Review of the Use of Transabdominal Ultrasonography to Distinguish Small Intestinal Lesions Resulting in Acute Colic

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In addition to a complete physical examination, transabdominal ultrasonography is an effective way to distinguish small intestinal lesions in mature horses presenting with acute abdominal pain. Typically, efficient localized transabdominal ultrasonography can be completed in less than 15 minutes in the acute abdomen patient. In addition to a complete physical examination and ancillary diagnostic findings such as a leukogram and results of an abdominocentesis, the ultrasonographic appearance of small intestinal contents, degree of distension, motility, and wall thickness can be used collectively to improve the accuracy of diagnosis of small intestinal disease. Progressive distension to turgid, round, and amotile loops of small intestine more likely indicates the need for surgical intervention. Author’s address: University of Georgia, 201 DW Brooks Drive, Athens, GA 30602; e-mail: bartonmh@uga.edu. © 2012 AAEP.

1. Introduction

The availability of affordable, reliable, and portable ultrasound equipment makes it possible to perform transabdominal ultrasonography in both the field and hospital setting. Although it is not a replacement for a complete physical examination nor a panacea for diagnosis in all cases, transabdominal ultrasonography can be a particularly useful ancillary tool for distinguishing causes of acute abdominal pain associated with a small intestinal anatomic etiology. This report will review how to use transabdominal ultrasonography to distinguish inflammatory lesions (enteritis), from nonstrangulating obstructive lesions, from strangulating lesions of the small intestine in adult horses with acute onset of abdominal pain. This presentation will use computer generated three-dimensional images from the Glass Horse Project to illustrate key points.

2. Technique

Most imaging of the adult horse’s abdomen can be completed with a 2- to 5-MHz curvilinear array transducer. Ideally, before ultrasonography, the patient’s hair should be clipped with a No. 40 blade, and the skin should be cleansed with isopropyl alcohol and couplant gel should be applied. If clipping the hair is not an option, soaking the hair with water or isopropyl alcohol will often suffice. Many horses will tolerate transabdominal ultrasonography without sedation. If sedation is needed, α2 agonists, such as xylazine and detomidine, will induce a transient state of ileus, and thus intestinal motility may be reduced and the luminal diameter of the small intestine may appear more dilated than in a patient that is not sedated. Normally, the jejunum can be seen contracting 6 to 15 times per minute. The effect of sedation on small intestine...
motility is both dose- and time-dependent, with higher doses more profoundly reducing contractions for up to an hour.

3. Normal Ultrasonographic Anatomy of Small Intestine

Just as the small intestine should be difficult if not impossible to feel on rectal examination of the healthy mature horse, the small intestine should be difficult to visualize by transabdominal ultrasonography in normal horses. In one study in healthy horses, it was reported that small intestine could only be identified in about one third of the subjects. Difficulty in locating small intestine is due in part to its small diameter and often collapsed lumen. Only when a peristaltic wave generates transient expansion of the lumen from movement of fluid contents can small intestine be confidently identified. Furthermore, the presence of gas and fluid mixed ingesta in adjacent large intestine or cecum often obscures easy identification of small intestine.

