of severe effusion based solely on its dorsal location. Although significant effusion may be present, this location is merely a potential space for small effusions to accumulate. Assessment of quantity is

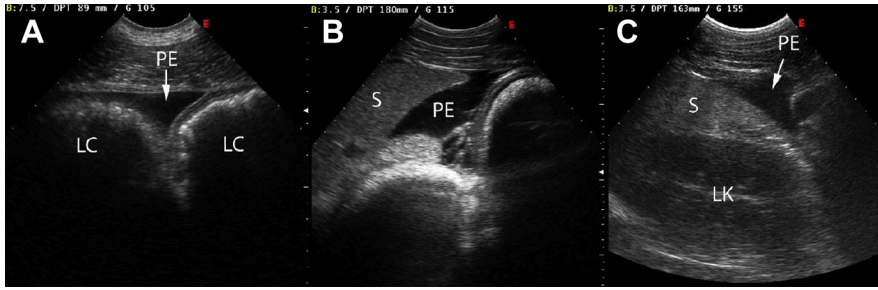


Fig. 15. Common locations to visualize peritoneal effusion (PE) in the equine abdomen. (*A*) Ventral abdomen. A small pocket of anechoic effusion is visible in this horse with mild to moderate large colon (LC) thickening. (*B*) Gastrosplenic window. Peritoneal fluid may be detected dorsal to the spleen (S) in horses with mild to moderate peritoneal effusion. (*C*) Renosplenic window. Effusion may also be visible dorsal to the spleen (S) and left kidney (LK) in the left caudal ICS.

somewhat subjective, but multiple small- to moderate-size pockets of peritoneal effusion throughout the abdomen is generally considered abnormal.

A rectal transducer is often sufficient to detect ventral fluid accumulations, depending on the size and body condition of the horse. In thin or young horses, 4 to 8 cm of scanning depth may be adequate. Horses with a thick retroperitoneal fat layer will require an increased scanning depth, which may exceed the capabilities of a rectal transducer. Most horses have some retroperitoneal fat. Fat should not be mistaken for peritoneal fluid or liver, which can occur in difficult to image horses due to the hypoechoic and somewhat speckled appearance of fat (**Fig. 16**). Close inspection will reveal that fat will indent on peristalsis of overlying bowel. Swirling will be noted in horses with cellular effusion.

The character of peritoneal fluid should be also be evaluated, especially when faced with large effusions. Hemorrhagic fluid generally shows a fairly homogeneous and cellular appearance. It characteristically shows swirling with gentle external ballottement, respiratory, or peristaltic movements (**Fig. 17**). Ultrasound should then be

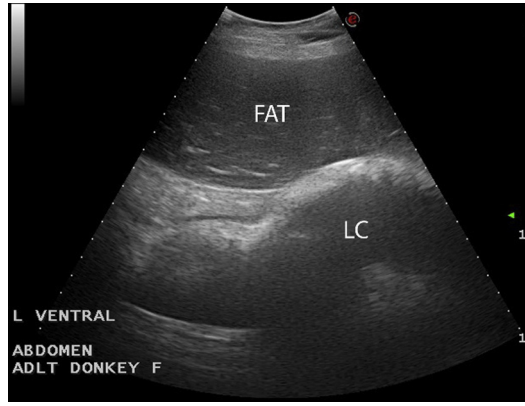


Fig. 16. Thick retroperitoneal fat layer visible from the ventral abdomen in an adult donkey. Retroperitoneal fat of varying thicknesses is visible throughout the ventral abdomen in nearly all horses/equids. Its hypoechoic and speckled appearance should not be confused with hepatic parenchyma or cellular peritoneal effusion. LC, large colon.

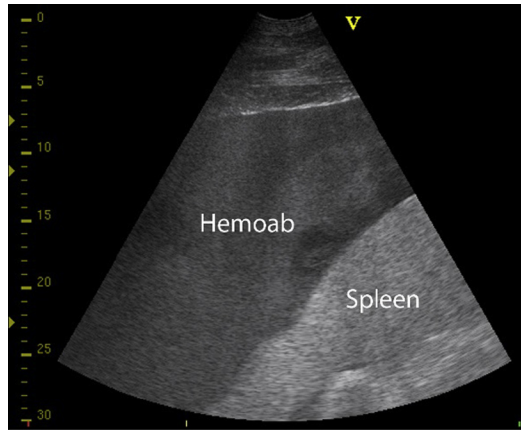


Fig. 17. Severe cellular-appearing effusion in a horse with hemoabdomen (Hemoab) due to splenic fracture (not visible in this image). Note the somewhat homogeneous appearance of the fluid, which swirls with movement of the GI tract and shifting of the horse's weight.

directed to identify the source of the hemoperitoneum, which may include splenic hematoma or fracture, hemangiosarcoma, and other neoplasias.[45–47] Fluid that is heterogeneous, contains debris, or contains hyperechoic gas echoes is most consistent with bowel rupture. Severe anechoic effusion may be due to uroabdomen (**Fig. 18**) or neoplasia such as metastatic peritoneal carcinomatosis or mesothelioma. Uroabdomen is an uncommon cause of acute colic and is more likely in foals secondary to urinary bladder rupture. However, it can be found in adult horses with urinary rupture due to urolithiasis and should be suspected when large amounts of anechoic fluid are present within the abdominal cavity even if a urine-distended bladder can be seen, because the urine leakage can result from other parts of the urinary tract.

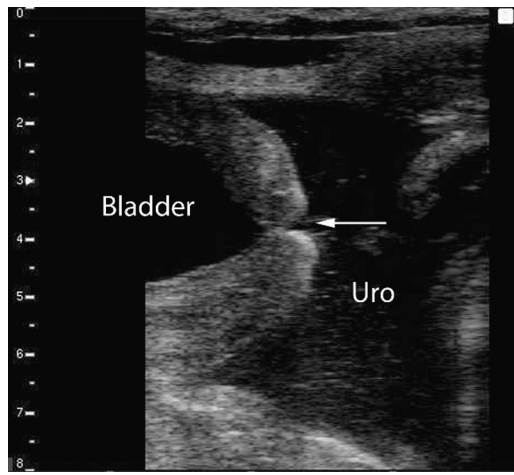


Fig. 18. Severe anechoic peritoneal effusion due to uroabdomen (Uro) in a 12-year-old Quarter Horse mare with bladder rupture (*arrow*) considered to be traumatic in origin. Although the bladder wall defect is visible in this case, it may not be identified in all cases. The tear was surgically repaired, and the mare recovered uneventfully.

