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Echocardiographic Measurement of Systolic Time Intervals In Healthy Great Dane Dogs

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Abstract

Objective- to determine the range of systolic times intervals using Pulsed-wave Doppler and m-mode echocardiography in normal, healthy Great Dane dogs.
Design- Descriptive study.
Animals- Thirty healthy Great Dane dogs.
Procedures- This study examined 30 clinically healthy Great Dane dogs by the two-dimensional, M-mode and Pulsed-wave Doppler echocardiography. The dogs were awake and unsedated. The following parameters were measured on the both Pulsed-wave Doppler and M-mode echocardiographic images: pre - ejection period (PEP), left ventricular ejection time (LVET), ratio of PEP to LVET (PEP/LVET) and the total electrical-mechanical systole (QAVC). Acceleration time of aortic flow (AT) was also measured by Doppler mode.
Results- The following values have been acquired: PEP = 0.067 ± 0.010 s; LVET = 0.188 ± 0.011 s; QAVC = 0.254 ± 0.016 s and PEP/LVET = 0.354 ± 0.054 measured by M-mode echocardiography and PEP = 0.062 ± 0.009 s; LVET = 0.193 ± 0.007 s; QAVC = 0.256 ± 0.011s; PEP/LVET = 0.323 ± 0.051 and AT = 0.080 ± 0.107 s measured by Doppler echocardiography.
Conclusion and Clinical Relevance- On Doppler mode, there was a significant correlation between the body weight and PEP and PEP/LVET. M-mode echocardiography

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showed significant correlation between the body weight and body surface area and QAVC. Results of this study revealed the importance of determination of breed-specific echocardiographic parameters and indices, and evaluating of measured values with range using same method for accurate diagnosis.
Key Words- echocardiography, systolic time intervals, Great Dane, M-mode, Pulsed-wave Doppler.

Introduction

Echocardiography has become a powerful diagnostic tool in the noninvasive evaluation of the size, structure, function and blood flow dynamics of the canine and feline heart.[1] The Echocardiographic indices show significant breed variation and it is important to know the normal echocardiographic values for each breed considering the influence of the body weight on the established echocardiographic values.[2,3,4,5,6]
Systolic time intervals (STI) measurement is nonspecific indicators of global left ventricular systolic performance.[7] STI were first defined in the 1920s, they received little attention until 1960s, and their importance in human was not validated or fully appreciated until the 1970s. These measurements were originally obtained in patient using the electrocardiogram (ECG), phonocardiogram and either the external carotid arterial-pulse tracing (noninvasive) or the central arterial-pulse tracing (invasive).[8] Stefadouros and Witham (1975)[9] and Pipers et al (1978)[10] described and validated a method for determination of STI using M-mode echocardiography and simultaneous ECG in human and dogs, respectively.
There are three basic internal measurements of the phases of systole. They are included pre-ejection period (PEP), left ventricular ejection time (LVET) and the onset of the QRS complex to the closure of the aortic valve (QAVC). The ratio of PEP to LVET (PEP/LVET) and acceleration time of the aortic flow (AT) are also measured.[7,11]
Several studies have reported normal systolic time intervals using M-mode[5,8,10] and Pulsed-wave Doppler mode.[12,13,14] These reference ranges are based on different breeds of dogs. Only one article described reference ranges in whippet dogs.[15] In this study, the range of systolic time intervals using Pulsed-wave Doppler and M-mode echocardiography in normal, healthy Great Dane dogs were determined.

Materials and Methods

Thirteen healthy Great Dane dogs of both sex (14 males and 16 females) ranging from 12 to 84 months (mean ± SD, 33.8 ± 18.1 months) and body weight from 34 to 70 Kg (mean ± SD, 49.7 ± 9.2 Kg) were recruited. Body surface area (BSA) was calculated as BSA (m2) = (10.1BW2/3)/104, with BW expressed in g (15). It was ranging from 1.05 to 1.70 m2 (mean ± SD, 1.35 ± 0.17 m2). All dogs underwent physical, cardiological and conventional hematological examination.
The dogs with heart murmur or signs of systemic disease on physical examination, rhythm abnormalities on the ECG, signs of congenital or acquired heart disease and dilated cardiomayopathy based on the proposed guidelines[16] on echocardiography were excluded.
The dogs were examined by two-dimensional, M-mode and Pulsed-wave Doppler echocardiography with simultaneous lead II electrocardiogram. All echocardiographic studies were performed by using an ultrasound unit, Sonosite, Micromax (Sonosite, Inc. USA) with a 1-5 MHz phased-array transducer. The animals were positioned on the right and left lateral recumbency, respectively using a manual restraint. Three individual measurements of each variable were performed and the average data was obtained.

