Ultrasonography has gained acceptance in veterinary medicine as a valuable diagnostic imaging modality. The primary advantage of ultrasonography is that it can noninvasively image structural or architectural parenchymal abnormalities. Although radiography can determine organ outline and therefore organ size and shape, ultrasound's unique ability to image the internal structure of an organ makes it a valuable imaging modality. The inherent capability of ultrasonography to image internal parenchymal architecture also means that it is better at detecting the focal lesions that involve or displace normal architecture. The diffuse parenchymal abnormalities that may only alter the relative echogenicity of an organ's parenchyma may be subtle and more difficult to detect than the focal lesions.

Focal parenchymal lesions involving an organ may be solitary or multiple, solid and homogeneous, heterogeneous, or cavitated. The more numerous the lesions and the greater their heterogeneity, destructiveness, or displacement of normal parenchyma, the easier it is for ultrasound and the ultrasonographer to detect the abnormality. Lesion detection is only one in a series of steps employed in constructing an accurate list of ultrasonographic differential diagnoses. The objectives of this article are to describe the ultrasonographic structural characteristics of abdominal cavitary lesions and to produce an accurate list of differential diagnoses using these characteristics and the organ(s) involved.

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CAVITARY LESION CLASSIFICATION

A cavity is defined as a potential space or hollow space in a body or organ. Cavities may be normal (e.g., the peritoneal cavity or urinary bladder) or may represent a pathologic process. In the context of this article, cavities are considered to be abnormal collections of fluid or gas in parenchymal organs or body spaces. These cavitary lesions may be congenital or acquired. Congenital collections of fluid are more likely to be contained in a cyst, which is a closed cavity or sac lined by epithelium. Acquired cavitary lesions are fluid collections in inflammatory, vascular, degenerative, neoplastic, and pseudocystic lesions.

THE ROLE OF RADIOGRAPHY

Although this article deals with the ultrasonographic diagnosis of cavitary parenchymal lesions, the important role of survey radiographs must be emphasized. Survey radiographs allow a global view of abdominal organ size and shape. Small cavitated lesions such as liver cysts cause no radiographically perceivable alteration of organ size and shape and therefore go undetected. Large cavitated lesions may produce a mass effect, resulting in irregular organ enlargement and displacement of adjacent structures. With extremely large masses, the organ of origin may be difficult to determine. Because the radiopacity of soft tissue and fluid is identical, the internal soft tissue or fluid composition of the mass cannot be ascertained radiographically. Only when a soft tissue mass contains focal radiolucent regions compatible with gas can it be inferred that the mass is cavitated. A horizontal beam radiograph can then be obtained to detect a straight line fluid-gas interface.

THE ROLE OF ULTRASONOGRAPHY

As previously stated, the foremost advantage of ultrasonography is its ability to define the parenchymal structure of an organ in addition to its size and shape. The greatest shortcoming of ultrasonography is the lack of tissue specificity; that is, the ultrasound characteristics of a lesion rarely provide a histopathologic-type diagnosis. In order to provide as accurate a diagnosis as possible, the ultrasonographer must therefore pay particular attention to the appearance of both the cavitary lesion and the surrounding parenchyma. Ultrasound is used to determine the organ or organs involved and the number of lesions. The lesion’s size, shape, and outer border definition; the cavity’s border characteristics; and the echogenicity of the cavity’s contents should be ascertained. Normal cavities such as the fluid-filled stomach must be differentiated from true cavitated lesions. Finally, the ultrasonographic abnormalities must be correlated with the history, clinical signs, physical examination findings, and clinical laboratory results.
IMPORTANT ULTRASOUND ARTIFACTS

An understanding of the physical laws of sound beam propagation in tissue is necessary to interpret ultrasound images accurately. This understanding is critical with ultrasound imaging of cavitated lesions. The complex nature of cavitary lesions may produce abnormal sound beam attenuation, resultant image artifacts, and erroneous interpretations. By understanding image artifact production, an ultrasonographer can use artifact presence diagnostically to more accurately assess cavitary lesion shape and internal structure.

Acoustic Shadow Artifact

An acoustic shadow appears as an anechoic band deep to bone or gas-containing structures and occurs because the reflection amplitude of the sound beam is reduced deep to these two strongly reflecting or attenuating structures. Bone and other mineralized structures cause an anechoic shadow because they absorb 70% to 80% of the sound beam; only the remaining portion of the beam is reflected. Gas reflects 99% of the beam, resulting in an acoustic shadow. "Clean" sharp-edged shadowing or "dirty" shadowing with hazy indistinct borders depends on the reflecting surface properties. Clean shadows result from rough-surfaced or small-radius objects composed of bone or other mineral(s). Gas usually results in a dirty shadow containing reverberation echoes.

Edge Shadowing Artifact

Edge shadowing appears similar to an acoustic shadow but occurs deep to the edge of curved surfaces of round or oval structures. When the sound beam strikes the curved surface, the beam is refracted as its velocity changes with passage from normal through abnormal tissue. The refracted portion of the beam broadens or becomes more diffuse, beam intensity decreases, and a hypoechoic or anechoic shadow results deep to the curved surface.

