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A Comparison of Hepatic Sonographic Features and Histopathologic Diagnosis in Canine Liver Disease: 138 Cases

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Background: Ultrasound examination is commonly used in the diagnostic evaluation of liver disease in dogs.

Hypothesis/Objectives: To determine if hepatic sonographic features were predictive of findings on liver histopathology. We hypothesized that there would be a relationship between sonographic features and the category of liver disease based on histologic assessment.

Animals: One hundred and thirty-eight dogs in which the liver was evaluated by both abdominal ultrasound examination and histopathologic examination. Twenty-five dogs were included in each of the following categories based on histopathology: normal, degenerative, vascular, inflammatory, and neoplasia. Thirteen dogs had nodular regeneration.

Methods: Retrospective study. Medical records of dogs from 2005 to 2010 were searched for cases in which the liver was evaluated by abdominal ultrasound examination as well as by histopathology. After independent evaluation of ultrasound images, the recorded sonographic features were analyzed to identify abnormalities associated with each histopathologic diagnosis or degree of fibrosis.

Results: Sixty-four percent of sonographically unremarkable livers had histologic abnormalities. Both microhepatia and the identification of abnormal vasculature were significantly associated with a histopathologic diagnosis of vascular disease. Hepatic masses were significantly associated with a diagnosis of neoplasia. Dilated common bile duct and thickened gall bladder wall were significantly associated with hepatitis. There were no sonographic findings consistently present with hepatic fibrosis.

Conclusion and Clinical Importance: Although some ultrasonographic findings, including masses, microhepatia, anomalous veins, and biliary changes, are associated with specific histopathologic abnormalities, sonographic findings are inconsistently detected in many disorders. Overall, hepatic ultrasonographic abnormalities have substantial limitations in predicting the underlying disease.

Key words: Fibrosis; Nodular regeneration; Ultrasound.

The specific diagnosis of liver disease in dogs can be difficult to determine based on physical examination findings and laboratory abnormalities alone.[1,2] Most often, histopathologic examination of a liver biopsy is necessary for accurate diagnosis. However, sonographic imaging of the liver can sometimes be helpful in prioritizing differential diagnoses.[3–6] Ultrasound examination is safe, minimally invasive, and often can be conducted without sedation.[7,8] Hepatic features typically evaluated during abdominal ultrasound examination include parenchymal echogenicity, parenchymal uniformity, vascular structures, biliary structures, and an estimate of liver size.[7,9–12]

Despite the widespread use of ultrasonography in the diagnostic evaluation of liver disease in dogs, few studies have systematically evaluated its accuracy. Ultrasound examination of the canine liver rarely identifies changes that are pathognomonic for a specific disease.[3,6,9,13–15] In addition, the liver may be sonographically unremarkable in the presence of severe disease, especially diffuse disease.[13] Although ultrasonography has been shown to be an accurate means of diagnosing some types of diffuse liver pathology in humans,[16–19] it is reported to be of variable use in the diagnosis of diffuse disease in dogs.[10,13,20]

Although frequently necessary for definitive diagnosis of hepatic disease, liver biopsy is inherently risky to the patient as well as of substantial cost to the client. Therefore, the ability to utilize sonographic patterns as a reliable predictor of specific liver pathology would be an important diagnostic tool that may allow patients to forgo invasive and expensive procedures.

The objective of this retrospective study was to determine if hepatic sonographic features were predictive of findings on liver histopathology. We hypothesized that there would be a relationship between hepatic sonographic features and the category of disease based on histologic assessment.

Case Selection

The medical records of dogs presented to the Virginia-Maryland Regional College of Veterinary Medicine from 2005 to 2010 were searched for cases in which the liver was evaluated by abdominal ultrasound examination as well as by histopathologic examination. Acquisition of liver tissue for histopathologic examination was accomplished either by antemortem biopsy or by necropsy. With the exception of macrovascular

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anomalies, imaging and biopsy must have taken place within 1 week of each other for inclusion in the study. In cases of confirmed macrovascular portosystemic shunts, up to 1 month was allowed between imaging and biopsy because most samples were obtained at the time of surgical correction. Cases were enrolled as they were identified, with a goal of including 25 cases in each of the histopathologic disease categories. Cases were enrolled starting with the year 2010 and progressed backward until 2005. Enrollment in each category ceased once 25 cases were identified or when all identified medical records in the specified period had been reviewed. If fewer than 25 cases in a category were identified between 2010 and 2005, analysis was limited to the cases available.

