

# Evaluation of computed radiographic lateral surface area of liver to 11<sup>th</sup> thoracic vertebrae ratio in dogs

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## ABSTRACT

**Aim:** The aim of the study was to evaluate radiographic liver area to 11<sup>th</sup> thoracic vertebral area ratio for setting up a quantitative index in clinically healthy dogs.

**Materials and Methods:** Total 75 dogs were examined through computed radiography. One year and above aged dogs of 9 breed of different body weights were included in the study. A complete computed radiography was done to obtain right lateral (RL) and ventro-dorsal (VD) views in all dogs. The ratio was evaluated according to signalment characteristics i.e. age, sex, body weight, breed and neutering status.

**Results:** The ratio of radiographic liver area in lateral view (RLA-L) to T11 vertebral area (T11 A) was recorded as 27.62±0.74, 27.45±1.11, 27.97±1.17 and 30.71±2.80 in 1-3 year, 3-6 year, 6-9 year and 9-12 year of age group, respectively. Sex wise ratio 26.83±0.85 in male and 28.73±0.76 in female group was measured. Body weight wise ratio was 27.44±1.26, 28.17±0.76 and 28.35±1.02 in upto-20 Kg, 20-30 Kg and 30-40 Kg of body weight group, respectively. Breed wise ratio was 27.21±0.99, 28.78±1.65, 29.74±1.97, 27.44±0.95, 28.88±1.30, 28.55±2.21, 24.82±1.67, 28.59±2.38 and 30.79±3.75 in German Shepherd, Belgian Shepherd, Siberian Husky, Dobermann pinscher, Golden Retriever, Labrador Retriever, Indian Mongrel, Pomeranian and Pug respectively. Neutering status wise ratio was 28.37±0.88 and 27.74±0.75 in castrated or spayed and intact group, respectively.

**Conclusion:** It was concluded that the ratio of radiographic liver lateral area to T11 vertebral area is set as a quantitative index of radiographic liver size in dogs. The lateral surface area of normal liver is 27.97 times to the lateral surface of T11 vertebrae.

**Keywords:** Radiographic liver lateral area, 11<sup>th</sup> thoracic vertebral area, radiographic liver measurements.

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## Introduction

Liver plays a crucial role in carbohydrate metabolism by converting glucose into glycogen and actively storing, reabsorbing and releasing glucose. Liver also plays a significant part in protein metabolism, deaminates amino acids and transforms them into carbohydrates and lipids (Birmingham *et al.*, 2001). Liver produces many proteins including albumin, fibrinogen, globulin and clotting factors (Ziccardi *et al.*, 1991). Liver performs a wide range of essential functions in the maintenance, performance and regulation of homeostasis in body. It is involved in almost biochemical pathway to growth, disease resistance, nutrient supply and reproduction (Taub, 2004 and Michalopoulos, 2007).

Liver conditions such as hepatomegaly, microhepatia, liver cysts, liver abscesses, neoplasia and mineralization of the liver are frequently reported (Negasee, 2021). Diagnosis of a particular liver conditions can be challenging since the organ's symptoms may not be certain or easily confused with other liver diseases. In certain circumstances, animal may not exhibit any clinical signs; however, liver may have already significant damage. Liver disorders can be caused by a variety of factors including infection, genetics, autoimmune and metabolic conditions (Kozat and Sephehrizadeh, 2017).

Changes in hepatic size are frequently used as indicators of liver disease (Wrigley, 1985; Choi *et al.*, 2013; Cockett, 1986; Lee and Leowijuk, 1982; Penninck and Berry, 1997). Radiographic evaluation of liver size involves both morphological and quantitative assessment. In dogs with generalized liver enlargement, the caudo-ventral liver margin appears round or

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blunt and extends beyond the costal arch and caudal deviation of gastric axis is seen (Wrigley, 1985; Suter, 1982; Partington and Biller, 1995 and Larson, 2018). In cats, it can be difficult to determine whether change in radiographic liver size is caused by liver disease, in contrast to the relationship between liver size and liver disease observed in dogs (Tivers and Lipscomb, 2011). The clarity with hepatic margin is demarcated and depended upon the amount of fat within the falciform ligament (Wrigley, 1985; Suter, 1982; Partington, and Biller, 1995; Larson, 2018). The exact position of caudo-ventral tip of the liver is appreciated in the lateral projection (Lee and Leowijuk, 1982; Root, 1974; Hardy, 1975). It appears as a wedge-shaped shadow with its apex extending caudally and consists of the partially superimposed right medial and left lateral lobes (Suter, 1982; Gibbs, 1981 and O'Brien, 1978). Its relationship to the costal arch is a parameter often used to evaluate liver size (Wrigley, 1985; Suter, 1982; Gibbs, 1981; O'Brien, 1978; Douglas and Williamson, 1970; Ackerman and Silverman, 1977; Chandna and Nigam, 1980) but this protrusion can merge and be difficult to distinguish from the outline of the spleen (Douglas and Williamson, 1970 and Kealy, 1979). A substantially enlarged or reduced liver size is a reliable sign of disease (Suter, 1982). Liver diseases are frequently encountered in the veterinary clinical practices. Dogs primarily present with parenchymal pathologies such as hepatitis (Watson, 2004 and Center, 2009). The estimated frequency of canine hepatitis depends on the investigated population and accounts for 1%–2% of clinic referral population (Poldervaart et al., 2009) and up to 12% in a general population (Watson et al., 2010). Potential causes of canine hepatitis include micro-organisms, toxins and drugs and immune-mediated reactions. Disorders of copper metabolism account for roughly 30% of chronic canine hepatitis cases (Favier, 2009). Liver affections i.e. hepatomegaly, microhepatica, liver cyst and abscess, neoplasia and mineralization of liver etc. are commonly observed (Negasee, 2021).