Acoustic Enhancement Artifact

Acoustic enhancement is characterized by a hyperechoic zone, or a relative increase in the reflected sound beam amplitude deep to nonattenuating fluid-filled structures. Although characteristically seen deep to fluid-filled structures, acoustic enhancement may also be seen deep to other weakly attenuating structures such as inflamed or neoplastic lymph nodes. Acoustic enhancement is best seen when imaging fluid-filled structures in the focal zone of high-frequency transducers.
Section Thickness Artifact

The section thickness artifact is caused by the finite thickness of the ultrasound beam width perpendicular to the scan plane.\textsuperscript{29} Echoes displayed in the image result from both the center and edges of the beam. When scanning the curved wall of a round or oval structure, echoes from the wall are displayed in the anechoic fluid. Anechoic fluid may therefore appear to contain particulate material or a cystic object may actually appear to be solid.\textsuperscript{29} Such false debris within a cyst may be recognized by the lack of a horizontal line between the fluid and debris or by echoes occurring in the nondependent portion of the structure.\textsuperscript{25}

Side Lobe Artifact

Similar to the section thickness artifact, the side lobe artifact produces false echoes in an anechoic fluid-filled structure.\textsuperscript{25, 29} Side lobes are normal, multiple, weak sound beams directed to the side of the central ultrasound beam. When the weak side lobes strike either a curved reflecting surface or a highly reflective gas interface, detectable echoes are produced and displayed along the central beam at the same depth as the reflector.\textsuperscript{25} The side lobe artifact is most evident in an anechoic structure such as the urinary bladder; adjacent bowel gas produces side lobe echoes which are then displayed within the bladder and may mimic urine debris in the bladder.\textsuperscript{25}

Reverberation Artifact

Reverberation of the ultrasound beam is characterized by multiple, evenly spaced, hyperechoic foci deep to a highly reflective interface.\textsuperscript{25, 29} Reverberation usually results from gas; the high-amplitude reflections from gas striking the transducer reflect back into the body and create evenly spaced, deeper, hyperechoic foci similar in shape to that of the original reflector.

Comet Tail Artifact

The comet tail artifact is a form of reverberation in which a series of tightly spaced discrete echoes appear deep to a highly reflective interface.\textsuperscript{25, 29} This artifact is more likely to result with reverberations arising from metallic objects.\textsuperscript{25}
Ring Down Artifact

The ring down artifact is similar to a comet tail artifact, and the two are often confused. The ring down artifact appears as a solid echogenic streak deep to a highly reflective interface. This artifact usually occurs deep to gastrointestinal gas but is also seen with biliary or abscess gas. This artifact is actually caused by resonance of bugle-shaped fluid collections trapped between two gas bubbles.

ULTRASONOGRAPHIC APPEARANCE OF CAVITARY STRUCTURES

Although ultrasonography is sensitive for detecting focal parenchymal alterations of organ architecture, the ultrasonographic appearance of a lesion lacks tissue specificity. There is no reported pathologic classification scheme for cavitary lesions; however, based on their ultrasonographic appearance, they are best divided into cystic and noncystic lesions. The ultrasonographic appearance of a smooth-walled, round, anechoic collection of fluid is distinctive of a cyst. Noncystic cavitary lesions generally result from fluid collections associated with necrosis and hemorrhage. Abscesses, hematomas, and neoplasms may be indistinguishable ultrasonographically or may have only subtle differences. For instance, abscesses vary not only in appearance but may appear similar to hematomas. It is therefore unreasonable to expect the ultrasonographic appearance to provide enough characteristic information for a specific tissue diagnosis. Despite the nonspecific ultrasonographic appearance of a majority of cavitary lesions, careful attention to the lesion’s characteristics may permit an accurate assessment of its composition and content. The tables cited in the following sections present published information on the multitude of differential diagnoses for abdominal cavitary structures.

Normal and Artifactual Cavitary Structures

When performing an abdominal ultrasound examination, several normal structures mimicking cavitary structures must be ruled out. Some of these normal structures are cavities filled with fluid, although others falsely appear to be cavitary lesions (Table 1). These normal structures are differentiated from cavitated lesions by their ultrasonographic appearance and location. For example, the normal gallbladder and urinary bladder are cystic structures. In cats, bilobed gallbladders have been reported as a normal variant. Bilobed gallbladders appear V-shaped with two separate bodies and funduses adjoining at a single neck. Transverse sections through normal portal veins, hepatic veins, or grossly dilated biliary ducts in hepatic parenchyma may mimic cysts. Rotating the transducer 90° produces a longitudinal image along the
Table 1. NORMAL AND ARTIFACTUAL CAVITARY STRUCTURES

