

RADIOGRAPHIC LIVER SIZE IN PEKINGESE DOGS VERSUS OTHER DOG BREEDS

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Differential diagnoses for canine liver disease are commonly based on radiographic estimates of liver size, however little has been published on breed variations. Aims of this study were to describe normal radiographic liver size in Pekingese dogs and to compare normal measurements for this breed with other dog breeds and Pekingese dogs with liver disease. Liver measurements were compared for clinically normal Pekingese ($n = 61$), normal non-Pekingese brachycephalic ($n = 45$), normal nonbrachycephalic ($n = 71$), and Pekingese breed dogs with liver disease ($n = 22$). For each dog, body weight, liver length, T11 vertebral length, thoracic depth, and thoracic width were measured on right lateral and ventrodorsal abdominal radiographs. Liver volume was calculated using a formula and ratios of liver length/T11 vertebral length and liver volume/body weight ratio were determined. Normal Pekingese dogs had a significantly smaller liver volume/body weight ratio (16.73 ± 5.67 , $P < 0.05$) than normal non-Pekingese brachycephalic breed dogs (19.54 ± 5.03) and normal nonbrachycephalic breed dogs (18.72 ± 6.52). The liver length/T11 vertebral length ratio in normal Pekingese (4.64 ± 0.65) was significantly smaller than normal non-Pekingese brachycephalic breed dogs (5.16 ± 0.74) and normal nonbrachycephalic breed dogs (5.40 ± 0.74). Ratios of liver volume/body weight and liver length/T11 vertebral length in normal Pekingese were significantly different from Pekingese with liver diseases ($P < 0.05$). Findings supported our hypothesis that Pekingese dogs have a smaller normal radiographic liver size than other breeds. We recommend using $4.64 \times$ the length of the T11 vertebra as a radiographic criterion for normal liver length in Pekingese dogs. © 2012 *Veterinary Radiology & Ultrasound*.

Key words: dog, liver size, Pekingese, radiography

Introduction

LIVER SIZE IS one of the principal criteria used to develop differential diagnoses for dogs with suspected hepatic diseases, i.e. microhepatica for portosystemic shunt or hepatic cirrhosis, or hepatomegaly for hepatic congestion, inflammatory and infiltrative disease, hepatic neoplasia.¹ Previous reports have quantified normal liver size in dogs using radiography, ultrasonography, scintigraphy, computed tomography (CT), and magnetic resonance imaging (MRI). Computed tomography and MRI are not suitable as screening tests because these modalities require anesthesia and their availability is still limited in veterinary medicine.² Compared with scintigraphic and ultrasonographic measurements, measurements made from right lateral radiographs were found to have the highest correlation with actual liver weight in dogs.^{3,4} Radiographic liver size has been evaluated based on gastric axis position and by measuring the length of the liver.⁵⁻⁸ Normal gastric axis po-

sition has been described as perpendicular to the spine in dogs and this method is most commonly used to assess liver size in general practice. Radiographic criteria for generalized hepatomegaly include round or blunted caudoventral liver margins, extension of liver margins beyond the costal arch, and caudal displacement of the gastric axis.⁵ Radiographic criteria for microhepatica include cranial displacement of the gastric axis and decreased distance between the diaphragm and gastric lumen.⁶ However, recent reports have indicated that gastric axis position and the position of liver margins relative to the costal arch also may be affected by nonpathologic conditions such as the patient's age, size, weight, breed, conformation, volume of gastric contents, and degree of inspiration.⁷ Measuring the length of the liver may be a more reliable criterion because it is not influenced by thoracic conformation.^{1,8-10} Moreover, the length of the liver, measured from right lateral radiographs, has been correlated with actual volume of the liver in dogs.⁸

The objectives of this study were to describe normal radiographic liver sizes in clinically healthy Pekingese dogs and compare liver sizes in normal Pekingese with those of other brachycephalic breed dogs, nonbrachycephalic breed dogs, and Pekingese dogs with liver disease. We hypothesized that normal Pekingese dogs have smaller livers than

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Received July 1, 2012; accepted for publication September 12, 2012.
doi: 10.1111/j.1740-8261.2012.01992.x

Vet Radiol Ultrasound, Vol. 54, No. 2, 2013, pp 103–106.

other normal dogs, based on observations in our clinic that numerous Pekingese dogs without hepatic disease had a cranial shift of the pylorus and a change in the gastric axis in abdominal radiographs.