M-mode echocardiography was performed on the right lateral recumbency; the ultrasound beam was directed at level of the aortic root and left atrium in the short axis view. The left coronary cusp of the aortic valves is consistently imaged as a thin structure opening towards the posterior wall of the aorta during systole and closing toward the center of the aorta during diastole.[7] The Pre-ejection Period (PEP) was measured from the onset of ventricular depolarization (initial QRS deflection on the electrocardiogram) to the beginning of the left ventricular ejection (opening of the aortic valves). The left ventricular ejection time (LVET) was measured from opening to the closure of the aortic valve. Total electrical-mechanical systole was then defined as the interval from the mechanical onset of the QRS complex to the closure of the aortic valve (Fig. 1).[7,11]
Pulsed-wave Doppler echocardiography of the left ventricular outflow tract was done on left apical view. The PEP and LVET were measured from the onset of the electrocardiographic QRS complex to the onset of ejection (onset of the aortic flow) and from the onset to the end of the aortic flow, respectively. The time between onset of QRS complex and the end of aortic flow was measured as QAVC. The acceleration time (AT) was defined from the beginning of the ejection to the peak flow velocity (Fig. 2).[11,12,13]

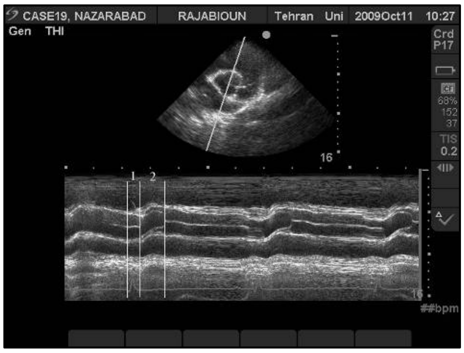

Figure 1. M-mode echocardiographic image, Right parasternal short axis view at the level of the aortic valve. (1): pre-ejection period, (2): left ventricular ejection time.

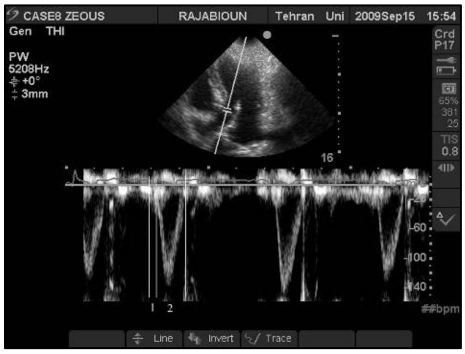

Figure 2. Pulsed-wave Doppler echocardiographic tracings of the left ventricular outflow tract, obtained from the left apical position. (1): pre-ejection period, (2): left ventricular ejection time.

Statistical analysis was made by using the software package SPSS 11.5 for windows. The mean, standard deviation (SD) and range of measurements were applied. First, multivariate linear regression analysis was performed to assess the relationship between echocardiographic parameters with body weight (BW), age, sex and body surface area (BSA), only those variables that were significant ($P<0.05$) were kept in the models. Regression equation for significant correlated dependent variables was calculated. Second, the percentage of dogs that fell out the reference ranges was determined; this percentage was further subdivided in the dogs that fell below and above the reference ranges. Third, a comparison among the values of systolic time intervals, measured by both M-mode and Pulsed-wave Doppler echocardiography was carried out.

Results

Descriptive statistics, indicating the number of dogs examined for each parameter (N), mean value, standard deviation (SD), minimum and maximum range for each Doppler and M-mode derived parameter are shown in table 1.

No effect of gender on all variables was detected. On Doppler mode, PEP (P=0.025) and PEP/LVET (P=0.019) were negatively related to body weight, the regression equations are PEP = 0.083 – 0.0004 × BW and PEP/LVET = 0.441 – 0.002 × BW. Body weight was negatively associated with QAVC (P=0.034) calculated in M-mode and positive correlation between body surface area and QAVC was also obtained, the regression equation is QAVC = – 0.008 – (0.011 × BW) + (0.6 × BSA). The percentage of dogs below and above the references ranges for Pulsed-wave Doppler[121314] and M-mode echocardiography (5) (8) (10) (15) are shown in table 2 and 3, respectively. M-mode derived PEP and PEP/LVET were more than Doppler derived PEP and PEP/LVET. M-mode derived LVET and QAVC were less than Doppler derived LVET.