<table>
<thead>
<tr>
<th>Cavity Type</th>
<th>Differential Diagnosis</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cystic</td>
<td>Rotating transducer 90° to view vessel longitudinally. Artery will pulsate.</td>
<td></td>
</tr>
<tr>
<td>Renal medullary false cyst⁴¹, ⁶²</td>
<td>Created by hyperechoic renal cortex and hypoechoic medullary papilla creating the illusion of medullary parenchymal cysts or hydronephrosis.</td>
<td></td>
</tr>
<tr>
<td>Gallbladder</td>
<td>May contain dependent inspissated bile. Rely on normal teardrop shape and location.</td>
<td></td>
</tr>
<tr>
<td>Bilobed gallbladder⁷⁰</td>
<td>Incidental finding in cats. Complete division at fundic region or internal longitudinal septum with two chambers.</td>
<td></td>
</tr>
<tr>
<td>Hepatic pseudomass⁶³</td>
<td>Created by right renal cranial pole in caudate lobe renal fossa. Cranial medullary papilla may appear as a cyst.</td>
<td></td>
</tr>
<tr>
<td>Hydronephrosis⁴¹</td>
<td>In transverse view, dilated renal pelvis may appear as a medullary cyst.</td>
<td></td>
</tr>
<tr>
<td>Bladder</td>
<td>Rely on normal location. Cellular debris in urine produces speckles or dependent sediment.</td>
<td></td>
</tr>
<tr>
<td>Gastrointestinal tract⁵⁷</td>
<td>Foreign body: report of homogeneous rubber ball appearing anechoic and mimicking fluid-filled structure.</td>
<td></td>
</tr>
<tr>
<td>Noncystic</td>
<td>Illusion of cavity produced by small amount of fluid or debris in lumen plus circumferential wall thickening.</td>
<td></td>
</tr>
<tr>
<td>Stomach</td>
<td>Gallbladder wall thickened (cholecystitis).</td>
<td></td>
</tr>
<tr>
<td>Gallbladder</td>
<td>Gallbladder wall thickened (cholecystitis).</td>
<td></td>
</tr>
<tr>
<td>Bladder⁸</td>
<td>Empty or thickened wall due to cystitis.</td>
<td></td>
</tr>
<tr>
<td>Intestines using transverse image plane</td>
<td>Dilated secondary to functional or mechanical ileus with luminal fluid or debris. Look for normal wall layering and motility. Rotate transducer 90° for longitudinal view.</td>
<td></td>
</tr>
</tbody>
</table>

length of the vessel or duct and differentiates these structures from cysts.⁴¹

The illusion of a renal medullary cyst or hydronephrosis can be created by an abnormally hyperechoic renal cortex causing the normally hypoechoic medullary papilla to appear anechoic.⁶¹ The same effect by an abnormally hyperechoic right renal cortex may result in an apparent mass in the adjacent caudate liver lobe.⁶³ This hepatic pseudomass may appear as a hypo-, iso-, or hyperechoic mass with an anechoic center.⁶³ True renal pelvic dilation seen in the transverse scan plane orientation can appear similar to a medullary cyst.¹⁸, ³¹

The appearance of noncystic cavitary lesions can be created by transverse scan sections through the normal stomach containing a small
amount of luminal fluid. Irregular thickening of the urinary bladder or gallbladder wall encircling a small amount of urine or bile, respectively, may also mimic a noncystic cavitary lesion. These false lesions can be differentiated from true cysts and other cavitary lesions by imaging the structures using different scan plane orientations.

Cystic Cavitary Structures

A cyst is a well-defined epithelial-lined sac containing fluid or a semisolid material. Ultrasonographically, cysts appear as well-defined, thin-walled, generally spherical or ovoid structures (Figs. 1, 2). They may be solitary or multiple and may vary in size. The cystic fluid is typically serous in nature and therefore appears anechoic. Some cystic content appears hypoechoic due to inflammatory, necrotic, or hemorrhagic cellular debris in the fluid. The cyst may be divided by internal septa which will appear as distinct, thin, hyperechoic bands traversing the anechoic fluid. Two ultrasound beam artifacts are generally created by cysts and are used diagnostically. First, cysts are characterized by acoustic enhancement of the cyst far wall and tissue deep to the cystic structure, and second, the curved walls of the cyst produce ultrasound beam refraction and hypoechoic or anechoic edge shadows.

The presence of a solitary cyst in an organ is typically an incidental and insignificant finding (Tables 2, 3). Solitary cysts generally are considered to be congenital in origin. For example, intrahepatic congenital cysts originate from embryonic bile ducts; however, rather than

Figure 1. Longitudinal sonogram of the right kidney (white arrowheads) obtained with a convex 4-7 MHz transducer. There was an anechoic cyst approximately 2 cm in diameter involving the caudal pole. The well-defined, thin-wall cyst was also characterized by anechoic fluid content, deep acoustic enhancement (black arrowheads), and hypoechoic edge shadowing (open arrows) bordering both sides of the deep acoustic enhancement.
# Table 2. LIVER AND SPLEEN CAVITARY LESIONS

