Schweiz. Arch. Tierheilk.

E. Mottet, C. Amberger, M.G. Doherr, C. Lombard, Band 154, Heft 2, Februar 2012, 75–80
DOI 10.1024/0036-7281/a000299

Echocardiographic parameters in healthy young adult Sphynx cats

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Summary

The objective of this retrospective study is to determine normal reference values for 2-Dimension (2D) and Motion-mode (M-mode) echocardiographic parameters in nonsedated healthy young adult Sphynx cats and to compare them to those of the domestic shorthair (DSH). 131 Sphynx cats underwent cardiac screening prior to breeding. The control group consisted of 30 healthy adult domestic cats. A complete cardiac ultrasound was performed on all cats using right parasternal long and short axis views. There were few echocardiographic parameters in the Sphynx that differed from those of the healthy DSH. Only the left atrial (LA) dimension in 2D and M-mode, the left atrial/aortic (LA/Ao) ratio and the internal dimension of the left ventricle in systole (LVIDs) measured with M-mode were different. In conclusion, although the heart of Sphynx cat can often have a particular 2-D echocardiographic appearance, the M-mode cardiac dimensions are similar to those of the DSH.

Keywords: Sphynx cat, echocardiography, phenotype, hypertrophic cardiomyopathy

Echokardiographische Parameter bei jungen, gesunden, erwachsenen Sphynxkatzen

Das Ziel dieser retrospektiven Studie ist die Festlegung von Normalwerten für 2D- und Motion-Mode (M-Mode) echokardiographische Parameter bei nicht sedierten, gesunden, jungen, erwachsenen Sphynxkatzen und diese Werte mit denjenigen der Europäischen Kurzhaarkatze zu vergleichen. 131 Sphynx Katzen wurden vor dem ersten Zuchteinsatz kardiologisch untersucht. Die Kontrollgruppe bestand aus 30 gesunden, erwachsenen Hauskatzen. Eine komplette Herzprüfung wurde unter Berücksichtigung der rechten parasternalen, langen und kurzen Achsen durchgeführt. Einige echokardiographische Parameter bei der Sphynxkatze unterscheiden sich von denen gesunder Europäischer Kurzhaarkatzen. Die LA-Werte im 2D- und M-Mode, das LA/Ao-Verhältnis und die interne Messung des linken Ventrikels in der Systole (LVIDs) in M-Mode weichen voneinander ab. Unsere Studie zeigt, dass die bei der Sphynxkatze gemessenen Werte im M-Mode denen der Europäischen Kurzhaarkatze ähnlich sind, während das 2-D Aussehen zwischen beiden Katzenarten verschieden ist.

Schlüsselwörter: Sphynxkatze, Echokardiographie, Phänotyp, hypertrophische Kardiomyopathie

Introduction

Cardiomyopathies are the most common type of cardiac diseases in cats (Ferasin et al., 2003; Riesen et al., 2007; Ferasin, 2009). Primary cardiomyopathies are classified into five categories according to their morphologic appearance: hypertrophic cardiomyopathy (HCM), idiopathic dilated cardiomyopathy (DCM), restrictive cardiomyopathy (RCM), arrythmogenic right ventricular cardiomyopathy (ARVC) and unclassified cardiomyopathy (UCM). HCM is the most common myocardial disease seen in cats, accounting for approximately two thirds of the cases (Ferasin et al., 2003; Riesen et al., 2007; Ferasin, 2009). In Maine Coon cats, familial HCM has been described with an autosomal dominant mode of inheritance (Kittleson et al., 1999). A similar inheritance pattern has been described in Ragdolls (Meurs et al., 2007), American shorthair cats (Meurs et al. 1997) and British shorthairs

(Granström et al., 2011). In the Scottish fold and Norwegian Forest Cats, HCM was more frequently present than in the DSH (Riesen et al., 2007).
Sphynx cats, similar to the Maine Coon, have a genetic predisposition for the development of HCM, although the mode of inheritance has not been described yet. Another similarity between Sphynx and Maine Coons is that they both have a different morphologic echocardiographic appearance when compared to the DSH (Drourr et al., 2005). Since HCM has been frequently observed in the Sphynx cat, a cardiac screening prior to breeding has been declared mandatory by many breeding associations. The purpose of this study was to determine the normal echocardiographic reference values in the non-sedated adult healthy Sphynx cat and to compare them with the reference values of the DSH.

