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### Original Article

## Study of Normal Cardiac Parameters by Echocardiography in Healthy Kordi Sheep

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ARTICLE INFO	ABSTRACT
<p><i>Article History:</i></p> <p>Received 13 October 2022            Revised 21 November 2022            Accepted 14 December 2022            Online 14 December 2022</p> <hr/> <p><i>Keywords:</i></p> <p>Echocardiography            Doppler            Kordi sheep</p>	<p>The objectives for this study are to report reliability, normal cardiac dimensions and time indices adult Kordi sheep. Twelve healthy adult Kordi sheep were recruited. Full echocardiographic examinations were performed in the standing unsedated animals. In such a way that Mitral, tricuspid, aortic and pulmonary flows were measured. Images were stored and measured offline. The difference between left and right side measurements and the intraobserver inter-day repeatability were tested and then the reference values of PW Doppler echocardiographic parameters in healthy adult female Kordi sheep were established. As documented in other species, all sheep PW Doppler parameters demonstrated a poor inter-day repeatability and a moderate variability. Tricuspid and pulmonary flows were best evaluated on the right side whereas mitral and aortic flows were best obtained on the left side and reference values are reported for healthy adult Kordi sheep. PW Doppler echocardiography allows the measurement of intracardiac blood flow indices in sheep. The reference values establishment will help interpreting these indices of cardiac function in clinical cardiac cases and developing animal models for human cardiology research.</p>

### Introduction

Kordi sheep is considered as a meat breed among Iranian sheep. Kordi sheep have a medium body with long arms and legs and are strong. The color of their body wool is sugar white and their hands, feet and head are brown or black. This breed has a large tail.<sup>1</sup> Echocardiography is a non-invasive method for assessment of the ovine and caprine heart. However, it is a technique that has been utilised more frequently in the assessment of clinical disease in small animals and

horses for evaluation of changes in wall thickness, chamber size and valvular appearance and function. For measurements to be accurate and reliable, images must be taken from correctly orientated imaging planes in relation to internal landmarks.<sup>2</sup> Sheep and goats are infrequently clinically diagnosed with structural cardiac abnormalities. This may be due to these species being relatively resistant to cardiac disease or because these animals are rarely presented for detailed medical evaluation. Descriptions of endocarditis in small ruminants have not been reported. Myocarditis due to

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bacterial (e.g. Clostridial spp. and Mycobacterium spp.), viral (e.g. foot and mouth disease), parasitic (e.g. toxoplasmosis or sarcocystosis) or toxic causes (e.g. monensin, gossypol, Cassia occidentalis, Phalaris spp, oleander) could be seen in small ruminants; reports are however lacking.<sup>3</sup> Although Kordi sheep breed is one of the important breeds in northwest and northeast of Iran, there is no data on Pulsed Wave (PW) Doppler echocardiography.

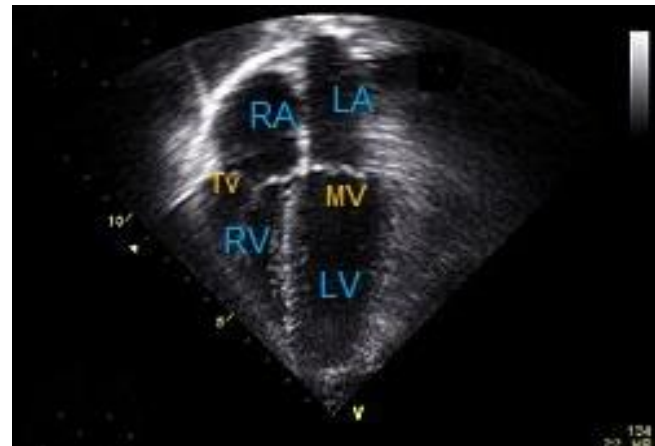
## Materials and Methods

Twelve healthy adult male Kordi sheep with aged 20 to 32 months were recruited. All animals received a routine clinical examination and a base-apex electrocardiogram (ECG) was recorded at rest. The animals were only included in the study if they were reported to have been in good health in the previous four weeks prior to echocardiographic examination. Before imaging, the hair was shaved on both sides, from the 3th to the 5th right intercostal space just caudal to the triceps muscle mass, from 3 to 5 cm below the right olecranon to 5 to 10 cm above it. The shaved areas were then copiously rinsed with water and acoustic coupling was obtained using ultrasound gel. A 5 MHz phased-array transducer attached to ultrasound machine was used to acquire the images. Echocardiography was prepared from the 4th and 5th intercostal spaces in the longitudinal and transverse views and on the left and right the measured parameters, the ratio PEP/ET was calculated and the stroke volume (SV) and the cardiac output (CO) were obtained using the following standard formulae (Figure 1). Then, mean  $\pm$  standard deviation (SD) of measurements was calculated (for each of the parameters) and the analysis between indicators in all sheep was conducted by ANOVA test.