Materials and Methods

This retrospective study was performed in dogs that underwent abdominal radiography, complete blood counts, and serum chemistry at the Seoul National University Hospital for Animals and Haemaru Referral Animal Hospital from January 01, 2002 to January 31, 2009. Dogs with congestive heart failure, pleural effusion, peritoneal effusion, abdominal masses, excessive gastric distension, malpositioning, or age under 1 year old were excluded from the study. Normal dogs were defined as those with normal complete blood count and serum enzyme level (alanine aminotransferase, alkaline phosphatase, aspartate aminotransferase, bilirubin, albumin, and glucose) and no history or clinical signs of hepatic diseases. Pekingese dogs with liver disease were defined as those with abnormal clinical signs consistent with liver disease, elevated serum hepatic enzyme levels, and abnormal findings on liver ultrasonography. Twenty-two Pekingese dogs were assigned to this group.

Radiographs were obtained using a 300-mA, 125-kV x-ray unit, with a focal film distance of 100 cm. Film in combination with rare earth intensifying screens or direct digital radiography system was used. Right lateral and ventrodorsal radiographs were retrieved and reviewed in all dogs by two of the authors (J.C. and S.K.). Radiographs in which the caudoventral liver margin could not be clearly identified were excluded from the study. Digital images were assessed on a DICOM workstation and conventional films were evaluated using radiographic viewboxes. Measurements for digital images were made using electronic calipers and measurements for conventional radiographs were made using manual calipers. Radiographs were reviewed in random order independently, and readers were unaware of breed and clinical status at the time of review.

On right lateral radiographs, liver length, the length of the 11th thoracic (T11) vertebra, and thoracic depth were obtained (Figs. 1A–C). Liver length (cm) was measured as the length of the axis from ventral border of caudal vena cava to the apex of hepatic caudal border. The length of T11 vertebra was measured at the level of the midpoint parallel to the long axis of the vertebral body. Thoracic depth was measured as the length of the perpendicular axis from the caudal tip of the sixth sternum to the axis between the ventral border of T11 vertebra and the ventral border of the fourth lumbar vertebra. Thoracic width was measured by drawing a line between the costophrenic recesses on ventrodorsal view (Fig. 1D). In each dog, a ratio of liver length/T11 vertebral length was calculated to compare data taken from dogs with various body weights and sizes. In

addition, a ratio of thoracic depth to thoracic width allowed comparison of dogs with various thoracic conformations.

Liver volume was calculated with following formula: liver volume = $11.62 + 0.154$ (liver length \times thoracic depth \times thoracic width) and then a ratio of the volume of the liver (cc) to body weight (kg) was determined.

All statistical tests were selected and conducted by one of the authors (H.K.). Data were expressed as mean \pm standard deviation (SD). Mean ratios of liver volume/body weight and liver length/T11 vertebral length in normal Pekingese, normal non-Pekingese brachycephalic breed dogs, and normal nonbrachycephalic breed dogs were compared using one-way ANOVA. Mean ratios for liver volume/body weight and liver length/T11 vertebral length in normal Pekingese were compared with those in Pekingese with liver disease using the Mann–Whitney U test. Body weights of normal Pekingese and Pekingese with liver disease were compared using the paired Student's *t*-test. Interobserver reproducibility and intraobserver repeatability were determined using an independent Student *t*-test. For all tests, a *P* value < 0.05 was considered significant. Statistical analysis was performed with SPSS (SPSS for Windows, Release 13.0, standard version, SPSS, Inc., Chicago, IL).

Results

After initial screening, the sample population of normal dogs consisted of 177 dogs and eight different breeds. Normal dogs were divided into three groups; normal Pekingese group ($n = 61$), brachycephalic breed group ($n = 45$), and nonbrachycephalic breed group ($n = 71$). The brachycephalic group included Shihtzu ($n = 39$), Pug ($n = 3$), and Boston terrier ($n = 3$). Nonbrachycephalic group included Maltese ($n = 19$), Poodle ($n = 22$), Yorkshire terrier ($n = 17$), and Pomeranian ($n = 13$).

Mean body weights did not differ for normal Pekingese (5.57 ± 1.25 kg) vs. Pekingese with liver diseases (5.80 ± 1.32 kg) ($P < 0.05$). Mean body weights differed for normal non-Pekingese brachycephalic breeds (5.62 ± 1.50 kg) vs. normal nonbrachycephalic breeds (4.12 ± 1.39 kg). Mean age of normal Pekingese was 4.15 ± 1.32 yr, and there was no significant difference between ages of normal non-Pekingese brachycephalic breeds (5.98 ± 2.04 years) and normal nonbrachycephalic breeds (6.48 ± 1.79 years). Mean ages differed for the normal versus liver disease Pekingese groups ($P > 0.05$). There were 21 males (5 castrated) and 40 females (11 spayed) in the normal Pekingese group, and 5 males (3 castrated) and 17 females (1 spayed) in the Pekingese with liver disease group.

