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Measurement of Heart Size in the Rabbit (*Oryctolagus cuniculus)* by Vertebral Scale System

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Authors' contributions

This work was carried out in collaboration between both authors. Author ROU designed and drafted the manuscript of the study, coordinated the research and carried out literature searches. Author JII handled all radiographic measurements and conducted the statistical analyses. Together, both authors performed all radiographic procedures, read and approved the final manuscript.

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ABSTRACT

Aim: Cardiac and pericardial diseases are frequently associated with a change in the size of the heart. Therefore, the radiographic evaluation of the heart size is invaluable in the determination of the extent and severity of the cardiac or pericardial disorder. This research was aimed at establishing reference values of vertebral heart size (VHS) of normal New Zealand White (NZW) rabbit.

Materials and Methods: Heart sizes of ten (5 females, 5 males) clinically normal NZW rabbits were studied. A right lateral thoracic radiograph was obtained from each research animal. In each of the radiographs, the cardiac long axis (LA) was measured in centimeters, transposed onto the thoracic vertebrae from T4, and the result read in vertebral lengths. The cardiac short axis (SA) was similarly converted to lengths of thoracic vertebrae. The VHS was then obtained from the addition of the LA and SA thoracic vertebral lengths.

Results: Mean plus or minus standard error of mean (M±SEM) VHS was 8.5±0.3 vertebrae, and

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the difference between male and female VHSs was insignificant.
Conclusion: Clinically, VHS is objective and easily applicable in radiographic determination of heart size.

Keywords: Lateral view; measurement of heart and thoracic vertebrae; vertebral heart size; new zealand white rabbit.

1. INTRODUCTION

Vertebral heart scale is an index developed for measurement, in a lateral thoracic roentgenograph, of cardiac silhouette size. In this method, the long and short axes of the heart are measured and their lengths summed up after comparing them, one after the other, with mid-thoracic vertebrae producing the VHS of the animal breed concerned [1]. Other researchers who worked with different dog breeds reported that the VHS is an effective cardiac diagnostic modality [2–5].

Heart diseases are frequently diagnosed when limb abduction, neck extension, dry cough, reluctance to lie down, ascites, hepatomegaly, etc are identified on physical examination of a patient [6]. Diagnostic yield is improved when radiographic findings are compared with history and laboratory results. Unfortunately, VHS values obtained so far are all breed-specific and cannot be used to determine heart size in other animal breeds/species as a result of differences in chest conformation within the animal kingdom [7–9]. This body conformation problem has urgently necessitated the generation of breed-specific reference radiographic values for every breed of domestic, laboratory, and zoo animals including rabbits.

The rabbit (*Oryctolagus cuniculus*) is widely used as the experimental model in various fields of studies. A number of factors are responsible for the popularity and widespread use of the rabbit in animal-based researches. One of these factors, undoubtedly, is the ease with which the rabbit is handled and maintained within the laboratory. Its sensitivity to a variety of infectious diseases that affect man and other animals is another reason for its usefulness. The similarity in the physiology of rabbits to that of humans makes rabbits ideal for use as animal of choice in human disease researches. Rabbits change distinctly with age enabling researches to study changes in blood components, cardiovascular parameters, hypertension, artherosclerosis, etc [10–16]. The rabbit is also a cheap food animal and a source of high protein white meat. Rabbits can digest large amount of fibrous feed with the help of their caecal microbes, and these qualities confer them the potential to bridge the shortage of animal protein in developing countries [17,18].

The importance of rabbits as a protein source and an animal model for many biomedical researches and in teaching is general knowledge and has been stated. However, in spite of their useful economic and scientific (research) roles; there is clearly a paucity of radiologic reports on the rabbit. Therefore, the present work was conducted to estimate reference measurement values for size of cardiac silhouette in healthy NZW rabbits as a basis for radiographic diagnosis of cardiac disease in this breed of animal.

2. MATERIALS AND METHODS

Ten NZW rabbits (5 males) of average weight of 2.25 kg (1.65 – 2.55kg), selected from different colonies, and bought from local breeders were used for this project. The rabbits were kept for two weeks to acclimatise and given food *ad libitum* within that period. Within the adaptation period the animals were examined generally and their vital parameters were all within normal values documented for the rabbit, and so the animals were adjudged healthy [19] for the radiographic study.

The animals were chemically restrained for radiography by the use a sedative, xylazine hydrochloride, administered intramuscularly at the dose of 30 mg/kg [20]). The rabbits were positioned for radiography with the help of an assistant who was well protected with lead-impregnated apron and lead hand gloves [21].

Survey right lateral (RtL) thoracic projection was obtained of each project animal at full inspiration. The entire thorax, in each case, from the cranial end of the first rib to a point just caudal to the first lumbar vertebra, was captured. The x-ray field was centred at the middle of the 4^{th} intercostal space [22,23]. Each x-ray film was permanently identified with lead markers, processed manually, dried in the air, and kept in a labelled envelope.