Masses, Neoplasia, and Abscessation

Although horses with abdominal abscessation or neoplasia more commonly exhibit clinical signs, such as fever of unknown origin, weight loss, or chronic intermittent colic, they can present with acute colic signs especially if the mass is causing gastrointestinal (GI) obstruction.[48–56] Masses and abscesses can be found throughout the abdomen, but large masses are often found on the ventral abdomen due to their dependent nature.[55] Diagnosis usually requires a low-frequency curvilinear transducer and a skilled eye. Masses palpable by rectum can be evaluated with a linear rectal transducer; however, transrectal examination with a small curvilinear transducer (microconvex) may provide a more complete evaluation due to its wider, sector-shaped image. Transcutaneous ultrasound is often necessary to completely evaluate masses palpable by rectum due to scanning depth limitations of rectal and microconvex transducers.

Abdominal neoplasia

The most common intestinal tumors are lymphoma and adenocarcinoma.[56] Small intestinal lymphoma tends to produce annular thickening of the intestinal wall. Affected loops are often visible on the dependent abdominal floor (**Fig. 19**). Differentials for annular thickening include idiopathic muscular hypertrophy,[27,28] IBD,[57] and muscular hypertrophy due to a distal obstruction. A trial with corticosteroids may help to differentiate between neoplasia and IBD. Cecal lymphadenopathy may be found in horses with intestinal neoplasia (see **Fig. 19**B), but may also be present in horses with infectious or inflammatory conditions.[20] In contrast to lymphoma, adenocarcinoma tends to produce focal or solitary masses (**Fig. 20**), although diffuse colonic infiltration has been seen by the authors. Proximal small intestinal distention ± mural thickening may be evident due to functional obstruction. Gastrointestinal stromal cell tumors are less common and tend to produce solitary masses with or without proximal small intestinal distention and mural thickening (**Fig. 21**). Tumors often involve the cecum. Interestingly, affected horses may be asymptomatic.[49,52] Leiomyomas and leiomyosarcomas have also been described.[56]

Additional tumor types that can cause clinical signs of colic include large granulosa cell tumors (**Fig. 22**), splenic lymphoma (**Fig. 23**), and gastric squamous cell carcinoma, among others. Gastroscopy is typically the imaging modality of choice for the diagnosis of gastric squamous cell carcinoma, but ultrasound can detect proliferative masses emanating from the gastric wall in the gastrosplenic space in some horses.[23]

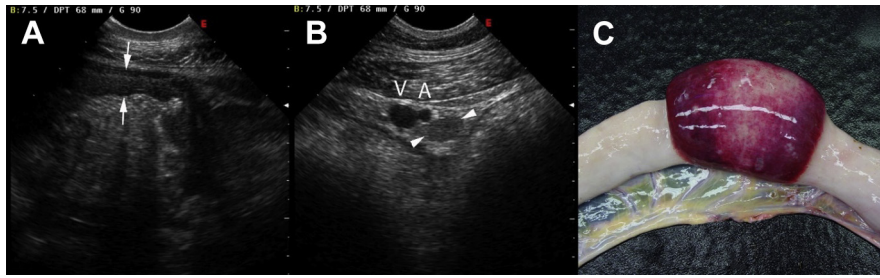


Fig. 19. Small intestinal lymphoma in a 23-year-old Quarter Horse mare. (*A*) Severe small intestinal thickening (*arrows*) was present throughout the ventral abdomen. (*B*) Enlarged cecal lymph nodes (*arrowheads*) were seen adjacent to the lateral cecal artery (A) and vein (V) in the right paralumbar fossa region. (*C*) Postmortem specimen of the same horse showing severe annular small intestinal thickening due to T-cell lymphoma.

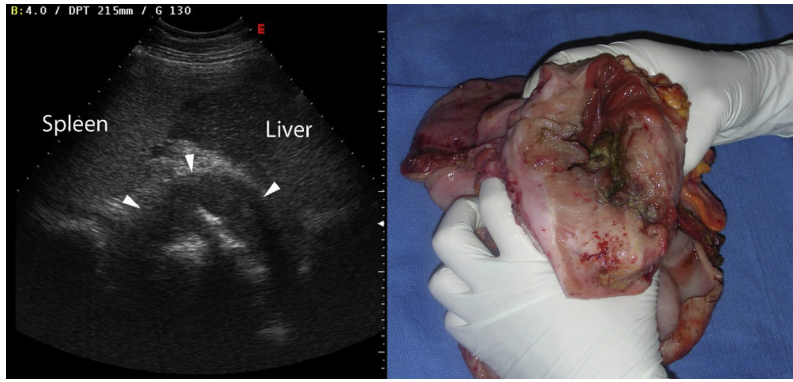


Fig. 20. Ultrasound image and corresponding surgical specimen from a horse with adenocarcinoma involving the large colon. Severe thickening (2–3 cm) of the large colon wall (*arrowheads*) and an irregular lumen was visible deep to the left liver lobe and spleen from the left 5th through 7th ICS. The owner opted for exploratory celiotomy, and the mass was removed via colon resection.