The position of the duodenum is fixed by its suspending mesoduodenum. It can reliably be found descending the right middle abdomen at about the level of the shoulder and is located between the liver and the right dorsal colon, where it can be imaged transversely between ribs where it will appear in its short axis (Fig. 1A). Patience must be exercised when looking for the descending duodenum because one must wait for a peristaltic contraction to deliver ingesta, thereby distending the lumen. Otherwise, the duodenum appears as a flattened and ill-defined hyperechoic curvilinear shape adjacent to the right dorsal colon (Fig. 1B). When a peristaltic wave of ingesta passes through the lumen, the entire diameter of the duodenum can often be seen as an oval to circular structure. The wall of the duodenum is typically less than 3 mm in thickness (serosa to mucosa). Using a 2- to 5-MHz transducer, it is difficult to distinguish the individual layers of the small intestinal wall. However, if a high-frequency probe is used, five distinct ultrasonographic layers to the duodenal wall may be apparent in regions where the ultrasound beam is aligned perpendicular to the intestinal wall and include (1) hyperechoic serosa, (2) hypoechoic muscularis, (3) hyperechoic submucosa, (4) hypoechoic mucosa, and (5) hyperechoic mucosal-lumen interface. When ingesta flows through the duodenum, gas-fluid contents often create a dirty acoustic shadow that may preclude visualization of the distal wall (Fig. 2B). In healthy horses, it would be unusual for the entire duodenal diameter to exceed 4 cm during peristaltic propulsion of ingesta. The duodenum contracts between 1 to 4 times per minute in fed horses, though contractions will be reduced in anorexic, starved, or heavily sedated horses. The duodenum can be followed caudad to the 16th to 17th intercostal space ventral to the right kidney and dorsal or dorsolateral to the base of the cecum, wherein it crosses medially into the abdomen to become the jejunum (Fig. 2).

The large colon obstructs direct visualization of most of the small intestine. The jejunum is most reliably found in the left inguinal area, medial to the spleen and the left ventral colon (Fig. 3A). The jejunum has the most visible motility of any part of the gastrointestinal tract, with peristaltic waves producing rhythms contractions. The relative hyperechoic fluid content of the lumen enables distinction of the wall thickness (up to 3 mm) and visualization of the distal wall in either its long or short axis (Fig. 3B). Like the duodenum, up to five distinct layers of the jejunal wall are visible, but only with high-frequency probes. If gas is in the lumen, it casts an acoustic shadow that precludes visualization of the distal wall. In the normal horse, luminal diameters rarely exceed 3.5 cm and should be rhythmically contracting down to obscu-
Fasting and sedation with α2 agonists will individually and additively decrease motility of the small intestine, though fasting for at least 8 hours will increase the length of jejunum visible ultrasonographically. The medial location of the ileum precludes distinct identification.

4. Abnormal Findings

Ileus is disruption of the normal propulsive motility of the intestinal tract. Ileus of the small intestine of any etiology can result in distension of small intestine. For this reason, ultrasonographically, ileus is often referred to as creating an “obstructive pattern.” However, in its strictest definition, obstructive ileus infers that there is something mechanically in the way that literally obstructs the lumen, thereby causing distension. Mechanical ileus can be further divided into nonstrangulating obstructions in which the lumen is physically obstructed but the adjacent intestinal blood supply is intact, and strangulating obstructions, in which the lumen and the adjacent blood supply are both occluded. However, paralytic ileus can also cause luminal distension and the ultrasonographic ap-
pearance of an “obstructive” pattern, but it is from lack of motility in which there is no mechanical or structural problem. Paralytic ileus can be the result of electrolyte derangements (especially hypokalemia), increased sympathetic tone, medications (such as atropine, butylscopolamine, and α2 agonists), and inflammation (enteritis). Using a combination of clinical signs and some distinguishing ultrasonographic features, it can be possible to differentiate inflammatory lesions of the small intestine, from nonstrangulating obstructions from strangulating obstructions. In making these distinctions, several ultrasonographic parameters should be studied including the degree of distension (i.e., luminal diameter), motility, location, appearance of the luminal contents, and wall thickness.

Ultrasonographically, distended small intestine often looks the same, despite the etiology of paralytic or mechanical ileus. That is, various dilated (>3.5 cm) cross-sectional to longitudinal views of small intestinal of reduced motility can be readily found. Despite the etiology, as more small intestine becomes distended, it is easier to detect it transabdominally outside of the areas indicated above for finding normal duodenum or jejunum (Fig. 4). Likewise, despite etiology, as more small intestinal becomes distended, it will often fold back on itself, appearing ultrasonographically as hairpin or “U” turns in long axis (Fig. 5). The degree and duration of distension may ultimately be useful in distinguishing inflammatory and nonsurgical obstructive lesions of the small intestine from surgical lesions. That is, inflammatory and nonsurgical obstructive lesions of the small intestine will initially appear less turgidly circular and the degree of distension will dissipate with appropriate medical intervention, whereas surgical lesions of small intestine will become progressively less motile and more turgid. Furthermore, as loss of motility progresses, ingesta may appear more hyperechoic as denser portions settle dependently in the lumen of amotile segments (Fig. 6).

