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Radiographic Measurements Related With the Cardiac Size in Apparently Healthy Goats (*Capra hircus*)

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ABSTRACT

Present study was conducted on twelve apparently healthy goats free from cardiothoracic diseases. The animals were divided into two groups each containing 6 animals to evaluate various the cardiothoracic parameters. Mean ± SE values of body weight and age were measured 11.83 ± 0.70 (range 10 - 15) kg, 3.75 ± 0.31 (range 3 - 5) month and 25.67 ± 1.73 (range 16-30) kg, 8.58 ± 0.95 (range 6.5 - 12) month in animals of the group-I and II, respectively. In thoracic radiographic examination, routinely used in cases which cardiac evaluation is indicated, quantitative assessment of the heart is a useful role to be used in combination with subjective analysis. The purpose of this study was to establish the standard values (range) for radiographic parameters of the heart and thorax. Cardiophrenic contact (cm), Cardiac inclination angle (degree), Tracheal angle (degree), Tracheal diameter (cm), Cardiac height/thoracic height, Cardiac width/thoracic height, Cardiac width / T_3-T_5, Cardiac height / R_3-R_5, Cardiac width / R_3-R_5, Cardiophrenic contact /cardiac height, Cardiac height + cardiac width/R_3-R_5, cardiac height + cardiac width /thoracic height and Tracheal diameter/T_4, except cardiosternal contact (No. of sternabae), cardiac height/T_3-T_5, and cardiac height + cardiac width /T_3-T_5, were found to be non-significantly different between animals of the group-I and group-II. The standardized values of cardiothoracic parameters and their correlation with age and weight would be helpful to diagnose various cardiothoracic illnesses in goats.

Keywords: Goats, thoracic radiography, Lateral, heart

Thoracic radiography is routinely used in goats with known or suspected cardiac and respiratory disease. It is also a screening procedure for non-specific clinical signs and when blood work indicates an inflammatory process. Abundant literature is available regarding the thoracic radiographic appearance in most species. A better understanding of normal thoracic radiology in goats will allow more accurate assessment of disease states. Although echocardiography now plays a substantial role in assessment of heart disease, it has not eliminated the contribution of thoracic radiography in assessment of the cardiovascular system.

Radiographic abnormalities of the cardiac silhouette, however, are only detected if normal parameters are known and, to this end, abundant studies related to the radiographic assessment of the cardiac size have been performed in several species, including cats (Litster and Buchanan, 2000a; Litster and Buchanan, 2000b; Ghadiri *et al*., 2008), dogs (Spasojević-Kosić *et al.,* 2007; Kraetschmer *et al.,* 2008), ferrets (Stepien *et al.,* 1999), llamas (Mattoon *et al.,* 2001), Psittacines (Straub *et al.,* 2002), cattle (Jilintai *et al*., 2006), monkeys (Harada *et al.,* 2009), rabbits (Onuma *et al.,* 2010) and alpacas (Nelson *et al.,* 2011).

In young individuals, radiographic evaluation of the cardiac size is challenger, since heart normally appears to

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be larger in relation to thoracic size in these animals in comparison to its aspect in maturity (Owens and Biery, 1999). The relative variation in heart size in young individuals have motivated investigations related to the normal radiographic anatomy and, in consequence, studies have been conducted in young individuals of some species, including cats (Gaschen *et al.,* 1999), dogs (Sleeper and Buchanan, 2001), cattle (Jilintai *et al.,* 2006), monkeys (Harada *et al.,* 2009) and alpacas (Nelson *et al.,* 2011), in order to provide normal references and, consequently, aid in the diagnosis of cardiac diseases. The purpose of this study was to establish normal thoracic radiographic parameters. In this study was to determine the mean results and suggest the range of expected normal values for radiographic parameters related to the cardiac size in goats.

MATERIALS AND METHODS

Present study was carried out in the Teaching Veterinary Clinical Complex, Kothari Veterinary Hospital, College of Veterinary Science and Animal Husbandry, U.P. Pandit Deen Dayal Upadhyaya Pashu - Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan, Mathura (U.P.).

