Ultrasonographic measurement of the pancreas and pancreatic duct in clinically normal dogs

Dominique G. Penninck, DVM, PhD; Ulrich Zeyen, DVM; Olivier N. Taeymans, DVM, PhD; Cynthia R. Webster, DVM

Objective—To obtain ultrasonographic reference values for the thickness of the pancreas and the diameter of the pancreatic duct in clinically normal dogs.

Animals—242 adult dogs with no clinical signs of gastrointestinal tract disease.

Procedures—The maximum pancreatic thickness and the diameter of the pancreatic duct were recorded ultrasonographically at the level of the left lobe, body, and right lobe of the pancreas.

Results—Mean ± SD pancreatic thickness measurements were as follows: left lobe, 6.5 ± 1.7 mm (n = 214); body, 6.3 ± 1.6 mm (155); and right lobe, 8.1 ± 1.8 mm (239). The mean pancreatic duct diameter was 0.6 ± 0.2 mm (n = 42) in the left lobe and 0.7 ± 0.2 mm (213) in the right lobe. The right pancreatic duct was visible in 213/242 (88.0%) dogs, and the left pancreatic duct was visible in 41/242 (16.9%) dogs. However, the body was visible in only 16/242 (6.6%) dogs. Pancreatic thickness and diameter of the pancreatic duct significantly increased with body weight in all lobes, but age was not correlated with the measurements.

Conclusions and Clinical Relevance—Ultrasonographic reference values for the pancreas and pancreatic duct of dogs were determined. Results of this study indicated that the pancreatic duct was visible, especially in the right lobe of the pancreas. These values may be useful for the assessment of pancreatic abnormalities, such as chronic pancreatitis and exocrine pancreatic insufficiency. (*Am J Vet Res* 2013;74:433–437)

The ultrasonographic appearance and location of the canine pancreas have been described, but neither the size of the pancreas nor the presence of the pancreatic duct has been adequately assessed.[1–4] Acute pancreatitis in dogs is a common disease that can often be diagnosed ultrasonographically because the pancreas is enlarged, hypoechoic, and frequently surrounded by hyperechoic peripancreatic fat.[2] However, in chronic pancreatitis, morphological and consequently ultrasonographic changes may be subtle or complex, compared with those in acute pancreatitis.[5,6] The incidence of chronic pancreatitis in dogs is still unknown and may be underestimated, as determined in a recent postmortem study[7] in which chronic pancreatitis was diagnosed in 51 of 151 (34%) dogs. Additionally, pancreatic insufficiency is reportedly associated with a reduction in size of the pancreas.[8]

Established reference values of ultrasonographic pancreatic size have been reported for clinically normal cats,[9–11] but no published data are available for dogs of various ages and sizes. Although the ultrasonographic appearance of the pancreatic duct has been described in cats, it has not been adequately described in dogs. A relationship between pancreatic duct dilation and pancreatitis in dogs[12] or cats[13] has been proposed; however, dilation of the pancreatic duct has also been reported as an incidental, age-related change in cats.[10,11] To aid in evaluation of the endoscopic ultrasonographic appearance of chronic pancreatitis in humans, dogs with chronic pancreatitis were evaluated, which revealed sequential changes such as accentuated lobularity, changes in parenchymal echogenicity, and irregular margins of the pancreatic duct and branches.[14]

The resolution and quality of ultrasonographic equipment is increasing, and the clinicopathologic knowledge about pancreatic disorders in dogs is improving; therefore, it is becoming increasingly important to have reference values for pancreas and pancreatic duct size. The main objective of the study reported here was to describe the appearance and size of the pancreas and pancreatic duct in a large population of dogs with no clinical evidence of gastrointestinal tract disease. The second objective was to assess the potential effects of age and body weight on the measurements.