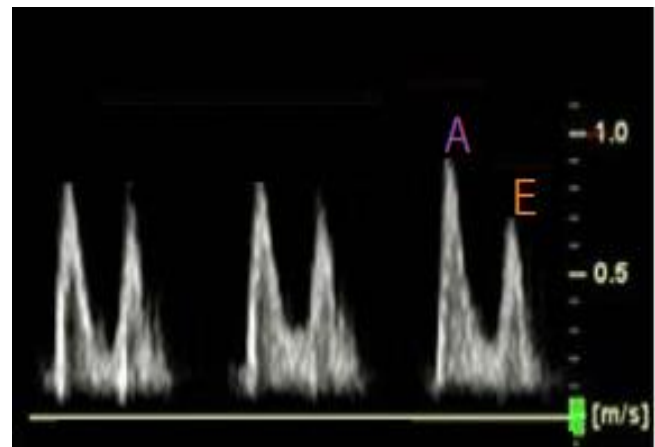
## Results

The mean HR during the echocardiographic examination was  $98.25 \pm 12.95$  beats/minute and ranged from 82 to 125 beats/minute. The image quality and the Doppler spectra were good in all sheep, except for the quality of the tricuspid flow and the right side aortic flow which were often poor. Moreover, obtaining a good quality 2D right parasternal view of the heart base at the level of the pulmonary valves before to shift in PW-mode appeared to be sometimes difficult. For this view, the transducer had to be advanced far forward under the forelimb, which required an assistant pulling the right forelimb forward and upward during the examination.

The least square mean value and the standard error to the mean of each blood flow measurements obtained on day 1, day 2 and day 3 and the multivariable ANOVA test were calculated to evaluate the repeatability of these measurements. Concerning the aortic flow, significant between days differences were observed for Vmax, VTI, CO and CI. Almost all measurements of the pulmonary flow were significantly different between days except PEP and PEP/ET. Mitral and tricuspid flow velocities (E<sub>max</sub>, E<sub>mean</sub>, A<sub>max</sub>, A<sub>mean</sub>, E<sub>max</sub>/A<sub>max</sub>) and E<sub>peak</sub> and A<sub>peak</sub> mitral and tricuspid VTI were significantly different between days (Figure 2). Comparisons of the PW Doppler echocardiographic measurements of the aortic and mitral flows obtained from the right and from the left side are shown in Tables 1 and 2 respectively. For the aortic flow, only PEP and PEP/ET were not significantly different whilst all other parameters were significantly different from the right and the left side. Most of the parameters, especially V<sub>max</sub> and V<sub>mean</sub>, were significantly higher when they were obtained from the left side than from



**Figure 1.** 2D image of the heart. LA: left atrium, LV: left ventricle, MV: mitral valve, RA: right atrium, RV: right ventricle, TV: tricuspid valve.



**Figure 2.** Pulsed wave Doppler of mitral inflow velocity.

the right side. For mitral flow, all parameters of Apeak but oasless than 125 beats per minute to obviate a stress effect. A color ET of Epeak were not significantly different from both sides. The mitral Emax, Emean and VTI of E peak were higher when obtained from the left side than when obtained from the right side. The results of the measurements of the aortic, mitral, pulmonary and tricuspid flows are shown in Tables 1, 2, 3, and 4, respectively. Most of the parameters had low to moderate variability excepted for TTP of the aortic flow, acc slope of the aortic and pulmonary flows, and Dec time and Dec slope of the mitral and tricuspid Epeaks that showed a high variability. For all flows, within-day variability was clearly lower than between-day variability.

