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Measurement and comparison of vertebral heart size (VHS) in Muzaffarnagari sheep using two different methods

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Abstract
The present study was conducted to establish the standard values (range) for parameters of the heart and thorax, to evaluate the Vertebral Heart Size of the twelve apparently healthy Muzaffarnagari sheep divided into group I (10-20 kg, age 3-6 months) and group II (25-40 kg, age 12-15 months) six in each. The Vertebral Heart Size was recorded as per Buchanan and Bucheler (1995) and Ljubica *et al.* (2007) method and differed significantly between groups I and II animals. The mean Long Axes, Short Axes and Vertebral Heart Size in group I was 10.83 ± 0.23cm, 6.53 ± 0.14cm and 8.40 ± 0.14v respectively, whereas in group II these mean values were 12.47 ± 0.23cm, 7.55 ± 0.30cm and 8.23 ± 0.21v respectively using Buchanan and Bucheler method, when calculated as per Ljubica *et al*. method Vertebral Heart Size was 9.27 ± 0.13cm and 9.15 ± 0.16cm in group I and group II respectively.

Keywords: Muzaffarnagari sheep, lateral radiograph, vertebral heart size (VHS)

Introduction
The method of measuring the heart size in thoracic radiography by comparing it to the length of thoracic vertebrae is marked as vertebral heart size (VHS). Radiographic evaluation of cardiac size in animals is a primary diagnostic tool for the detection of heart disease (Thrall, 2002) [1]. Heart disease is to be considered, and cardiac assessment should be carried out, if any of the following signs are identified on physical examination of a patient: limb abduction, bulging eyes, neck extension, reluctance to lie down, ascites, syncope, (jugular) venous distension, feeble pulse, oedema, hepatomegaly, water-hammer pulse, rales, rhonchi, cough, arrhythmias, bradycardia, tachycardia etc (Merck Veterinary Manual, 2016) [2]. Alteration in the shape and size of cardiac silhouette, abnormal size, and shape of pulmonary vessels and the presence of pulmonary edema or ascitis on thoracic radiographs are often the hallmarks for radiographic diagnosis of cardiac diseases in dogs (Root and Bahr, 2002) [3]. Thoracic radiographs are helpful in the diagnosis of heart disease especially when radiographic findings are compared with results of other diagnostic modalities. The radiographic examination of the thoracic cavity allows a fast non-invasive assessment of the lung, heart size and vascularisation. The VHS provide the ratio of the heart size in comparison to the thoracic vertebra that helpful in evaluation of cardiac diseases. Vertebral heart size (VHS) is a predictive factor for cardiac enlargement. The goal of the present study was to establish correlation of age and body weight with VHS in apparently healthy Muzaffarnagari Sheep.

Materials and Methods
Present study was conducted on twelve apparently healthy Muzaffarnagari sheep of either sex, free from cardiothoracic diseases. The animals were divided into group I (10-20 kg of 3-6 months age) and group II (25-40 kg and 12-15 months age) having six animals in each. The sheep had normal physiological parameters were considered healthy and selected for present study. Rectal temperature (°F), respiratory rate (breaths/min), heart rate (beats/min) and pulse (beats/min) were recorded in animals to ascertain health status. All examinations were performed with manual restraint of the animals, without the use of sedation or anesthesia.
To obtain good quality radiographs, X-ray machine (Heliophos-D, Siemens Healthcare India) and computed radiography system (Regius Model 110 S with Regius direct digitizer software, Konica Minolta Healthcare, India) were used. Lateral radiographs were taken on fixed 95 cm focal film distance (FFD) and 320 mA, 9.5-13 mAs and 58-70 KVP. The phosphor plates

(14 x 17 inches) were horizontally oriented to obtain the right lateral radiographs for complete visualization of the thorax from spine to sternum and first rib to diaphragm.

Radiographs of all Muzaffarnagari sheeps were analyzed by subjective assessment and then two methods of VHS measurement were performed.

Location of the cardiac silhouette in the lateral radiographs was determined visually as described by Ukaha (2015) [4]**.** The position of the carina was located visually over the rib or within the intercostal space as described by Lehmukhl *et al*. (1997) [5].

First Measurement: The Buchanan and Bucheler's (1995) [6] method was used to measure VHS. The longest axis (LA) of the cardiac silhouette was measured from the ventral border of the carina to the most distant ventral contour of the cardiac apex. The short axis (SA) was measured at the widest part of the cardiac silhouette, perpendicular to the long axis (at the level of ventral margin of the caudal vena cava). Both these measurements were done using electronic calipers of CR system. The lines conforming to these measurements (LA and SA) were transposed over the vertebral column starting at the cranial edge of the vertebral body of fourth thoracic vertebra (T_4) Finally, the sum of both values (long and short axes) was equivalent to the vertebral heart size (Figure 1).

