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Development and evaluation of methods for vertebral heart score determination in guinea pig (*Cavia porcellus*)

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Abstract

Cardiac problems are highly fetal diseases among exotic animals, not only in the rabbit which is prone to such diseases but also in the guinea pig (*Cavia porcellus*). In rodents, imaging studies such as thoracic radiography are more practical and easier to perform than echocardiography. Cardiac size is primarily evaluated using vertebral heart size (VHS) as reported in ferrets and rabbits. We therefore attempted to determine standard cardiac dimensions in the guinea pig by thoracic radiography using VHS. The purpose of this research was getting an indicator of the normal range of male and female, mature and apparently healthy guinea pigs heart. Standard radiographs of the thorax in lateral and ventro-dorsal (VD) views were taken and interpreted. In our study to determine VHS in VD view conventional method was used. In addition to conventional VHS method, two other measurement methods were performed in lateral view. Statistical analyses were performed with a SPSS Software and Mann-Whitney U test to compare results. Mean and standard deviation were also calculated. According to the results, the total average of VHS in lateral view by the first method was 7.80 ± 0.12, by the second method was 7.80 ± 0.16, by the third method was 7.60 ± 0.15 and the total of average of VHS in VD view was 9.20 ± 0.23. According to present research findings, gender had no meaningful effect on the measuring of the heart size. More researches on the same age and the same species guinea pigs are needed for more accurate evaluation.

Introduction

Guinea pigs are very calm and social animals. The circulation system of guinea pigs like other mammals is simple, close and double. Cardiac problems in guinea pigs are most commonly seen as recurrent respiratory problems including upper respiratory tract infections not being treated using antibiotics.[1] As in other species (both farm and companion animals), cardiac problem diagnosis is made using a combination of history, clinical examination, thoracic radiography and echocardiography as well.[2] Whereas there has not been a study to date about the normal size of the heart of this animal, diagnosis of cardiomegaly is not easy. One of the radiographic techniques that help to diagnose any change in heart size is vertebral heart score (VHS).

Vertebral heart score is a method for measuring heart size in thoracic radiograph described by Buchanan and Bücheler in dogs in 1995.[3] In small mammals field, it has been reported that there are statistical differences in VHS index between male and female ferrets.[4] Also, in another study, 27 rabbits were studied. Their results showed that right lateral radiography is more valuable than left lateral positioning and animals weight can emphasize VHS in both genders.[5] Reportedly, VHS was also assembled in seventeen marmosets showing that there is a good correlation between lateral and ventro-dorsal or dorso-ventral projections about VHS index.[6] Reportedly, the VHS of right lateral view in New Zealand white rabbits is bigger than left lateral view; although, there was no significant difference between long and short axes in right and left lateral views.[7]

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Little information has been published concerning heart problems in rodents especially guinea pigs and there was no normal range of VHS for this species until now. The purpose of this study was to develop normal ranges for typical measurements of the cardiac silhouette in mature guinea pigs (*Cavia porcellus*).

Materials and Methods

The present study protocol was approved by the ethical committee of University of Tehran. This study was examined on 20 mature guinea pigs, which were not related to each other (10 males weighing 750 ± 100 g and 10 females weighing 700 ± 75.00 g) being presented to the Faculty of Veterinary Medicine, University of Tehran, Tehran, Iran, in 2018. Prior to the procedures, the animals were checked or health, based on history and clinical examination. All guinea pigs were restrained manually and radiographic positioning was performed without anesthesia. Standard digital radiographs (Direct-View, Classic CR System; Care Stream, Montreal, Canada) were obtained in right lateral (RL) and ventro-dorsal (VD) projections of thoracic cavity using fixed X-ray unit (KXO-15R; Toshiba Co., Tokyo, Japan) under 66.00 Kvp and 3.20 mAs.

