



Normal M-mode, Pulsed Wave and Tissue Doppler Echocardiographic Studies in Healthy Working Police Dogs

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10.18805/IJAR.B-5294

ABSTRACT

Background: Physical activity alters the cardiovascular system of dogs depending on the exercise characteristics and the animal's physical conditioning. Little is known about the cardiovascular changes in working police dogs. This study evaluated the cardiovascular responses of working Labradors to regular exercise and various workload.

Methods: Twelve working Labradors of Tamil Nadu police department that were regularly trained and exercised 30 minutes morning and evening and twelve normal household pet Labradors brought for regular checkup to Madras Veterinary College Teaching hospital were taken for the study. All the animals were subjected to physical, clinical, hematobiochemical, electrocardiographic examinations and cardiac auscultation before performing echocardiography. Those animals which showed normal recordings in all the above tests were further subjected to M-mode, pulsed wave and tissue doppler echocardiography. In this study, the resting heart rate values of working groups were lesser than that of normal pet dogs.

Result: The results of echocardiography showed significant increase in Interventricular septal diameter during diastole, left atrial diameter, aortic artery diameter and the left atrium to aortic diameter ratio without impairing systolic and diastolic cardiac functions in working dogs. The present study indicated that there were few changes in the echocardiographic parameters which might be a response to physiological adaptation and regular exercise.

Key words: M-mode, Pulsed wave, Tissue Doppler echocardiography, Working dog.

INTRODUCTION

Working police dogs, an extraordinary category of canines, exhibit exceptional intelligence, endurance and adaptability in various professional fields, playing an indispensable role in endeavors such as search and rescue, law enforcement, agriculture and therapy. Depending on their work, these dogs are subjected to different kinds of exercise and training on regular basis. These working schedules and various environment expose them to different levels of physical and mental stress comparing to untrained household pets. Although, these dogs undergo routine checkup, preventive cardiovascular assessment has not been given much importance. Therefore, it is essential to include cardiological assessment as a routine procedure in working police dogs. The importance of assessing cardiac parameters in working dogs cannot be overstated. These animals are subjected to rigorous physical and mental demands during their service and their cardiovascular systems bear the brunt of these challenges. Monitoring their cardiac health is essential not only for their longevity but also for their operational efficiency.

M-mode echocardiography allows for precise measurement of chamber dimensions (Vurucu, 2021), while pulsed wave Doppler assesses blood flow velocity (Boon, 2011). Tissue Doppler Imaging measures the velocity of myocardial tissue aiding in the evaluation of myocardial function. These techniques collectively enable a comprehensive evaluation of cardiac parameters in animals, including working dogs. Although normal

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How to cite this article: Madhumitha, C.M., Ramprabhu, R., Jeyaraja, K. and Subapriya, S. (2024). Normal M-mode, Pulsed Wave and Tissue Doppler Echocardiographic Studies in Healthy Working Police Dogs. Indian Journal of Animal Research. 58(11): 1867-1871. doi: 10.18805/IJAR.B-5294.

Submitted: 25-12-2023 **Accepted:** 23-05-2024 **Online:** 22-07-2024

echocardiographic values for dogs have been published but there is variation within the breeds, age and somatotype. Variation in working condition may affect the values which needs to be assessed and standardized. There is a need for normal, reliable values of chamber size, wall dimensions and velocities for evaluation of cardiac diseases in working dogs. To our knowledge, limited reports are available on the echocardiographic changes in working dogs in comparison to normal pet dogs. So, the purpose of this study is to record the changes if any in echocardiographic parameters between working and pet groups.

