Journal of Scientific Research & Reports

18(2): 1-6, 2018; Article no.JSRR.35181
ISSN: 2320-0227

Heart Size Measurement in the New Zealand White Rabbit by Cardiothoracic Ratio

Rock O. Ukaha[1*] and Jessica I. Iloh[1]

[1]Department of Veterinary Surgery and Theriogenology, College of Veterinary Medicine, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.

Authors' contributions

This work was carried out in collaboration between both authors. Author ROU designed and wrote the draft manuscript, supervised the research and reviewed the literature. Author JII measured all radiographic parameters and analysed the data. Both authors jointly carried out all the radiographic exposures and darkroom procedures; both authors also studied and approved the submission of the final manuscript.

Article Information

DOI: 10.9734/JSRR/2018/35181
Editor(s):
(1) Ahmed Hassan El-Sabbagh, Faculty of Medicine, University of Mansoura, Mansoura, Egypt.
(2) Mihaly Mezei, Department of Structural & Chemical Biology, Icahn School of Medicine at Mount Sinai, USA.
Reviewers:
(1) Kim Hyun Jung, Eulji University Hospital, South Korea.
(2) Ivan Simic, Universisty of Kragujevac, Serbia.
(3) Gustavo Luiz Gouvêa de Almeida, Gama Filho University, Brazil.
Complete Peer review History: http://www.sciencedomain.org/review-history/23560

Original Research Article

Received 30th June 2017
Accepted 17th February 2018
Published 8th March 2018

ABSTRACT

Aim: Assessing the heart and other thoracic structures radiographically is very important, in small animal practice, when decisions must be made regarding staging a patient with the suspected cardiac anomaly, deciding about therapy protocols, and monitoring disease progression or response to treatment. The present work was carried out to generate a value for radiographic measurement of heart size in the New Zealand White (NZW) rabbit by the cardiothoracic ratio (CTR).
Materials and Methods: Ten healthy NZW rabbits were used for the study. A dorsoventral (DV) thoracic radiograph was obtained in each of the animals. Cardiac and thoracic diameters of the ten rabbits were evaluated to determine a reference value of CTR in normal NZW rabbits.
Results: Mean plus or minus standard error of mean (M±SEM) CTR were 0.54 ± 0.01. There was not a significant difference between male (0.54 ± 0.01) and female (0.54 ± 0.01) CTR values. There

**Corresponding author: E-mail: ukarock1@gmail.com;*

was no correlation between sex and CTR.
Conclusion: In clinical practice, the application of CTR in radiographic assessment of the heart is objective and very easy.

Keywords: Thoracic radiograph; measurement; cardiac diameter; thoracic diameter; cardiothoracic ratio; Dorsoventral projection; New Zealand White rabbit.

1. INTRODUCTION

Assessing cardiovascular system becomes important when a decision must be made regarding staging a patient with the suspected cardiac disease, deciding about therapy, and monitoring response to therapy or progression of disease. Unfortunately, radiographs are not very accurate for assessing either cardiovascular function or morphology due to the very wide range in dogs of the normal cardiac appearance [1–3]. With respect to the wide range of the normal cardiac appearance, muscular dogs or those with a barrel-shaped thorax often have a heart that appears large. Conversely, the normal heart in breeds with a laterally compressed but deep thoracic cavities, such as the greyhounds and collies, will appear abnormally small, radiographically. Therefore, whenever the heart is evaluated, the breed and body physique should be factored in. In other words, normal values of heart size should be established for every breed of animals due to their thoracic conformational differences. If there is any suspicion of a cardiac anomaly due to radiographic appearance or clinical or historical finding, then echocardiography should be performed [4].

Patient positioning can also significantly affect the appearance of the cardiac silhouette [5]. The most significant effect, perhaps, is the difference in cardiac silhouette appearance in dorsoventral (DV) compared with ventrodorsal (VD) projections. The diaphragm is displaced cranially in the DV views physically pushing the heart cranially mostly into the left hemithorax. This positional displacement is more pronounced in medium and large dogs than small dogs and cats. Alternately, the heart in large-breed dogs is significantly magnified in VD views compared with DV radiographs [6].

It should be kept in mind that the cardiac silhouette is composed of tissues other than the heart. The pericardium, any fluid or tissue in the pericardial space, and any fluid or tissue in the mediastinum immediately adjacent to the heart will blend with the heart, thereby contributing to the overall size and shape of the cardiac silhouette. This principle is probably most important when attempting to evaluate heart size in obese patients because fat in the mediastinum will silhouette with heart (border effacement), increasing the size of the cardiac silhouette. Occasionally, the mediastinal fat is visualized as a region of decreased opacity immediately adjacent to the heart [7].

