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Ultrasound techniques for the field practitioner: Emphasis on neonate

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Scanning technique
Ultrasoundographic examination of the thorax and abdomen of foals has been well described. (Reef 1998, Reimer 1998) The highest frequency transducer that penetrates to the area of interest should be used and the smallest depth of field necessary should be displayed. Many field practitioners will have a 5 – 7.5mHz Linear transducer available and this will suffice for most examinations in foals.

In many field situations it is adequate to apply isopropyl alcohol after ensuring that the coat is clean to provide surface contact between the transducer and the foal. The alcohol helps to reduce the intervening trapped air. This produces an inferior image than clipping and the use of ultrasound coupling gel, but in many instances extensive clipping is not tolerated by the owner.

Umbilical remnants
The umbilical vein is located along the midline from the external umbilicus to the liver and becomes the round ligament of the liver. The umbilical arteries course caudally from the external umbilical remnant and become the round ligaments of the bladder. They are thick walled and commonly contain an echogenic clot. The urachus retracts after birth and becomes the median ligament of the bladder. In the normal foal it contains no fluid. Anechoic fluid within the urachus that is continuous with the bladder apex and external umbilicus is indicative of a patent urachus.

<table>
<thead>
<tr>
<th>Umbilical vein</th>
<th>Umbilical artery</th>
<th>Umbilical arteries and urachus at apex of bladder</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;1cm</td>
<td>&lt;1.3cm</td>
<td>&lt;2.5cm</td>
</tr>
<tr>
<td>most prominent enlargement at or near the external umbilical remnant</td>
<td>Usually largest just caudal to the external umbilical remnant or at the apex of the bladder.</td>
<td>Near the external umbilical remnant</td>
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</table>

Enlargement of any of the internal remnant structures, with the detection of intraluminal fluid, indicates the presence of infection. Longstanding infections may become walled off and appear as encapsulated abscesses. Identification of infection of any of the internal umbilical remnants should be followed by careful examination of adjacent organs.

Urinary Bladder
Ultrasound is extremely useful in detecting uroabdomen associated with defects of the bladder wall or urachus. (Kablack et al 2000) The ultrasound image obtained shows free peritoneal fluid. The volume and character of the fluid vary depending on the time course involved. The gastrointestinal viscera are seen floating in the abdominal fluid and the urinary bladder can also be imaged floating in the fluid. Depending on the size and location of the defect the bladder may contain anechoic urine or be collapsed and folded upon itself.
Kidneys
The renal pelvis and calices are hyperechoic, the renal cortex is hypoechoic in relation to the renal calices and the renal medullary pyramids are relatively anechoic, allowing for a prominent corticomedullary junction. Renal hypoplasia is recognized as a smaller than normal kidney and can be unilateral or bilateral. Renal dysplasia is recognized ultrasonographically as misshapen, hyperechoic kidneys with decreased corticomedullary demarcation. Renal agenesis should be considered when a kidney cannot be found in a normal or ectopic location.

Liver
Septicemia in foals may result in bacterial hepatitis via hematogenous inoculation with an ultrasonographic appearance of multiple small areas of increased echogenicity scattered throughout the hepatic parenchyma. Cholangiohepatitis has been reported in foals as a sequela of gastroduodenal ulceration. Thickening of the bile ducts with echogenic material imaged within the biliary tree is indicative of cholangiohepatitis.

Spleen
Splenic abnormalities are rare in foals. Trauma resulting in a splenic hematoma and/or hemoabdomen may occur.

Gastrointestinal viscera
Abdominal disorders are common in the neonatal period and thorough evaluation of the gastrointestinal tract should be performed in all foals with signs referable to the gastrointestinal tract or in those with non specific signs. The stomach is located medial to the spleen in the mid to ventral abdomen between the 6th and 12th ICS on the left side. In foals less than 7 days, luminal contents are visible. In older foals the presence of gas prevents imaging of the gastric contents and at this stage the foal’s stomach resembles that of an adult with a large curvilinear echo medial to the spleen and caudal to the liver. Distention of the stomach may be pronounced and easily detected with small intestinal obstructions and gastroduodenal ulcers. The small intestine can be visualized in a larger area of the abdomen in young foals compared with adults. The small intestine has a hypoechoic wall and its lumen is easily observed. The duodenum is visualized between the ventral and caudal aspect of the liver and the dorsal margin of the right dorsal colon. It can also be seen ventral to the caudal pole of the right kidney and dorsal to the cecal base. The large intestine is recognized by its larger diameter and sacculated appearance. The lumen of the large intestine is not normally visualized due to the presence of gas.

Small intestinal disorders
Small intestinal disorders are common in foals and range from congenital defects such as scrotal/inguinal hernias and Meckel’s diverticulum to enteritis, ascarid impaction, volvulus, intussusception or abdominal abscesses.

