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Research Article

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# Measurement of Cardiac Parameters by Echocardiography in Normal Healthy Najdi Goat

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**Abstract**

**Bachground and aim:** The objectives for this study are to report reliability, normal cardiac dimensions and time indices adult Najdi goats.

**Material and Methods**: Fifteen healthy adult Najdi goats were recruited. Full echocardiographic examinations were performed in the standing unsedated animal. In such a way that Mitral, tricuspid, aortic and pulmonary flows were measured. Images were stored and measured offline.

**Results:** 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 Najdi goats were established. As documented in other species, all caprine PW Doppler parameters demonstrated a poor inter-day repeatability and a moderate variability.

**Conclusion:** 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 Najdi goats. PW Doppler echocardiography allows the measurement of intracardiac blood flow indices in goats. The reference values establishment will help interpreting these indices of cardiac function in clinical cardiac cases and developing animal models for human cardiology research.

**Keywords**: *Echocardiography, Doppler, Najdi goat*

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**Introduction**

Goat species is an important component of animal genetic resources. Together with sheep, they are commonly called small ruminants, partly because of their size (Sandra, 2010). Goats provide meat, milk and skins; they also contribute to socioeconomic, cultural and recreational needs of mankind. In the last decade, the demand for goat meat and cheese has increased in the USA, because population demographics have shifted toward those that traditionally consume goat products (Boyazoglu *et al.,* 2005; Devendra, 2006; Sandra, 2010). Goat breeds are usually classified by their geographical origin, their region and productivity, or their height at the withers (Glowatzki *et al.,* 2008; Morand-Fehr *et al.,* 2004). Najdi goat breed is relatively small and has a good milk production. This breed, which is also called Tali, is one of the main dairy breeds kept in the hot and humid area south of Iran (Gall, 1996). Echocardiography is a non-invasive method for assessment of the ovine and caprine heart ment 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, cham- ber size and valvular appearance and function. For mea- surements to be accurate and reliable, images must be taken from correctly orientated imaging planes in rela- tion to internal landmarks (Schiller *et al.,* 1989). Sheep and goats are infrequently clinically diagnosed with structural cardiac abnormalities. This may be due to these species being relatively resistant to cardiac dis-ease or because these animals are rarely presented for detailed medical evaluation. Descriptions of endocarditis in small ruminants have not been reported. Myocarditis due to 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 (Reef & McGuirk, 2002). Although Najdi breed is one of the important breeds in world, there is no data on Pulsed Wave (PW) Doppler echocardiography.

**Materials and Methods**

Fifteen healthy adult Najdi goats were used. All animals received a full 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 echocardio-graphic examination. Before imaging, the hair was shaved on both sides, from the 3rd 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 of 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 ± standard deviation (SD) of the measurements was calculated (for each of the parameters) and the analysis between indicators in all goats was conducted by ANOVA test.

**Results**

The mean HR during the echocardiographic examination was 91.55±10.75 beats/minute and ranged from 65 to 115 beats/minute. The image quality and the Doppler spectra were good in all goats, except for the quality of the tricuspid flow and the right side of 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 shifting to 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 of 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 was 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



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were significantly different between days except PEP and PEP/ET. Mitral and tricuspid flow velocities (Emax, Emean, Amax, Amean, Emax/Amax) and Epeak and Apeak mitral and tricuspid VTI were significantly different between days (Figure 2).