Materials and Methods

Animals—Ultrasonographic examinations were performed on 242 adult dogs (123 males and 119 fe-

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From the Foster Hospital for Small Animals, Department of Clinical Sciences, Cummings School of Veterinary Medicine, Tufts University, North Grafton, MA 01536 (Penninck, Taeymans, Webster); and the Centro Veterinario Specialisito, Via Giovannini 51-53, Roma, Italy 00137 (Zeyen).
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Address correspondence to Dr. Penninck (Dominique.Penninck@tufts.edu).

males) between 1 and 16 years old with body weights ranging from 1.4 to 55 kg. The examinations were performed at 2 clinics (the Foster Hospital for Small Animals and the Centro Veterinario Specialisito). Because the prospective study included ultrasonographic examinations performed during routine evaluation of the abdomen, owner consent was not requested. None of the dogs had evidence of gastrointestinal tract disease, as indicated on the basis of history and results of physical and ultrasonographic examinations. Dogs with anorexia, vomiting, diarrhea, constipation, signs of nausea, weight loss, signs of abdominal pain, or abdominal effusion during the 2 months prior to the start of the study were excluded.

The most common reasons for ultrasonographic evaluations (n = 242 dogs) were echocardiographic assessment (71 [29.3%] dogs), health assessment (39 [16.1%] dogs), staging of a nonabdominal tumor (37 [15.3%] dogs), reproductive disorders (30 [12.4%] dogs), and urinary tract problems (24 [9.9%] dogs). The remaining 41 (16.9%) dogs were examined for numerous reasons, such as orthopedic assessment, cranial abdominal organomegaly, immune-mediated hemolytic anemia, perineal hernia, presurgical evaluation for tumor staging, cutaneous changes, neurologic signs, evaluation of shunts, and perianal abscess. The age, sex, body weight, and breed of each dog were tabulated, and the main clinical sign or reason for an abdominal ultrasonographic examination was recorded.

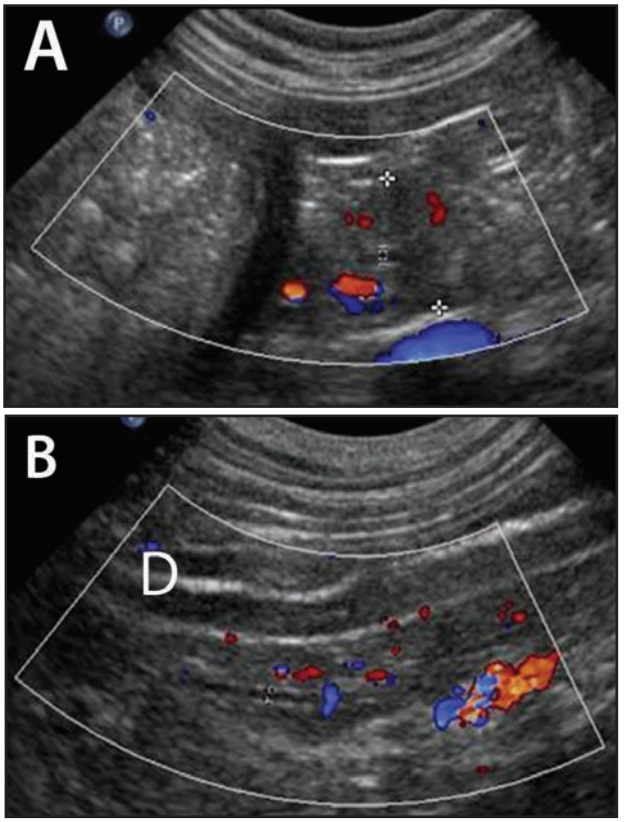

Figure 1—Transverse (A) and sagittal (B) ultrasonographic views of the pancreas in a clinically normal hound-type dog. A—The left lobe of the pancreas (area between plus signs) has a thickness of 10 mm, and the pancreatic duct is 1 mm in diameter. Color-flow Doppler ultrasonography reveals a lack of vascular flow, which confirms the presence of the centrally located pancreatic duct (small square). Part of the ingesta-filled stomach adjacent to the pancreas is visible to the left. B—The right pancreatic lobe is located parallel to the duodenum (D). The pancreatic duct is visible and is 0.8 mm in diameter. Similar to panel A, color-flow Doppler ultrasonography reveals a lack of vascular flow, which confirms the presence of the centrally located pancreatic duct.