A number of methods and measurement techniques have been developed for objective estimation of cardiac size. One of the most important of these measurement systems is the cardiothoracic ratio (CTR). The CTR, developed by Danzer [8] and cited by Miller et al. [9] and Baron [10], is a relationship derived by adding the horizontal distances from the midline to the most lateral aspect of the right heart border and the most lateral aspect of the left heart border and dividing that sum by the maximum horizontal diameter of the thorax, measured from left pleural surface to right pleural surface (taken at the level of the diaphragmatic apices) in a posteroanterior chest radiograph in humans and dorsoventral thoracic projection in animals. Mathematically, CTR = $(d_R + d_L)/w_T$, where d_R and d_L have respectively measured distances of the most rightward and most leftward borders of the cardiac silhouette to the spinal column, and w_T is the maximum transverse width of the thoracic cavity.

Unfortunately, radiologic reports in the rabbits are very scanty, and there is a dearth of scientific findings in this field documented for the NZW 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 morphometry of the heart in this breed of animal.

2. MATERIALS AND METHODS

Ten NZW rabbits (5 males) weighing 1.65 – 2.55 kg (average = 2.25 kg), were bought from breeders and used for this project. The rabbits were acclimatised for two weeks and given food *ad libitum* within that period. Within the

adaptation period, vital parameters taken of the animals were all within normal values documented for the rabbit, and so the animals were adjudged healthy [11] for the radiographic study. Before radiography, the animals were chemically restrained with xylazine hydrochloride (a sedative), given i.m. at 30 mg/kg [12].

Plain dorsoventral DV thoracic projections were obtained for each rabbit 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 most prominent parts of the scapulae for DV views and at the middle of the 4^{th} intercostal space for lateral views [13,14]. Radiographic measurements on the experimental radiographs were performed as described below: (i) Addition of the measured horizontal lengths from the vertebral column to the most rightward (d_R) and the most leftward (d_L) heart borders was recorded as the cardiac diameter CD [9,10]. (ii) The horizontal breadth of thorax, from the inner costal surface, measured at the diaphragmatic apices, was measured and recorded as the thoracic diameter TD [9,10].

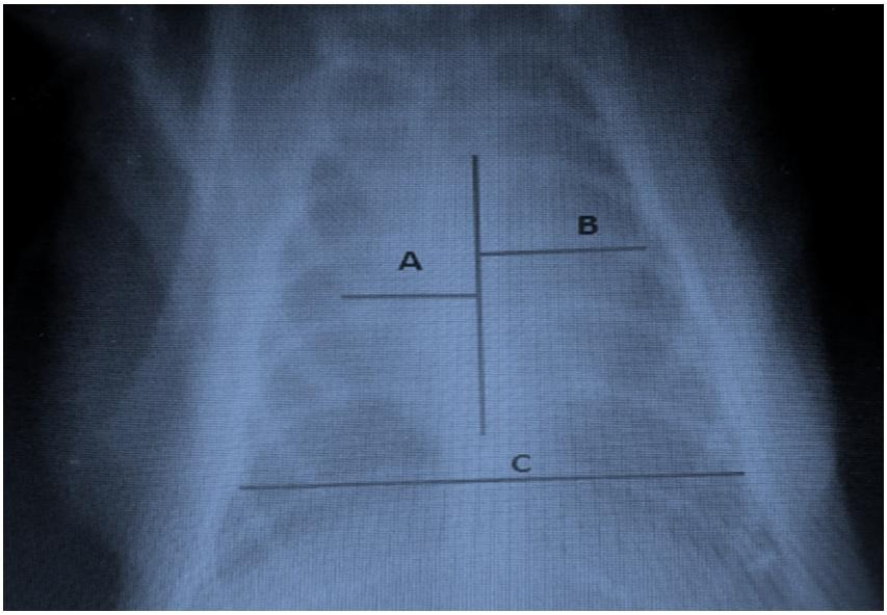
The data obtained were expressed as means plus or minus standard error of means (M±SEM). Variables were compared using Pearson's product moment correlation coefficient and Student's t-test statistics. Statistical significance was defined at probabilities less than five percent.

3. RESULTS

A test of the difference between male and female animals with an individual mean of 0.5360, pooled mean of 0.5360 and an SD of 0.1838. A t-test of -0.216 was not significant, which confirms that there was no difference in mean between the sexes.

The regression table below is the test of the relationship between sex and CTR using Simple Linear Regression Model. The result shows that there is no significant relationship between Sex and CTR. A Durbin Watson test was also carried out to determine the strength of the correlation between Sex and CTR and a value of 2.434 shows there is no correlation between CTR and Sex.