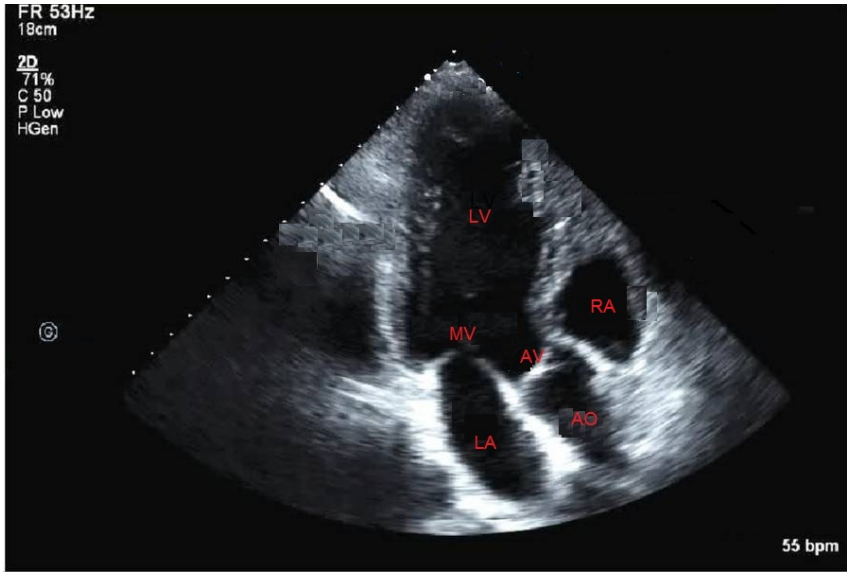


**Figure 1.** 2D images of the heart. AV: Aortic valve; AO: Aorta; LA: Left atrium; LV: Left ventricle; MV: Mitral Valve; RA: Right ventricle.

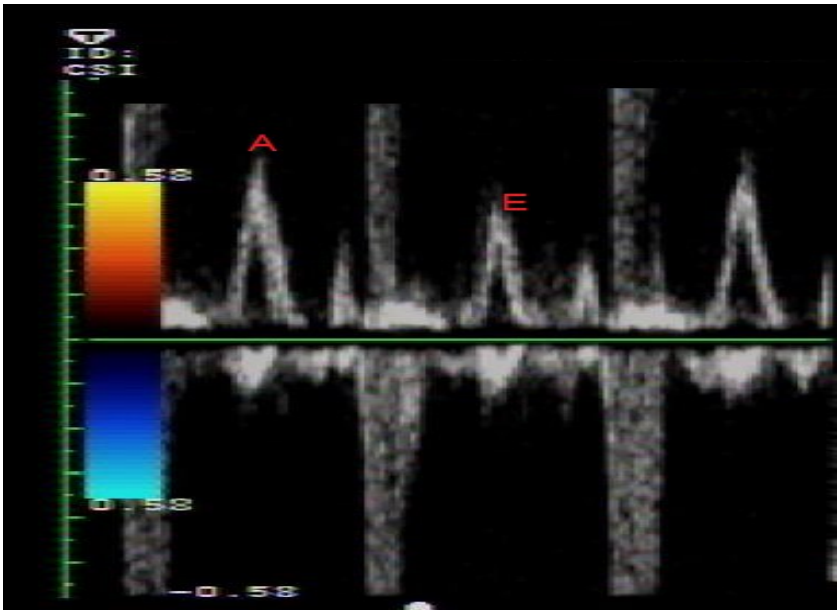


**Figure 2.** Pulsed wave Doppler of mitral inflow velocity.

Comparisons of the PW Doppler echocardiographic measurements of the aortic and mitral flows obtained from the right and left sides 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 Vmax and Vmean, were significantly higher when they were obtained



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from the left side than from the right side. For mitral flow, all parameters of Apeak but oasless than 120 beats per minute to obviate a stress effect. A color ET of Epeak was 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.

| Parameters | Mean±SD |
|---|---|
| Vmax (m/s) | 1.1±0.15 |
| Vmean (m/s) | 0.65±0.05 |
| ET (ms | 288.20±23.1 |
| VTI (cm) | 19.85±2.1 |
| PEP (ms | 50.25±5.75 |
| TTP (ms) | 93.1±20.1 |
| SV (ml) | 68.5±9.2 |
| CO (l/min) | 5.4±0.1 |
| PEP/ET | 0.17±0.02 |

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

| Epeak Parameters | Mean±SD |
|---|---|
| Vmax (m/s) | 0.80±0.03 |
| Vmean (m/s) | 0.50±0.03 |
| ET (ms | 9.20±0.75 |
| VTI (cm) | 240.02±21.75 |
| Apeak Parameters | |
| Vmax (m/s) | 0.70±0.04 |
| Vmean (m/s) | 0.40±0.04 |
| ET (ms) | 118.25±15.10 |
| VTI (cm) | 4.15±0.65 |
| Emax/Amax | 1.14±0.11 |

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

| Parameters | Mean±SD |
|---|---|
| Vmax (m/s) | 0.90±0.15 |
| Vmean (m/s | 0.85±0.5 |
| ET (ms) | 275.5±20.4 |
| VTI (cm) | 20.20±1.95 |
| PEP (ms) | 45.8±5.5 |
| TTP (ms) | 120.5±15.5 |
| SV (ml) | 85.35±16.08 |
| CO (l/min) | 8.25±1.80 |
| PEP/ET | 0.16±0.01 |