Procedures

For inclusion in the study, both ultrasound images and histopathology samples must have been available for review. Histopathology slides and ultrasound images were evaluated independently by a single board-certified pathologist (GS) and board-certified radiologist (ML), respectively. Neither the radiologist nor pathologist was aware of the other's findings.

The presence of the following ultrasound characteristics was recorded: abnormal echogenicity (hyperechoic or hypoechoic), masses, nodules, mottled parenchyma, dilated common bile duct, thickened gall bladder wall, disruption of the gall bladder wall, abnormal vasculature (macroscopic shunt), subjective liver size (hepatomegaly or microhepatia), or normal findings. All identified hepatic abnormalities from each sonographic examination were recorded, and if 1 liver had >1 abnormal characteristic, all were recorded. The original ultrasound report was available to the radiologist for clarification if needed.

The liver was defined as hyperechoic if the hepatic parenchyma was isoechoic or hyperechoic to adjacent splenic parenchyma, and substantially hyperechoic to the right renal cortex.[12] The liver was defined as hypoechoic if the hepatic parenchyma was substantially hypoechoic to the adjacent right renal cortex.[12] Mottled liver parenchyma was defined as a primarily hyperechoic parenchymal background with poorly defined diffusely distributed hypoechoic nodules.[12] A liver mass was defined as a relatively focal hyperechoic or hypoechoic (to normal liver parenchyma) lesion measuring >3 cm in diameter. In comparison, a nodule was defined as a distinct focal structure measuring ≤ 3 cm in diameter. The common bile duct was considered dilated if any part of the duct measured >3 mm in diameter.[12] The gall bladder wall was considered thickened if >3 mm.[21] This category also included the presence of a biliary mucocele. A biliary mucocele was diagnosed when centralized, nondependent biliary sediment, along with peripheral striations, was identified.[4] The gall bladder wall was described as disrupted if it appeared discontinuous or poorly defined. The presence of adjacent hyperechoic fat, focal effusion adjacent to the gall bladder, or both was considered additional evidence of gall bladder wall rupture or disruption. Hepatomegaly was subjectively diagnosed when the liver extended well beyond the xiphoid cartilage, hepatic margins were rounded or blunted, and liver lobes extended well beyond the gastric fundus (left liver lobes) or more completely covered the cranial pole of the right kidney (caudate liver lobe).[12] The liver was subjectively assessed as small if there was a limited imaging window to evaluate the liver between the diaphragm and stomach, and if the gall bladder appeared to take up a large portion of liver volume.[12] Abnormal vasculature was defined as the presence of an abnormal vessel connecting the portal and systemic circulation.[12]

The corresponding histopathologic samples were stained with hematoxylin and eosin, slides were reviewed, and each was classified into one of the following primary disease categories: normal, degenerative change (vacuolar degeneration), vascular abnormality, inflammatory, neoplastic, or nodular regeneration. The histologic diagnosis was treated as the gold standard for the diagnosis of the underlying pathology. Classification of each sample was based on the predominant primary disease as determined by the pathologist. If >1 predominant disease process was identified, the case was removed from analysis. The World Small Animal Veterinary Association Liver Standardization Group criteria were employed for histologic interpretation.[22]

A degenerative change was diagnosed when the hepatocytes had a swollen, vacuolated appearance.[23] Primary vascular disease was diagnosed by identification of small or absent portal veins, arteriolar proliferation, hepatocellular atrophy, or some combination of these.[23] Inflammatory diseases were classified into categories of acute hepatitis, chronic hepatitis, reactive hepatitis, and cholangiohepatitis. Acute hepatitis was characterized as a combination of inflammatory cells and hepatocellular apoptosis and necrosis, with or without regeneration. Chronic hepatitis was characterized by a combination of hepatocellular apoptosis or necrosis with variable mononuclear or mixed inflammation, regeneration, and fibrosis. Reactive hepatitis was characterized by neutrophilic or mixed inflammation in portal areas and the hepatic parenchyma, without necrosis. Cholangiohepatitis was characterized by neutrophilic, lymphocytic, or mixed inflammation within the lumen or the epithelium of bile ducts, and extending into the hepatic parenchyma. Neoplastic disease was diagnosed by identification of neoplastic cells throughout the biopsy specimen.[23] Nodular regeneration was diagnosed by identification of a nodule composed of normal hepatocytes forming a normal lobular architecture.[23] Fibrosis was diagnosed by a proliferation of fibroblasts and collagen.[23]

In addition, each sample was given a score based on the amount of fibrosis present.[16,24] A score of 0 indicated no detectable fibrosis. A score of 1 was assigned when stellate enlargement of portal tracts without septa formation was noted. A score of 2 was assigned

when enlargement of portal tracts with rare septa formation (bridging fibrosis) was present. A score of 3 was assigned when numerous fibrous septa without cirrhosis was noted. A score of 4 indicated hepatic cirrhosis (fibrosis with nodular regeneration). Once the histopathologic diagnosis was recorded, the corresponding imaging characteristics of the samples were compared.