MATERIALS AND METHODS

The present study involved 24 Labrador Retrievers, comprising 12 working police dogs and 12 pet dogs, all of which were clinically healthy and conscious. These dogs included both sexes and exhibited a body weight ranges from 20-41 kgs, with an age ranging from 16 months to 8 years. Selection criteria included a comprehensive evaluation encompassing physical, clinical, electrocardiographic and blood examinations. Heart rate was recorded by auscultation before echocardiographic examination. Any animals displaying clinical signs of cardiac abnormalities were excluded from the study. The dogs were examined by two-dimensional, M-mode and Doppler echocardiography. To facilitate echocardiography, the haircoat was clipped from the costochondral junction to the sternum, specifically at the level of the 4th to 6th intercostal ribs on both the side. The dogs were positioned in lateral recumbency on a table featuring a central slit with the side to be examined placed over the slit. Ultrasound coupling gel was generously applied to the skin to ensure intimate contact between the skin and the transducer head. Two dimensional and M-mode echocardiography was performed using a 2-6 MHz annular array sector transducer (Aero scan). During imaging, the transducer was positioned on the dependent side of the body at a point where the strongest palpable apex beat was heard. All measurements were taken from a right parasternal long-axis view of the left ventricular outflow tract. For left ventricular images, the cursor was situated just posterior to the chordae tendinae, perpendicular to the interventricular septum and the left ventricular posterior wall. Measurements included left ventricular internal dimensions at diastole (LVIDd) and systole (LVIDs), left ventricular posterior wall dimensions at diastole (LVPWd) and systole (LVPWs), interventricular septal thickness at diastole (IVSd) and systole (IVSs). Fractional shortening (FS), end-systolic volume, end-diastolic volume and ejection fraction were calculated using standard formulas. Left ventricular volumes like end diastolic volume and end systolic volume were calculated by the Teicholz formulae:

$$\text{End diastolic volume (EDV in ml)} = \frac{7 (X) \text{LVDd}^3}{(2.4 + \text{LVDd})}$$

$$\text{End systolic volume (ESV in ml)} = \frac{7 (X) \text{LVDs}^3}{(2.4 + \text{LVDs})}$$

$$\text{Stroke volume (SV in ml)} = \text{EDV} - \text{ESV}$$

$$\text{Ejection fraction (EF\%)} = \frac{(\text{EDV} - \text{ESV}) (X) 100}{\text{EDV}}$$

$$\text{Left ventricle fractional shortening (LVFS in \%)} =$$

$$\frac{(\text{LVDd} - \text{LVDs}) (X) 100}{\text{LVDd}}$$

The Mitral flow velocity profile was acquired through the left caudal (apical) four-chamber view. The sample volume was placed in the left ventricle just distal to the mitral annulus at the point of maximal opening of the mitral valve. Doppler curves were meticulously traced to ascertain the trans mitral early peak velocity (E) and late peak velocity (A) of diastolic filling. Additionally, the ratio of peak early to peak late diastolic flow (E/A ratio) was determined. The aortic valve flow velocity profile was assessed from the left caudal (apical) long-axis view of the left ventricular outflow region and occasionally from an apical five-chamber view of the heart. The sample volume was positioned just distal to the aortic valve and the sinus of Valsalva. Parameters such as aortic peak velocity, velocity time integral and ejection time were determined.

Tissue doppler imaging was performed at the level of the lateral mitral annulus from a left apical 4-chamber view after optimizing the alignment of the ultrasound beam with the myocardium and the lateral Sa velocity, lateral Ea velocity early diastolic [e'] and late diastolic [a'] and lateral Aa velocity were recognized and their peak velocities were recorded as described by Boon (1998).

Statistical analysis was carried out by IBM SPSS version 20.0 for windows and by paired T test.

RESULTS AND DISCUSSION

A total of 24 Labradors including police dogs and pet dogs were included in this study. The two groups in this study were similar with regard to age ranging from 16 months to 8 years, weight ranges from 20-41 kgs.

At rest, the mean heart rate of working Labrador (78.67±4.9 bpm) was lower than the heart rate of normal pet Labrador (114.78±4.3 bpm). Heart rate was one of the parameters that significantly decreased in working group which might be due to neurovegetative adaptation, a common observation found in well trained dogs (Rovira 2007b). Mukerjee (2015) also reported that the trained dogs showed lower heart rates when compared to their non trained counterparts. It is well known that physical training can cause decreased heart rates in animals at rest and during exercise at sub maximum workloads. Changes in the intrinsic mechanisms acting on the sinus node and alterations in the autonomic nervous system control of the heart have been reported to contribute to resting bradycardia in trained animals (Martinelli *et al.*, 2005). The Mean±S.E values of Heart rate of normal pet and working Labrador were summarized in the Table 1.