Selection of animals

Present study was conducted on twelve apparently healthy goats free from cardiothoracic diseases. The animals were divided into two groups each containing 6 animals. Group-I included animals varying between 5-15 kg body weight and 3-6 months of age. Group-II included animals varying between 15-30 kg body weight and 6-12 months of age.

Criteria for selection of animals

The goats had normal physiological parameters were considered healthy and selected for present study. Temperature (°F), Respiratory rate (breaths/min), Heart rate (beats/min), Pulse (beats/min) were recorded using digital thermometer, observing thoracic excursions, stethoscope, auscultation using stethoscope and palpation of femoral artery respectively.

Radiography

The X-rays machine (Heliophos-D, Siemens Healthineers India) and computed radiography system (Regius Model 110 S with Regius direct digitizer software, Konica Minolta Healthcare, India) were used to obtained good quality radiography. Lateral radiographs were taken on fixed 90 cm focal film distance (FFD) and 320 mA, 9.5-13 mAs and 58-63 KVP. The cassettes (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.

Cardiac height, cardiac width and thoracic height

Cardiac height, cardiac width and thoracic height were measured as described by Mattoon *et al*., (2001). Cardiac height (base-to-apex) was measured from the ventral floor of the origin of the mainstem bronchi to the apex of the heart (Fig 1 A). Cardiac width (cranial-to-caudal) was measured from the junction of the ventral margin of the caudal vena cava on caudal border of the heart to the cranial margin of the cardiac silhouette in a perpendicular direction in relation to long axis (Fig. 1B).

Thoracic height was measured by a line drawn from the cardiac apex to defined ventral margin of the 5th thoracic vertebra, essentially a continuation of base-to-apex measurement to the thoracic vertebra. Because the ventral margin of the thoracic vertebrae is not flat but concave, thoracic height measurement differed by several millimetres depending where the point of intersection on the ventral vertebral body occurred. To eliminate error introduced by ventral vertebral body concavity, a line was drawn between the ventral margin of the cranial and caudal endplates of the 3rd and 5th vertebrae. Thoracic height distances were then determined from the point of intersection along this line (Fig.1 C).

Length of thoracic vertebrae 3rd - 5th and distance between ribs 3rd - 5th

The length of thoracic vertebrae 3rd - 5th was determined from the mid-point of the cranial end plate of the 3rd thoracic vertebra to the mid-point of the caudal endplate of the 5th thoracic vertebra. The midpoint of the endplates was chosen because slight curvature of the ventral margins of

the endplates could have introduced error in measurement from animal to animal if the ventral vertebral endplate margins were used as points of reference (Fig. 1F).

The distance between 3rd - 5th ribs was measured from the cranial edge of the left 3rd rib to the caudal edge of the left 5th rib at the level of the floor of the trachea, perpendicular to the long axis of the ribs. The left rib was identified by differences in magnification as the right rib was more magnified (Mattoon *et al.,* 2001) (Fig. 1G).

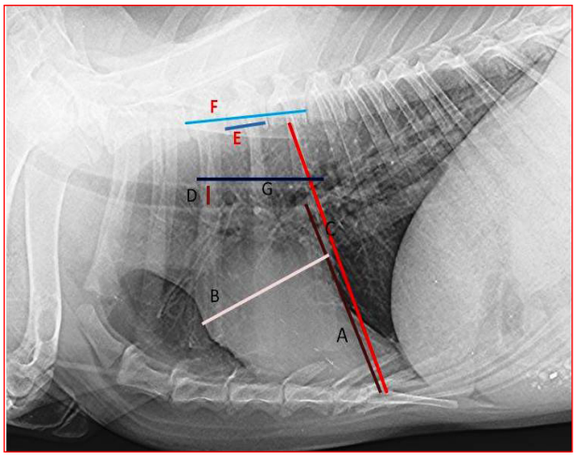

Fig. 1: Right lateral thoracic radiograph showing the measurement landmarks of cardiac height (A), cardiac width (B), thoracic height (C), tracheal diameter (D), $_{T4(E)}$, T_{3-5}(F) and R_{3-5} (G)

Cardiophrenic contact

Cardiophrenic contact was determined by the distance from the apex of the heart to the dorsal-most point of intersection of the cardiac silhouette with diaphragm (Mattoon *et al.,* 2001) (Fig. 2C).