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



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| Epeak Parameters | Mean±SD |
|---|---|
| Emax (m/s) | 075±0.18 |
| Emean (m/s) | 0.58±0.18 |
| VTI (cm) | 11.15±2.85 |
| ET (ms) | 245±45.5 |
| Apeak Parameters | |
| Amax (m/s) | 0.65±0.15 |
| Amean (m/s | 0.55±0.15 |
| VTI (cm) | 5.20±1.45 |
| ET (ms) | 124.8±15.8 |
| E/A | 1.10±0.10 |

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

**Discussion**

In the studied goats, 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 goats, 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-chamber view is recommended in horses, and a left parasternal, apical view is recommended in sheep and dogs ( Blissitt *et al.,* 1995; Kirberger *et al.,* 1993; Yuill *et al.,* 1991). The Emax/Amax ratio is a parameter often used to evaluate the left ventricular diastolic function in man (Anderson, 2007; Demaria *et al.,* 1991; Leroux *et al.,* 2012). Apart from the side which it is measured, the Emax/Amax ratio of the mitral flow was rather similar to the tricuspid flow Emax/Amax. On the contrary to what was reported in sheep, in most goats of this study, Emax was higher than Amax for both mitral and tricuspid flows, and only one goat had Emax/Amax < 1 for mitral flow obtained from the right side. 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 (Blissitt *et al.,* 1995; Kirberger *et al.,* 1993). 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 115 beats/min, fusion of the two peaks can occur (Kirberger *et al.,* 1993). Measurements of aortic velocity spectrum are very interesting because they allow assessing left ventricular SV and CO (Anderson, 2007). In this study, except for PEP and PEP/ET, the aortic velocity spectrum measurements obtained from the tilted, left parasternal, long axis, five-chamber view were significantly higher than those obtained from a tilted, right parasternal, long axis, five-chamber 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 hemi thorax (Blissitt *et al.,* 1995).

Sadi and Alizadeh, measured heart parameters in the breed of Markhoz in 2018. The results were consistent with the results of the present study and there is no significant difference between the results (Sadi & Alizadeh, 2018). The similarity of the results of these two studies can be due to the similarity of the weight and physical structure of the two breeds of the goat and Najdi. By performing this study, the parameters of healthy heart echocardiography were obtained in the Najdi goats that can be used as a reference value in goats. Meanwhile, heart disease in goats is diagnosed by comparing these reference values with the obtained from the echocardiography.



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# اندازه گیری پارامترهای قلبی به وسیله اکوکاردیوگرافی داپلر امواج ضربه‌ای در بزهای به ظاهر سالم نژاد نجدی

**فواد سعدی***

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**چکیده**

**زمینه و هدف:** هدف از این مطالعه گزارش دقیق و قابل اطمینان از ابعاد طبیعی و شاخص های زمانی قلبی در بزهای بالغ نجدی سالم می باشد.

**مواد و روش‌ها:** ۱۵ بز بالغ نژاد نجدی انتخاب شدند.سپس بررسی های کامل اکوکاردیوگرافی حیوانات در حالت ایستاده وبدون استفاده از آرام بخشی انجام گرفت.به این صورت که جریان خون در دریچه میترال ودریچه سه لختی و آئورت و عروق ریوی اندازه گیری شد.

**یافته‌ها:** یافته های حاصل از انجام اکوکاردیوگرافی داپلر امواج ضربه های در بزهای سالم نشان داد که جریان خون در عروق آئورت و ریوی در نمای راست جناغی و جریان خون در دریچه میترال و دریچه سه لختی در نمای چپ جناغی در بهترین شکل ارزیابی و بررسی می شوند. مقادیربه دست آمده به عنوان مرجع برای بز نجدی سالم بالغ گزارش گردید.

**نتیجه‌گیری:** اکوکاردیوگرافی داپلر امواج ضربهای اندازهگیری شاخصهای جریان خون را در داخل قلب در بز میسر می سازد. مقادیر به دست آمده به عنوان مرجع میتواند در تفسیر شاخصهای عملکردی قلب در بزهای بیماری که علایم بیماری قلبی را به صورت بالینی نشان میدهند موثر باشند و همچنین در تحقیقات قلب در موارد انسانی تاثیرگذار باشند.

**واژه‌های کلیدی:** *اکوکاردیوگرافی، داپلر، بز نجدی*

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