<table>
<thead>
<tr>
<th>Organ-Cavity Type</th>
<th>Differential Diagnosis</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cystic liver</strong></td>
<td><strong>Small hepatic cysts</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(biloma)¹⁴</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Large biliary pseudocyst</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hepatobiliary cystadenoma (cats)⁵⁹</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Polycystic renal disease (cats)⁶¹</td>
<td></td>
</tr>
<tr>
<td><strong>Noncystic liver</strong></td>
<td><strong>Abscess</strong>¹⁵, ²⁰, ²⁷, ⁴⁰</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hematoma⁴⁰</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nodular hyperplasia³⁵, ⁵⁶</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hemangiosarcoma⁴⁰</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Primary/metastatic neoplasia⁶⁴</td>
<td></td>
</tr>
<tr>
<td><strong>Noncystic spleen</strong></td>
<td><strong>Hematoma</strong>²¹, ⁶⁶</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Infarction²², ²⁸, ⁵²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abscess⁴¹</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hemangiosarcoma⁶⁷</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lymphosarcoma³², ⁶⁸</td>
<td></td>
</tr>
</tbody>
</table>

**Small, cysts of variable size and number. Incidental findings.**

**Large hepatic cyst secondary to previous hepatic biopsy in a cat with hepatic lipodosis.**

**Benign, solitary, or multifocal. Anechoic fluid or echogenic cellular debris.**

**Concurrent hepatic cysts reported.**

**Generally hypoechoic with thick, irregular, ill-defined margins. Cavity echogenicity and presence of acoustic enhancement depend on cavity content. May become more hyperechoic with resolution (fibrosis, caseous fluid).**

**Varied appearance (anechoic, hypoechoic, hyperechoic) depending on lesion age.**

**Usually hypoechoic nodules. Larger nodules may be irregularly marginated, and hypoechoic with central anechoic cavities (necrosis, blood-filled sinusoids). Gas may accompany necrosis.**

**Poorly defined hypoechoic to anechoic (areas of hemorrhage).**

**Ranges from hyperechoic (hepatocellular carcinoma) to mixed (carcinoma). Massive central necrosis not a prominent feature, except in one large (14-cm diameter) hepatocellular carcinoma.**

**Anechoic, hypoechoic, or hyperechoic depending on lesion age. Smaller (<5 cm in diameter) ill-defined borders; larger (>6 cm in diameter) well-defined borders.**

**Usually hypoechoic, "lacy" appearance. One report of cavitated region representing a hematoma within an infarct.**

**Rare: only reported at site of hematoma in a horse and in humans.**

**Mixed, nonhomogeneous, complex, echogenic pattern. Well-defined anechoic areas lacking encapsulation (areas of blood-filled cavernous channels, chronic hematomas, fluid-filled cysts) with or without deep acoustic enhancement.**

**Atypical: one dog with histiocytic lymphosarcoma had large cavitated splenic mass.** More common: multiple, varying size, poorly marginated, hypoechoic to anechoic lymphomatous nodules without acoustic enhancement.
Figure 2. Sonogram of the hypoechoic liver (left side of image) and adjacent hyperechoic spleen (right side of image). The hepatic parenchyma contained an anechoic cyst (large white arrowhead) characterized by cyst far wall enhancement (two white arrows) and deep acoustic enhancement (small white arrowheads). The hypoechoic nodule (black arrowhead) in the splenic parenchyma had internal echoic texture and lacked far wall and deep acoustic enhancement.