5. Enteritis
Proximal or anterior enteritis refers to an acute hemorrhagic and suppurative inflammation of the small intestine of unknown etiology. In addition to the clinical signs and ancillary diagnostic findings of

Fig. 4. This image was obtained from an afebrile horse with an ileal impaction and was obtained in the left lower flank with a 3.5-MHz curvilinear transducer displayed to a depth of 17 cm. The left of the image is dorsal. Note at least three turgidly round loops of small intestine that were proximal to the obstruction that displaced the spleen medially off the left body wall. The loops are distended with hypoechoic fluid and the walls of the distended loops are normal thickness and thus appear as single hyperechoic circles. In real time, these affected segments had reduced motility (<6 contractions per minute).

Fig. 5. This image was from a horse with simple obstruction of small intestine and was obtained in the left lower flank with a 3.5-MHz curvilinear transducer displayed to a depth of 15 cm. The left of the image is dorsal. Note the “hair pin” or “U” turn appearance of this longitudinal segment.

Fig. 6. This image was from a 25-year-old afebrile horse with a pedunculated lipoma that strangulated 1 foot of jejunum and was obtained in the left lower flank with a 3.5-MHz curvilinear transducer displayed to a depth of 12 cm. The left of the image is dorsal. The white arrow marks the serosal surface of the strangulated loop and the red arrow marks the mucosal surface. The affected marked segment was amotile, with uniformly thickened walls and contained dependently settled ingesta.
proximal enteritis (low-grade fever, excessive and persistent gastric reflux, inflammatory leukogram, pain followed by leathargy after gastric decompression), transabdominal ultrasonography may reveal that the proximal portions of the small intestine, especially the duodenum (Fig. 7) and the stomach are symmetrically distended with fluid. The motility of small intestine may vary from low to apparently no movement to hypermotile.° The degree of distension depends on the severity and duration of the inflammation, but turgid distension with complete lack of peristalsis are atypical of enteritis.° With appropriate medical intervention, the degree of distension should dissipate and motility should improve. Although in milder cases of enteritis the intestinal wall may appear normal, a classic ultrasonographic sign of enteritis is a thickened (>3 mm), irregular or “wavy” appearance to the mucosa that resembles the edge of a lasagna noodle (Figs. 8 and 9). Often the layers of the thickened, inflamed small intestine appear more distinct. If hyper-echoic gas echoes are seen within the wall of the small intestine, it is indicative of either necrosis or anaerobic infection (clostridium) and is a poor prognostic sign.

6. Obstructive (Nonstrangulating) Lesions
Examples of nonstrangulating lesions of the small intestine of the mature horse include ileal impaction, mural and extramural masses, displaced colon compressing small intestine, and adhesions. Here, the combination of clinical signs (persistent pain, lack of fever, lack of sanguineous peritoneal fluid, normal leukogram) may be helpful in distinguishing the simple nonstrangulating obstruction from enteritis and strangulating obstructions. Ultrasonographically, the intestine proximal to the obstruction will be distended with either gas or fluid, and post-obstruction intestinal will appear compressed. The degree of distension and motility vary with the extent of obstruction, though progressive distension of pre-obstruction segments of small intestine is consistent with the likely need for surgical intervention.° With complete obstructions, the distended proximal loops will often be seen to have a “hair-pin” appearance, as distended loops of bowel stack upon each other and ingesta will settle into the dependent portions of amotile segments (Figs. 4 and 5). An important ultrasonographic feature of nonstrangulating obstructions is that the walls of the affected intestine typically appear uniformly normal. In other words, unless the obstruction is complete and long-standing, the walls of the small intestine usually remain <3 mm thick.

