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Research Article

Age and Neutering as a Determinant of Liver Size in Cats: A Radiographic Length of the Liver to the Length of the 11th Thoracic Vertebra Ratio

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Abstract

It is generally known that liver size changes in liver diseases. In addition to imaging modalities such as computed tomography, which require anesthesia, radiographic measurements can also be used to measure liver size. The aim of this study was to estimate liver size in healthy cats by radiographic measurement. A total of 60 healthy tabby cats were used in this study. Liver length and T11 vertebra length were measured on right lateral thorax radiographs and LL/T11 ratios were calculated. While 2-sample t test was used for pairwise comparison between groups, ANOVA one-way analysis of variance was used for multiple comparisons. Differences between groups were determined by Tukey comparison test. It was determined that gender and neutering status had no effect on LL/T11 ratio in cats of different age groups. However, statistically significant changes were determined in cats under 1 year of age and over 4 years of age. In conclusion, it was determined that radiographic LL/T11 ratio in cats is a usable index without being affected by the parameters evaluated. Therefore, radiography, which is a more practical application in clinics and animal hospitals, can be used for liver measurements as an alternative to measurement methods requiring anesthesia.

Keywords: Cat, Liver size, LL/T11 ratio, radiography

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Introduction

Liver size is one of the main criteria used in liver diseases such as hepatic congestion, hepatic cirrhosis, infiltrative disease, inflammation or hepatic neoplasia (Wrigley 1985). While congenital vascular anomalies, inflammation and cirrhosis lead to a reduction in liver size (Choı et al 2012), hepatic lipidosis, vascular stasis and neoplasms may cause hepatomegaly (Evans 2005). The gastric axis position is generally used to determine the size of the liver radiographically (Larson, 2007). However, recent studies have reported that the position of the gastric axis may be affected by physiological conditions such as age, weight, volume of gastric contents and degree of inspiration, and inaccurate measurements may be made (Partington et al., 1995). Therefore, measurement of liver length was considered a more reliable method as it is not affected by thoracic conformation (Van Bree et al 1989). While an association between liver disease and liver size has been established in dogs, it can be difficult to determine whether liver size in cats is due to disease (Tivers et al 2011). While excessive fat deposition in the falciform ligaments causes the liver parenchyma to deviate dorsally (Lee et al 1982), hepatomegaly may be misdiagnosed in older cats with elongation of the triangular ligament (Choı et al 2012). Previous studies have shown that the radiographic ratio of the length of the liver to the length of the 11th thoracic vertebra (LL/T11) is an objective method for estimating liver size in dogs (Choı et al 2012). The same measurement method has been used in cats and it was reported that the measurements were correlated with liver volume on computed tomography (An et al 2019).

Based on this information, the aim of this study was to determine the radiographic changes in LL/T11 ratio in healthy tabby cats according to gender, age and whether they were neutered or not.

Material and Methods

This study was designed to evaluate the effect of age, gender and neutering on LL/T11 ratio in 60 healthy tabby cats (30 females and 30 males) upon the approval by Kastamonu University Animal Experiments Local Ethics Committee (HADYEK, 2024/34). The study material is given in Table 1.

Right lateral thorax radiographs were taken without anesthesia after noting whether had been previously neutered or not the cats brought to the animal hospital for control purposes. Radiographs were obtained using appropriate exposure settings based on abdominal thickness measurements, which were automatically adjusted according to the weight of the animal. (IPS Medical-Philosophy HF 200, Italy, average 200 mA, 60 kV, 80 cm film-tube distance) All digital images were evaluated and measurements were made using a Digital Imaging and Communications (DICOM) imager (Carestream Image Suite 4.0, USA). Right lateral thorax radiographs were used for the measurements of all cats included in the study. Liver length (LL, cm) and T11 vertebra length (cm) were measured on these radiographs. Liver length was measured as the length of the axis from the intersection of the most cranial point of the diaphragm and caudal vena cava to the apex of the caudal hepatic border. The length of the T11 vertebra was measured at the level of the midpoint parallel to the long axis of the vertebral body (Choı et al 2012) (Figure 1).