Abdominal abscessation

The classic appearance for abscessation is a spherical structure containing echogenic fluid contents and a well-defined capsule. This appearance is more often seen with mesenteric abscesses due to *Streptococcus zooepidemicus* or *Streptococcus equi* subspecies *equi*.[54] Although *Rhodococcus equi* abscesses can create a similar appearance (**Fig. 24**), poorly marginated abscesses of mixed echogenicity were reported in a study of 11 foals with intra-abdominal abscessation.[55] Abscessation due to *Corynebacterium pseudotuberculosis* typically involves abdominal organs (liver, kidneys, and spleen, in that order). Mesenteric abscesses due to this pathogen are relatively rare, and colic is uncommon.[58]

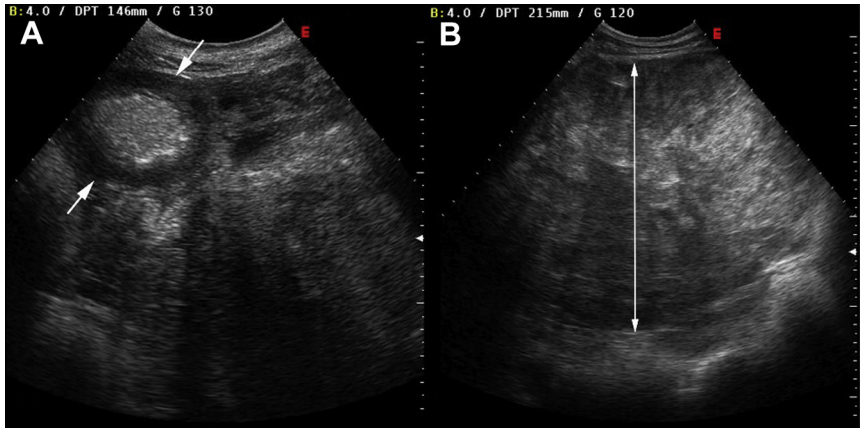


Fig. 21. Ultrasonographic findings in a horse with a large GI stromal cell tumor involving the cecum. (*A*) Severe annular small intestinal thickening involving the muscular layer (*arrows*) was detected near the large solitary mass (*B*, *double headed arrow*). Both were visualized from the right paralumbar fossa and inguinal region in a 21-year-old Arab gelding with mild colic, inappetence, and weight loss. The mass measured 16 cm × 19 cm × 16 cm. The horse was euthanized 2 weeks later due to declining condition. Necropsy confirmed GI stromal cell tumor.

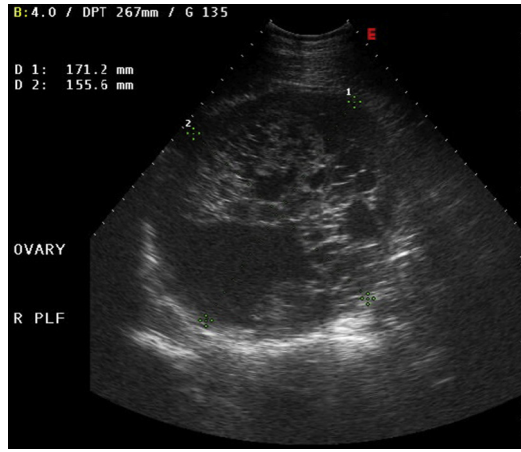


Fig. 22. Large granulosa cell tumor (15.6 cm × 17.1 cm) of the right ovary visible from the right paralumbar fossa/flank region. This granulosa cell tumor was only partially visible and palpable via transrectal ultrasound. Transcutaneous ultrasound allowed assessment of its full size to aid in surgical planning.

Abdominal abscesses may also show irregular margins with heterogeneous, solid-appearing contents that may appear similar to masses or neoplasia. Ultrasonographic differentiation between neoplasia and abscessation is not straightforward in such cases. Anaerobic abscesses typically show an additional component of hyperechoic gas echoes (Fig. 25). This finding should prompt abdominal radiographs to rule out a migrating metallic foreign body such as a wire. Ultrasound can be used to monitor response to treatment in horses with abscessation.[58] Ultrasound-guided aspiration is generally not recommended for mesenteric abscesses due to the risk for bowel

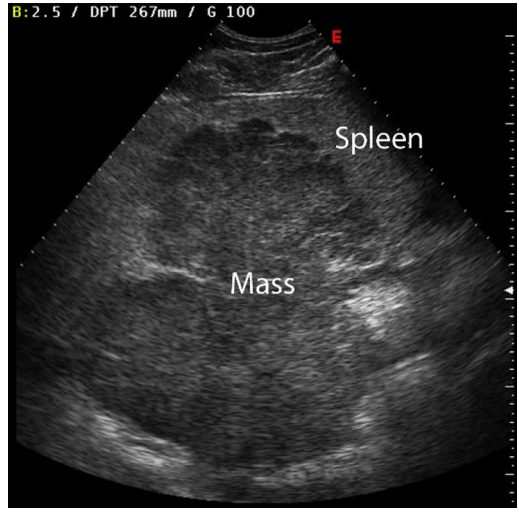


Fig. 23. Large heterogeneous splenic mass in a 4-year-old Thoroughbred racehorse with recent colic. The heterogeneous, cauliflower-like appearance of this mass is highly suggestive of splenic lymphoma. Ultrasound-guided biopsy confirmed the diagnosis.

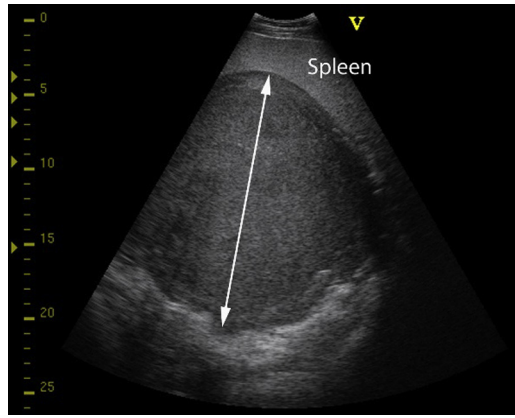


Fig. 24. Large mesenteric abscess (*double headed arrow*) due to *R equi* in a 3-month-old Thoroughbred foal. A well-defined capsule is apparent in this case, but poorly defined abscesses of mixed echogenicity may also be found. The abscess extended for a length of 28 cm along the ventral abdomen.