Cardiothoracic Ratio



Dorsoventral Views

Plate 1. Determining CTR

CTR= (A+B)/C.

Key: A = Most rightward distance from the vertebral column; B = Most leftward distance from the vertebral column; C = Maximum transverse width of thoracic cavity

Table 1. CTR values in DV views of the NZW rabbit

S/N	Sex	TD(cm)	CD(cm)	CTR(CD/TD)
1	F	5.4	2.8	0.52
2	F	5.7	3.0	0.53
3	F	5.2	2.9	0.56
4	F	4.8	2.6	0.54
5	F	4.5	2.4	0.53
6	M	5.5	2.9	0.52
7	M	5.2	2.8	0.54
8	M	5.5	2.8	0.51
9	M	4.9	2.8	0.57
10	M	4.6	2.5	0.54
Total	10	51.3	27.5	5.36
Average		5.13	2.75	0.54
Mean				0.54
SEM				0.01

Mean CTR = 0.54 ± 0.01
Key: TD = Thoracic diameter; CD = Cardiac diameter

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

	Females			Males		
S/N	TD(cm)	CD(cm)	CTR(CD/TD)	TD(cm)	CD(cm)	CTR(CD/TD)
1	5.4	2.8	0.52	5.5	2.9	0.52
2	5.7	3.0	0.53	5.2	2.8	0.54
3	5.2	2.9	0.56	5.5	2.8	0.51
4	4.8	2.6	0.54	4.9	2.8	0.57
5	4.5	2.4	0.53	4.6	2.5	0.54
Total	25.6	13.7	2.68	25.7	13.8	2.68
Average	5.12	2.74	0.54	5.14	2.76	0.54
Mean			0.54			0.54
SEM			0.01			0.01

Female Mean CTR = 0.54 ± 0.01, Male Mean CTR = 0.54 ± 0.01, No significant mean sex difference in CTRs ($p<0.05$), Key: TD = Thoracic diameter; CD = Cardiac diameter

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

Variables	Individual mean	Pooled mean	SD	df	t-Test
Female	0.5360	0.5360	0.1838	9	-0.216^{ns}
Male	0.5360				

^{ns} No significant sex difference ($p<0.05$)

Table 4. Determination of the influence of Sex on the CTRs of NZW rabbits

Variables	B	SD error	t	Significance
Constant	0.536	0.009	61.483	0.000
Sex	0.000	0.012	0.000	1.000^{ns}
R^2	0.000			1.000
F-factor	0.000			
Durbin Watson				2.434

^{ns}No significant relationship between SEX and CTR ($p<0.05$)

4. DISCUSSION

The cardiothoracic ratio (CTR), the ratio of the widest expanse of the heart relative to the thoracic width in a dorsoventral projection, ranges from 0.51 – 0.57 with a mean of 0.54±0.01 in the radiographs studied. This mean value is well within the “two-thirds rule” for dogs

and cats (*Felis sylvestris catus*), which states that a normal heart width should be less than two-thirds the width of the thorax [13,15]. The mean CTR, 0.54±0.01, obtained for the NZW rabbit is close to the reference values of 0.50, 0.55, 0.60 – 0.65, and 0.66 reported for normal people, psittacine and flying fox species, dogs and goats, respectively [16,11,17,18,19]. None of the authors documented any significant ($p>0.05$) sex difference in the mean CTR, just like we observed in the present work.

Accurate cardiac evaluation, especially in subtle conditions, can be achieved by the application of the normal CTR for the animal breed concerned [11,17,18,20]. Causes of a CTR ratio greater than normal value include cardiac failure, heart attack, high blood pressure; inability to take deep breath due to obesity, pregnancy, pectus excavatum deformity, and ascites [17,21]. On the other hand, reduced heart size relative to chest volume, termed microcardia, may be due to wasting diseases or cachexia, hypovolaemia, asthernia, senile atrophy, constrictive pericarditis, and hypoadrenocorticism [21–24].

5. CONCLUSION

CTR is a diagnostic index for the assessment of cardiothoracic diseases. However, normal cardiac silhouette does not rule out the presence of heart disease. Therefore, in some circumstances, radiographic findings should be compared with at least another imaging observation such as echocardiography or electrocardiography, in the light of case history, general examination, and laboratory results. Clinically, the applicability of CTR in cardiac assessment is easy and objective. The results of this study proffer a standard for cardiothoracic investigation in the NZW rabbit. The present work evaluated the heart size using dorsoventral projections of the rabbits. A ventrodorsal cardiac size determination should also be carried out. Moreover, further researches should be embarked upon to extrapolate these results to other breeds of rabbits.