Cardiosternal contact

Cardiosternal contact was determined by noting how many sternebrae were in contact with the heart (Mattoon *et al*., 2001) (Fig. 2F).

Tracheal diameter

Tracheal lumen diameter was measured at the level of 3rd rib and the ratio of tracheal diameter to length of the 4th thoracic vertebra (T_4) was calculated. Dorsal and ventral tracheal walls were not included in tracheal luminal measurements (Mattoon *et al*., 2001) (Fig. 1D).

Cardiac height: thoracic height, Cardiac width: thoracic height, Cardiac height: thoracic vertebrae 3-5, Cardiac width: thoracic vertebrae 3-5, Cardiac height: ribs 3-5, Cardiac width: ribs 3-5, Cardiophrenic contact: cardiac height, Cardiac height + cardiac width: thoracic vertebrae 3-5, Cardiac height + cardiac width: thoracic height, Cardiac height + cardiac width: ribs 3-5 and Tracheal diameter: thoracic vertebrae T_4 were calculated on the basis of above mentioned parameters.

Tracheal angle

Tracheal angle was determined using angle measurement option by drawing lines along the dorsal border of the trachea and the ventral margin of T_3 - T_5 vertebrae (Babicsak *et al*., 2017) (Fig. 2E).

Cardiac inclination angle

The angle of cardiac inclination was determined using angle measurement option by the angle formed between the cranial border of heart and dorsal margin of the sternum (Diniz *et al.,* 2013) (Fig. 2D).

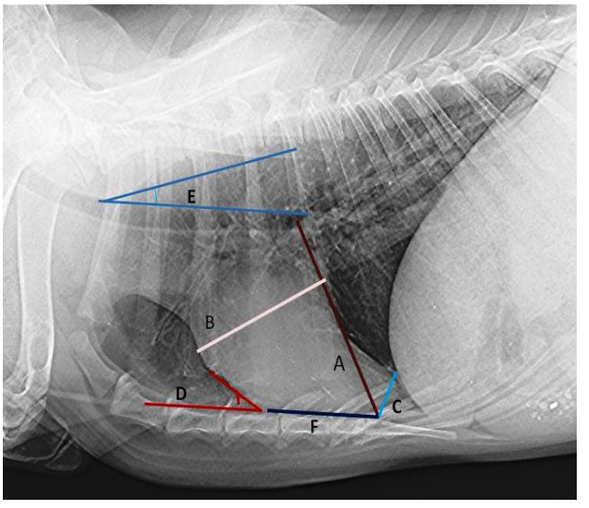

Fig. 2: Right lateral thoracic radiograph showing the measurement landmarks of cardiac long axis (A), cardiac short axis (B), (c), cardiophrenic contact (C), cardiac inclination angle (D), tracheal angle (E),) and cardiosternal contact (F)

RESULTS AND DISCUSSION

Cardiac height, cardiac width and thoracic height

Cardiac height, width and thoracic height, used separately or together, are of potential parameter in determining the right side, left side or generalized cardiac enlargement. Cardiac height, cardiac width and thoracic height were found 10.55 ± 0.48 (range 9.0 - 12.5) cm, 6.47 ± 0.35 (range 5.6 - 7.6) cm, 14.22 ± 0.72 (range 12.2 - 17.3) cm and 11.98 ± 0.32 (range 10.8 - 12.9) cm, 6.78 ± 0.26 (range 5.8 - 7.6) cm, 16.77 ± 0.54 (range 14.6 - 18.4) cm in animals of the group-I and II, respectively (Table 1). Mean ± S.E values of cardiac height, cardiac width and thoracic height did not differ significantly ($p \geq 0.05$) between the goats of group-I and group-II. Significant ($p < 0.01$) positive correlation was found in the values of the cardiac height and thoracic height with age and body weight of the animals. While cardiac width were found positively correlated ($p \geq 0.05$) with age and body weight of the animals. In comparison to our study, Babicsak *et al*. (2017) documented the higher values of cardiac height (cm) 13.83 ± 0.57 and cardiac width (cm) 8.99 ± 0.37 in young female Bergamasca sheep. These values were showed the positive correlation with age and body weight of the animals. Absolute measurements have limited value due to differences in body size and non standardized radiographic technique.