perforation or leakage but has been used successfully for the diagnosis of hepatic, renal, and splenic abscesses due to *C pseudotuberculosis*.[58]

Other

Urolithiasis

Horses with obstructive urolithiasis may present with signs of colic, but more often show hematuria and azotemia.[59–61] In horses with urinary obstruction due to uroteroliths or cystoliths, distention of the renal pelvis may be the only finding on

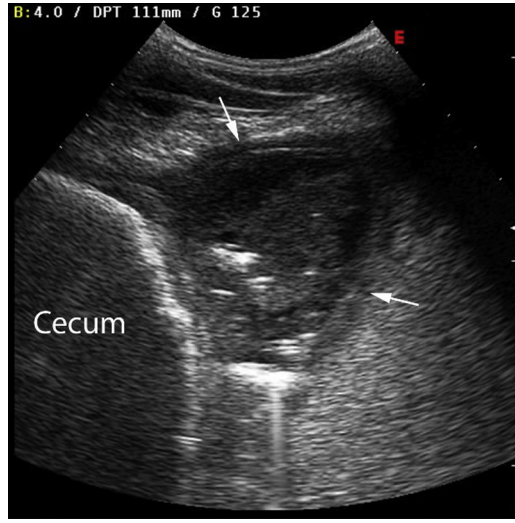


Fig. 25. Anaerobic abscess (*arrows*) at the cecal apex visible from the ventral abdomen. Hyperechoic gas echoes within the abscess raised the suspicion for a migrating foreign body, which was later confirmed on abdominal radiographs. The abscess was surgically resected via partial typhlectomy. Partial splenectomy was also necessary due to adhesions to the spleen.

transcutaneous ultrasound. Palpation of a bladder stone may be found during rectal palpation of colic patients and should be confirmed via transrectal ultrasound (Fig. 26); the entire urinary tract should be scanned to rule out additional uroliths. This scan is especially important in horses with ureteral obstruction as the primary cause of colic, in which case removal of the bladder stone will not resolve the horse's clinical signs. Ultrasound is also important to evaluate for significant underlying renal disease to aid in prognostication. It is important to perform ultrasound before cystoscopy to prevent the introduction of gas that would obscure ultrasonographic visualization of urinary structures.

Uroliths, regardless of their location, appear as hyperechoic structures that cast hard shadows. Ureteroliths can be found along the length of the ureter via transrectal ultrasonography and are often associated with distention and ureteral thickening proximal to the obstructing stone (Fig. 27A). The left and right ureters are evaluated individually by starting at the bladder trigone and following each as far cranially as possible. Normal wall thickness of the caudal ureters is 1.5 to 2.0 mm, with motility used to differentiate between ureters and deferent ducts/ampulla in male horses.[62] Cystoliths located at the trigone region may also create ureteral thickening and distention, and even renal pelvic distention in some cases.

Nephroliths are recognized as hyperechoic structures within the renal pelvis that cast hard shadows. Renal sludge appears similarly but may produce a "dirty" or less distinct shadow (see Fig. 27B). Differentiation between nephroliths and renal sludge is not straightforward. Care should be taken not to misinterpret the hyperechoic appearance of the renal pelvis as nephrolithiasis.

Cholelithiasis

Hepatic causes of colic primarily include obstructive cholelithiasis[63–65]; however, this is an uncommon finding in the authors' experience. In contrast to that seen with urolithiasis, hepatoliths can be of variable echogenicity and can create variable acoustic

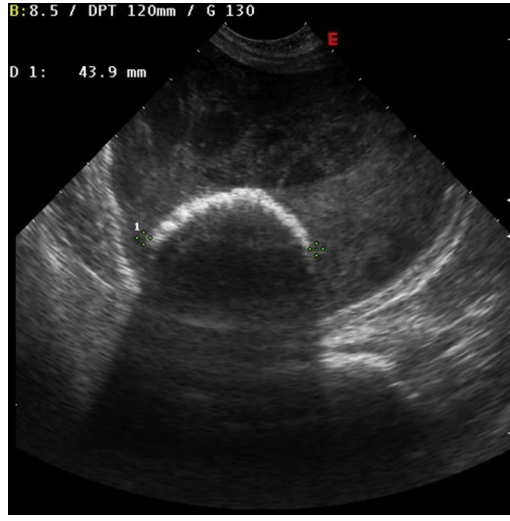


Fig. 26. Cystolith in a 17-year-old Argentinian sport horse gelding with frequent posturing to urinate. Ultrasound of the urinary tract revealed no additional uroliths or renal or ureteral abnormalities. The cystolith was removed under general anesthesia. Five years later, the horse has had no recurrence of urolithiasis.

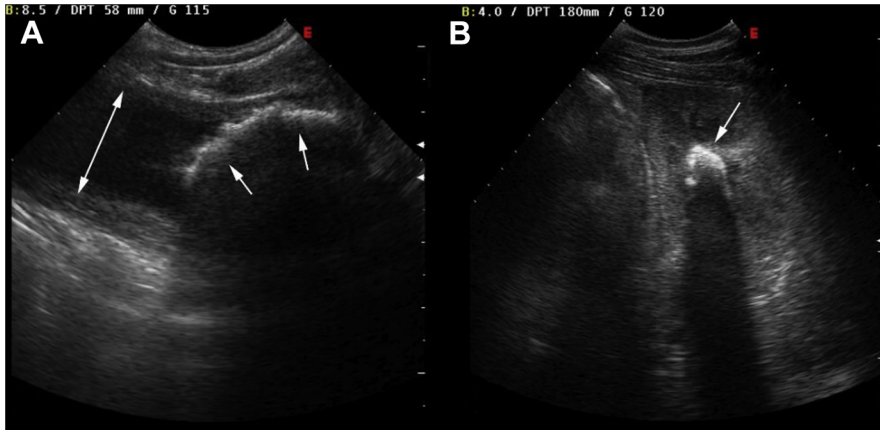


Fig. 27. Ultrasound images from a 4-year-old Warmblood gelding with urolithiasis. (*A*) Transrectal ultrasound shows a large ureterolith (*small arrows*) within the right ureter and severe ureteral distention (*double headed arrow*) proximal to the stone. (*B*) Transcutaneous ultrasound reveals one of several nephroliths (*arrow*) within the right renal pelvis. Note the characteristic strong shadow cast by the stone. Additional findings included bilateral renal enlargement, thickened renal cortices, and changes consistent with chronic renal failure. The horse was euthanized due to poor prognosis based on the extent and severity of ultrasonographic findings throughout the urinary tract.