Using a viewing-box, the physical parameters measured in the radiographs were: (i)

apicobasilar length of the heart, recorded as the cardiac long axis (LA) and (ii) the maximum heart width drawn on a line perpendicular to LA, recorded as the cardiac short axis (SA).

Parametric data obtained from this work was analysed using t-test, simple linear regression and Pearson's product moment correlation coefficient statistics. For all measurements, the means and standard errors of means were calculated for each sex and for both sexes, and the results were presented as means plus or minus standard error of means (M±SEM). A probability value less than 0.05 was considered statistically significant.

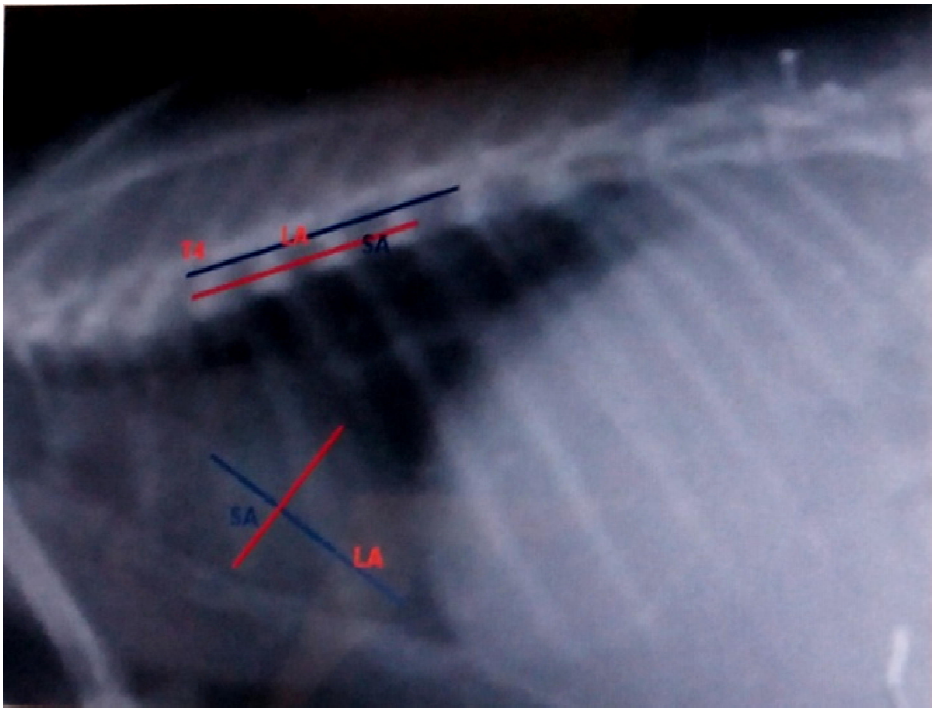
3. RESULTS

A test of difference between male and female animals with individual means of 8.5000 and 8.5400, pooled mean of 8.5200 and a SD of 0.59029. A t-Test of -32.633 was not significant, which confirms that there is no difference between the means of the sexes.

The Regression table below is the test of relationship between Sex and VHS using Simple Linear Regression Model. The result shows that there is no significant relationship between Sex and VHS. A Durbin Watson test was also carried out to determine the strength of the correlation between Sex and VHS and a value of 2.366 shows there is no correlation between VHS and Sex.

4. DISCUSSION

Enlargement or reduction in heart size is a clinical sign of cardiac anomaly. Cardiomegaly may be due to hypertrophy (thickening due to sustained pulmonary and systemic blood pressure) or dilation (weakening, thinning and stretching out due to the damaging effect of heart attack, inflammation, vascular disorders, alcohol abuse in man) on cardiac muscles [24-26]. However, cardiac hypertrophy and dilatation can be differentiated by echocardiography, computed tomography, etc and not by radiography [8,26,27]. On the other hand, microcardia may be due to hypovolaemic states (shock, severe blood loss), wasting diseases (*kwashiorkor*, tuberculosis), senile atrophy, cystic fibrosis, and constrictive pericarditis [28-30].