Table 3. URINARY TRACT CAVITARY LESIONS

<table>
<thead>
<tr>
<th>Organ-Cavity Type</th>
<th>Differential Diagnosis</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cystic kidney</td>
<td>Cortical/medullary cysts</td>
<td>Incidental findings.</td>
</tr>
<tr>
<td></td>
<td>Polycystic renal disease</td>
<td>Multiple anechoic cysts displacing normal parenchyma. Echoes within cyst may be due to inflammatory debris.</td>
</tr>
<tr>
<td></td>
<td>Perinephric pseudocyst (cats, dog)</td>
<td>More common in cats. Perinephric accumulation of fluid between renal capsule and renal reflection of the peritoneum. Filled with urine, blood (perinephric hematoma), lymph (perinephric lymphocele), or of undetermined origin (perinephric pseudocyst).</td>
</tr>
<tr>
<td>Noncystic kidney</td>
<td>Neoplasia</td>
<td>Usually complex echoic-hyperechoic areas (fibrosis), anechoic areas (hemorrhage, necrosis). May be expansile and disruptive.</td>
</tr>
<tr>
<td></td>
<td>Abscess</td>
<td>Not reported. Expect similar characteristics to those of abscesses in other organs.</td>
</tr>
<tr>
<td></td>
<td>Hematoma</td>
<td>Subcapsular hematoma associated with feline renal lymphoma.</td>
</tr>
<tr>
<td>Ureter</td>
<td>Urinoma (paraureteral pseudocyst)</td>
<td>Encapsulated retroperitoneal accumulation of urine postovariohysterectomy due to ureteral ligation.</td>
</tr>
<tr>
<td>Organ-Cavity Type</td>
<td>Differential Diagnosis</td>
<td>Comments</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Cystic prostate</td>
<td>Benign cystic hyperplasia&lt;sup&gt;70&lt;/sup&gt;</td>
<td>Hyperechoic prostatic parenchyma with multiple, small (3–4mm diameter), anechoic cysts.</td>
</tr>
<tr>
<td></td>
<td>Hematocyst&lt;sup&gt;70&lt;/sup&gt;</td>
<td>Similar to benign cyst. May have internal echoes.</td>
</tr>
<tr>
<td></td>
<td>Paraprostatic cysts&lt;sup&gt;17, 95&lt;/sup&gt;</td>
<td>Hypoechoic or anechoic, smooth internal margin cysts not confined to prostatic parenchyma. Possible internal septa. Cysts wall may be thin or thick with hyperechoic rim suggestive of mineralization. Complex, cystic, echogenic pattern suggestive of hematoma.</td>
</tr>
<tr>
<td>Noncystic prostate</td>
<td>Abscess&lt;sup&gt;70&lt;/sup&gt;</td>
<td>Poorly defined, irregular cavities (20–50-mm diameter).</td>
</tr>
<tr>
<td></td>
<td>Abscess, bacterial and nonbacterial prostatitis, and benign cystic disease&lt;sup&gt;17&lt;/sup&gt;</td>
<td>Intraparenchymal cavities of various sizes (1.5–4.0-cm diameter) reportedly seen in this group of diseases. Cavity characteristics (size and interface) insufficient to differentiate between these diseases.</td>
</tr>
<tr>
<td>Noncystic testicles</td>
<td>Neoplasia (adenocarcinoma)&lt;sup&gt;3, 70&lt;/sup&gt;</td>
<td>Intraprostatic cysts (more common in benign hyperplasia or bacterial prostatitis) or cavities seen. Hyperechoic parenchymal foci with acoustic shadowing indicative of mineralization (more common with neoplasia).</td>
</tr>
<tr>
<td>Cystic ovaries</td>
<td>Ovarian follicles&lt;sup&gt;14, 60&lt;/sup&gt;</td>
<td>Multiple hypoechoic structures with possible anechoic center. Pre- and postovulatory follicles appear similar. Corpora lutea: thickened wall and central anechoic region; smaller than estrus follicle.</td>
</tr>
<tr>
<td></td>
<td>Luteal ovarian cyst&lt;sup&gt;49&lt;/sup&gt;</td>
<td>Anechoic, well-defined, thin-walled, smooth cyst with deep acoustic enhancement.</td>
</tr>
<tr>
<td></td>
<td>Cystic ovaries&lt;sup&gt;46&lt;/sup&gt;</td>
<td>Multiple hypoechoic structures with deep acoustic enhancement each with an isoechoic (to renal cortex) rim of tissue.</td>
</tr>
<tr>
<td>Noncystic ovaries</td>
<td>Neoplasia (adenocarcinoma)&lt;sup&gt;19&lt;/sup&gt;</td>
<td>Irregular, mixed echoic, large (6-cm diameter) mass with multiple cystic regions.</td>
</tr>
<tr>
<td>Organ-Cavity Type</td>
<td>Differential Diagnosis</td>
<td>Comments</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Cystic uterus</td>
<td>Normal gestational (chorionic) cavity&lt;sup&gt;66&lt;/sup&gt;</td>
<td>20 days postluteinizing hormone surge: 2-mm anechoic sac surrounded by hyperechoic uterine wall. Days 23–25: oblong fetus with heart beat within cyst. Days 25–28: U-shaped yolk sac also in cyst.</td>
</tr>
<tr>
<td></td>
<td>Uterine wall cyst (periuterine cyst)&lt;sup&gt;16&lt;/sup&gt;</td>
<td>Typical cyst appearance in uterine wall.</td>
</tr>
<tr>
<td></td>
<td>Polyhydramnios&lt;sup&gt;46&lt;/sup&gt;</td>
<td>Larger than normal anechoic gestational sac.</td>
</tr>
<tr>
<td>Noncystic uterus</td>
<td>Normal postpartum involution&lt;sup&gt;45&lt;/sup&gt;</td>
<td>Early (1–4 days): thickened wall (especially placentation sites) with luminal hypoechoic (fluid) and hyperechoic (blood clots, membrane remnants). Later (8–24 days): target appearance (hypoechoic fluid-filled lumen, hyperechoic endometrium, hypoechoic myometrium).</td>
</tr>
<tr>
<td></td>
<td>Uterine stump granuloma&lt;sup&gt;27, 46&lt;/sup&gt;</td>
<td>Ill-defined mixed to hyperechoic structure. Hyperechoic region due to granulomatous tissue.</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Cystic uterus masculinus&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Bihorned pear- or sausage-shaped cysts dorsal to bladder. Hypo-or hyperechoic viscous cyst fluid.</td>
</tr>
<tr>
<td></td>
<td>Vaginal cyst&lt;sup&gt;6&lt;/sup&gt;</td>
<td>Multilobulated thin- and smooth-walled, anechoic structure extending from bladder neck caudally into pelvic canal. Gas or cellular debris in fluid.</td>
</tr>
</tbody>
</table>