ETHICAL APPROVAL

As per international standard or university standard ethical approval has been collected and preserved by the authors. The housing, environment, and management of the research animals were as stipulated in the Guide for the Care and Use of Laboratory Animals, 8th Edition, National Research Council, USA, downloaded from the National Academic Press, Washing D.C. www.nap.edu.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kittleson MD. Radiology. In Kittleson MD, Kienle RD (eds): Small Animal Cardiovascular Medicine, Mosby Yearbook, St Louis; 1998.
2. Lord PF, Suter PF. Radiology. In Fox PR, Sisson D, and Moise S (eds): Textbook of Feline and Canine Cardiology 2nd edn, WB Saunders Co., Philadelphia; 1999.
3. Webster N, Adams V, Dennis R. The effect of manual lung inflation versus spontaneous inspiration on the cardiac silhouette in anaesthetized dogs, Vet Radiol Ultrasound. 2009;50:172.
4. Lamb CR, Boswood A. Role of survey radiography in diagnosing canine cardiac disease. Compen Contin Educ Pract Vet. 2002;24:316-326.
5. Ruehl WW, Thrall DE. The effect of dorsal versus ventral recumbency on the radiographic appearance of the canine thorax, Vet Radiol. 1981;22:10.
6. Carlisle C, Thrall DE. A comparison of normal feline thoracic radiographs made in dorsal versus ventral recumbency, Vet Radiol. 1982;23:3.
7. Bahr R. The heart and pulmonary vessels. In Thrall DE (ed): Textbook of Veterinary Diagnostic Radiology 6th edn, Elsevier Saunders, St Louis; 2013.
8. Danzer CS. The cardiothoracic ratio: An index of cardiac enlargement. Amer J Med Sci. 1919;157:513.
9. Miller JA, Singer A, Hinrichs C, Contactor S, Doddakashi S. Cardiac dimensions derived from computed tomography: Correlation with plain film radiography. Internet Journal of Radiology. ISSAN: 1528-8404 1(1); 2000.
   Available:http://www.ispub.com
10. Baron MG. Radiology of the heart. Cecil Textbook of Medicine.
    (Accessed 12 March, 2004)
    Available:http://www.merckmedicus.com
11. Straub J, Pees M, Krautwald-Junghanns ME. Measurement of the cardiac silhouette in psittacines. J Am Vet Med Assoc. 2002; 221(1):76-79.

12. Flecknell PA. Laboratory Animal Anaesthesia, 2nd edn: Academic Press, London; 2009.
13. Ettinger SJ, Suter PF. Radiographic Examination. In Ettinger SJ and Suter PF (eds) Canine Cardiology; WB Saunders Co., Philadelphia; 1970.
14. Douglas SW, Herrtage ME, Williamson HD. Principle of Veterinary Radiology 4th edn; Bailliere Tindall, London; 1987.
15. Van den Broek AM, Darke PG. Cardiac measurements on thoracic radiographs of cats, J Small Anim Pract. 1987;28:125.
16. Schnelling CG. Radiology of the heart. In Miller MS and Tilley LP (eds): Manual of Canine and Feline Cardiology 2nd edn, WB Saunders Co, Philadelphia; 1995.
17. Herring W, Ostrum BJ. The ABCs of heart disease.
(Accessed 23 September, 2013)
Available:http://www.learningradiology.com
18. Gardner A, Thompson MS, Heard DJ, Fontenot D, Gibson N. Radiographic evaluation of cardiac size in flying fox species (*Pteropus rodricensus, P. hypomenalus and P. vampyrus).* J Zoo Wildlife Med. 2007;38(2):192-200.
19. Ukaha RO. Estimation of cardiothoracic ratios in thoracic radiographs of the West African Dwarf Goat. Nig Vet J. 2013;34(3): 845-850.
20. Lupow JB, Sivak SL, Boss D. The accuracy of cardiothoracic ratio as a predictor of cardiac enlargement and dysfunction.
(Accessed 22 August, 2012)
Available:http://www.aemj.org/cgi/content/abstract /9/5/462
21. The Merck Veterinary Manual. Abnormalities of cardiovascular system, 8th edn, Merck & Co. Inc., New Jersey, USA; 1997.
22. Blood DC, Studdert VP. Bailliere's comprehensive veterinary dictionary. BaillereTindall, London. 1990;724.
23. Preuter JC. Hypoadrenocorticism (Addison's disease).
(Accessed 23 September, 2013)
Available:http://www.beaconforhealth.org/Addisons-Preuter.html
24. Reeder MM, Bradley WG. Reeder and Felson's Gamuts in Radiology. Comprehensive Lists of Roentgen Differential Diagnoses, 3rd edn. Springer-Verlag New York Inc., New York; 1993.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/23560