shadowing (Fig. 28A).[65] Biliary distention is a concurrent finding in most cases, seen as a "parallel channel sign" whereby the bile duct becomes distended adjacent to portal veins (see Fig. 28B). In some cases, hepatoliths cannot be visualized if located deep within the biliary tree. Additional findings that may be confused with hepatoliths include hepatic granulomas,[66] biliary fibrosis, or biliary inflammation. These findings can create distal shadowing, and when diffuse, a starry sky pattern has been described in a group of horses with hepatic granulomas.[66] Hepatoliths should be differentiated by their location within the biliary tree.

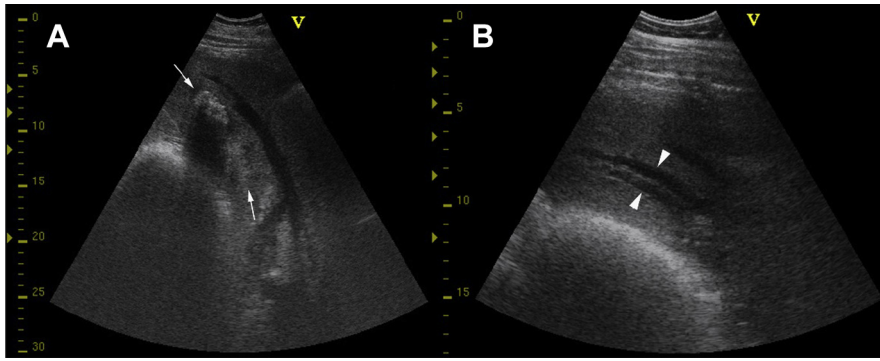


Fig. 28. Ultrasound images from a 14-year-old Thoroughbred breeding stallion with colic and icterus. (*A*) Hyperechoic hepatoliths (*arrows*) are seen within the biliary tree of the left liver lobe. These stones cast variably dirty shadows, in contrast to that seen with uroliths. (*B*) No hepatoliths were seen at any location within the right liver lobe; however, a parallel channel sign (*arrowheads*) is evident secondary to distention of the bile ducts adjacent to the portal vein.

Thoracic and cardiac causes of colic

Pleuritis Horses with pleurodynia caused by pleuritis may occasionally present with acute colic signs (Fig. 29). It is therefore recommended to evaluate the ventral lung margins during abdominal ultrasound, which will aid in the detection of comet tails and/or pleural effusion that may implicate the thoracic cavity as the source of clinical signs. A few small comet tails are generally considered clinically insignificant, especially in older horses that may have residual scarring from previous lung infections. Diffuse or large comet tails, pulmonary consolidation, or pleural effusion should prompt complete thoracic examination.

Pericarditis Although relatively uncommon, pericardial effusion with or without cardiac tamponade and tachycardia may produce clinical signs consistent with acute colic (Fig. 30). Pleural effusion can appear similar to pericardial effusion in some horses. Identification of fluid that extends around the apex of the heart is often seen in horses with large pericardial effusions.

Aortic root disease Aortic root aneurysms and aortocardiac fistulas are rare painful conditions that frequently present as colic patients.[67,68] Mature breeding stallions are most often affected, but aortic root disease has been reported in mares and geldings. Aortic root disease should be considered in horses with severe tachycardia unresponsive to sedation, a continuous right-sided murmur, electrocardiographic evidence of ventricular tachycardia (usually monomorphic), and lack of significant GI signs on colic examination. Echocardiographic diagnosis can be challenging for the novice imager, and definitive diagnosis may require a specialist familiar with echocardiography. Ultrasound findings include dilatation of the aortic root, fistula formation that extends into the right atrium or right ventricle, and/or dissecting tracts through the interventricular septum (Fig. 31). Prognosis is poor. Reported survival times range from a few days to 12 months in most cases. Sudden death has been reported.

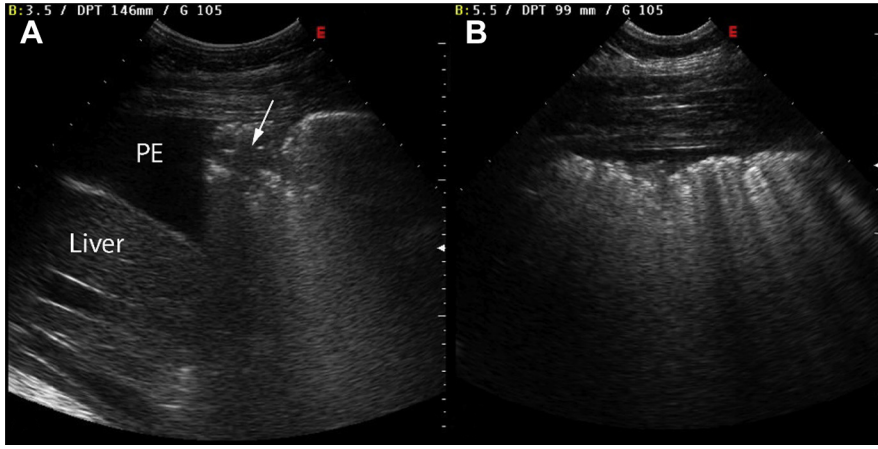


Fig. 29. Evidence of pleuropneumonia detected during abdominal ultrasound in a 14-year-old Quarter Horse gelding presenting for colic and occasional grunting. (*A*) Moderate pleural effusion (PE) and ventral pulmonary consolidation (*arrow*) were evident within the cranioventral thorax bilaterally. (*B*) Multiple diffuse comet tails were detected throughout the right ventral lung fields. The lung was adhered to the parietal pleural surface at this location (right 11–12th ICS) and showed jerky movements with respiration. The horse was treated for primary pleuropneumonia and recovered uneventfully.