Liver size comparisons for the three groups of normal dogs are summarized in Table 1. The length of the liver in normal Pekingese was 4.64 times of the length of

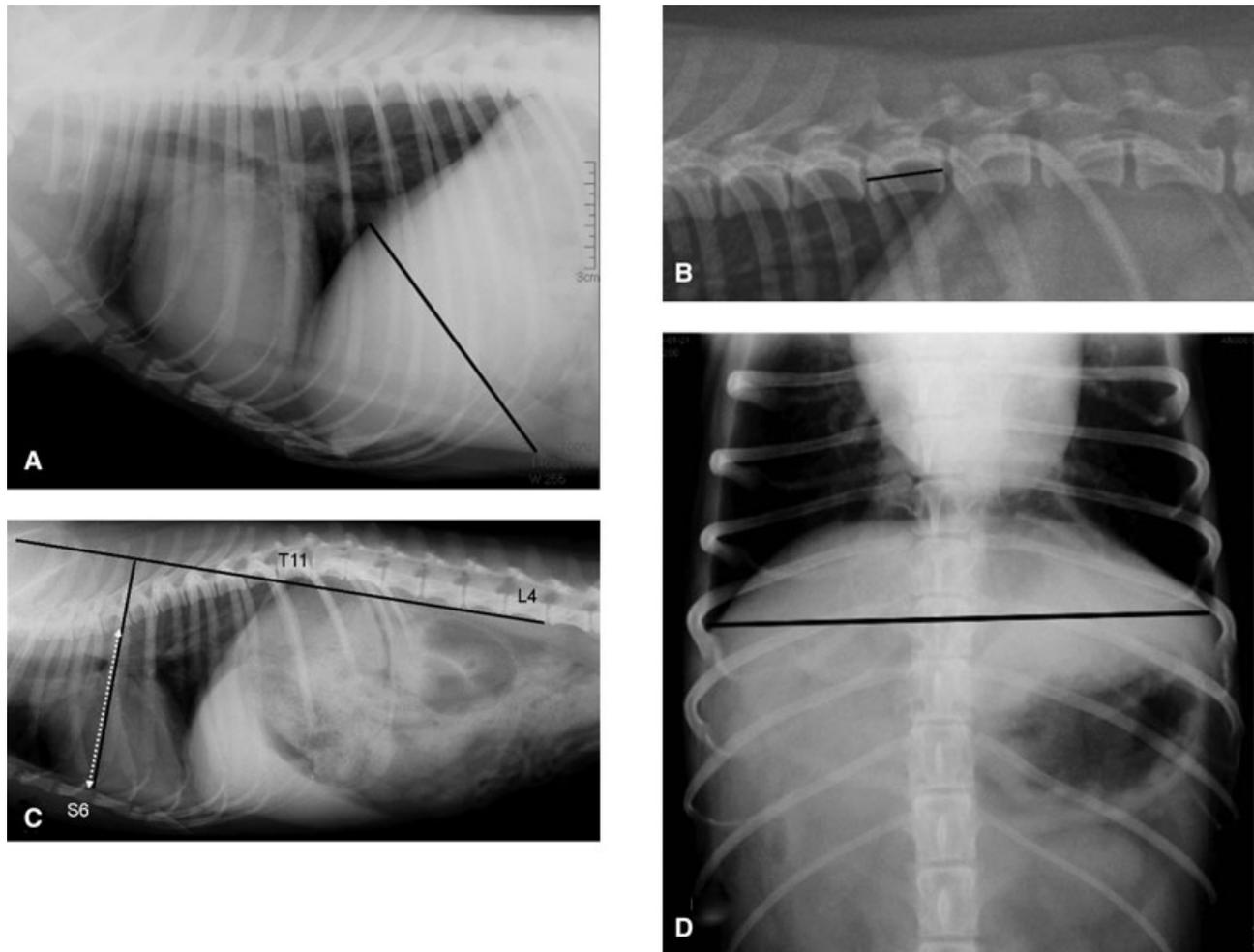


FIG. 1. Right lateral and ventrodorsal radiographs illustrating the measuring methods for liver length, length of the 11th thoracic vertebra, depth of thoracic cavity, and width of thoracic cavity. The length of the liver was measured as the length of a line drawn from the ventral border of caudal vena cava to the apex of the hepatic caudal border (A). The length of T11 was measured at the level of the midpoint, parallel to the long axis of the vertebral body (B). The depth of the thoracic cavity was measured as the length of the perpendicular axis (dotted arrow) from the caudal tip of the sixth sternebra (S6) to the axis between the ventral border of the 11th thoracic vertebra (T11) and the ventral border of the fourth lumbar vertebra (L4) (C). The width of thoracic cavity was measured by drawing a line between the costophrenic recesses (D).