Length of thoracic vertebrae 3rd-5th (T_3-T_5) and distance between ribs 3rd-5th (R_3 - R_5) and length of the fourth thoracic vertebra (T_4)

Difficulty in accurately determining the left pair of ribs in some subjects, slight patient obliquity or differences in rib spacing due to the phase of respiration are possible explanations, although effort was made to make full inspiratory radiographs. Therefore measurements using rib spaces 3 - 5 appears to be of less value in accurately determining heart size then thoracic vertebrae 3 - 5 and thoracic height. In present study, Mean ± S.E values of length of the thoracic vertebrae 3rd - 5th (T_3 - T_5) and distance between the ribs 3rd- 5th (R_3 - R_5) and length of the fourth thoracic vertebra (T_4) were 6.0 ± 0.25 (range 5.4 - 6.9) cm, 5.92 ± 0.44 (range 4.8 – 7.3) cm , 1.92 ± 0.09 (range 1.7 - 2.2) cm and 6.95 ± 0.23 (range 6.1 - 7.8) cm, 6.08 ± 0.35 (range 5.1 - 7.5) cm , 2.13 ± 0.11 (range 1.9 - 2.6) cm, respectively in animals of the group-I and II (Table 1). In present study, values of the T3 - T5 and T4 were observed less than previously documented mean ± SD of Length of T3 - T5 (cm) 7.53 ± 0.30 and Length of T4 (cm) 2.46 ± 0.11 values of young sheep (Babicsak *et al.,* 2017). These values were showed the positive correlation with age and body weight of the animals. Similar findings were also documented in sheep (Babicsak *et al.,* 2017).

Cardiosternal contact and cardiophrenic contact

The standard data of cardiosternal contact and cardiophrenic contact are important to assess the size of the heart. These data are standardized for dogs (Owens and Biery, 1999; Kealy *et al.,* 2011; Suter and Lord, 1984) and llamas (Mattoon *et al*., 2001). In present study, we documented the cardiosternal contact and cardiophrenic contact 2.37 ± 0.42, 3.53 ± 0.40 and 2.05 ± 0.12, 3.13 ± 0.31, respectively, in group-I and group-II of the goats (Table 1). Cardiosternal contact greater than 2.5 sternebrae may indicate cardiac enlargement in llamas (Mattoon *et al.*, 2001). Cardiophrenic contact, cardiosternal contact could potentially be used to assess a small heart (e.g., hypovolemia, restrictive pericarditis) or help in determining hyperinflation of the thorax (Kealy, 1987; Suter and Lord, 1984). However these may be influenced by the degree of inspiration. Specific criteria for assessment of cardiophrenic contact in goats are lacking. In cats, cardiophrenic contact is usually an abnormal finding (Suter and Lord, 1984). Cardiosternal contact and cardiophrenic contact were found negatively correlated ($p \geq 0.05$) with age and body weight of the animals. An increased cardiophrenic contact may be a result of cardiomegaly. An increased cardiophrenic contact could also be secondary to disease states in which hypoventilation of the lung occurs (e.g., pulmonary fibrosis, upper airway obstruction or radiographs made at less than full inspiration or at expiration) or due to an increase in intra-abdominal volume (Mattoon *et al.,* 2001).

Cardiac inclination angle, tracheal angle and tracheal diameter

Cardiac inclination angle is a fundamental element in clinical medicine of wild and domestic animals because progressive increases, especially in the right ventricle, can alter the heart shape and decrease the cardiac inclination

Table 1: Mean ± S.E values of various cardiothoracic parameters in right lateral thoracic radiographs in goats of groups I and II