The presence of numerous cysts should be considered a significant and potentially hereditary finding (see Tables 2, 3).<sup>6</sup> In cats with polycystic renal disease, the cysts may become so numerous that they displace the normally functioning renal parenchyma, eventually causing renal failure.<sup>5, 61</sup> As was cited in one report, several of the multiple renal cysts may appear hypoechoic due to inflammatory cellular debris.<sup>61</sup> Concurrent hepatic cysts have been seen in cats with polycystic renal disease.<sup>61</sup> Polycystic renal disease can be confused with multifocal or diffuse, solid, noncavitated, small (<1 cm), hypoechoic nodules representing diffuse round cell neoplastic (lymphoma and mast cell) invasion.<sup>61</sup> These nodules can be differentiated from cysts by the absence of acoustic enhancement deep to the nodules (see Fig. 2).<sup>61</sup> Pseudocysts differ from cysts only by the absence of an epithelial lining; hence, they appear similar ultrasonographically (Tables 3, 4, 5). Similar to the ultrasonographic appearance of cysts, pseudocysts have a well-defined wall of variable thickness.<sup>1, 36, 49</sup> The echogenicity of the encapsulated fluid varies depending on fluid composition: anechoic if containing bile, they contain clear serous fluid.<sup>24</sup>
Table 5. MISCELLANEOUS CAVITARY LESIONS

<table>
<thead>
<tr>
<th>Organ-Cavity Type</th>
<th>Differential Diagnosis</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cystic pancreas</td>
<td>Pseudocyst(^{49})</td>
<td>Pancreatic region: anechoic, fluid-filled, cystic structure with internal cellular debris. Collection of pancreatic secretions encapsulated by granulation and fibrous tissue.</td>
</tr>
<tr>
<td>Noncystic pancreas</td>
<td>Pancreatitis(^{12, 42, 51})</td>
<td>Anechoic regions in pancreatic region associated with pancreatitis. Areas of necrosis and hemorrhage.</td>
</tr>
<tr>
<td>Cystic peritoneum</td>
<td>Mesothelioma(^{19})</td>
<td>Multiple cystic structures of the peritoneal serosal surfaces.</td>
</tr>
<tr>
<td>Noncystic adrenal glands</td>
<td>Neoplasia(^{47})</td>
<td>Mixed echoic masses in adrenal region. Anechoic regions in larger masses due to necrosis (adrenocortical carcinoma) or vessels (pheochromocytoma).</td>
</tr>
<tr>
<td>Noncystic gastrointestinal</td>
<td>Neoplasia(^{39, 44})</td>
<td>Mass may appear cavitary due to presence of intestinal lumen gas and fluid. Normal gastrointestinal wall layers may be destroyed by tumor invasion.</td>
</tr>
</tbody>
</table>

of serous nature and hypoechoic or hyperechoic in the presence of cellular debris or hemorrhage.\(^{1, 37, 49}\) Internal septa may be present. If the pseudocyst contains echogenic fluid and the wall is thick and irregular, it may be indistinguishable from an abscess.\(^{49}\)

Pseudocysts typically are an acquired significant abnormality occurring in association with certain organs and disease processes. The organ or disease association is the only manner by which pseudocysts may be ultrasonographically differentiated from cysts. For example, a large cystic-appearing structure enveloping the kidney is likely to be a perinephric pseudocyst (Fig. 3).\(^{1, 36}\) A cystic-like structure in the pancreatic region following pancreatitis is likely to be a pancreatic pseudocyst (see Table 5).\(^{49}\) Conversely, a cyst-like structure adjacent to but not within the prostate is more compatible with a paraprostatic cyst than with a pseudocyst (see Table 4).\(^{55}\)

Noncystic Cavitary Structures

Noncystic cavitary lesions generally result from acquired collections of blood, necrotic fluid, or cellular debris contained within abscesses,\(^{15, 27}\) hematomas,\(^{21, 66}\) nodular hyperplasia,\(^{56}\) or large neoplastic masses (see Tables 2, 3, 4, 5).\(^{40}\) These different cavitary lesions are grouped together, because the ultrasonographic appearance varies within and across each lesion type; therefore, it is difficult to differentiate lesion type based on ultrasonographic appearance. Despite similarities, certain lesions do
Figure 3. Longitudinal sonogram of the left kidney and perinephric pseudocyst in a 17-year-old, castrated male Domestic Shorthair cat with bilateral perinephric pseudocysts. The pseudocyst measured 7.35 cm in diameter (+), and the left kidney remnant measured 2.50 cm (+). The anechoic pseudocyst fluid was aspirated; the transudate fluid was clear and yellow with no evidence of sepsis and inflammation.

have subtle ultrasonographic features enabling a more precise description of the lesion.