Radiographic measurements. In the RL view, three methods were used to calculate VHS. In the first method, the long axis was measured from the carinal of the main stem bronchus to the cardiac apex. The short axis was measured in the mid-third of the heart, which was completely perpendicular to the long axis. Then, these scales were transferred to the vertebrae, started at the cranial end plate of the fourth thoracic vertebrae (T4), and sum of vertebrae below the lines were counted. In the second method, the calculations of the long and short axes were similar to the first method. In this method, the length of the T4 was determined. Then, the scales obtained from the long and short axes were divided into it. Finally, from the sum of two numbers the VHS was obtained.

In the third method, the long axis was measured from the cranial of the main stem bronchus to the cardiac apex (similar to two previous methods); but, the short axis was measured from the middle part of caudal vena cava junction with heart being completely perpendicular to the long axis. In VD view, the long axis was measured from midline of the cranial edge of cardiac silhouette to the apex and the short axis was measured perpendicular to the measurement of the long axis at the point of maximum cardiac width. The two numbers were then added together to give the value of VHS in RL and VD views (Fig. 1). Radiographs were examined by a veterinary radiologist being expert in cardiopulmonary system.

Statistical analysis. Data analyses were performed using SPSS Software (version 24.0; IBM Corp, Armonk, USA). For all animals, the distribution of data was evaluated with Mann-Whitney U test. Mean ± standard deviation (SD) values were calculated for each variable. Differences between means at $p \leq 0.05$ were considered statistically significant.

Results

Table 1 exhibits the mean ± SD of all measured parameters including long axis, short axis, VHS and total VHS in all four methods. Statistical analysis was done using Mann-Whitney U test and $p \leq 0.05$ showed significant differences. Long axis, short axis and VHS was significantly higher in male guinea pigs among the three lateral methods compared to females, although these parameters did not indicate significant difference within each gender ($p > 0.05$). There was no significant difference in total VHS parameter in three lateral methods ($p > 0.05$). In VD method, although short axis was significantly higher in male guinea pigs, but there was no significant difference between long axis and VHS parameters in male and females ($p > 0.05$). The total VHS in VD projection was 9.20 ± 0.23, which was significantly higher in comparison to lateral methods ($p < 0.05$).

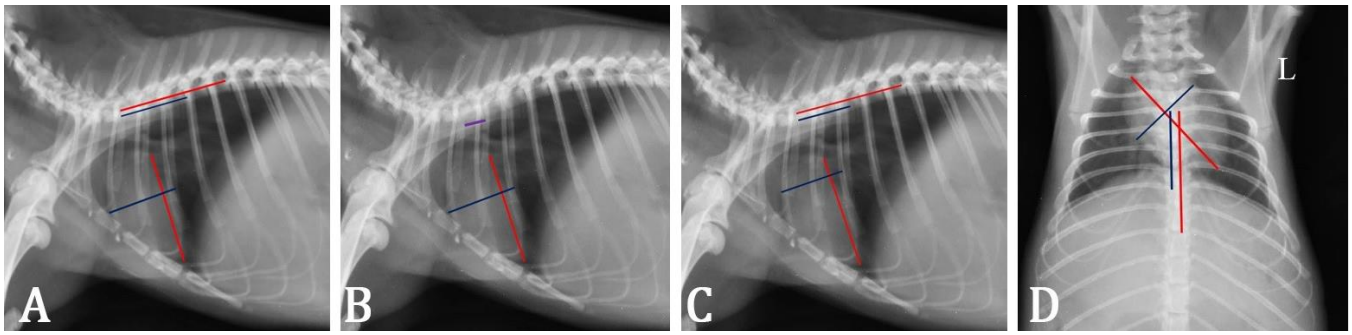

Fig. 1. A, B and **C)** Measurement of long axis and short axis in first, second and third methods in lateral view, respectively (the short purple line shows length of T4's body). **D)** Measurement of long axis and short axis in fourth method in ventro-dorsal view (the red line shows long axis and blue line shows short axis of cardiac silhouette, afterwards, these two lines were placed at the cranial end plate of the fourth thoracic vertebrae).