The Mean±S.E values of M- mode echocardiographic values for normal pet and working Labrador were summarized in the Table 1. The mean IVSd values of working dogs (0.97±0.03 cm) was significantly higher than the IVSd value of normal pet Labradors (0.89±0.03) but values were within the normal reference range as described by Boon (2011). This increase in working dogs when compared with normal pet dogs might be due to the physiological

adaptation capacity of these dogs to maintain cardiac output (Stepien *et al.*, 1998). An increase in IVSd is a consistent finding in human endurance athletes and dogs after athletic training (Wyatt and Mitchell, 1974) (Table 1).

The LA value of working Labrador dogs (2.59 ± 0.1532) was significantly higher than that of normal pet Labrador (1.95 ± 0.1044 cm) but the values were within the reference range as stated by Boon (2011). The higher prevalence of left atrial (LA) enlargement in trained athlete had an association with endurance exercise training and early echocardiographic study demonstrated that a group of endurance athletes had larger left atria than control subjects. Although, Aortic (Ao) value in working police Labradors were higher than in control group, there is no statistical significance between these two groups. The left atrium is one of the four chambers of the heart responsible for receiving oxygenated blood from the lungs and pumping it into the left ventricle, which then sends the blood throughout the body. During exercise, the demand for oxygen-rich blood increases, leading to an enhanced cardiac output. In response to regular aerobic training, both dogs and humans may experience left atrial enlargement as a result of the heart's adaptive response to the increased workload. This adaptation is often considered a positive outcome of exercise, reflecting the heart's ability to pump a larger volume of blood with each contraction (Santos, 2018). It's important

to note that aortic enlargement due to exercise is generally considered a normal and adaptive response in athletes. The heart, including the aorta, undergoes these changes to enhance its efficiency and meet the increased demands placed on it during physical activity. Athlete's heart is typically characterized by a slightly larger left ventricle and aorta, allowing for greater stroke volume and cardiac output.

The mean LA/Ao value in working Labradors (1.38 ± 0.1375) was significantly higher than the LA/AO values in normal pet Labradors (0.98 ± 0.0475) but does not exceed the normal reference range quoted by Boon (2011). This increase in LA/Ao in working dogs might be due to the characteristic of the dog breeds used or a cardiovascular adaptive physiological response to prolonged physical training to which those animals are subjected (Lima *et al.*, 2022). Also, LA/Ao ratio greatly depends on age, breed, weight and intensity of exercise and it need to be considered.

The Aa Lateral (cm/s) in working Labradors (-8.22 ± 0.5029) was decreased when compared with the normal pet Labradors (-11.13 ± 0.7967) (Table 2). However, the range was within the normal as reported by Chetboul (2002) and all other pulsed wave and tissue Doppler echocardiographic parameters didn't show any significant difference between working and normal pet Labradors (Table 3). Mockel (1996) reported that the athletes with

Table 1: M-mode echocardiographic values in normal pet and working labrador (Mean $\pm$ S.E).

Parameter	Normal labrador group (n=9)	Working labrador group (n=9)	t-value
LVID d (cm)	3.85 ± 0.11	4.08 ± 0.1	1.62 ^{NS}
LVIDs (cm)	2.12 ± 0.16	2.53 ± 0.18	1.76 ^{NS}
IVS d (cm)	0.89 ± 0.03	0.97 ± 0.03	2.18*
IVSs (cm)	1.49 ± 0.11	1.25 ± 0.09	1.69 ^{NS}
LVPW d (cm)	1.20 ± 0.08	1.28 ± 0.03	0.96 ^{NS}
LVPWs (cm)	1.78 ± 0.11	1.68 ± 0.16	0.51 ^{NS}
EDV (mL)	73.82 ± 3.99	73.96 ± 3.97	0.02 ^{NS}
ESV (mL)	26.79 ± 3.30	24.63 ± 3.28	0.47 ^{NS}
EF (%)	61.99 ± 2.89	67.16 ± 4.04	1.04 ^{NS}
SV (mL)	49.32 ± 4.22	49.33 ± 3.38	0.00 ^{NS}
FS (%)	34.76 ± 2.29	38.09 ± 3.83	0.75 ^{NS}
AO (cm)	1.98 ± 0.0943	2.23 ± 0.1048	1.76 ^{NS}
LA (cm)	1.95 ± 0.1044	2.59 ± 0.1532	3.46**
LA/AO	0.98 ± 0.0475	1.38 ± 0.1375	2.75*
Heart rate (bpm)	114.78 ± 4.3	78.67 ± 4.9	5.54**

Table 2: Comparative pulsed wave doppler echocardiographic values in normal pet labrador and working labrador.