Parameter	GROUP-I	GROUP-II	Correlation with Age	Correlation with B.W.
Cardiac height (cm)	10.55±0.48	11.98 ±0.32	0.723**	0.737**
Cardiac width (cm)	6.47±0.35	6.78 ±0.26	0.314	0.408
Thoracic height (cm)	14.22 ±**0.72**	16.77 ±**0.54**	0.769**	0.771**
T_3-T_5 (cm)	6.0±**0.25**	6.95 ±**0.23**	0.760**	0.775**
R_3-R_5 (cm)	5.92± **0.44**	6.08 ± **0.35**	0.253	0.222
T_4 (cm)	1.92± **0.09**	2.13 ±**0.11**	0.664***	0.617***
Cardiosternal contact (No. of sternabae)	2.37 ±**0.42**	2.05* ±**0.12**	-0.332	-0.310
Cardiophrenic contact (cm)	3.53 ±**0.40**	3.13 ±**0.31**	-0.057	-0.021
Cardiac inclination angle (degree)	23±2.31	22.33 ±**2.08**	-0.020	-0.096
Tracheal angle (degree)	14.83±**1.51**	17.83 ±**1.58**	0.381	0.328
Tracheal diameter (cm)	0.89±**0.03**	0.97 ±**0.08**	0.364	0.382
Cardiac height/thoracic height	0.85±**0.11**	0.71 ±**0.01**	-0.401	-0.327
Cardiac width/thoracic height	0.45 ±**0.03**	0.43 ±**0.03**	0.073	0.050
Cardiac height / T_3-T_5	1.76±**0.06**	1.72* ±**0.02**	-0.145	-0.158
Cardiac width / T_3-T_5	1.07±**0.03**	0.98±**0.02**	-0.675*	-0.556
Cardiac height / R_3-R_5	1.80±**0.10**	1.99±**0.09**	0.304	0.355
Cardiac width / R_3-R_5	1.10±**0.03**	1.12±**0.03**	-0.030	0.174
Cardiophrenic contact /cardiac height	0.34±**0.04**	0.26±**0.02**	-0.315	-0.290
Cardiac height + cardiac width /T_3-T_5	2.83±**0.05**	2.70*±**0.02**	-0.559	-0.505
Cardiac height + cardiac width/R_3-R_5	2.90±**0.12**	3.11±**0.12**	0.229	0.330
Cardiac height + cardiac width /thoracic height	1.20±**0.03**	1.12±**0.02**	-0.566	-0.501
Tracheal diameter/T_4	0.47±**0.03**	0.46±**0.03**	-0.273	-0.215

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

angle to the sternum (Kealy *et al.,* 2011). In present study, mean ± S.E values of the cardiac inclination angle, tracheal angle and tracheal diameter were 23.0 ± 2.31 (range 17 - 30) degree, 14.83 ± 1.51 (range 11 - 19) degree, 0.89 ± 0.03 (range 0.80 - 0.98) cm and 22.33 ± 2.08 (range 16 - 31) degree, 17.83 ± 1.58 (range 13 - 24) degree, 0.97 ± 0.08 (range 0.77- 1.3) cm, respectively in animals of the group-I and II (Table 1). The agouti heart was inclined cranially at an angle of 21.2 ± 6.4°. Comparison of the males (16.73 ± 7.12°) and females (22.8 ± 8.5°) showed that the males presented smaller cardiac inclination angle and there was significant difference ($p = 0.01$, $p < 0.05$) (Dinize *et al.,* 2013).

Tracheal angle measurement is an indirect parameter useful in quantitative radiographic evaluation of the cardiac size too, since a reduced tracheal angle indicates a dorsal positioning of the trachea, a radiographic sign usually evident in cardiomegaly (Mattoon *et al.,* 2001). Similar to our finding, the tracheal angle of young sheep (14.72 ± 3.08°) Babicsak *et al*. (2017) and alpaca crias (14.24 ± 3.57°) (Nelson *et al.,* 2011) were documented. Recognition of dorsal deviation of the trachea, as a variant of normal is important when considering the possibility of a mediastinal mass or tracheobronchial lymph node enlargement (Mattoon *et al.,* 2001). The trachea is for the most part of uniform diameter. However, Mattoon *et al.* (2001) advocated mild dilation or dorsal deviation of the dorsal tracheal wall just proximal to the carina, cantered at the origin of the right cranial bronchus must be considered a normal variation, not to be mistaken for focal tracheal disease in llamas.

Cardiac inclination angle values were found negatively correlated ($p \geq 0.05$) with age and body weight of the animals. Tracheal angle and tracheal diameter values were found positively correlated ($p \geq 0.05$) with age and body weight of the animals.