In general, noncystic cavitary lesions are mixed or complex echoic structures with either well- or poorly defined borders. Irregular poorly defined borders result in edge shadowing that is less apparent than that occurring from well-defined cysts. The wall surrounding the cavity may be difficult to discern, especially if the cavity fluid is echogenic and there is lack of contrast between the echogenicity of the wall and the fluid cavity. Hyperechoic areas lacking deep acoustic shadowing likely represent areas of suppuration or fibrosis. Hyperechoic areas with deep acoustic shadowing may represent areas of dystrophic mineralization or mineralized foreign bodies. Hyperechoic areas accompanied by deep acoustic shadowing with reverberation, comet tail, or ring down artifacts are compatible with areas of gas accumulation or a metallic foreign body.

The ultrasonographic appearance of the fluid-filled cavitary portion of a lesion varies depending on fluid viscosity and the amount of cellular elements present. Anechoic regions accompanied by deep acoustic enhancement are compatible with collections of a transudate-type acellular fluid. Echoes originating within anechoic fluid may be due to necrotic debris or artifacts as previously discussed. Increasing cellularity of the fluid results in greater echogenicity; exudates or pus may appear hypoechoic. The amount of deep acoustic enhancement also depends on fluid viscosity and cellularity; deep acoustic enhancement will become less apparent with thick cellular fluid.
The aforementioned ultrasonographic characteristics of noncystic cavitary lesions can be used to describe the appearance of abscesses, hematomas, hepatic nodular hyperplasia, and larger neoplastic masses regardless of the organ involved. In a review of eight dogs with intra-abdominal abscesses, although the most common ultrasonographic appearance was an irregularly defined hypoechoic mass with minimal deep acoustic enhancement, the authors concluded that a consistent ultrasonographic pattern was not seen. Five of the 8 abscesses had no evidence of deep acoustic enhancement; in the remaining 3 abscesses, the fluid viscosity and amount of cellular debris accounted for either mild or moderate amounts of deep acoustic enhancement and echogenicity within the abscess (Fig. 4). Hyperechoic regions with acoustic shadowing representing gas in an abscess are reported to be rare; in three reviews of intra-abdominal and hepatic abscesses in dogs, only 1 of 19 abscesses had an ultrasonographic appearance consistent with gas. A second abscess in another dog had a hyperechoic focus and deep acoustic shadowing due to a bony foreign body. A progressive increase in echogenicity, probably due to fibrosis, was seen associated with the resolution of a hepatic abscess.

Hematomas present a spectrum of appearances depending on their size, amount of internal hemorrhage, and age. In a review of dogs with splenic hematomas, hematomas less than 5 cm in diameter appeared as ill-defined, focal, hypoechoic to anechoic areas. Larger splenic hematomas were well-defined and contained blood of varying echogenicity; some larger hematomas also had internal septations. Some chronic

Figure 4. Sonogram of a spherical mid-abdominal mass in a 3-year-old castrated male Labrador retriever. The mass was characterized by a thick hyperechoic far wall (open arrows) and complex echoic soft-tissue-appearing interior. At necropsy, a chronic omental abscess was found which had ruptured and caused peritonitis. The abscess contained thick pus, which explained the complex echoic appearance of the abscess cavity.
splenic hematomas contained coarse aggregates of echogenic material surrounded by thick irregular walls. Some chronic hematomas continued to enlarge with repeated internal hemorrhage. Conversely, a resolving traumatic splenic hematoma became small and discrete, with previously seen anechoic regions becoming more hypoechoic. Calcification in old hematomas is reported and would cause the appearance of hyper-echoic foci with acoustic shadowing.

Hematoma echogenicity varies with lesion age due to the varied echogenicity of recent hemorrhage, clot formation, and clot retraction. In vitro ultrasound studies using artificial blood clots, the combination of layered red blood cells within a fibrin matrix resulted in clot echogenicities in the first 24 hours. During the next 24 to 48 hours, the echogenicity decreased because of red blood cell hemolysis and clot retraction. The nonuniform hemolysis seen in the artificial clots may cause the mixed echogenic appearance of aging in vivo hematomas. Progressively increasing clot echogenicity following the initial 48-hour period was ascribed to differences in acoustic impedance as the clot organized and fragmented.

The ultrasonographic appearance and echogenicity of neoplasms, regardless of the organ involved, are similar to those of abscesses and hematomas. The appearance of neoplasms is determined by their cell-type homogeneity, amount of vasculature, extent of hemorrhage or necrosis, presence of fibrous tissue, and mineral deposition. For example, vascular structures create multiple interfaces; therefore, vascular tumors without hemorrhage or necrosis are more echogenic. Poorly vascularized nonscarious tumors such as lymphosarcoma or tumors with hemorrhage and necrosis are more hypoechoic. One cited ultrasonographic characteristic used to differentiate renal neoplasms from benign masses was the expansile and disruptive nature of neoplasms.