Ultrasonographic examinations—Ultrasonographic examinations were performed with the dogs in dorsal or lateral recumbency, and no sedation was used. The hair was clipped from the ventral aspect of the abdomen, and acoustic coupling gel was applied. All ultrasonographic examinations were performed with a curvilinear- or linear-array transducer.[a–c] Images of the pancreas were obtained as described elsewhere.[1,2] The pancreatic parenchyma was subjectively evaluated for homogeneity and echogenicity. Measurements of the right lobe, body, and left lobe of the pancreas were obtained in the sagittal or transverse planes (or both) with electronic calipers (**Figure 1**).

The term thickness was used, although it was not clear in some locations whether the measurement actually represented the height or width of the pancreas. Considering that the pancreas has a variably amorphous to triangular shape and its position can shift on the basis of a dog's position, the term thickness was considered an acceptable compromise to describe the measurement obtained perpendicular to the long axis of the pancreas. The right lobe was measured ventromedial to the right kidney and medial to the descending duodenum. Measurements of the body of the pancreas were obtained immediately caudal to the pyloroduodenal angle, ventral to the portal vein in transverse section, and medial to the proximal aspect of the descending duodenum. The left lobe was measured caudal to the gastric antrum and body, cranial to the transverse colon, and medial to the dorsal aspect of the head of the spleen. When > 1 measurement was available, the mean of all measurements obtained was calculated. In all dogs, measurements of the maximum transverse thickness were recorded.

The pancreatic duct was differentiated from the pancreaticoduodenal vein by means of color-flow Doppler ultrasonography. It was then measured with electronic calipers placed perpendicularly to the long axis of the duct in the left or right lobe or in the body of the pancreas.

Statistical analysis—For all measurements, plots were visually inspected; no outliers were identified, and all data points were used for analysis. Descriptive statistics (eg, mean, SD, median, and range) were calculated

Table 1—Measurements (mm) of the thickness of the pancreas and diameter of the pancreatic duct determined ultrasonographically in 242 dogs with no clinical signs of gastrointestinal tract disease.

Variable	Mean ± SD	Range
Thickness		
Left lobe (n = 214)	6.5 ± 1.7	3.6–14
Body (n = 155)	6.3 ± 1.6	3.5–11.2
Right lobe (n = 239)	8.1 ± 1.8	3.9–16
Pancreatic duct diameter		
Left lobe (n = 42)	0.6 ± 0.2	0.4–1.0
Right lobe (n = 213)	0.7 ± 0.2	0.1–1.2

Table 2—Values for 95% prediction limits and 90% tolerance limits for various measurements (mm) of the pancreas in 242 adult dogs with no clinical signs of gastrointestinal tract disease grouped on the basis of body weight.

Variable	Weight category (kg)	No. of dogs	Mean ± SD	95% parametric prediction limits	90% nonparametric tolerance limits*
Left lobe	< 15	114	5.75 ± 1.20	3.36–8.13	3.90–10.00
	15–30	57	7.28 ± 1.75	3.78–10.79	4.30–12.60
	> 30	43	7.68 ± 1.60	4.46–10.90	4.90–14.00
Right lobe	< 15	121	7.25 ± 1.47	4.34–10.17	4.50–11.90
	15–30	68	8.62 ± 1.64	5.34–11.90	4.50–13.00
	> 30	50	9.30 ± 1.80	5.69–12.91	6.00–16.00
Body	< 15	92	5.56 ± 1.16	3.26–7.87	3.80–9.20
	15–30	48	7.27 ± 1.48	4.30–10.24	4.10–11.00
	> 30	15	7.97 ± 1.52	4.71–11.22	5.20–11.20
Pancreatic duct					
Left lobe	< 15	28	0.59 ± 0.11	0.37–0.82	0.40–0.80
	15–30	10	0.74 ± 0.20	NA	NA
	> 30	4	0.78 ± 0.21	NA	NA
Right lobe	< 15	115	0.63 ± 0.15	0.33–0.93	0.10–1.00
	15–30	56	0.75 ± 0.20	0.35–1.15	0–1.2
	> 30	42	0.78 ± 0.21	0.35–1.20	0–1.2

Results for the pancreatic duct in the body of the pancreas are not reported because of insufficient data.
*Nonparametric (distribution-free) tolerance intervals that provide (with 95% confidence) that 90% of the sample will be within the calculated bounds.
NA = Not applicable; values were not calculated because of insufficient data.