Table 1. Systolic time intervals measurement in Great Dane dogs using Doppler and M-mode echocardiography.

Variable	N	Mean	SD	Range	
				Min	Max
Doppler mode					
PEP(s)	30	0.062	0.009	0.500	0.082
LVET(s)	30	0.193	0.007	0.180	0.210
QAVC(s)	30	0.256	0.011	0.232	0.285
PEP/LVET	30	0.323	0.051	0.238	0.427
AT(s)	30	0.080	0.107	0.052	0.650
M-mode					
PEP(s)	30	0.067	0.010	0.040	0.090
LVET(s)	30	0.188	0.011	0.165	0.203
QAVC(s)	30	0.254	0.0157	0.222	0.290
PEP/LVET	30	0.354	0.054	0.210	0.450

N: number
SD: standard deviation
PEP: pre-ejection period
LVET: left ventricular ejection time
QAVC: QRS complex to the closure of the aortic valve
AT: acceleration time; s: second

Discussion

No significant correlation was found between obtained parameters and indices with sex and age on both methods. These results were similar to previous studies.[8,12,15,13]

It has been previously reported that body weight did not have an important effect on systolic time intervals.[8121315] In this regards, we only found a negative correlation between M-mode derived QAVC and body weight, and positive correlation between body surface area and QAVC. On Doppler derived parameters, statistical analysis showed negative correlation between PEP and PEP/LVET with body weight. This finding was different with other studies[12,13], however, published data have been achieved on various breeds of dog with different size, and there is no data on M-mode or Doppler echocardiography in a specific large breed.

Compared with published data, the Great Dane values for M-mode and Doppler echocardiography were significantly different (table 4). Bavegems et al (2007) who determined the echocardiographic parameters in whippet, showed that PEP and LVET, on M-mode, were significantly lower than the reference values ($P<0.0001$).[15]

Table 2. Percentage of values below and above published Doppler derived reference ranges.

Paramater	Kireberger et al 1992		Brown et al 1991		Dark et al 1993	
	% below	% above	% below	% above	% below	% above
PEP	0	16.6	—	—	—	—
LVET	0	0	20	0	—	—
PEP/LVET	—	—	—	—	0	76
AT	0	0	—	—	0	33.3

Table 3. Percentage of values below and above published M-mode derived reference ranges.

Paramater	Piper et al 1978		Boon et al 1983		AKtins and synder 1992		Bavegems et al 2007	
	% below	% above	% below	% above	% below	% above	% below	% above
PEP	16.6	10	0	10	0	73.3	0	43.3
LVET	100	0	0	20	0	73.3	0	63.3
PEP/LVET	0	70	0	3.3	0	90	3.3	16.6

In this study, M-mode derived PEP and LVET were higher and lower than Doppler derived PEP and LVET, respectively. These findings explain the high ratio between PEP and LVET on M-mode relative to Doppler mode. No similar study which compares the estimated values of systolic time intervals on both methods in dogs was found. When systolic function is normal, the PEP is short and blood pressure increase is faster at systole onset. This is clear with M-mode images but more thoroughly with the Doppler speed curve, which will reveal a short PEP, fast blood acceleration and a ventricular ejection time set within normal values.[17] Even with a normal ventricular function, intervals can be affected in relation to preload and afterload dynamic. Independently of the reason why a preload decrease occurs, this decrease will cause an increase of PEP, because the ventricle will need a longer time to reach the pressure required for opening of aortic valve, while the ventricular ejection time will decrease. The opposite phenomenon will produce opposite response.[8] To decrease operator errors, parameters were measured at least on three cycles and mean values were obtained. Possible minor errors on exact cursor positioning that have a critical role in echocardiographic measurement might be considered. Meanwhile, in M-mode, systolic time intervals were measured by using aortic valve movement compared with Doppler echocardiographic aortic flow measurements. The onset of the aortic valve opening in M-mode echocardiography was sharper than the onset of aortic flow on Doppler mode; it may also explain the differences between two methods. Overall, measurements differences between M-mode ad Doppler echocardiography are within the millisecond ranges and may be overlooked.