Radiographs (lateral and ventro-dorsal views) can help to detect morphological anomalies in the size, shape, location and density of the liver (Kumar et al., 2012). Radiographic anatomy (Thrall and Robertson, 2016) and measurements have an importance in evaluation of radiographic liver size. Changes in liver size

are frequent indicators of hepatic diseases (Carlson, 1976; Wrigley, 1985). In small animals (Douglas and Williamson, 1970; Carlson, 1976; Suter, 1982 and Wrigley, 1985) as well as in humans (Meschan, 1967 and Gelfand, 1975) survey radiographic measurements provide an imprecise estimation of hepatic sizes (Bree and Sackx, 1987). Radiographic assessment of liver size includes both morphological and quantitative measurements (Lee et al., 2019, Karir et al., 2024 and Bharti et al., 2025). Radiographic diagnosis of liver disorders is a valuable module for both clinical practices and research in dogs. Therefore, main purpose of the present study was to evaluate radiographic liver area to 11<sup>th</sup> thoracic vertebral area ratio for setting up a quantitative index to clinically healthy dogs.

### Materials and Methods

The study was carried out by examining 75 dogs of nine different breeds that encountered thoracoabdominal computed radiography. The study included dogs with good general health, no history of chronic illnesses or systemic disorders, brought to the clinics for a general health check-up. The study comprised dogs aged one year or older, different breeds and of various body weights.

Radiographic examinations were done using a 500 mA X-Ray machine (EP-CORSA 40kw/Epsilon Health Care Solutions Pvt. Ltd.) at a focal film distance of 90cm in right lateral and ventro-dorsal radiographic projections and interpreted for all dogs. Right lateral radiography revealed the liver lateral region and the T11 spinal area. Radiographic liver lateral area (cm<sup>2</sup>) was assessed using computed radiography (CR) equipment (FCR-CAPSULA XLII). RLA-L was drawn to represent the cranial boundary which was defined by the radiolucent lung diaphragm border and the caudal border which was defined by cranial edge of the stomach, proximal aspect of the duodenum and cranial pole of right kidney. Surface area of T11 vertebral body was measured in right lateral radiographic view using a computed radiography (CR) system.

The data obtained in the present study were analyzed by independent sample t test and oneway analysis of variance (ANOVA) technique using the statistical package SPSS software version 21.

### Results and Discussion

The ratio of radiographic liver lateral surface area to T11 vertebrae area was recorded  $27.97 \pm 0.82$  as a mean  $\pm$  S.E. in all dogs included German Shepherd (n=17), Belgium Shepherd (n=7), Dobermann Pinschers (n=8), Labrador Retriever (n=8), Golden Retriever (n=8), Siberian Husky (n=6), Indian Mongrel (n=9), Pomeranian (n=6) and Pug (n=6) dog breeds. Radiographic liver lateral area to T11 vertebral area ratio was recorded in context of age, sex, body weight, breed and neutering status. Similarly, Washizu et al. (2004) investigated liver size by comparing the area of liver to the area of fourth lumbar vertebra in dogs. Kim et al. (2018) also measured length of the liver through radiography in right lateral recumbency.

In the present study, ratio of radiographic liver area in lateral view (RLA-L) to T11 vertebral area (T11 A) was recorded as  $27.62 \pm 0.74$ ,  $27.45 \pm 1.11$ ,  $27.97 \pm 1.17$  and  $30.71 \pm 2.80$  in 1-3 year, 3-6 year, 6-9 year and 9-12 year of age group, respectively. It was showed no significant ( $p > 0.05$ ) changes to RLA-L/T11A according to age in dogs. Lee et al. (2019) also measured RLA-L/T11A values in dogs. Karir et al., (2024) and Bharti et al. (2025) also reported different normal radiographic liver measurements according to age in deep chested dogs.