Similar to abscesses and hematomas, anechoic portions of neoplastic masses generally represent areas of hemorrhage and necrosis. These areas of hemorrhage and necrosis may be interspersed throughout the tumor and are more common in larger masses. In a review of canine primary and metastatic hepatic tumors, large central areas of necrosis were not a prominent feature of focal and multifocal lesions, although one large (14-cm diameter) hepatocellular carcinoma did have an area of central necrosis (Fig. 5). Splenic hemangiosarcomas are characterized by multiple hematomas and therefore appear grossly similar to splenic hematomas and nodular hyperplasia (Figs. 6, 7). Some areas of hemorrhage may be contained in cystic cavities. The echogenicity of the tumorous hematomas and cysts depends on the time of hemorrhage and clot maturity. Cysts have also been reported with prostatic adenocarcinomas, although intraprostatic cysts are more frequent in dogs with benign prostatic hyperplasia and bacterial prostatitis.

Hyperechoic areas within neoplastic masses can be due to areas of recent hemorrhage, fibrosis, dystrophic mineralization, a foreign body, or gas. The presence of these findings is not pathognomonic for
Figure 5. Sonogram of a large hepatic mass in a 9-year-old, castrated male, Labrador retriever. The mass measured approximately 7.6 cm (1 + ) by 9.6 cm (2 + ). The mass was complex echoic and contained a large, well-defined, anechoic cyst (black arrowheads) demonstrating deep acoustic enhancement. An area of several smaller, poorly defined cysts (open arrow) was present; the sum of these fluid-containing cysts also resulted in deep acoustic enhancement. The mass was removed at surgery; the histopathological diagnosis was hepatocellular carcinoma. The cysts were areas of hepatocellular necrosis.

Figure 6. Sonogram of a splenic mass in a 10-year-old, female spayed, Golden retriever. The mass (arrowheads) measured approximately 6 × 4 cm. Several anechoic cysts with enhancement of the deep wall of the cyst (small arrows) but with no deep acoustic enhancement were seen. Several irregular hypoechoic areas (large arrows) were also seen. A splenectomy was performed; the histopathological diagnosis was splenic hematoma.
Figure 7. Sonogram of a large (7.6 x 10.8 cm) splenic mass in a 14-year-old, female spayed soft-coated Wheaton terrier. The splenic mass was characterized by multiple, poorly defined hypoechoic areas; a few anechoic areas (arrowhead) were also seen. Compared with the splenic hematoma in Figure 5, there is little difference in ultrasonographic appearance other than size and anechoic cyst definition. A splenectomy was performed; the histopathological diagnosis was splenic hemangiosarcoma.

neoplasms; they may also be present in abscesses and hematomas. Careful attention to the presence of deep acoustic shadowing or reverberations with either comet tail or ring down artifacts is used to differentiate between gas, mineralization, and a foreign body. Recent hemorrhage and fibrosis should possess neither shadowing nor reverberation. Gas is uncommon in neoplasms, except when the mass arises from the gastrointestinal tract. Actually, the presence of intraluminal gastrointestinal gas within or adjacent to the mass can be used to correctly identify the mass as being of bowel origin. If the typical bowel wall layering is destroyed by the neoplastic invasion, it may be difficult to identify the neoplasm as arising from the bowel wall.

Hepatic nodular hyperplasia appears ultrasonographically similar to primary and secondary hepatic neoplasia. In a review of hepatic nodular hyperplasia, most nodules were hypoechoic and ill-defined. Two larger hyperplastic nodules had anechoic regions: one had a central cavity and the other had a complex array of mixed echoic and anechoic tissue. The anechoic regions correspond to areas of coagulation necrosis of hepatocytes and blood-filled sinusoids. There is one report of hepatic nodular hyperplasia in which gas associated with necrosis was seen radiographically.

The ability of ultrasound to noninvasively image the internal architecture of body cavities and organs also lends itself towards greater focal rather than diffuse parenchymal lesion detection. Cavitary parenchymal lesions are one form of focal lesion and can be characterized by a soft
tissue structure containing fluid or gas. Ultrasound can determine the organ or organs containing cavitary lesions, lesion number and size, and lesion internal characteristics. The complex mix of soft tissue, fluid of varying composition, and possible gas encountered with cavitary lesions causes ultrasound beam propagation artifacts which, if properly interpreted, can be used diagnostically to more accurately characterize the lesion. Despite close attention to the ultrasonographic characteristics of cavitary lesions, many lesions are indistinguishable ultrasonographically. The ultrasonographic appearance of cysts is consistent: spherical or oval well-defined structures containing anechoic fluid with or without suspended cellular debris. Noncystic cavitary lesions (e.g., abscesses, hematomas, hepatic nodular hyperplasia, cavitated neoplasms) frequently appear ultrasonographically similar and are therefore difficult to differentiate one from another. Differentiation of lesion type may rely more on patient history, clinical signs, physical examination findings, and clinical laboratory results.

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ULTRASONOGRAPHY OF ABDOMINAL CAVITARY PARENCHYMAL LESIONS

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