Table 4. Comparison between systolic time intervals values[1]

Research	M-mode echocardiography				Pulsed-wave Doppler echocardiography				
	PEP(s)	LVET(s)	QAVC(s)	PEP/LVET	PEP(s)	LVET(s)	QAVC(s)	PEP/LVET	AT(s)
Present study	0.067 (0.010)	0.188 (0.011)	0.254 (0.016)	0.354 (0.054)	0.062 (0.009)	0.193 (0.007)	0.256 (0.011)	0.323 (0.051)	0.080 (0.107)
Pipers et al 1978	0.069 (0.008)	0.256 (0.013)	0.324 (0.007)	0.24 (0.090)	—	—	—	—	—
Boon et al 1983	0.057 (0.018)	0.178 (0.017)	—	0.32 (0.110)	—	—	—	—	—
Atkins and Synder 1992	0.054 (0.007)	0.159 (0.015)	0.218 (0.018)	0.34 (0.050)	—	—	—	—	—
Bavegems et al 2007	0.0519 (0.0097)	0.167 (0.022)	—	0.314 (0.059)	—	—	—	—	—
Kireberger et al 1992	—	—	—	—	0.058 (0.012)	0.182 (0.029)	—	—	0.055 (0.015)
Brown et al 1991	—	—	—	—	—	0.205 (0.015)	—	—	—
Dark et al 1993	—	—	—	—	—	—	—	0.22 (0.06)	0.050 (0.010)

[1]Mean (Standard deviation)

In conclusion, Doppler and M-mode echocardiography provides a useful and noninvasive method for estimating of systolic time intervals. It is acknowledged that, in human, the measurement of STI is a more reliable index of left ventricular systolic function than the assessment of ejection phase indices.[17] Similar to ejection phase indices, STI do not allow direct assessment of myocardial contractility, but rather, they provide suggestions on the global activity of the ventricles (especially the left ventricle) because, like the ejection phase indices, they are affected by preload, afterload and heart rate.[18,19] This study revealed that Great Dane dogs have a different systolic time intervals compare with other breeds. The clinician should be aware of these specific differences to avoid misdiagnosis. Also, depending to the estimating systolic time intervals method, the measured values must be compared with the reference values of the same method. For further evaluation, we propose to measure STI in other large breeds using both M-mode and Doppler echocardiography.

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References

1. Belanger MC. Echocardiography. In: Ettinger SJ, Feldman EC, eds. Text book of Veterinary Internal Medicine. 6th ed. Elsevier Saunders, 2005;311-326.
2. Muzzi RAL, Muzzi LAL, Baracat de Araujo R et al. Echocardiographic indices in normal German shepherd dogs. J Vet Sci 2006;7(2):193-198.
3. Crippa P, Ferro E, Melloni E et al. Echocardiographic parameters and indices in the normal Beagle dog. *Lab Anim* 1992;26:190-195.
4. O'Leary C, Machay B, Taplin R et al. Echocardiographic parameters in 14 healthy English Bull Terriers. *Aust Vet J* 2003;81:535-542.
5. Boon J, Wingfield W, Miller M. Veterinary echocardiographic indices in the normal dog. *Vet Radiol* 1983;24:214-221
6. Thomas WP, Gaber CE. Recommendations for standards in transthoracic two-dimensional echocardiography in the dog and cat. Echocardiography Committee of the Specialty of Cardiology, American College of Veterinary Internal Medicine. *J Vet Intern Med* 1993;7:307-312.
7. Kienle RD, Thomas WP. Echocardiography. In: Nyland TG and Mattoon JS, eds. *Small Animal Diagnostic Ultrasound*. 2nd ed. WB Saunders Co, 2002;354-423.
8. Atkins C, Synder P. Systolic time intervals and their derivatives for evaluation of cardiac function. *J Vet Intern Med* 1992;6:55-63.
9. Stefadouros M, Witham A. Systolic time intervals by echocardiography. *Circulation* 1975; 51:114-117.
10. Pipers F, Andrysco R, Hamlin R. A totally noninvsive method for obtaining systolic time intervals in dogs. *Am J Vet Res* 1978;39:1822-1826.
11. Brown D, Gaillot H. Heart. In: Penninck D, Marc-Andre' d'Anjou. *Atlas of Small Animal Ultrasonography*. First ed. Blackwell, 2008:151-216.
12. Brown D, Knight D, King R. Use of pulsed-wave Doppler echocardiography to determine aortic and pulmonary velocity and flow variables in clinically normal dogs. *Am J Vet Res* 1991;52:543-550.
13. Kirberger R, Bland-van de Berg P, Grimbeek R. Doppler echocardiography in the normal dog: Part II. Factors influencing blood flow velocities and comparison between left and right heart flow. *Vet Radiol Ultrasound* 1992;33:380-386.
14. Darke P, Fuentes V, Champion, S. Doppler echocardiography in canine congestive cardiomyopathy, In *Proceedings*. 11th ACVIM Forum 1993;531-534.
15. Bavegems V, Duchateau L, Sys S et al. Echocardiographic reference values in Whippets. *Vet Radiol Ultrasound* 2007;48(3):230-238.
16. Dukes-McEwan J, Borgarelli M, Tidholm A et al. Proposed guldlines for the diagnosis of canine idiopathic dilated cardiomayopathy. *Journal of Veterinary Cardiology* 2003;5:7-19.
17. Otto C. *Valvular Heart Disease*. Philadelphia:WB Saunders, 1999.
18. Boon J. *Manual of Veterinary Echocardiography*. firth ed. Philadelphia: William & Wikins, 1998.