Right Lateral View
Plate 1. Method of measuring VHS
VHS = LA + SA
KEY: T4 = 4th thoracic vertebrae, LA = Cardiac long axis, SA = Cardiac short axis

Table 1. VHS values in right lateral view of the NZW rabbits

S/N	SEX	LA(cm)	LA(v)	SA(cm)	SA(v)	VHS(LA+SA)
1	F	4.2	4.5	2.9	3.5	8.0
2	F	4.6	5.5	2.7	3.5	9.0
3	F	4.4	5.0	2.7	3.2	8.2
4	F	4.0	5.2	2.7	3.6	8.8
5	F	3.6	5.0	2.6	3.5	8.5
6	M	4.8	5.5	3.1	3.9	9.4
7	M	4.4	5.5	2.8	3.6	9.1
8	M	4.1	4.5	2.8	3.0	7.5
9	M	4.1	5.2	2.6	3.5	8.7
10	M	4.3	5.0	2.3	3.0	8.0
Total	10	42.5	50.9	27.2	34.3	85.2
Average		4.25	5.1	2.72	3.4	8.5
Mean						**8.5v**
SEM						**0.3v**

Mean VHS = 8.5±0.3 vertebrae; KEY: LA = Cardiac long axis, SA = Cardiac short axis, v = vertebrae

Table 2. The VHS values of male and female NZW rabbits

	Males					Females				
S/N	**LA(cm)**	**LA(v)**	**SA(cm)**	**SA(v)**	**VHS(LA+SA)**	**LA(cm)**	**LA(v)**	**SA(cm)**	**SA(v)**	**VHS(LA+SA)**
1	4.80	5.5	3.10	3.9	9.4	4.20	4.5	2.90	3.5	8.0
2	4.40	5.5	2.80	3.6	9.1	4.60	5.5	2.70	3.5	9.0
3	4.10	4.5	2.80	3.0	7.5	4.40	5.0	2.70	3.2	8.2
4	4.10	5.2	2.60	3.5	8.7	4.00	5.2	2.70	3.6	8.8
5	4.30	5.0	2.30	3.0	8.0	3.60	5.0	2.60	3.5	8.5
Total	21.70	25.7	13.60	17.0	42.7	20.80	25.2	13.60	17.3	42.5
Average	4.34	5.1	2.72	3.4	8.5	4.16	5.0	2.70	3.5	8.5
Mean					**8.5**					**8.5**
SEM					**0.4**					**0.2**

Male Mean = 8.5 ± 0.4 vertebrae Female Mean =8.5 ± 0.2 vertebrae
Mean Sex difference in VHS ($p<0.05$) not significant.
KEY: LA = Cardiac long axis, SA = Cardiac short axis

Table 3. t-Test comparing the mean VHS of male and female NZW rabbits

Variables	Individual mean	Pooled mean	SD	d.f	t- Test
Female	8.5000	8.5200	0.59029	9	-32.633[xxx]
Male	8.5400				

Mean difference not significant (p<0.05).

Table 4. Determination of the influence of sex on VHS of NZW rabbits

Variables	B	SD error	t	Significance
Constant	8.500	0.280	30. 377	0.000
Sex	0.40	0.396	0.101	0.922
R^2	0.001			
F-factor	0.001			0.922
Durbin Watson				2.366

No significant relationship between Sex and VHS (p>0.05)

The mean vertebral heart size (VHS) from the pooled data of both sexes of the rabbits was 8.5±0.3 vertebrae. This result is slightly lower than the reference parameter for dogs, 9.7±0.5 vertebrae [1,31], but higher than the value reported for adult cats, 7.5±0.3 vertebrae [7]. There was no significant difference in this study between female (8.5±0.2) and male (8.5±0.4) mean VHS (p>0.05). Other investigators equally found no gender significant difference in mean VHS values [7,31,9]. The VHS system was developed originally as a screening test for cardiac enlargement, but the system may also function very well as a means to monitor changes in heart size with cardiac disease progression as well as in the patient's response to drug treatment [32].

In other similar researches, right lateral versus left lateral or ventrodorsal views were used, and no VHS significant difference was observed between the right and left or ventrodorsal projections [1,31,33]. For this reason, only the right lateral views were studied in the present work. Moreover, right lateral recumbency is the positioning of choice in the lateral plane, and ventrodorsal positioning is contraindicated in patient with intra-thoracic effusion [23,34].

5. CONCLUSION

In most cases of radiographic evaluation, the exact measurement of cardiac silhouette size is not necessary. A reasonably experienced clinician can achieve an acceptable degree of interpretative accuracy by visual estimation. However, the greatest effect on apparent heart size during radiographic examination is the phase of respiration, but Baron [35] reported that the influence of respiratory phase on thoracic and cardiac diameters is negligible. Error due to scattering of photons was removed, or at least minimized, by the use of grid. Results of this project may not only be a guide to the diagnosis of cardiothoracic disease in the rabbit, but may also contribute immensely to future radio-biometric researches. Vertebral heart scale is easy and objective method to use for clinical practice in assessing cardiac size. The study used only one breed of rabbit and so the extrapolation of the findings to other breeds of the animal needs to be further investigated.

CONSENT

It is not applicable.

ETHICAL APPROVAL

As per international standard or university standard ethical approval has been collected and preserved by the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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