Table 3—Pearson correlation coefficients, *P* values, and sample sizes for measurement variables of the canine pancreas in 242 adult dogs with no clinical signs of gastrointestinal tract disease.

	Variable						
						Pancreatic duct	
Variable	Weight	Age	Left lobe	Right lobe	Body	Right lobe	Left lobe
Weight	1.000	–0.134	0.495	0.482	0.591	0.346	0.562
	—	0.037	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
	242	241	214	239	155	213	42
Age	–0.134	1.000	–0.024	0.065	0.081	0.057	–0.212
	0.037	—	0.730	0.319	0.320	0.409	0.184
	241	241	213	238	154	212	41
Left lobe	0.495	–0.024	1.000	0.515	0.713	0.390	0.545
	< 0.001	0.729	—	< 0.001	< 0.001	< 0.001	< 0.001
	214	213	214	212	146	194	42
Right lobe	0.482	0.065	0.515	1.000	0.601	0.452	0.421
	< 0.001	0.319	< 0.001	—	< 0.001	< 0.001	0.006
	239	238	212	239	155	212	42
Body	0.591	0.081	0.713	0.601	1.000	0.425	0.439
	< 0.001	0.320	< 0.001	< 0.001	—	< 0.001	0.007
	155	154	146	155	155	143	37
Pancreatic duct							
Right lobe	0.346	0.057	0.390	0.452	0.425	1.000	0.388
	< 0.001	0.409	< 0.001	< 0.001	< 0.001	—	0.015
	213	212	194	212	143	213	39
Left lobe	0.562	–0.212	0.545	0.421	0.439	0.388	1.000
	< 0.001	0.184	< 0.002	0.006	0.007	0.015	—
	42	41	42	42	37	39	42

Within each set of results, the value in the top row represents the Pearson correlation coefficient, the value in the middle row represents the *P* value, and the value in the bottom row represents the number of dogs. Values were considered significant at $P < 0.05$.
— = Not applicable.

from the tabulated measurements. Subsequently, the dogs were arbitrarily allocated into 3 weight categories (< 15, 15 to 30, and > 30 kg).

Parametric 2-sided 95% prediction limits and nonparametric tolerance intervals that include 90% of the population with 95% confidence were calculated for the pancreas thickness and duct diameter of the left lobe and right lobe.[15] Insufficient data for the duct diameter in the body of the pancreas were available for statistical analysis. Histograms and P-P plots of data of each measurement were reviewed, and the D'Agostino-Pearson omnibus test of normality was calculated for each weight category to assess normality.[16] Finally, Pearson correlation coefficients were also calculated to assess the effect of body weight and patient age on pancreatic thickness and duct diameter at the 3 locations (right and left lobes and body). Values of $P < 0.05$ were considered significant.[d]

Results

The measured thickness of the right lobe, body, and left lobe of the pancreas and pancreatic duct were summarized (**Table 1**). The right lobe of the pancreas was

the most consistently visible and measured (239/242 [98.8%]), compared with the left lobe (214/242 [88.4%]) and body (155/242 [64.0%]). Similarly, the pancreatic duct was visible more consistently in the right lobe (213/239, 89.1%), compared with the left lobe (42/214 [19.6%]) and body (16/155 [10.3%]). The pancreatic duct, when detected, appeared as a tubular structure with anechoic content and highly echogenic walls. The pancreas was subjectively considered slightly heterogeneous or containing few small hyperechoic foci in 20 of 242 (8.3%) dogs.

Visual assessment of histograms and P-P plots suggested all measurements had a reasonably normal distribution. Statistical testing of normality via the D'Agostino-Pearson omnibus test of normality on the basis of skewness and kurtosis revealed significant deviations from normality for the left lobe measurements of all 3 weight categories, which appeared somewhat leptokurtic (more concentrated near the mean than expected). The omnibus normality test was also rejected for the high weight category of the right lobe (leptokurtic) and the low weight category of the body (small right skew).