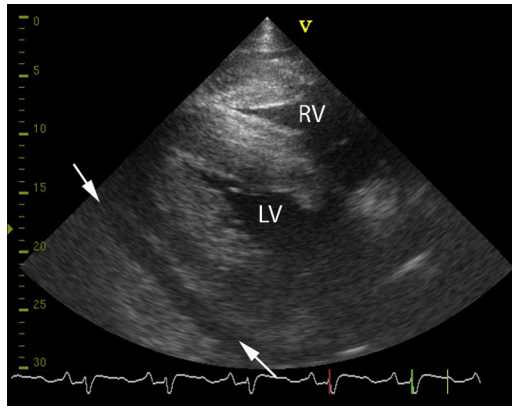


Fig. 30. Pericardial effusion (*arrows*) in a horse presenting for colic. No abdominal abnormalities were detected. Echocardiography was performed due to persistent tachycardia and an irregular rhythm. Toxin screens were negative. Effusive-constrictive pericarditis due to an unknown toxin was suspected. The horse responded to supportive care. LV, left ventricle; RV, right ventricle.

Diaphragmatic hernia Diaphragmatic hernia can cause acute colic in adults and foals.[69,70] Preoperative diagnosis can be difficult because of the absence of affected intestine within the abdominal cavity and the lack of peritoneal fluid changes. Depending on the size of the defect within the diaphragm, either small or large intestine can herniate. Typically, large defects result in large intestinal herniation that leads to dyspnea and respiratory distress. In contrast, small defects more often result in small intestinal herniation and strangulating obstruction that lead to acute colic signs. Ultrasonography of the thorax and cranial abdomen can allow visualization of intestinal contents within the thorax even when pleural effusion is present (**Fig. 32**). Diagnosis is not always straightforward, especially in cases with large colon herniation,

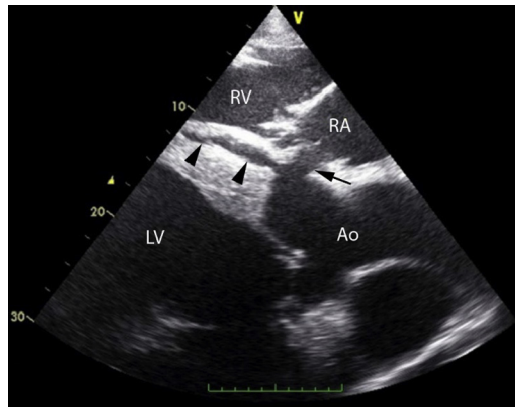


Fig. 31. Dissecting aortic root aneurysm (*arrowheads*) and aortocardiac fistula (*arrow*) extending into the right atrium in a 27-year-old thoroughbred breeding stallion that presented for tachycardia and a continuous right-sided murmur after collapsing immediately following breeding. The dissecting tract extended 8 to 9 cm into the interventricular septum. Ao, aorta; LV, left ventricle; RA, right atrium; RV, right ventricle. (*Courtesy of* Johanna Reimer, DVM, DACVIM, Lexington, KY.)

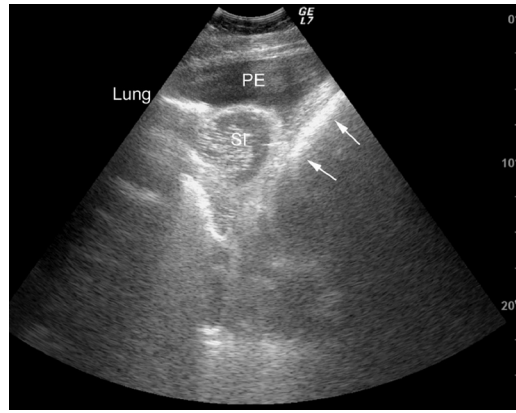


Fig. 32. Ultrasound image from a 17-year-old Quarter Horse gelding with a diaphragmatic hernia involving 10 feet of SI. A SI loop is seen within the pleural space between the lung and diaphragm (*arrows*). Pleural effusion (PE) is also seen. Dorsal is to the left. (*Courtesy of* Dr Erin Byrne, Alamo Pintado Equine Medical Center, Los Olivos, CA.)

where the hyperechoic bowel wall may appear similar to lung. Even horses with small intestinal herniation may require close scrutiny to appreciate the presence of amotile bowel within the pleural space.

REFERENCES

1. Fischer AT Jr. Advances in diagnostic techniques for horses with colic. Vet Clin North Am Equine Pract 1997;13(2):203–19.
2. Scharner D, Rotting A, Gerlach K, et al. Ultrasonography of the abdomen in the horse with colic. Clin Tech Equin Pract 2002;1:118–24.
3. Freeman S. Ultrasonography of the equine abdomen: findings in the colic patient. In Pract 2002;24:262–73.
4. Freeman S. Ultrasonography of the equine abdomen: techniques and normal findings. In Pract 2002;24:204–11.
5. Henry Barton M. Understanding abdominal ultrasonography in horses: which way is up? Compend Contin Educ Vet 2011;33(9):E2.
6. Klohnen A, Vachon AM, Fischer AT Jr. Use of diagnostic ultrasonography in horses with signs of acute abdominal pain. J Am Vet Med Assoc 1996;209(9):1597–601.
7. Fontaine GL, Hanson RR, Rodgerson DH, et al. Ultrasound evaluation of equine gastrointestinal disorders. Compend Cont Educ Pract Vet 1999;21:253–62.
8. Bithell S, Habershon-Butcher JL, Bowen IM, et al. Repeatability and reproducibility of transabdominal ultrasonographic intestinal wall thickness measurements in thoroughbred horses. Vet Radiol Ultrasound 2010;51(6):647–51.
9. Epstein K, Short D, Parente E, et al. Gastrointestinal ultrasonography in normal adult ponies. Vet Radiol Ultrasound 2008;49(3):282–6.
10. Beccati F, Pepe M, Gialletti R, et al. Is there a statistical correlation between ultrasonographic findings and definitive diagnosis in horses with acute abdominal pain? Equine Vet J Suppl 2011;(39):98–105.
11. 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(1):77–82.