Statistics

Statistical analysis to detect an association between a sonographic finding and a histopathologic diagnosis was carried out when ≥ 5 cases in a category were available for review (Table 1). Fisher's exact test was used to evaluate associations between histopathologic categories and sonographic characteristics. Subsequently, all P values were adjusted for multiple comparisons by the Benjamini-Hochberg false discovery rate method of "proc multtest". Level of significance was set at $P < .05$. All analyses were performed by commercial software.[a] Data were expressed as the proportion (percentage) with 95% binomial confidence intervals.

Results

The inclusion criteria were met by the records of 138 cases (Table 1). The histopathologic diagnoses included normal (n = 25), degenerative (n = 25), vascular (n = 25), inflammatory (n = 25), neoplastic (n = 25), and nodular regeneration (n = 13). The method of acquisition of liver tissue included surgical (n = 81), necropsy (n = 29), tru-cut needle (n = 22), and clamshell laparoscopic (n = 5) biopsy.

There was a significant association between a normal ultrasound examination (no abnormality detected) and normal histopathology ($P = .0021$). Of dogs with no abnormality detected on hepatic ultrasound exam, 17 (37%; 0.23–0.52) had normal histopathology results. However, 29 (63%; 0.48–0.77) of the sonographically unremarkable livers had histopathologic abnormalities, including inflammatory (14), degenerative (8), neoplastic (3), nodular regeneration (3), and vascular (1) diagnoses (Table 1). In contrast, 8 dogs had normal histopathology, but an abnormal ultrasound examination, including nodules (4), hepatomegaly (2), mottled (2), microhepatia (1), thickened gallbladder wall (2), and dilated common bile duct (1).

No sonographic findings were significantly associated with a histologic diagnosis of degenerative disease, but sonographic identification of nodules approached significance ($P = .052$). Dogs with a histopathologic diagnosis of degenerative disease had sonographic abnormalities identified in 17 (68%; 0.47–0.85), including nodules (10), hepatomegaly (7), mottled parenchyma (6), hyperechoic parenchyma (2), mass (1), thickened gallbladder wall (1), and gallbladder rupture (1). Of the 25 degenerative disease cases, 8 (36%; 15–54%) had no abnormality detected on ultrasound examination.

Table 1. Sonographic findings in each histopathology category of liver disease. P values are presented for groups with 5 or more cases.

	Cases	No Abnormality Detected	Hyperechoic	Hypoechoic	Hepatomegaly	Microhepatia	Mass	Nodules	Mottled	Dilated Bile Duct	Thick Gall Bladder	Gall Bladder Rupture	Abnormal Vessel
Histopathology													
Normal	25	17 (**$P = .0021$**)			2	1		4	2	1	2		
Degenerative	25	8 ($P = 1.0$)	2		7 ($P = .13$)		1	10 ($P = .052$)	6 ($P = .13$)		1	1	
Vascular	25	1				24 (**$P < .001$**)							21 (**$P < .001$**)
Inflammatory	25	14 ($P = .065$)			5 ($P = .62$)	2	1		5 ($P = .36$)	4	9 (**$P < .001$**)		1
Neoplastic	25	3		1	3		16 (**$P < .001$**)	10 ($P = .052$)	1	1	1		25
Nodular Regeneration	13	3			2		3	4	2				13
Total	138	46	2	1	19	27	21	28	16	6	13	1	22

Bold values represent statistically significant findings.

Both microhepatia ($P < .001$) and the identification of abnormal vasculature ($P < .001$) were independently associated with a histopathologic diagnosis of vascular disease. Dogs with a histologic diagnosis of vascular disease had sonographic findings of microhepatia and abnormal vasculature identified in 96% (0.80–1.0) and 84% (0.64–0.95) of cases, respectively. Of the 25 cases with vascular histopathology, 21 had a single congenital portosystemic shunt confirmed at surgery. Twenty (95%; 0.76–1.0) of the congenital portosystemic shunts were identified sonographically. Of the remaining dogs, 2 had multiple acquired shunts confirmed at surgery and 2 had vascular lesions without shunting diagnosed by transplenic portal scintigraphy using Tc^{99m} pertechnetate. Both of the cases with acquired shunts were diagnosed with noncirrhotic portal hypertension.