VHS was calculated using following formula given below by Buchanan and Bucheler (1995) [6].

VHS = LA+SA

Second Measurement: Ljubica *et al*. (2007) [7] marked the method of measuring heart size in thoracic radiography by comparing it to the length of forth thoracic vertebrae as vertebral heart size (VHS). The long and short axes of the heart were placed on the same way as previously described in the first measurement and both the values were divided with the length of the body and caudal disc of T4. The two VHS measurement (for long and short axes) were than summed (figure 2).

$VHS=LA/T_4+SA/T_4$

Statistical analysis

The mean and standard error for each parameter were calculated by using SPSS software version 16.0, one way analyses of variance (ANOVA). Bivariate Pearson's correlation test was used to establish the correlation of radiographic parameters with body weight and age of animals (Snedecor and Cochran, 1994) [8].

Results and Discussion

Radiographs were of good technical quality, so anatomic landmarks were used as references points for cardiac silhouette size determination.

The mean LA, SA and VHS as per Buchanan and Bucheler (1995) [6].in group I was 10.83 ± 0.23cm, 6.53 ± 0.14cm and 8.40 ± 0.14v respectively, whereas in group II these mean values were 12.47 ± 0.23cm, 7.55 ± 0.30cm and 8.23 ± 0.21v respectively. The mean LA and SA values showed positive correlation with age and body weight in both the groups, however, mean VHS value showed negative correlation. While as per Ljubica *et al*. (2007) [7] method, the mean LA, SA,T4 and VHS in group I was 10.83 ± 0.23cm, 6.53 ± 0.14cm, 1.84 ± 0.06cm, 9.27 ± 0.13v respectively, , whereas in group II these mean values were 12.47 ± 0.23cm, 7.55 ± 0.30cm, 2.15 ± 0.04and 9.15 ± 0.16respectively (Table 1). Mean±S.E values of long axis (LA), short axis (SA) and T4, did not differ significantly ($p\geq0.05$) between the sheep of groups-I and II. Whereas, the mean±S.E values of VHS by Buchanan and Bucheler (1995) [6] and Ljubica *et al*. (2007) [7] methods were significantly ($p\leq0.05$) low in the animals of group-II, in comparison to group-I. Significant ($P\leq0.05$) positive correlation was found in the values of T4 with age and body weight of the animals. The VHS by Buchanan and Bucheler (1995) [6] and Ljubica *et al*. (2007) [7] methods was negatively correlated ($p\geq0.05$) with age and body weight of the animals. (Table 1)

In this study the carina (funnel-shaped appearance of terminal trachea transition to the mainstem bronchi) was located at the 4^{th}-5^{th} intercostal space.

The heart was located between 3-6 intercostal spaces. The cranial cardiac border was located approximately between the cranial and caudal margin of the 3^{rd} rib in all subjects. The caudal cardiac border was located from the caudal border of the 5^{th} rib to the cranial margin of the 6^{th} rib. Llamas had heart widths of 2- 3 intercostal spaces (Mattoon *et al*., 2001) [9]. Precise assessment of heart width relative to ICS was less straight forward because of significant contribution of rib width. In llamas the ribs are wide, approximating the width of the intercostal space. Cardiac margin overlap of a cranial and/or caudal rib adds significant heart width, not reflected in ICS assessment (Mattoon *et al*., 2001) [9]. In lateral views, location of heart can easily be used to evaluate cardiac enlargement in thoracic radiographs (Farrow, 1996) [10]. It was found that, the heart of 90% of the experimental animals was located between the 3^{rd} and 6^{th} ribs while in 10% of the animals the heart occupies between ribs 2 and 5 Ukaha (2015) [4].

Lamb *et al*. (2000) [11] assessed the influence of the vertebral heart score (VHS) on the accuracy of radiographic diagnosis of cardiac disease in dogs.

Cardiothoracic indices are screening tests for cardiomegaly. Cardiac enlargement can objectively be measured in thoracic radiographs with the application of reference cardiac indices (Thrall, 2002 [1]; Gardner *et al*., 2007 [12]).

In clinical practice, lateral recumbency is more comfortable and less stressful for animals, especially in patients with pneumo-thorax and intra-thoracic fluid (Douglas *et al*, 1987 [13]).