TABLE 1. Radiographic Liver Size Comparisons in Three Groups of Normal Dogs

| Liver measurement (Mean \pm SD) | Pekingese (n = 61) | Non-Pekingese brachycephalic (n = 45) | Nonbrachycephalic (n = 71) |
|-----------------------------------|--------------------|---------------------------------------|----------------------------|
| LL/T11 ratio | 4.64 \pm 0.65* | 5.16 \pm 0.74 | 5.4 \pm 0.74 |
| TD/TW ratio | 0.66 \pm 0.12 | 0.68 \pm 0.08 | 0.64 \pm 0.1* |
| LV (cc) | 88.4 \pm 4.65* | 109.8 \pm 11.52* | 71.52 \pm 8.84* |
| LV/BW ratio | 16.73 \pm 5.67* | 19.54 \pm 5.03 | 18.72 \pm 6.52 |

*Indicates statistically different at $P < 0.05$.

SD, standard deviation; LL, liver length; T11, 11th thoracic vertebral length; TD, thoracic depth; TW, thoracic width; LV, liver volume; BW, body weight (kilograms).

T11. This value was significantly smaller than the liver lengths of other normal brachycephalic (5.16 times) and nonbrachycephalic breeds (5.4 times), respectively. The liver length/T11 vertebral length ratio in the normal Pekingese group was significantly lower than those in the brachy-

cephalic and nonbrachycephalic groups ($P < 0.05$). The ratio of thoracic depth to thoracic width of the normal Pekingese group did not differ from that of the brachycephalic group ($P > 0.05$). Mean thoracic depth/thoracic width ratios were significantly different in normal Pekingese and brachycephalic groups versus the nonbrachycephalic group ($P < 0.05$). The ratio of the volume of the liver to body weight was significantly lower in normal Pekingese vs. other breeds ($P < 0.05$). Liver volume/body weight (21.19 ± 8.45) and liver length/T11 vertebral length ratio (5.33 ± 0.98) were significantly larger in Pekingese with liver disease (16.73 ± 5.67 and 4.64 ± 0.65 , respectively) ($P < 0.05$).

Discussion

In this study, we found that standard radiographic criteria for normal liver size may not be valid for use in Pekingese

breed dogs. The liver length was measured on right lateral view and compared with T11 vertebral length in this study because the ratio of the length of the liver to the length of T11 has been reported to have a significant correlation with the ratio of the volume of the liver to body weight in dogs. The length of the liver in normal Pekingese was 4.64 times of the T11 vertebral length in our study. This differed from a previous report describing the normal length of the liver to be 5.5 ± 0.8 times of the length of the T11.⁸ Liver lengths that we measured in non-Pekingese brachycephalic and nonbrachycephalic dogs were more consistent with the previous report (5.16 and 5.4 times the length of T11, respectively).

The volume of the liver was divided with body weight to compensate for the difference of in liver size according to body weight in each dog, because a high correlation between liver weight and liver volume and between liver weight and body weight of the dogs has been previously reported.¹¹ In our study, the volume of the liver per body weight in normal Pekingese was significantly smaller than normal non-Pekingese brachycephalic and normal nonbrachycephalic breeds. The length of the liver compared with T11 vertebral length and the volume of the liver per body weight in normal Pekingese were significantly lower than those values obtained from Pekingese with liver disease. This finding indicates that hepatomegaly likely predominated in our liver disease group.

One limitation of our study was that we did not measure actual liver volume using necropsy, 3D CT, or MRI. However, previous studies have reported close correlation between liver volume estimates from radiographic measurements and actual liver volume in dogs.⁸ Other limitations

in this study were the small number of Pekingese with liver disease and a lack of histological classification for the hepatopathies. We chose to exclude dogs from our study if we could not clearly identify the caudal border of the liver. This could have contributed to our small sample size for liver disease Pekingese dogs. Radiographic measurements can be limited by variability in visibility of the ventral and caudoventral borders of the liver shadow, potential merging of silhouettes of the liver and spleen or poor visualization of the stomach.^{12,13} Also, we did not confirm normal status in our dogs using functional tests such as ammonia tolerance test, bile acid measurements, or histologic examination. Therefore, it is possible that some dogs with subclinical hepatic diseases may have been included in the normal group.

In summary, findings from our study indicated that radiographic liver size in normal Pekingese was smaller than that of other breed dogs, including other normal brachycephalic dogs such as Shihtzus, Boston terriers, and Pugs. This is important to take into consideration so that false diagnoses of microhepatica can be minimized in Pekingese. The normal length of the liver was 4.64 times of the length of T11 in Pekingese dogs of our study. This was lower than the previously published standard. Further studies testing the diagnostic sensitivity of these liver size criteria for differentiating Pekingese with normal vs. diseased livers are needed.

ACKNOWLEDGMENTS

This study was supported in part by the Animal Medical Institute of Chonnam National University and the Research Institute for Veterinary Science at Seoul National University.

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