12. Porzuczek A, Kielbowicz Z, Haines G. The use of percutaneous abdominal ultrasound examination in diagnosing equine small intestinal disorders. Pol J Vet Sci 2012;15(4):759–66.
13. Abutarbush SM. Use of ultrasonography to diagnose large colon volvulus in horses. J Am Vet Med Assoc 2006;228(3):409–13.
14. Pease AP, Scrivani PV, Erb HN, et al. Accuracy of increased large-intestine wall thickness during ultrasonography for diagnosing large-colon torsion in 42 horses. Vet Radiol Ultrasound 2004;45(3):220–4.
15. Freeman SL, Mason PJ, Staley C. Comparison of ultrasonographic and histological assessment of normal and strangulated intestine in the horse. Eur J Ultrasound 2001;13:1–35.
16. Reef VB. Adult abdominal ultrasonography. In: Reef VB, editor. Equine diagnostic ultrasound. Philadelphia: WM Saunders Co; 1998. p. 273–363.
17. Biscoe EW, Whitcomb MB, Vaughan B, et al. Ultrasonographic features and clinical outcome in horses with severe large colon thickening: (2003-10). Am Assoc Equine Pract 2011;57:459.
18. Hendrickson EH, Malone ED, Sage AM. Identification of normal parameters for ultrasonographic examination of the equine large colon and cecum. Can Vet J 2007;48(3):289–91.
19. Lores M, Stryhn H, McDuffee L, et al. Transcutaneous ultrasonographic evaluation of gastric distension with fluid in horses. Am J Vet Res 2007;68(2):153–7.
20. Vaughan B, Whitcomb MB, Pusterla N. Ultrasonographic findings in 42 horses with cecal lymphadenoapthy. Am Assoc Equine Pract 2013;59:238.
21. Kirberger RM, van den Berg JS, Gottschalk RD, et al. Duodenal ultrasonography in the normal adult horse. Vet Radiol Ultrasound 1995;36(1):50–6.
22. Mitchell CF, Malone ED, Sage AM, et al. Evaluation of gastrointestinal activity patterns in healthy horses using B mode and Doppler ultrasonography. Can Vet J 2005;46(2):134–40.
23. Taylor SD, Haldorson GJ, Vaughan B, et al. Gastric neoplasia in horses. J Vet Intern Med 2009;23(5):1097–102.
24. Cavalleri JM, Bienert-Zeit A, Feige K. Examination of horses with acute colic - clinical pathology and diagnostic imaging. Tierarztl Prax Ausg G Grosstiere Nutztiere 2013;41(2):124–34 [quiz: 135] [in German].
25. Bernard WV, Reef VB, Reimer JM, et al. Ultrasonographic diagnosis of small-intestinal intussusception in three foals. J Am Vet Med Assoc 1989;194(3):395–7.
26. Fontaine-Rodgerson G, Rodgerson DH. Diagnosis of small intestinal intussusception by transabdominal ultrasonography in 2 adult horses. Can Vet J 2001;42(5):378–80.
27. Chaffin MK, Fuenteabla IC, Schumacher J, et al. Idiopathic muscular hypertrophy of the equine small intestine: 11 cases (1980-1991). Equine Vet J 1992;24(5):372–8.
28. Dechant JE, Whitcomb MB, Magdesian KG. Ultrasonographic diagnosis–idiopathic muscular hypertrophy of the small intestine in a miniature horse. Vet Radiol Ultrasound 2008;49(3):300–2.
29. Santschi EM, Slone DE Jr, Frank WM 2nd. Use of ultrasound in horses for diagnosis of left dorsal displacement of the large colon and monitoring its nonsurgical correction. Vet Surg 1993;22(4):281–4.
30. van Harreveld PD, Gaughan EM, Valentino LW. A retrospective analysis of left dorsal displacement of the large colon treated with phenylephrine hydrochloride and exercise in 12 horses (1996-98). N Z Vet J 1999;47(3):109–11.