Parameter	Normal labrador group (n=9)	Working labrador group (n=9)	t- value
MV E vel (cm/s)	70.81 ± 1.2834	68.44 ± 3.0194	0.72 ^{NS}
MV A vel (cm/s)	48.76 ± 3.3657	42.53 ± 2.7997	1.42 ^{NS}
E/A	1.51 ± 0.1036	1.67 ± 0.1828	0.76 ^{NS}
AV max (cm/s)	-110.00 ± 5.8300	-118.90 ± 7.8589	0.91 ^{NS}
AV V mean (cm/s)	-57.78 ± 2.9333	-61.14 ± 3.3251	0.76 ^{NS}
AV VTI (cm)	18.31 ± 1.1226	16.94 ± 0.7387	1.02 ^{NS}

Table 3: Comparative tissue doppler echocardiographic values in normal pet labrador and working labrador.

Parameter	Normal labrador group (n=9)	Working labrador group (n=9)	t-value
Sa lateral (cm/s)	12.76±0.8590	13.47±0.6594	0.65 ^{NS}
Ea lateral (cm/s)	-10.45±0.3292	-11.06±0.6888	0.80 ^{NS}
E/E'	5.46±0.2336	6.17±0.2940	1.88 ^{NS}
Aa lateral (cm/s)	-11.13±0.7967	-8.22±0.5029	3.09**
Ea/Aa	1.15±0.1113	1.41±0.1355	1.48 ^{NS}

physiological cardiac hypertrophy have normal or improved diastolic inflow patterns and doesn't show any major changes in Doppler echocardiography. Sometimes evaluating diastolic function only by PW-Doppler could be not so easy. Patterns of trans mitral diastolic flow change mainly with the age and it also depends on the variation of pre- or after-load conditions. In such cases by means of TDI, ventricular dysfunction can be disclosed even before the development of left ventricular hypertrophy and, a differentiation of left ventricular hypertrophy due to hypertrophic cardiomyopathy or systemic hypertension is possible by TDI (Krieg, 2007). E/E' ratio is an important parameter derived from a combination of traditional PW Doppler and PW-TDI. It's directly correlated with diastolic abnormality and it doesn't show any significant change in this study.

Morphological changes in left ventricular (LV) and tissue doppler echocardiography (TDI) are used to differentiate adaptational heart changes from pathological changes. According to the results of this study cardiovascular morphological changes in working police Labradors are associated with better systolic and diastolic ventricular filling patterns, all features supporting the physiological nature of left ventricular remodeling.

CONCLUSION

The differentiation of training-induced cardiac adaptations from pathological conditions is a key issue in sports cardiology. The results of this study demonstrated that working police Labradors have the significantly increased echocardiographic parameters of IVSd, LA, LA/Ao comparing with the normal pet dogs without impairing cardiac function. HR values of working Labradors were less than that of normal pet Labradors. The final conclusion stated that working dogs' heart has thicker walls, increased mass with unchanged internal dimensions. Systolic and diastolic function in these working police dogs is normal. Athlete's heart with those characteristics is a healthy organ. Therefore, the findings of the cardiovascular evaluation revealed there were few changes in the left ventricular measurement without any clinical signs and it might be due to the physiological adaptation formed because of regular exercise and training. This study will help the veterinarians to differentiate the physiological changes from pathological changes. It also enables early detection of cardiac abnormalities, allowing for timely intervention and treatment to mitigate potential health risks and ensure

the continued operational readiness of police working dogs. By identifying subtle changes in cardiac function, veterinarians can proactively address any emerging health concerns, thereby minimizing the impact on the dog's performance and well-being.

Moreover, the integration of echo parameters into routine health assessments of police working dogs facilitates data-driven decision-making regarding their deployment and workload management. By establishing baseline cardiac measurements and monitoring changes over time, can make informed decisions regarding the dog's suitability for various tasks and tailor their training and operational schedules accordingly.

Conflict of interest

All authors declare that they have no conflict of interest.

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