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Objective radiographic evaluation of cardiac size in clinically normal Zaraibi goats

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ABSTRACT

Radiographic evaluation plays a crucial role in the prediction and diagnosis of cardiac disease. Vertebral heart score (VHS) and cardiothoracic ratio (CTR) provide an objective measure to evaluate cardiac size. The aim of the present study was to establish the normal reference values of VHS and CTR in 25 clinically normal Zaraibi goats with homogenous age and body weight. Complete clinical, electrocardiographic, echocardiographic and radiographic examinations were included. The VHS and CTR were calculated from right lateral inspiratory radiographs. The VHS ranged from 7.3 to 8.8 (mean ± SD 8.0 ± 0.4) vertebrae and the CTR ranged from 17.1 to 24.6 (mean ± SD 20.1 ± 2.2) %. Significant weak correlation was recorded between VHS and CTR. Vertebral heart score and cardiothoracic ratio are clinically useful tool to evaluate cardiac size in Zaraibi goats.

Key words: Cardiothoracic ratio, Echocardiography, Goat, Heart, Radiography, Vertebral heart score.

INTRODUCTION

Radiographic examination of the thoracic cavity is the first diagnostic modality for evaluation of respiratory and cardiovascular disorders and also for early diagnosis. It allows rapid and valuable evaluation of trachea, lung, heart and vascularization (Rudorf *et al.,* 2008; Makungu and Paulo, 2014; Azevedo *et al.,* 2016).

The vertebral heart score (VHS) is an easy, available, widely used and applicable objective diagnostic tool for evaluation of cardiac size in dogs, cats, monkeys and small East African goats (Buchanan and Bucheler, 1995; Litster and Buchanan, 2000; Gulanber *et al.*, 2005; Gugjoo *et al.,* 2013; Makungu and Paulo, 2014; Rocha-Neto *et al.,* 2015). Breed specific variation has been reported in dogs and monkeys (Gugjoo *et al.,* 2013; Makungu and Paulo, 2014; Rocha-Neto *et al.,* 2015; Azevedo *et al.,* 2016). VHS has a high diagnostic accuracy in distinguishing left sided cardiac disorders and moderate-to-severe left atrial enlargement (Guglielmini *et al.,* 2009; Guglielmini and Diana, 2015).

Cardiothoracic ratio (CTR) is a novel diagnostic modality for evaluation of cardiac size based on measuring the ratio between cardiac and thoracic areas in lateral thoracic radiographs (Torad and Hassan, 2014).

Zaraibi (Nubian) goat is an important source of meat and milk production and one of the main progenitors of the standard Anglo-Nubian goats which are widely distributed in Europe (Porter *et al.,* 2016). Goat is an excellent model for cardiovascular researches; as the goat's heart is closely comparable to that of the human beings (Remes *et al.*, 2008; Singh *et al.,* 2017). Heart diseases represent a major challenge in goats including congenital disorders (atrial and ventricular septal defects, atrial hypoplasia, cardio-megaly, patent ductus arteriosus and valve anomalies) and acquired disorders (nutritional myodegeneration, bacterial endocarditis, ionophore toxicity and plant cardiotoxicity) (Cebra and Cebra, 2012).

To the authors' knowledge, no available literature is published documenting the reference values of VHS and CTR in Zaraibi goats. The aim of the present study was to establish the normal reference values of VHS and CTR in clinically normal Zaraibi goats.

MATERIALS AND METHODS

Animals: The present study was conducted on twenty five clinically normal Zaraibi goats of homogenous age 3.2 ± 1.1 (mean ± SD) year, body weight 34.9 ± 4.5 (mean ± SD) kg, and of both sexes (8 male and 17 female) belonging to Faculty of Veterinary Medicine- Cairo University and used for educational and research purposes. All study procedures were done in accordance to Animal Care and Use Committee of Faculty of Veterinary Medicine- Cairo University. Inclusion criteria included goats with normal vital health parameters (heart rate, respiratory rate, rectal temperature and mucous membrane), thoracic auscultation free from wheezes or murmurs. Goats were confirmed to be free from cardiac diseases based on echocardiographic examination with simultaneous electrocardiographic examination (Singh *et al.,* 2017).

Radiographic examination: Radiographic examinations were done without sedation or anesthesia. Animals were

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restrained in right lateral recumbency with the fore limbs cranially extended to expose the thoracic area. Radiographs were obtained at the point of peak inspiration using grid of medium (400) speed and (0.2- 30- 40 cm) dimensions with exposure factors 65-75 KVp, 3 mAs with 80-90 cm focal film distance.

Analogue radiographs were transferred to a computer system where VHS and CTR were measured using a computerized software program (Digimizer 4.2.2.0®image analysis software, MedCalc Software bvba, Ostend, Belgium).