Animals, Material and Methods

Animals

Between 2005 and 2009, 131 Sphynx cats underwent cardiac screening prior to breeding, which included a clinical exam and echocardiography. All cats were examined by the same board certified cardiologist at the Veterinary Hospital Amberger-Philip in Geneva. The clinical and echocardiographic data of this population were retrospectively reviewed. Cats over 12 month of age without heart murmur or gallop rhythm were included in the study, as defined by Gompf 2008. Cats younger than 12 months or those with a suspected congenital heart defect (ventricular septal defect, atrial septal defect, mitral or tricuspid dysplasia) or an early abnormality of the size and structure of the papillary muscles and/or myocardial thickness were excluded from the study. Even though many cats were examined several times for breeding purposes, only the last examination was included in the analyses. The control group consisted of 30 healthy adult DSHs (Brizard et al., 2009) older than 12 months of age. A physical and a complete echocardiographic examination were performed by the same examinator. All the cats were examined without sedation or anesthesia (Jacobs and Knight, 1985; Lamont et al., 2002).

Echocardiographic equipment and techniques

An ultrasound system (Esaote Megas GP) with a phased-array sector transducer of 7.5 MHz was used for all of the echocardiographic examinations. According to published standards (Ware 2007), cats were positioned in right lateral recumbency and manually restrained without sedation. A complete 2-Dimensional (2-D) and Motion-mode (M-Mode) exam was performed with standard right parasternal long and short axis views (Sahn et al., 1978, Thomas et al., 1993). Standard cardiac wall and chamber thicknesses were then measured.

Any suspected abnormalities were subsequently scanned in multiple planes to ensure that the heart was normal. Subjective comparisons of the left ventricle (LV), intraventricular septum (IVS) and right ventricle (RV) wall thicknesses to lumen size, as well as right heart to left heart structures were made. Specific parameters such as the hyperechogenicity of the papillary muscles, basal, septal to global hypertrophy of the myocardium in the short axis view, presence of abnormal global geometry in the long axis view, normal insertion of mitral chordae tendinea, presence of systolic anterior motion of the mitral valve associated with aortic flow turbulence and/or mitral regurgitation using color Doppler were used to classify the population into normal, equivocal or HCM cats. Left atrial (LA) maximum antero-posterior diameter and aortic root (Ao) were measured on 2-D views (Rishniw and Erb, 2000). The general appearance of the heart was also evaluated objectively on the short axis images: round symmetrical LV circumference (Boon, 1998), as well as the ratio of the LV to RV (Boon, 1998), size of pulmonic artery (PA) to Ao. Long axis measurements included: straight IV and interatrial (IA) septum (Boon, 1998), normal atrioventricular (AV) and semilunar (SL) valves (Boon, 1998), assessment of RV wall thickness in comparison to IV and free wall (FW) thickness (ratio 1:2) and RV chamber approximately 1/3 of LV chamber size (Boon, 1998). Left ventricular internal diameter in diastole was measured in 2D and M-mode.
M-mode measurements included: LA at end systole, Ao at end diastole, left ventricular internal diameter at end diastole (LVIDd) and end systole (LVIDs), interventricular septal thickness at end diastole (IVSd) and end systole (IVSs) and left ventricular posterior wall thickness at end diastole (LVFWd) and systole (LVFWs). The percent fractional shortening (%FS) was calculated by the standard formula: LVIDd – LVIDs divided by LVIDd. The LA:