The inflammatory hepatopathy category, when evaluated as a whole, had 14 (56%; 0.35–0.76) cases without any abnormality detected on ultrasound examination. The abnormalities detected in the remaining cases included thickened gallbladder wall (9), mottled (5), hepatomegaly (5), dilated common bile duct (4), microhepatia (2), and mass (1). The inflammatory hepatopathy group then was subdivided into specific diagnoses of reactive hepatitis, acute hepatitis, chronic hepatitis, and cholangiohepatitis (Table 2). A sonographically normal-appearing hepatic parenchyma was the most common finding in the chronic hepatitis group (57%; 0.29–0.82) and the second most common finding in the cholangiohepatitis group (63%; 0.25–0.91). Both dilated common bile duct (50%; 0.16–0.84) and thickened gall bladder (88%; 0.47–1.0) were commonly seen in cases of cholangiohepatitis, and sonographic identification of a thickened gall bladder wall was significantly associated with inflammatory histopathology ($P < .001$). Of the 4 dogs with both dilated common bile duct and thickened gall bladder, histopathology indicated cholangiohepatitis in 3.[25] Histopathology was normal in the single dog that was diagnosed with a gall bladder mucocele on ultrasound examination.

The 25 cases of hepatic neoplasia included hemangiosarcoma (8), hepatocellular carcinoma (8), lymphoma (2), metastatic carcinoma (2), biliary carcinoma (1), neuroendocrine carcinoma (1), fibrosarcoma (1), sarcoma (1), and mast call tumor (1) (Table 3). Ultrasound examination frequently identified sonographic abnormalities in livers with neoplasia. Only 3 of 25 (12%; 0.026–0.31) livers with neoplasia were sonographically normal. The identification of a hepatic mass was significantly associated with a diagnosis of neoplasia ($P < .001$) and was present in 16 (64%; 0.43–0.82) cases. Of the 9 dogs with neoplasia that did not have a mass identified on ultrasound examination, 5 had nodules identified. Three of these 5 dogs had multiple nodules. The 3 sonographically unremarkable livers with neoplasia had metastatic hemangiosarcoma (1), lymphoma (1), and metastatic carcinoma (1).

Of the 21 livers with masses identified on ultrasound examination, 76% (0.53–0.92) had neoplasia identified on histopathology. The histopathologic findings in the

Table 2. Sonographic findings in inflammatory hepatopathies.

	Cases	No Abnormality Detected	Hyperechoic	Hypoechoic	Hepatomegaly	Microhepatia	Mass	Nodules	Mottled	Dilated Bile Duct	Thick Gall Bladder	Gall Bladder Rupture	Abnormal Vessel
Histopathology													
Reactive Hepatitis	2	1			1						1		
Acute Hepatitis	1				1				1				
Chronic Hepatitis	14	8			2	1	1		3				1
Cholangiohepatitis	8	5			1	1			1	4	7		

Table 3. Sonographic findings in hepatic neoplasia.

	Cases	No Abnormality Detected	Hyperechoic	Hypoechoic	Hepatomegaly	Microhepatia	Mass	Nodules	Mottled	Dilated Bile Duct	Thick Gall Bladder	Gall Bladder Rupture	Abnormal Vessel
Histopathology													
Mast cell tumor	1				1			1					
Sarcoma	1						1						
Fibrosarcoma	1						1						
Neuroendocrine carcinoma	1							1					
Biliary carcinoma	1						1				1		
Metastatic carcinoma	2	1					1			1			
Lymphoma	2	1		1	1								
Hepatocellular carcinoma	8						8	2					
Hemangiosarcoma	8	1			1		4	6	1				

5 dogs with nonneoplastic masses included nodular regeneration (3), degenerative (1), and inflammatory (1). The liver biopsy samples in these cases were collected surgically (3), by ultrasound-guided biopsy (1), and at necropsy (1).