For VHS calculation, the long axis of the heart was measured from the carina to the cardiac apex. The short axis was measured at the widest point of the cardiac silhouette at the level of the caudal vena cava on a line perpendicular to the long axis. Measurements were transferred to the vertebrae starting at the cranial edge of the 4th thoracic vertebra and expressed as units of vertebral lengths. VHS was calculated by summation of vertebral units of long and short axes of the heart (Buchanan and Bucheler, 1995; Gulanber *et al.*, 2005). For CTR calculation, both cardiac and thoracic areas were measured using area measuring tool of the software program to trace the contour of cardiac silhouette and also the thoracic contour, respectively (Torad and Hassan, 2014). CTR = cardiac area / thoracic area X 100 (Fig 1).

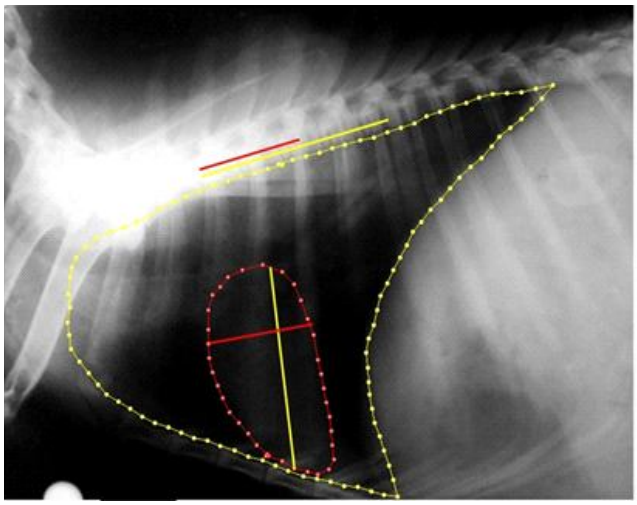

Fig 1: Right lateral thoracic radiograph demonstrating objective evaluation of cardiac size through vertebral heart score and cardiothoracic ratio.

Statistical analysis: Data were tabulated and expressed as mean ± SD and range. Normality of distribution of the obtained data was tested using Kolmogorov-Smirnov test. Correlation between CTR and VHS was tested using Pearson's correlation coefficient. The *r* value ≥ 0.5 was considered strongly correlated and < 0.5 was poorly correlated. Data were considered statistically significant when the *P* value < 0.05. Analysis of data was done using SPSS software 21 (IMP SPSS Inc, Chicago, IL).

RESULTS AND DISCUSSION

Objective evaluation of cardiac size was made through echocardiographic and objective radiographic evaluation. Echocardiographic measurements and indices of the examined goats are given in Table 1.

Radiographic examination of the thorax provided efficient visualization of the, trachea, lung, cardiac silhouette and major blood vessels. Thoracic boundaries included the thoracic vertebrae dorsally, sternum ventrally, the thoracic inlet cranially and the diaphragmatic crura caudally.

The VHS in clinically normal Zaraibi goats ranged from 7.3 to 8.8 with (Mean ± SD: 8.0 ± 0.4 vertebrae), while the CTR ranged from 17.1 to 24.6 % (Mean ± SD: 20.1 ± 2.2 %). Detailed VHS and CTR are represented in Table 2. Significant weak correlation was recorded between VHS and CTR in normal goats (Fig 2).

The study was conducted on clinically normal goats of only one breed (Radhika *et al.*, 2018) to exclude interbreeds variations of cardiac size and shape. Goats included in the study were of homogenous age and body weight to exclude the statistically significant differences related to age or body weight (Mule *et al.*, 2014; Panti *et al.*, 2016).

In the present study, right lateral thoracic radiographs were used to calculate the VHS and CTR. It has been reported that lateral thoracic radiographs were more preferable over the ventro-dorsal ones as it is less stressful for cardiac patients. Moreover, ventro-dorsal view may result in image magnification due to increased distance between the heart and the X-ray cassette. The long axis of the heart in ventro-dorsal view includes the right atrium and left ventricle, whereas it includes the left atrium and left ventricle in lateral views (Buchanan and Bucheler, 1995; Buchanan,

Table 1: Mean (mean ± SD) echocardiographic parameters and indices of Zaraibi goats (n= 25).