Table 1. Age wise mean  $\pm$  S.E. values of RLA-L: T11A ratio

Ratio	Age			
	1-3 Year	3-6 Year	6-9 Year	
RLA-L: T11 A	$27.62 \pm 0.74$	$27.45 \pm 1.11$	$27.97 \pm 1.17$	$30.71 \pm 2.80$

Table 2. Sex wise Mean  $\pm$  S.E. values of RLA-L: T11A ratio

Ratio	Sex	
	Male	Female
RLA-L: T11 A	$26.83 \pm 0.85$	$28.73 \pm 0.76$

Table 3. Body weight wise Mean  $\pm$  S.E. values of RLA-L: T11A ratio

Ratio	Body weight		
	Upto20Kg	20-30 Kg	30-40Kg
RLA-L: T11 A	$27.44 \pm 1.26$	$28.17 \pm 0.76$	$28.35 \pm 1.02$

In the present study, sex wise ratio  $26.83 \pm 0.85$  in male and  $28.73 \pm 0.76$  in female group was

Table 4. Breed wise Mean  $\pm$  S.E. values of RLA-L: T11 A ratio

Ratio	Breeds								
	German Shepherd	Belgian Shepherd	Siberian Husky	Dobermann pinscher	Golden Retriever	Labrador Retriever	Indian Mongrel	Pomeranian	Pug
RLA-L: T11 A	$27.21 \pm 0.99$	$28.78 \pm 1.65$	$29.74 \pm 1.97$	$27.44 \pm 0.95$	$28.88 \pm 1.30$	$28.55 \pm 2.21$	$24.82 \pm 1.67$	$28.59 \pm 2.38$	$30.79 \pm 3.75$

measured. It was exhibited non-significant ( $p > 0.05$ ) alterations to RLA-L/T11A according to sex in dogs. Karir et al., (2024) and Bharti et al. (2025) also noted non-significant alterations in different ratios of radiographic liver measurements based on sex.

However, Lee et al. (2019) also measured RLA-L/T11A values  $20.4 \pm 7.4$  for 34 cases with microhepatia and  $51.0 \pm 12.9$  for 37 hepatomegaly cases irrespective to the sex.

In the present study, Body weight wise ratio was  $27.44 \pm 1.26$ ,  $28.17 \pm 0.76$  and  $28.35 \pm 1.02$  in upto-20 Kg, 20-30 Kg and 30-40 Kg of body weight group, respectively. It was encountered no significant ( $p > 0.05$ ) differences to RLA-L/T11A according to body weight in dogs. Bharti et al. (2025) and Karir et al., (2024) also noted non-significant changes in different ratios of radiographic liver measurements based on body weight.

In the present study, Breed wise ratio was  $27.21 \pm 0.99$ ,  $28.78 \pm 1.65$ ,  $29.74 \pm 1.97$ ,  $27.44 \pm 0.95$ ,  $28.88 \pm 1.30$ ,  $28.55 \pm 2.21$ ,  $24.82 \pm 1.67$ ,  $28.59 \pm 2.38$  and  $30.79 \pm 3.75$  in German Shepherd, Belgian Shepherd, Siberian Husky, Dobermann pinscher, Golden Retriever, Labrador Retriever, Indian Mongrel, Pomeranian and Pug, respectively. It was exhibited non-significant ( $p > 0.05$ ) alterations to RLA-L/T11A according to breeds in dogs. Lee et al. (2019) also reported RLA-L/T11A values in small breed dogs. Cha et al. (2018) noted liver length to T11 vertebrae length ratio as  $5.98 \pm 0.40$  and  $5.99 \pm 0.47$  in Beagles with food deprivation while experiencing gastric distention at full expiration. Choi et al. (2013) also reported liver length to T11 vertebrae length ratio differed among Pekingese ( $4.64 \pm 0.65$ ), non-Pekingese ( $5.16 \pm 0.74$ ) and non-brachycephalic breeds ( $5.4 \pm 0.74$ ) which emphasized the variations in liver size based on breed. However, An et al. (2019) documented a ratio  $4.22 \pm 0.54$  for normal cats underlining the differences specific to species.

In the present study, Neutering status wise ratio was  $28.37 \pm 0.88$  and  $27.74 \pm 0.75$  in castrated or spayed and intact group, respectively.

Table 5: Status of neutering wise Mean±S.E. values of RLA-L: T11 A ratio

Ratio	Neutering status	
	Intact	Neutered
RLA-L: T11 A	27.74±0.75	28.37±0.88

It was assessed non-significant ( $p>0.05$ ) differences to RLA-L/T11A in context of neutering status in dogs. Karir et al., (2024) and Bharti et al. (2025) also reported non-significant alterations in different ratios of radiographic liver measurements based on neutering status.

### Conclusions

It was concluded that the ratio of lateral radiographic liver area to T11 vertebral surface area remains fairly consistent among various demographic groups with minor alterations concerned to age, body weight and breed. These results added to the expanding evidence to support radiographic measurements for liver size evaluation in dogs.

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