Table 1. Mean ± SD of long axis, short axis and vertebral heart size (VHS) in guinea pigs obtained from four methods (In the RL view, three methods were used. The long axis was measured from the carinal of the main stem bronchus to the cardiac apex. The short axis was measured completely perpendicular to the long axis).

Method	Long axis (mm)		Short axis (mm)		VHS		Total VHS
	Female	Male	Female	Male	Female	Male	
Lateral method 1	7.40 ± 0.46[a]	6.40 ± 0.46[b]	4.70 ± 0.29[a]	4.20 ± 0.25[b]	7.70 ± 0.10[a]	8.00 ± 0.21[b]	7.70 ± 0.12
Lateral method 2	7.40 ± 0.46[a]	6.40 ± 0.46[b]	4.50 ± 0.31[a]	4.20 ± 0.25[b]	7.60 ± 0.23[a]	8.00 ± 0.23[b]	7.70 ± 0.16
Lateral method 3	7.40 ± 0.46[a]	6.40 ± 0.46[b]	4.30 ± 0.18[a]	3.80 ± 0.26[b]	7.40 ± 0.19[a]	7.70 ± 0.25[b]	7.60 ± 0.15
Ventro-dorsal	7.00 ± 0.25	6.40 ± 0.16	5.70 ± 0.27[a]	5.20 ± 0.25[b]	9.20 ± 0.35[c]	9.20 ± 0.31[c]	9.20 ± 0.23

[abc] Different letters show statistical differences in long axis, short axis and VHS parameters between male and female in each method.

Discussion

In small mammals, several studies have been published reporting cardiac problems such as dilatory or hypertrophic cardiomyopathy, valvular insufficiency, infectious endocarditis or myocarditis most likely due to a bacterial infection and congenital septal defect being evaluated through heart auscultation, echo-cardiography or electrocardiography.[7,8] Furthermore, in hamsters, tumors of the cardiovascular system such as lymphoma and hemangiomas are infrequently reported.[8] The routine use of VHS method is to monitor cardiomegaly, often as an early clue of heart disease.[9,10]

Our protocols of radiographic positioning in current study were RL and VD views. The RL projection is standard and provides more accurate information to evaluate cardiac silhouette than left lateral.[8-10] However, there were incompatible ideas of the differences of VHS values between right and left projections. Some authors have denied the effects of left against right recumbency;[3,11,12] while, other authors have discovered significant higher VHS in RL radiographs.[13-17] The description for this difference is that, in RL recumbency, the angel of the x-ray beam causes higher magnification of the cardiac shadow.[12,14,15] We did not find significant gender influence on the mean of VHS. Statistical analysis showed that the total mean of VHS in three methods of lateral view and in the VD projection had no significant differences. The long axis measurement was the same in all methods of the lateral view; but, the measurement of short axis was different. Our findings were close to former findings in New Zealand white rabbits. In that study, the VHS in males was 7.40 ± 0.34 and in females was 6.90 ± 0.28.[7]

Cardiac problem in the rodents can lead to a variety of clinical signs, some of them may be mild involving the patient over a long period of time.[8] Similar to hamsters, clinical signs associated with heart disease in guinea pigs may include lower respiratory manifestations as well as lethargy, weakness and depression. Although clinical signs are often non-specific, a differential diagnosis with possibility of heart disease should be taken.[8] Considering this reason, thoracic radiography is needed to decrease aforementioned conditions.

In the present study, twenty mature and healthy guinea pigs were studied. Most of them had the same body mass; however, for accurate examination of heart through VHS method, using guinea pigs with the same weight in future studies is recommended to determine whether body size can affect heart measurements. Also, most of the samples were about one-year-old. Thus, using the same age animals can lead to more accurate evaluation.

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Conflict of interest

The authors declare that there is no conflict of interest.

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