7. Strangulating Obstructions
In addition to progressive pain with poor response to analgesics, lack of fever, a normal leukogram, and
serosanguineous peritoneal fluid are clinical features that distinguish strangulating lesions of the small intestine from simple obstructions and enteritis. As with obstructive lesions of small intestine, ultrasonographically, the intestine proximal to strangulating obstructions will be distended with either gas or fluid and post-stenotic intestinal will appear compressed. Likewise, the degree of distension and motility vary with the duration of strangulation, though progressive distension of pre-obstruction segments to turgidly circular and completely amotile loops of small intestine is most typical of strangulating lesions (Fig. 10A). An important distinguishing feature of strangulated small intestine is the appearance of focally and usually uniformly thickened walls at the site of the strangulation (Figs. 6, 10B, and 10C). Thus, when regional uniformly thickened small intestine is identified ultrasonographically, with other evidence of obstruction (hypomotile, U-turn stacks of turgidly round and distended loops of small intestine), a strangulating obstruction should be the top consideration. Frequently the strangulated loops are identified in the ventral portions of the abdomen. In one study, focally thickening and distended small intestine with no motility was 100% sensitive and specific for strangulation. Also bear in mind that most obstructive and strangulating lesions of the equine small intestine involve the distal jejunum and ileum. If the affected segments are most readily visualized adjacent to the spleen and stomach on the left or between the liver and right dorsal colon on the right, these respective locations are areas in which gastro-splenic and epiploic incarcerations are readily found.

Fig. 10. A, This image was obtained at the left 16th intercostal space at level half way between the olecranon and the shoulder. The turgid round loops of small intestine distended to between 5 to 7 cm with hypoechoic fluid is typical of areas proximal to mechanical obstruction. This image was obtained with a 3.5-MHz curvilinear transducer displayed to a depth of 21 cm. The left of the image is dorsal. B, Areas of strangulated small intestine (in this image depicted as a focal volvulus and marked by black arrows) are typically thickened as vascular compromise leads to mural edema. C, This image was obtained at the left 12th intercostal space at the level of the shoulder with a 3.5-MHz curvilinear transducer displayed to a depth of 21 cm in a horse with a gastro-splenic entrapment of small intestine. Note the two loops of distended and uniformly thickened walls of small intestine between the stomach and the spleen. The left of the image is dorsal. The more ventral loop is distended to almost a 6 cm diameter. This image was obtained from the same patient as panel A, showing the prestrangulated distended loops. The combination of the findings in panels A and C in the same patient with mildly sanguineous peritoneal fluid provided strong evidence of a strangulating small intestinal lesion.

Fig. 11. Ultrasonographic appearance of an intussusception. The numbers 1 and 2 are in the lumen of pre-obstructed segments of small intestine. The lumens are distended with hypoechoic fluid contents and these pre-obstructed loops have normal walls that appear as single thin hyperechoic walls. The white arrows mark the serosal surface of the outer intussusceptum and the red arrows mark the serosal surface of the inner intussciptiens. The walls of both the intussusceptum and intussciptiens are thickened, typical of a wall at the location of a strangulating lesion. This image was obtained in the left ventral flank with a 3.5-MHz curvilinear transducer displayed to a depth of 12 cm. The left of the image is rostral.
Finally, intussusceptions of the small intestine are most common in foals and young horses and have a characteristic “bull’s-eye” or target lesion appearance when imaged across the short axis of the small intestine (Fig. 11). The intussuscepted intestine tends to fall toward the dependent portion of the abdomen. Like other obstructive diseases, the proximal small intestine will be distended, with reduced motility and hairpin turns, depending on the degree of obstruction, and the patient may present with either chronic intermittent signs (incomplete obstruction) or acute intense signs (complete obstruction).

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References and Footnote

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