Cardio-thoracic parameters ratio

Cardiac height: thoracic height, cardiac width: thoracic height, cardiac height: thoracic vertebrae 3-5 (T 3- T5), cardiac width: thoracic vertebrae 3 - 5 (T3- T5), cardiac height: ribs 3-5 (R3 - R5) and cardiac width: ribs 3-5 (R3 - R5) were calculated. The use of ratios, comparing desired parameter measurements with consistent anatomic structures independent of body size or magnification is a realistic method to address these concerns of the three parameters used to assess cardiac size ratios, thoracic vertebrae 3 - 5 score and thoracic height appear to be the most reproducible based on small standard deviations and narrow range of values obtained. Rib 3- 5 scores had larger standard deviations and range of values.

The ratio of the sum of cardiac height and width to thoracic vertebrae 3-5 may be the most consistent and reliable quantitative method to evaluate heart size, since the length of thoracic vertebrae 3 - 5 is consistent within a patient.

Mean ± S.E values of cardiac height: thoracic height, cardiac width: thoracic height, cardiac height: thoracic vertebrae 3 - 5 (T_3 –T_5), cardiac width: thoracic vertebrae 3 - 5 (T_3- T_5), cardiac height: ribs 3 - 5 (R_3 - R_5), cardiac width: ribs 3 - 5 (R_3 - R_5) were 0.85 ± 0.11 (range 0.72 - 1.4), 0.45 ± 0.03 (range 0.38 - 0.53), 1.76 ± 0.06 (range 1.59 - 1.92), 1.07 ± 0.03 (range 1.0 - 1.2), 1.80 ± 0.10 (range 1.5 - 2.12) and 1.10 ± 0.03 (range 0.97 – 1.2), respectively in goats of the group-I (Table 1). These were 0.71 ± 0.01 (range 0.67 – 0.75), 0.43 ± 0.03 (range 0.37 – 0.59), 1.72 ± 0.02 (range 1.62 - 1.77), 0.98 ± 0.02 (range 0.93 – 1.04), 1.99 ± 0.09 (range 1.69 – 2.31) and 1.12 ± 0.03 (range 1.01 - 1.25), respectively in the goatss of the group-II.

Cardiac height: thoracic height and cardiac height: T_3 - T_5 values were found negatively correlated ($p \geq 0.05$) with age and body weight of the animals. While cardiac width: thoracic height and cardiac width: R_3 - R_5 values were found positively correlated ($p \geq 0.05$) with age and body weight of the animals. Significant ($p < 0.05$) negative correlation was found in the values of the cardiac width: T_3 - T_5 with age while negatively correlated ($p \geq 0.05$) with body weight of the animals and cardiac width: R_3 - R_5 values were found positively correlated ($p \geq 0.05$) with body weight while negatively correlated ($p \geq 0.05$) with age of the animals. Mean ± SD of Ratio of cardiac height to length of T3 through T5 1.84 ± 0.08 and Ratio of cardiac width to length of T3 through T5 1.20 ± 0.05 (Babicsak *et al.* (2017). Mean ± SD of cardiac height: thoracic height; cardiac width: thoracic height; cardiac height: ribs 3 – 5 and cardiac width: ribs 3-5 were 0.72 ± 020, 0.54 ± 0.04, 1.77 ± 0.15, 1.25 ± 0.15 in normal llama (Mattoon *et al.,* 2001)

Stepien *et al*. (1999) observed that, in ferrets, cardiac ratios appeared to result in lower measurement variation than the modified vertebral heart size method used in their study. On the contrary, in the present study, vertebral heart size showed the lowest coefficient of variation in comparison to the cardiac ratios, such as cardiac height and/or width to length of T_3 through T_5 and, therefore, it may be considered the most reliable parameter for cardiac evaluation in young sheep.