VHS was 8.99 ± 0.27 vertebrae and 10.36 ± 0.35 vertebrae in Bergamasca sheep and 5-months-old Santa Ines sheep (Babicsak *et al*., 2017 [14]; Souza *et al*., 2012 [15]) respectively. Similar to the present study, Ulian (2015) [16] obtained the VHS 10.07 ± 0.10, 9.97 ± 0.09, 9.65 ± 0.09, 9.53 ± 0.08, 9.36 ± 0.09 and 9.42 ± 0.08 vertebrae in the neonatal Ile de France sheep of age 24 hours and 7, 14, 21, 28 and 35 days of life, respectively. In present study, a progressive decrease in vertebral heart score was found during the progression of age, Similar to our observations, Ulian (2015) [16] also found progressive decrease in lamb. Ukaha *et al*. (2013) [17] documented VHS 10.1 ± 0.01 vertebrae in West African Dwarf goats. As stated above, present study showed that VHS was negatively correlated with age and body weight of the animals. It was lesser than the VHS reported by (Babicsak *et al*., 2017 [14]) and (Souza *et al*., 2012 [15]). It may be due to the higher weight and size of the animals of present study and breed difference.

The standardized VHS values and their correlation with age and weight will be helpful in monitoring a patient in which heart disease is suspected.

Table 1: Mean ± S.E values of vertebral heart score (VHS) in right lateral thoracic radiographs in sheep of groups I and II

Group	LA (cm)	SA (cm)	T_4 (cm)	VHS=LA/T_4+SA/T_4 (Ljubica *et al.* 2007) method	VHS=LA+SA (Buchanun and Bucheler, 1995) method
Group I	10.83 ± 0.23	6.53 ± 0.14	1.84 ± 0.06	9.27 ± 0.13	8.40 ± 0.14
Group II	12.47 ± 0.23	7.55 ± 0.30	2.15 ± 0.04	9.15* ± 0.16	8.23* ± 0.21
Correlation with Age	0.815**	0.728**	0.670***	-0.230	- 0.181
Correlation with B.W.	0.820**	0.710**	0.620**	-0.290	- 0.185

** Correlation is significant at the 0.01 level, ***Correlation is significant at the 0.05 level.

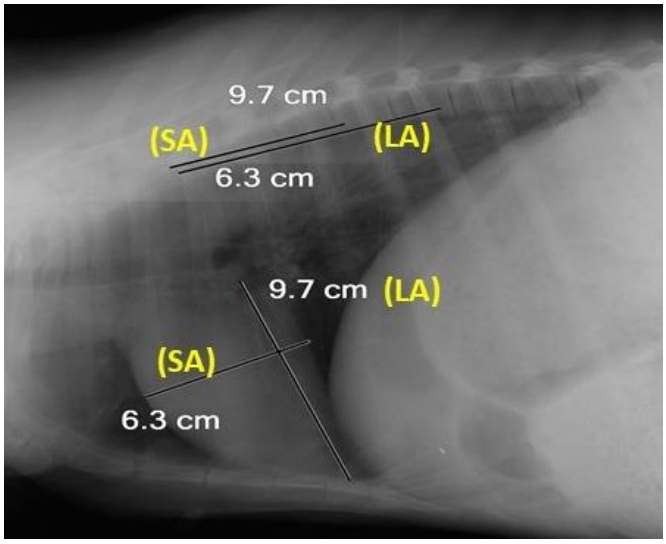

Fig 1: Radiograph showing the measurement long axes (LA), short axes (SA), and vertebral heart score (VHS) by Buchanan and Bucheler method

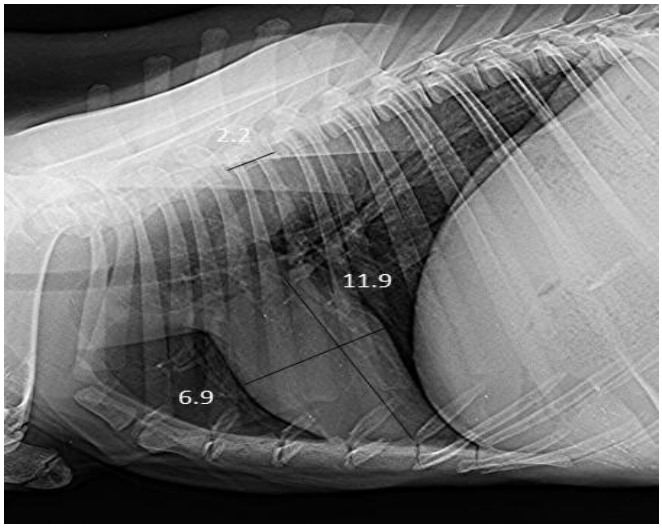

Fig 2: Radiograph showing the measurement long axes (LA), short axes (SA), T4 and vertebral heart score (VHS) by Ljubica *et al.* method.

Conclusion

Significant difference was observed in VHS measured by these two methods. The VHS by Buchanan and Bucheler (1995) [6] and Ljubica *et al.* (2007) [7] methods were negatively correlated ($p \geq 0.05$) with age and body weight of the animals.

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