No sonographic findings were significantly associated with any extent of fibrosis. Thirty-three (24%; 0.17–0.32) dogs had some degree of fibrosis identified on histopathology (Table 4). Of the 47 dogs in this study that had sonographically unremarkable livers, 19 (40%; 0.26–0.56) had some degree of fibrosis. Fibrosis scores in these sonographically unremarkable livers ranged from 1 to 4. The histopathologic abnormalities detected in the 11 cases with a fibrosis score of 3 or 4 included chronic hepatitis (4), cholangiohepatitis (3), nodular regeneration (2), degenerative (1), and hepatocellular carcinoma (1). Four dogs had grade 4 fibrosis (cirrhosis), and there was no sonographic finding significantly associated with severe fibrosis.

Discussion

Similar to other reports,[5,6,26,27] this study confirmed the accuracy of ultrasound examination for identification of portosystemic vascular shunts. The liver was considered small in 96% of dogs with primary vascular disease, and in 100% of dogs with macrovascular portosystemic shunts. Although all but 1 dog with a portosystemic shunt in this study was accurately identified on abdominal ultrasound examination, another dog with acquired multiple portosystemic shunts secondary to primary portal vein hypoplasia was classified as a congenital shunt. This misclassification is not surprising given that the reported sensitivity for sonographic identification of multiple acquired portosystemic shunts is low (67%) compared with that of congenital shunts (90–100%).[6]

Ultrasound examination identified abnormalities in 88% of livers with neoplastic disease, and sonographic identification of a mass was significantly associated with neoplasia. Although this demonstrates that hepatic ultrasonography is useful for the identification of hepatic neoplasia, 5 dogs with hepatic masses were found to have a variety of other diagnoses, primarily degeneration, inflammation, or nodular hyperplasia. Assuming that the histopathologic diagnosis was correct, our findings confirm that whereas the presence of a hepatic mass may raise concern for neoplasia, the diagnosis must be confirmed with histopathology. However, had our study recorded all sonographic examination abnormalities rather than just hepatic changes, the accuracy of diagnosing neoplasia may have improved. This is supported by findings of a recent study that reported that dogs with large liver masses and peritoneal effusion on ultrasound examination were most likely to have malignant hepatic neoplasia.[28] In addition, there is substantial variability in the expected sonographic appearance of diffuse versus focal hepatic neoplasms. For example, hepatocelluar carcinomas frequently produce mass lesions, whereas diffuse diseases such as lymphoma can have more variable

Table 4. Sonographic findings in livers with fibrosis. See text for description of fibrosis score.

Fibrosis Score	No Abnormality Detected	Hyperechoic	Hypoechoic	Hepatomegaly	Microhepatia	Mass	Nodules	Mottled	Dilated Bile Duct	Thick Gall Bladder	Gall Bladder Rupture	Abnormal Vessel	Total Cases
1	9			2	1	2		1		3		1	15
2	5			1			1		2	2			7
3	4			1		1			2	1			7
4	1			1	1			3		1			4
Total	19			6	2	3	2	4	4	7		1	33

sonographic findings[14]. We were unable to draw conclusions regarding the variability in these diffuse patterns, because the majority of neoplastic livers reported here contained either nodules or mass lesions.

Nodular hyperplasia can result in a mass that is consistent with the ultrasound findings in the nonneoplastic masses reported in this study, and often degenerative changes are noted on histopathology of this abnormality.[15,20] Alternatively, biopsies in these cases may not have been representative of the bulk of the mass and may not have include neoplastic tissue. Many primary hepatocellular neoplasms are well differentiated, with hyperplasia, adenoma, and even sometimes carcinoma being difficult to differentiate, particularly in small samples. Degenerative changes, including reticulated cytoplasm with a vacuolar appearance, can be present in nodular hyperplasia and primary hepatocellular neoplasia as well. Although it is possible that a neoplasm might have been diagnosed if additional tissue had been obtained, biopsies were collected surgically or at necropsy in 4 of these 5 cases.

An unremarkable ultrasound examination was significantly associated with normal histopathology ($P = .0021$), but 63% of cases in this category had abnormalities on histopathology. The inflammatory group made up nearly half of these cases. This finding is similar to other studies in which ultrasound examination frequently is normal in dogs with inflammatory hepatopathies.[20,29,30] An unremarkable ultrasonographic appearance of the liver also was common in dogs with degenerative lesions, similar to other reports.[29] These findings suggest that there are considerable limitations in the sonographic identification of diffuse liver diseases such as inflammatory or degenerative disease. Degenerative disease, in particular, had a wide variety of ultrasound abnormalities, and no specific pattern of findings was predictive of degenerative histopathology. Therefore, these findings demonstrate the variable appearance of this category.