Cardiophrenic contact: cardiac height, cardiac height + cardiac width: thoracic vertebrae 3 -5, cardiac height + cardiac width: thoracic height, cardiac height + cardiac width: ribs 3 – 5 and Tracheal diameter: thoracic vertebrae T4 were calculated. The ratios of the various cardio-thoracic parameters are important to evaluate the pathological conditions of the thoracic cavity without much variation of age and body weight. Mean ± S.E values of the cardiophrenic contact: cardiac height, cardiac height + cardiac width: T_3-T_5, cardiac height + cardiac width: thoracic height, cardiac height + cardiac width: R_3 - R_5, tracheal diameter: T_4 were measured 0.34 ± 0.04 (range 0.23 – 0.38), 2.83 ± 0.05 (range 2.67 - 2.96), 2.90 ± 0.12 (range 2.55 - 3.30), 1.20 ± 0.03 (range 1.10 -1.30) and 0.47 ± 0.03 (range 0.38 - 0.58), respectively in the goats of the group-I (Table 1). These were measured 0.26 ± 0.02 (range 0.19 - 0.35), 2.70 ± 0.02 (range 2.6 - 2.78), 3.11 ± 0.12 (range 2.7 - 3.57), 1.12 ± 0.02 (range 1.10 - 1.21) and 0.46 ± 0.03 (range 0.35 - 0.52), respectively in the goats of the group-II. The ratio of tracheal height to length of the fourth thoracic vertebra should allow identification of disease processes that reduce or enlarge tracheal diameter (Mattoon *et al.,* 2001). Examples might include congenital tracheal stenosis or hypoplasia, and reduction in luminal diameter from inflammation or accumulation of exudate. Increased diameter may occur secondary to upper airway obstruction, severe restrictive lower airway disease or other disease processes in which abnormally high intra thoracic pressure is generated.

Radiographic measurement of the cardiophrenic contact is useful in assessment of the cardiac size, since increased ratios of cardiophrenic contact to cardiac height may indicate cardiomegaly in absence of diseases that leads to hypoventilation of the lung or increased intra-abdominal volume (Mattoon *et al.,* 2001). Similar to our finding, the ratio of cardiophrenic contact to cardiac height calculated for sheep (0.33 ± 0.05) (Babicsak *et al.,* 2017) was lower than the value found for alpaca crias (0.39 ± 0.10) (Nelson *et al*., 2011), which may be explained by the existence of a lower cardiophrenic contact and/or a higher cardiac height in goats in comparison to alpacas (Mattoon *et al.,* 2001).

Babicsak *et al*. (2017) documented the 3.04 ± 0.11 (mean ± SD) ratio of cardiac height + width to length of T_3 - T_5 in young sheep. However, in present study we observed the lower values of this ratio in goats. Mean ± SD of ratio of cardiophrenic contact: cardiac height 0.49 ± 0.06, Cardiac height + width: ribs 3 - 5, 3.12 ± 0.28, Cardiac height + width: thoracic vertebrae 3-5, 2.80 ± 0.13, Height + width: thoracic height I .27 ± 0.05 and Trachea height: T4 0.99 ± 0.07 in normal llama (Mattoon *et al*., 2001). In the animals of the present study, these ratios were found lower side. This may be due the variation in shape and size of thorax of the goats.

Cardiophrenic contact: cardiac height, cardiac height + cardiac width: T_3 - T_5, cardiac height + cardiac width: thoracic height, tracheal diameter: T_4 values were found negatively correlated ($p \geq 0.05$) with age and body weight of the animals. While cardiac height + cardiac width: R_3 - R_5 values were found positively correlated ($p \geq 0.05$) with age and body weight of the animals.

CONCLUSION

Significant difference was observed only in cardiosternal contact, Cardiac height/T_3-T_5, Cardiac height + cardiac width /T_3-T_5 and right side castophrenic angle. Significant negative correlations with age and body weight were observed in cardiac width/T_3-T_5. Positive correlations with age and body weight were observed in tracheal angle, cardiac width /thoracic height, cardiac height/ R_3-R_5, cardiac height + cardiac width / R_3-R_5 and castophrenic angle while cardiac width / R_3-R_5 only with body weight.. Negative correlation with age and body weight were observed in heart inclination angle, cardiac height/ thoracic height, cardiac height/T_3-T_5, cardiophrenic contact/cardiac height, Cardiac height + cardiac width / T_3-T_5, cardiac height + cardiac width /thoracic height, Tracheal diameter/T_4 while only with age cardiac width / R_3-R_5, and cardiac width / T_3-T_5. The standardized values of cardiothoracic parameters and their correlation with age and weight would be helpful to diagnose various cardiothoracic illnesses in goats.

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