Statistical Analysis

Data are expressed as mean ± standard deviation (SD). While 2-sample t test was used for pairwise comparison between groups, ANOVA one-way analysis of variance was used for multiple comparisons. Differences between groups were determined by Tukey comparison test. P value < 0.05 was considered significant for all tests. Statistical analysis was performed with SPSS (SPSS for Windows, Release 13.0, standard version, SPSS, Inc., Chicago, IL).

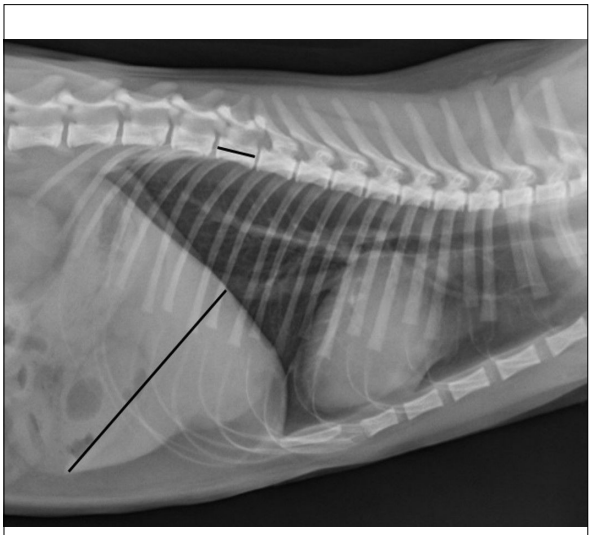

Figure 1. Radiographic measurement of liver length (LL) and T11 vertebral length in cats.

Results

Effects of Gender on T11 Length, LL and LL/T11 Ratio

According to the study data, gender had no effect on T11-liver length and LL/T11 ratio (Table 2).

Effects of Age on LL/T11 Ratio

The ages of the cats included in the study were grouped as under 1 year, 1 year, 2-3 years and over 4 years. When the effect of each age group on the LL/T11 ratio was analyzed, it was determined that the LL/T11 ratio was significantly higher in cats under 1 year of age compared to the other groups, while it was significantly lower in cats over 4 years of age. No significant difference was found between 1 year old cats and 2-3 years old cats. LL/T11 ratios according to age groups are shown in Table 3.

Table 1. Neutering status and gender distribution of the cats constituting the study material.

	Female	Male
Neutered	n=15	n=15
Non-neutered	n=15	n=15
Total	30	30

Table 2. The effect of gender on measurement parameters in cats.			
Parameters	Male	Female	P
T11 (cm)	13.86 (±1.82)	13.31 (±1.31)	>0.05
LL (cm)	65.94 (±8.24)	64.3 (±12.4)	>0.05
LL/T11 ratio	4.81 (±0.74)	4.87 (±1.01)	>0.05
Data presented mean±SD, sample size n=30 for each group (P<0.05).			

Effects of Neutering on T11 Length, LL and LL/T11 Ratio

Neutering had no effect on T11-liver length and LL/T11 ratio among male cats. However, while there was no difference in T11 length and LL/T11 ratios between neutered and non-neutered female cats, liver length was significantly higher in neutered females (Table 4).

Discussion

Liver size is frequently assessed in the evaluation of liver diseases (Choı et al 2012). However, it has been reported that obese cats are misdiagnosed as microhepatia without liver disease because the liver is dorsally deviated (An et al 2019). In human medicine, liver weight has been found to correlate with liver volume measured by Computed Tomography regardless of the disease (Schiano et al 2017). An et al (2019) reported a significant correlation between Computed Tomography liver volume and radiographically measured LL/T11 ratio in a study in healthy cats. Therefore, we calculated the LL/T11 ratio by measuring the length of the liver and T11 radiographically. As in the reference study, we think that it is advantageous to measure the LL/T11 ratio radiographically in the absence of computed tomography. Thus, a measurable criterion for the estimation of liver volume was established. Since gender is a factor affecting obesity (Lund et al 2005), we investigated the effect of gender on liver measurements. Although it is considered as a limitation of our study because the weight of the cats was not measured, An et al (2019) reported that obesity and gender had no effect on the LL/T11 ratio. Similarly, we found no effect of gender on LL, T11 and LL/T11 ratio. However, when we examined the effect of neutering, we found no significant difference in males, while liver length was significantly higher in neutered females. However, this increase was not effective on the LL/T11 ratio.