19. Otto C. *Textbook of Clinical Echocardiography*. 2nd ed. Philadelphia: WB Saunders, 2000.

چکیده

اندازه گیری فواصل زمانی سیستولیک با استفاده از اکوکاردیوگرافی در سگ های نژاد گریت دین سالم

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هدف- تعیین محدوده فواصل زمانی سیستولیک با استفاده از اکوکاردیوگرافی داپلر پالسی و مد حرکت در سگ‌های نژاد گریت دین سالم.

طرح مطالعه- مطالعه توصیفی.

حیوانات- ۳۰ قلاده سگ سالم نژاد گریت دین.

روش کار- در این مطالعه تعداد ۳۰ قلاده سگ نژاد گریت دین از نظر بالینی سالم تحت اکوکاردیوگرافی دوبعدی، مد حرکت و داپلر پالسی قرار گرفتند. سگ ها هوشیار بودند و برای انجام کار از داروهای آرام بخش استفاده نشد. پارامترهای ذیل بر روی تصاویر بدست آمده از اکوکاردیوگرافی داپلر پالسی و مد حرکت اندازه گیری شدند: زمان پیش از خروج خون از بطن چپ (PEP)، زمان خروج خون از بطن چپ (LVET)، نسبت PEP به LVET (PEP/LVET) و زمان کلی الکترومکانیکی سیستول (QAVC). زمان شتاب گرفتن جریان خون آئورت (AT) نیز با استفاده از روش داپلر پالسی اندازه گیری شد.

نتایج- مقادیر ذیل با استفاده از اکوکاردیوگرافی مد حرکت بدست آمد:
PEP = 0.067 ± 0.010 s، LVET = 0.188 ± 0.011 s، QAVC = 0.254 ± 0.016 s و PEP/LVET = 0.354 ± 0.05.
در اکوکاردیوگرافی با روش داپلر پالسی مقادیر ذیل حاصل شد: PEP = 0.062 ± 0.009 s، LVET = 0.193 ± 0.007 s، QAVC = 0.256 ± 0.011s، PEP/LVET = 0.323 ± 0.051 و AT = 0.080 ± 0.107 s.

نتیجه گیری و کاربردبالینی- در مد داپلر، ارتباط معنی‌داری بین وزن بدن و PEP و PEP/LVET بدست آمد. اکوکاردیوگرافی مدحرکت ارتباط معنی‌داری را بین وزن بدن و سطح بدن و QAVC نشان داد. نتایج این مطالعه بیانگر اهمیت تعین پارامترها و اندیس‌های اکوکاردیوگرافی مختص نژاد و ارزیابی پارامتراهای اندازه‌گیری شده با مقادیر استاندارد بدست آمده در روش مشابه جهت ارزیابی دقیق است.

کلید واژگان- اکوکاردیوگرافی، فواصل زمانی سیستولیک، گریت‌دین، مدحرکت، داپلر پالسی.