## Discussion

In the studied sheeps, the mean values of the mitral velocity spectrum obtained from a tilted left parasternal long axis four chamber view were significantly different from those obtained from a tilted right parasternal long axis four chamber view, except for all parameters of the Apeak and for ET of the Epeak. Moreover, Emax and Emean were lower when the measurements were performed from the right side than from the left side, which suggests that in sheeps, the mitral flow should be interrogated from the left rather than from the right hemi thorax. This result is in agreement with previous studies on other domestic animals since, to record the mitral flow, a tilted left parasternal long axis four chambers view is recommended in horses, and a left parasternal apical view is recommended in sheep and in dogs.<sup>4,6</sup> The Emax/Amx ratio is a parameter often used to evaluate the left ventricular diastolic function in man.<sup>7-9</sup> Independently of the side from which it is measured, the Emax/Amx ratio of the mitral flow was rather similar to the tricuspid flow Emax/Amx. The same was observed in 8 of 40 investigated healthy horses and was explained as a more accurate alignment of the transducer with the A wave of atrial contraction than with the E wave of the early rapid ventricular filling.<sup>4,5</sup> Measurements of Epeak and Apeak seemed also to depend on HR. In goats as in sheep, it has been reported that the Apeak is closer to the Epeak with increasing HR, and when HR was more than 120 beats/min, fusion of the two peak can occur<sup>5</sup>. Measurements of aortic velocity spectrum are very interesting because they allow assessing left ventricular SV and CO.<sup>7</sup> In this study, except for PEP and PEP/ET, the aortic velocity

**Table 1.** Pulse wave Doppler echocardiographic parameters of the aortic flow.

Parameters	Mean ± SD
Vmax (m/s)	1.2 ± 0.25
Vmean (m/s)	0.60 ± 0.015
ET (ms)	275.20 ± 15.5
VTI (cm)	18.75 ± 2.5
PEP (ms)	49.25 ± 4.95
TTP (ms)	91.5 ± 18.7
SV (ml)	65.5 ± 8.2
CO (l/min)	4.9 ± 0.3
PEP/ET	0.15 ± 0.03

**Table 2.** Pulse wave Doppler echocardiographic parameters of the mitral flow.

Epeak parameters	Mean ± SD
Vmax (m/s)	0.77 ± 0.05
Vmean (m/s)	0.48 ± 0.02
ET (ms)	8.90 ± 0.65
VTI (cm)	220.05 ± 19.15
Apeak parameters	
Vmax (m/s)	0.67 ± 0.05
Vmean (m/s)	0.42 ± 0.05
ET (ms)	115.25 ± 17.10
VTI (cm)	3.95 ± 0.55
Emax/Amx	1.02 ± 0.15

**Table 3.** Doppler echocardiographic measurements of the pulmonary.

Parameters	Mean ± SD
Vmax (m/s)	0.87 ± 0.17
Vmean (m/s)	0.80 ± 0.5
ET (ms)	265.5 ± 21.4
VTI (cm)	19.90 ± 1.85
PEP (ms)	43.8 ± 4.8
TTP (ms)	117.5 ± 12.5
SV (ml)	80.15 ± 15.05
CO (l/min)	8.05 ± 1.50
PEP/ET	0.15 ± 0.02

**Table 4.** Doppler echocardiographic measurements of the tricuspid flow.

Epeak parameters	Mean ± SD
Emax (m/s)	0.72 ± 0.15
Emean (m/s)	0.54 ± 0.19
VTI (cm)	10.75 ± 2.55
ET (ms)	239 ± 43.5
Apeak parameters	
Amx (m/s)	0.62 ± 0.25
Amean (m/s)	0.51 ± 0.25
VTI (cm)	5.05 ± 1.55
ET (ms)	119.8 ± 14.5
E/A	1.05 ± 0.05

spectrum measurements obtained from the tilted left parasternal long axis five chambers view were significantly higher than those obtained from a tilted right parasternal long axis five chambers view. This is in agreement with the results obtained in horses, and could be explained by a better alignment between the transducer and the blood flow from the left hemithorax.<sup>4</sup>

By Sadi *et al.* in 2018, heart parameters in breed of Markhoz were measured. The results were consistent with the results of the present study and there is no significant difference between the results.<sup>10</sup> Also, in 2021, a research was conducted by Sadi on Najdi goats, and considering that both goats and sheep are small ruminants, the results of this research are close to the results of the current research.<sup>11</sup> By performing this study, the parameters of healthy heart echocardiography were obtained in the Kordi sheeps that can be used as a reference values in sheeps. Meanwhile, heart disease in sheeps is diagnosed by comparing these reference values with the obtained from the echocardiography.

### Conflict of Interest

The Authors declare there is no conflict of interest.

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