It is generally known that breed and body structure affect liver size in dogs (Choı et al 2012) but not in cats (An et al 2019). This is the reason why the cats included in the study were not of different breeds. Since there is no change in liver size in tabby cats according to the degree of elongation of the body and recumbency (An et al 2019), radiographs were taken in the neutral position. All cats were evaluated in the right recumbency position, as there are not many studies indicating a gold standard for lateral recumbency.

Since the ages of the cats are different from each other, we preferred to group them as under 1 year old, 1 year old, 2-3 years old and over 4 years old. An et al (2019) warned in their study that the liver is larger in healthy young and newborn cats and can be interpreted as hepatomegaly. In our study, we determined that LL/T11 ratios were higher in cats under 1 year of age compared to other age groups. In the reference study, it was reported that the caudal edge of the liver in old cats gave the appearance of hepatomegaly because it extended over the costal arch. Whereas, as cats age, there is a reduction in the number and size of hepatocytes contributing to the overall decrease in liver volume (Day 2010). Similarly, we found the lowest LL/T11 ratio in cats over 4 years of age, which was statistically significant. It is important to consider age groups to minimize misdiagnosis in radiographic evaluation.

Table 3. LL/T11 ratio by age groups in cats.					
	Under 1 year old	1 year old	2-3 years old	Over 4 years old	P
LL/T11 ratio	5.59 (±0.85)[a]	4.77 (±0.52)[b]	4.88 (±0.52)[b]	4.02 (±0.85)[c]	<0.001
Data presented mean±SD, sample size n=30 for each group. The difference between the means with different letters in the same row is significant (P<0.05).					

Table 4. Measurement parameters in neutered and non-neutered cats.

Parameters	T11 (cm)	P	LL (cm)	P	LL/T11 ratio	P
Neutered Female	13.71 (±1.18)	>0.05	69.19 (±9.93)	<0.05	5.06 (±0.71)	>0.05
Non-neutered Female	12.91 (±1.36)		59.4 (±13.0)		4.67 (±1.23)	
Neutered Male	13.93 (±2.14)	> 0.05	65.57 (±6.31)	>0.05	4.796 (±0.758)	>0.05
Non-neutered Male	13.80 (±1.52)		66.3 (±10.0)		4.836 (±0.763)	

Data presented mean±SD, sample size n=30 for each group (P<0.05).

One limitation of our study is that the actual liver volume was not measured. However, previous studies have reported a correlation between radiographic measurements and actual liver volumes (Van Bree et al 1989; Schiano et al 2017). Another limitation is that liver functional tests were not performed in cats. Therefore, cats with subclinical hepatic diseases may have been included in the study. The number of studies testing diagnostic sensitivity should be increased.

Conclusion

In conclusion, measurement of the LL/T11 ratio on radiographs in the lateral position should be considered as an alternative to imaging methods requiring anesthesia in the evaluation of liver size. In the evaluation of LL/T11 ratio, it was concluded that there was no effect of gender and neutering in tabby breed cats, but there were statistically significant changes in cats under 1 and over 4 years of age. These results indicate that the LL/T11 ratio is a useful index for measuring liver size without being affected by the parameters evaluated.

Declarations

Competing Interests

Authors declares that there are no conflicts of interest related to the publication of this article.

Availability of Data and Materials

The data that support the findings of this study are available on request from the corresponding author.

Ethical Statement

Kastamonu University, Animal Experiments Ethics Committee 12.09.2024, 2024/34 Number Ethics Committee Decision

Author Contributions

Motivation / Concept: ED; Design: ED, CO; Control/Supervision: ED; Data Collection and Processing: ABD, CO; Analysis and Interpretation: ED, CO; Literature Review: ABD, ED; Writing the Article: ED; Critical Review: ED, CO, ABD

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