Echocardiographic parameters (cm)							**Echocardiographic indices (%)**		
LVIDd	LVIDs	IVSd	IVSs	LVWd	LVWs	LADd	AoDd	FS	EF
3.9 ± 0.5	2.2 ± 0.3	0.8 ± 0.1	1.2 ± 0.2	1.1 ± 0.2	1.4 ± 0.2	2.1 ± 0.4	2.3 ± 0.3	46.1 ± 5.0	78.2 ± 9.0

AoDd: aortic root diameter in diastole; EF: ejection fraction; FS: fractional shortening; IVSd: inter ventricular septal thickening in diastole; IVSs: inter ventricular septal thickening in systole; LADd: Left atrial diameter in diastole; LVIDd: left ventricular internal diameter in diastole; LVIDs: left ventricular internal diameter in systole; LVWd: left ventricular wall thickness in diastole; LVWs left ventricular wall thickness in systole.

Table 2: Mean ± SD and range with coefficient of variation (CV) of the Vertebral Heart Score (VHS) and Cardiothoracic Ratio (CTR) of goats in relation to body weight and age (n= 25).

	Mean ± SD	Range	CV
Age (months)	34.6 ± 4.5	26.0 - 42.0	13.1
Weight (kg)	34.6 ± 3.1	30.0 - 40.0	9.1
VHS (v)	8.0 ± 0.4	7.3 - 8.8	5.5
CTR (%)	20.1 ± 2.2	17.1 - 24.6	10.9

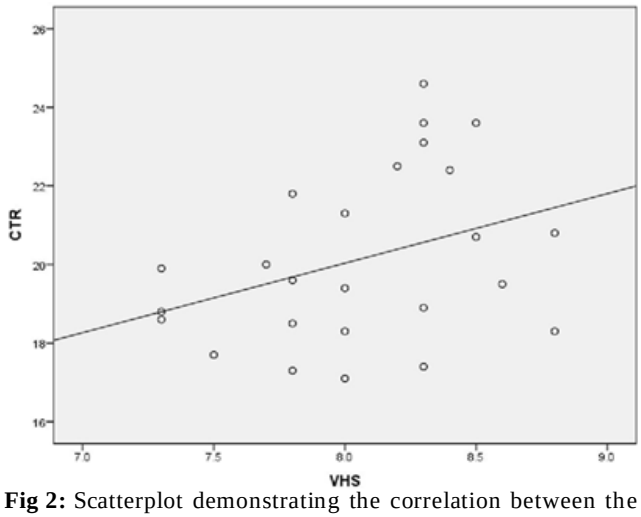

Fig 2: Scatterplot demonstrating the correlation between the Vertebral Heart Score (VHS) and Cardiothoracic Ratio (CTR) in goats (n= 25; r =0.4; p= 0.08; y=5.89+1.77*x).

2000, Fox, 2003; Gulanber *et al.,* 2005). Increased cardiac size was best diagnosed in lateral radiographs rather than ventrodorsal radiographs as the increase in cardiac size occurs in latero-medial direction more than in cranio-caudal direction (Torad and Hassan, 2014). No significant differences have been reported in VHS values calculated from right and left lateral thoracic radiographs in dogs (Marin *et al.,* 2007).

The procedure of VHS evaluation is easy and depends on selection of reference points to measure long and short axes of the heart. Hence, VHS is not affected by the observer experience (Hansson *et al.,* 2005).

The mean reference VHS obtained in Zaraibi goats included in the present study (8.0 ± 0.4 vertebrae) was relatively lower than previous reports on small East African goats (10.02 ± 0.33 vertebrae), although the mean weight in the present study (34.6 ± 3.1 kg) was relatively higher than the small East African goats (17.54 ± 3.85 kg) (Makungu and Paulo, 2014). This finding supported the breed-specific variations of normal heart size and shape (Root and Bahr, 2002; Azevedo *et al.,* 2016). One of the limitations of VHS calculation is that it relies only on two linear measurements and not the entire cardiac silhouette. Therefore, mild changes in cardiac size may not be detected by VHS (Lamb *et al.,* 2000; Torad and Hassan, 2014). The CTR is a newly developed diagnostic tool for cardiac size evaluation that has been previously used in human, dog, cat but not in goats (Screaton, 2010; Torad and Hassan, 2014; Birsan *et al.,* 2016). CTR depends on evaluation of the entire cardiac silhouette relative to the thoracic contour, therefore subtle changes in cardiac size as well as generalized cardiac enlargement could be detected (Torad and Hassan, 2014).

The weak correlation between VHS and CTR in the present study can be attributed to the VHS which relies on evaluating two linear measurements of cardiac dimensions, while the CTR relies on evaluating the entire cardiac area in relation to the thoracic area. The main limitation of the present study is evaluation of cardiac size in normal Zaraibi goats only, further studies warranting to evaluate cardiac size in goats with cardiac diseases.

CONCLUSION

In conclusion, the current study presented the normal reference values of VHS and CTR in clinically normal Zaraibi goats.

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