Both 95% prediction intervals were determined for each measurement in each weight category, which was based on the assumption of normal distributions of all measurements. More conservatively, nonparametric (distribution-free) tolerance intervals that provide (with 95% confidence) that 90% of the sample will be within the calculated bounds were determined. Both types of limits for each measurement for each weight category were summarized (**Table 2**).

Significant positive correlations were found between body weight and pancreatic thickness for the 3 locations. Positive correlations were found between body weight and pancreatic duct diameter in both the left and right lobes. Significant positive correlations were also found between the left and right pancreatic lobe and the size of the ipsilateral pancreatic duct. No significant correlations were found between age and pancreatic thickness or between age and pancreatic duct diameter. Pearson correlation coefficients and *P* values for the measurements were summarized (**Table 3**).

Discussion

In the present study, the thickness of the canine pancreas ranged from 3.5 to 16 mm, with a reference value of approximately 1 cm in medium-sized dogs (15 to 30 kg of body weight). Several reports[1–3] on transabdominal and endoscopic ultrasonographic appearance of the canine pancreas are available, but none of them provide a reference value for size of the pancreas. Additionally, the present study revealed that the pancreatic duct was visible in dogs of various sizes, especially in the right lobe. Mean diameter of the pancreatic duct was 0.8 mm in medium-sized dogs, with a range of 0.1 to 1.2 mm in all dogs. The pancreatic duct was not detected as frequently in the left lobe or in the body, compared with the frequency of detection in the right lobe. The reason for this low detection rate is unclear but was partially attributable to the lower rate for identification of the left pancreatic lobe than the right pancreatic lobe. In contrast to results for cats, analysis of the data for dogs did not reveal a significant correlation between the age of a dog and the size of the pancreatic duct. In dogs with experimentally ligated pancreatic ducts, the pancreatic duct was dilated up to 3.5 mm by 2 weeks after the procedure, and subsequent lobular atrophy was detected.[17] It is unknown whether similar findings can be extrapolated in dogs with naturally occurring disease, but the reference values reported here can assist clinicians in the detection and monitoring of pancreatic changes.

The present study had several limitations because it was performed on dogs presumed to be free of pancreatic disease only on the basis of the medical history and clinical signs; measurement of serum markers (eg, lipase, amylase, and canine pancreatic-specific lipase) was not performed. Clinical signs such as anorexia, vomiting, and diarrhea are reported in acute and chronic pancreatitis; therefore, our selection criteria allowed us to recruit a large number of dogs. However, the presence of subclinical, chronic, or past pancreatic disorders cannot be ruled out in this cohort. The value of canine pancreas-specific lipase and other serum markers has been evaluated and provides promising results[18]; however, there currently is no test sufficiently sensitive or specific for use in accurately diagnosing chronic pancreatitis.

Furthermore, we only subjectively evaluated the relative echogenicity of the pancreas because several factors (eg, transducer frequency, echogenicity of reference organs [eg, liver], or structures [adjacent fat]) would have resulted in the addition of variables to the study. However, nonhomogeneous echotexture or the presence of hyperechoic foci was detected in only 20 of 242 (8.3%) dogs. Interestingly, dogs with a nonhomogeneous echotexture or the presence of hyperechoic foci had a median age of 12 and 14 years, respectively; this may support the contention that these are age-related changes, but the possibility of underlying chronic pancreatitis cannot be completely ruled out despite the lack of clinical signs. In the present study, the overall thickness of the pancreas and pancreatic duct were not significantly affected by age, but further studies may be useful in assessing potential changes in size and echogenicity of the pancreas attributable to the aging process. The pancreas typically is more echogenic and the pancreatic duct wider in humans as they age.[19]

a. iU22 xMATRIX ultrasound system, Philips Healthcare, Andover, Mass.
b. LOGIQ 7, GE Healthcare, Little Chalfont, Buckinghamshire, England.
c. XVision MyLab 70, Esaote, Genova, Italy.
d. SAS, version 9.2, TS kevel 2M0 for Windows XP_PRO platform, SAS Institute Inc, Cary, NC.

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