Intussusception: The use of ultrasound to detect intussusceptions in foals is well reported with a characteristic “bull’s eye” or “target” sign being obtained by scanning through the apex of the intussusception where the intussusceptum is surrounded by fluid and the intussuscipiens.
Small intestinal volvulus/obstruction: Fluid filled, amotile small intestine with thicker than normal walls is suggestive of a small intestine volvulus. The degree of wall thickness increases with the passage of the time.

Ileus: Sonographic examination of foals with ileus usually reveals bowel with an increased diameter and little if any peristaltic activity.

Enteritis: The sonographic appearance of enteritis is variable but fluid filled hypermotile bowel is usually present. Intestinal wall thickness is also variable but is generally symmetric. Gas echoes may also be imaged in the wall of the affected intestine and is more common with *C. perfringens* type C infection and is considered a poor prognostic indicator.

Duodenitis: Duodenitis frequently accompanies enteritis regardless of the cause. Thickening of the duodenal walls and distention of the duodenal lumen are frequent sonographic findings. Fibrosis resulting from severe ulceration may lead to pyloric or duodenal strictures. Such cases demonstrate gastric distention and there may be a lack of normal duodenal motility evident during the sonographic examination.

Umbilical hernia
Ultrasoundography is used in addition to digital palpation to determine the size of the defect. The contents of the hernial sac (fluid, omentum or intestine) and the presence of concurrent internal umbilical or subcutaneous infection can also be assessed ultrasonographically. Strangled ileum (most common) or jejunum has a thickened, edematous wall with decreased or absent motility.

Abdominal abscesses
Abdominal abscesses in foals are commonly associated with *Rhodococcus equi* or *Streptococcus equi* infections. Unilocular or multilocular abscesses can be seen and are often imaged at or near the ventral abdominal wall, when the weight and size of the abscess cause it to displace ventrally. Such abscesses often have extensive adhesions to small and large intestine when identified.

Meconium impaction
Meconium impactions are readily diagnosed with ultrasonography. Meconium is normally imaged as an echogenic ball or log shaped structure within the terminal small colon. Meconium in the large colon has a more variable appearance from large hypoechoic to echogenic masses and is often surrounded by fluid.

Large intestine disorders
Large colon displacements or torsions are uncommon in foals and are difficult to diagnose ultrasonographically. The gas filled mucosal surface of the large intestine adjacent to the body wall is generally all that can be imaged. Thickening, congestion or edema of the bowel wall may occasionally be detected.

Thorax
Ultrasoundographic evaluation of the thorax is frequently performed in foals. There are many notable advantages over radiography with perhaps the most notable exception being failure to detect lung lesions that lack peripheral lung involvement. However, post-mortem studies have shown that frequently encountered lesions in foals have a high percentage of
peripheral lung involvement. After preparation of the area the thorax is thoroughly scanned in a dorsal to ventral plane from the 16th to the 3rd intercostal space.

Sound waves are completely reflected at the normal aerated lung interface, allowing only the pleura surface to be evaluated. Therefore, the normal visceral pleural edge of the lung appears as a straight hyperechoic line with characteristic equidistant reverberation air artifacts that indicate normal aeration of the pulmonary periphery. It is critical to examine the lung carefully during exhalation and inhalation, because lesions can move beneath an adjacent rib or the inhaled air into the alveoli. Surrounding airways will cause reflection of the sound waves and thereby prevent the visualization of pulmonary disease.

**Pleural effusion**

This is represented echographically as an anechoic space between the lung, thoracic wall, diaphragm and heart. In foals it is most commonly associated with pneumonia or lung abscesses. The echogenicity of the fluid is a reflection of its cellular content. Fibrin may be detected in pleural effusions and has a filamentous hypoechoic appearance. With time it becomes deposited in layers on the visceral and parietal pleural surfaces.

**Comet tails and pulmonary consolidation**

The accumulation of fluid or cellular debris in lung adjacent to the thoracic wall creates an acoustic window. The affected area of lung is hyperechoic and lacks the normal air echo at the surface. The earliest sign of consolidation may be a dimpling or irregularity of the visceral pleural surface. Comet tail artefacts radiate from these nonaerated areas. It is important to bear in mind that comet tails themselves are not diagnostic of a specific condition and may be found associated with a wide range of pleural or pulmonary conditions and indeed may even represent scarring from previous disease.

**Pulmonary abscesses**

Pulmonary abscesses are variable in size and are located anywhere in the lung. Abscesses are identified ultrasonographically in the lung by their cavitated appearance and the absence of normal pulmonary structures within the abscess. The center may appear hypoechoic, isoechoic, or septate, depending on the type of fluid present.

**References**