Cholecystitis and gall bladder mucocele are commonly associated with cholangitis and cholangiohepatitis,[30–32] likely accounting for the frequent identification of biliary inflammation in cases with dilated common bile duct or thickened gall bladder wall. In addition, sonographic identification of a thickened gallbladder wall was significantly associated with inflammatory histopathology ($P < .001$). This finding is similar to that reported by Guillot et al, where 9/15 dogs with inflammation on fine-needle aspiration cytology of the liver had an abnormal appearance of the biliary system on ultrasound examination.[33] However, because the results of hepatic cytology may not be comparable to hepatic histopathology, additional work is needed to better define the relationship between sonographic biliary abnormalities and hepatic parenchymal histopathologic findings. Furthermore, the canine biliary tract may remain dilated after resolution of a previous insult[25]; therefore, biliary dilatation is not always indicative of active biliary disease.

Eight cases with normal histopathology had ≥ 1 abnormalities identified on ultrasound examination.

The finding of normal histopathology in these cases raises concern for whether the biopsy sample may not have been representative of the actual underlying disease. However, in 5 of these 8 cases, samples had been collected surgically and were of high quality. The remaining 3 were collected by needle biopsy and were considered adequate for interpretation by the pathologist. This would suggest that not all sonographic abnormalities are truly associated with underlying hepatic pathology and reinforces the importance of considering all factors in a case before pursuing biopsy of the liver.

There were no sonographic features significantly associated with detectable hepatic fibrosis, and in many cases, substantial fibrosis produced no sonographic abnormalities. Forty-one percent of sonographically normal livers in this study had some degree of fibrosis ranging from mild to severe. Of the cases with a fibrosis score of 3 or 4, sonographic abnormalities were identified inconsistently. Ultrasound examination cannot reliably be used to detect or predict the presence or absence of or the degree of hepatic fibrosis.

Some limitations of this study include reliance on the opinion of a single pathologist as the gold standard for diagnosis of hepatic pathology and a single radiologist for interpretation of ultrasound examinations. Use of a single ultrasonographer likely resulted in more consistency in findings among cases compared with multiple observers.[13] However, this introduces bias toward the individual's interpretation that may be different from that of other ultrasonographers. For example, the low prevalence of generalized changes in echogenicity in our population might be the result of such bias. Furthermore, although some sonographic videos were available for review, the use of still sonographic images may have limited complete interpretation.

Standardized criteria for histopathologic and ultrasonographic findings were employed in this study in an attempt to minimize any bias. In addition, it was assumed that the biopsy specimen was representative of the actual hepatic disease. This may not have been accurate in cases of focal disease if the biopsy was taken from adjacent tissue. Furthermore, some livers contain multiple histopathologic abnormalities that require multiple biopsies for diagnosis.[34] Small or poor quality samples may have affected the accuracy of histopathology,[35] although most samples in this study were obtained at surgery or necropsy and all were judged adequate for histopathologic interpretation by the pathologist. It should be recognized that surgical and needle samples may be obtained for different reasons. For example, a surgical sample may be collected from a grossly or palpable abnormal area of the liver, whereas needle biopsies may target sonographically abnormal areas. Although ultrasound-guided needle biopsies may have the advantage of sampling deep lesions not grossly visible at the hepatic surface, the small sample size may lead to inaccurate histopathologic interpretation.[35] In this study, a mass was defined as a focal hyperechoic or hypoechoic area >3 cm in diameter. This measurement was chosen because a previous study demonstrated that hepatic masses >3 cm are likely to be neoplastic.[28] However, the measurement chosen to classify a hepatic nodule or a mass was arbitrary. Future studies should determine the measurement that would best differentiate neoplasia and benign disease.

Small numbers of liver samples with nodular regeneration or grade 4 fibrosis (cirrhosis) limited the ability to draw conclusions about these groups. Significant associations may have been identified if a larger sample had been obtained. An additional limitation of the study was the use of hematoxylin and eosin as the only stain on histopathologic evaluation. Stains specifically identifying fibrosis likely would have increased the sensitivity of the evaluation of fibrosis. Although the authors feel that substantial fibrosis would be identified by the stain utilized and the use of the grading system, additional study is indicated to more definitively explore any association of ultrasonographic abnormalities with fibrosis. Although hepatic sonographic abnormalities, including microhepatia, are significantly associated with histopathology, many sonographic changes are inconsistent and unable to accurately predict underlying disease.

These limitations of hepatic ultrasonography should be acknowledged when using hepatic ultrasound examination in the diagnosis of canine liver disease.

Footnote

[a] SAS/STAT® software version 9.2; Cary, NC

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