31. Abutarbush SM, Naylor JM. Comparison of surgical versus medical treatment of nephrosplenic entrapment of the large colon in horses: 19 cases (1992-2002). J Am Vet Med Assoc 2005;227(4):603–5.
32. Grenager NS, Durham MG. Ultrasonographic evidence of colonic mesenteric vessels as an indicator of right dorsal displacement of the large colon in 13 horses. Equine Vet J Suppl 2011;(39):153–5.
33. Ness SL, Bain FT, Zantingh AJ, et al. Ultrasonographic visualization of colonic mesenteric vasculature as an indicator of large colon right dorsal displacement or 180 degrees volvulus (or both) in horses. Can Vet J 2012;53(4):378–82.
34. Whitcomb MB. Advanced abdominal ultrasound for chronic colic. In: American College of Veterinary Surgeons: the surgical summit. San Diego (CA): 2005. p. 39–44.
35. Cohen ND. Right dorsal colitis. Equine Vet Educ 2002;14:212–9.
36. Cohen ND, et al. Medical management of right dorsal colitis in 5 horses: a retrospective study (1987-1993). J Vet Intern Med 1995;9(4):272–6.
37. Jones SL, Davis J, Rowlingson K. Ultrasonographic findings in horses with right dorsal colitis: five cases (2000-2001). J Am Vet Med Assoc 2003;222(9):1248–51.
38. Taintor J, Stewart AJ, Christmann U, et al. What is your diagnosis? Cecocolic intussusception. J Am Vet Med Assoc 2004;225(12):1829–30.
39. Valdes-Martinez A, Waguespack RW. What is your diagnosis? Cecocolic intussusception. J Am Vet Med Assoc 2006;228(6):847–8.
40. Lores M, Ortenburger AI. Use of cecal bypass via side-to-side ileocolic anastomosis without ileal transection for treatment of cecocolic intussusception in three horses. J Am Vet Med Assoc 2008;232(4):574–7.
41. Bell RJ, Textor JA. Caecal intussusceptions in horses: a New Zealand perspective. Aust Vet J 2010;88(7):272–6.
42. Martin BB Jr, Freeman DE, Ross MW, et al. Cecocolic and cecocecal intussusception in horses: 30 cases (1976-1996). J Am Vet Med Assoc 1999;214(1):80–4.
43. Boussauw BH, Domingo R, Wilderjans H, et al. Treatment of irreducible caecocolic intussusception in horses by jejuno(ileo)colostomy. Vet Rec 2001;149(1):16–8.
44. Korolainen R, Ruohoniemi M. Reliability of ultrasonography compared to radiography in revealing intestinal sand accumulations in horses. Equine Vet J 2002;34(5):499–504.
45. Conwell RC, Hillyer MH, Mair TS, et al. Haemoperitoneum in horses: a retrospective review of 54 cases. Vet Rec 2010;167(14):514–8.
46. Dechant JE, Nieto JE, Le Jeune SS. Hemoperitoneum in horses: 67 cases (1989-2004). J Am Vet Med Assoc 2006;229(2):253–8.
47. Pusterla N, Fecteau ME, Madigan JE, et al. Acute hemoperitoneum in horses: a review of 19 cases (1992-2003). J Vet Intern Med 2005;19(3):344–7.
48. Arnold CE, Chaffin MK. Abdominal abscesses in adult horses: 61 cases (1993-2008). J Am Vet Med Assoc 2012;241(12):1659–65.
49. Del Piero F, Summers BA, Cummings JF, et al. Gastrointestinal stromal tumors in equids. Vet Pathol 2001;38(6):689–97.
50. East LM, Savage CJ. Abdominal neoplasia (excluding urogenital tract). Vet Clin North Am Equine Pract 1998;14(3):475–93, v–vi.
51. Elce YA. Infections in the equine abdomen and pelvis: perirectal abscesses, umbilical infections, and peritonitis. Vet Clin North Am Equine Pract 2006;22(2):419–36, ix.

52. Hafner S, Harmon BG, King T. Gastrointestinal stromal tumors of the equine cecum. Vet Pathol 2001;38(2):242–6.
53. Magee AA, Ragle CA, Hines MT, et al. Anorectal lymphadenopathy causing colic, perirectal abscesses, or both in five young horses. J Am Vet Med Assoc 1997;210(6):804–7.
54. Pusterla N, Whitcomb MB, Wilson WD. Internal abdominal abscesses caused by Streptococcus equi subspecies equi in 10 horses in California between 1989 and 2004. Vet Rec 2007;160(17):589–92.
55. Reuss SM, Chaffin MK, Schmitz DG, et al. Sonographic characteristics of intra-abdominal abscessation and lymphadenopathy attributable to Rhodococcus equi infections in foals. Vet Radiol Ultrasound 2011;52(4):462–5.
56. Taylor SD, Pusterla N, Vaughan B, et al. Intestinal neoplasia in horses. J Vet Intern Med 2006;20(6):1429–36.
57. Scott EA, Heidel JR, Snyder SP, et al. Inflammatory bowel disease in horses: 11 cases (1988-1998). J Am Vet Med Assoc 1999;214(10):1527–30.
58. Pratt SM, Spier SJ, Carroll SP, et al. Evaluation of clinical characteristics, diagnostic test results, and outcome in horses with internal infection caused by Corynebacterium pseudotuberculosis: 30 cases (1995-2003). J Am Vet Med Assoc 2005;227(3):441–8.
59. Ehnen SJ, Divers TJ, Gillette D, et al. Obstructive nephrolithiasis and ureterolithiasis associated with chronic renal failure in horses: eight cases (1981-1987). J Am Vet Med Assoc 1990;197(2):249–53.
60. Schott HC. Hematuria. In: Robinson NE, editor. Current therapy in equine medicine. Philadelphia: W. B. Saunders Company; 1997. p. 489–91.
61. Schumacher J, Schumacher J, Schmitz D. Macroscopic hematuria of horses. Equine Vet Educ 2002;14(4):201–10.
62. Diaz OS, Smith G, Reef VB. Ultrasonographic appearance of the lower urinary tract in fifteen normal horses. Vet Radiol Ultrasound 2007;48(6):560–4.
63. Johnston JK, Divers TJ, Reef VB, et al. Cholelithiasis in horses: ten cases (1982-1986). J Am Vet Med Assoc 1989;194(3):405–9.
64. Peek SF, Divers TJ. Medical treatment of cholangiohepatitis and cholelithiasis in mature horses: 9 cases (1991-1998). Equine Vet J 2000;32(4):301–6.
65. Reef VB, Johnston JK, Divers TJ, et al. Ultrasonographic findings in horses with cholelithiasis: eight cases (1985-1987). J Am Vet Med Assoc 1990;196(11):1836–40.
66. Carlson KL, Chaffin MK, Corapi WV, et al. Starry sky hepatic ultrasonographic pattern in horses. Vet Radiol Ultrasound 2011;52(5):568–72.
67. Marr CM, Reef VB, Brazil TJ, et al. Aorto-cardiac fistulas in seven horses. Vet Radiol Ultrasound 1998;39(1):22–31.
68. Sleeper MM, Durando MM, Miller M, et al. Aortic root disease in four horses. J Am Vet Med Assoc 2001;219(4):491–6, 459.
69. Santschi EM, Juzwiak JS, Moll HD, et al. Diaphragmatic hernia repair in three young horses. Vet Surg 1997;26(3):242–5.
70. Firth EC. Diaphragmatic hernia in horses. Cornell Vet 1976;66(3):353–61.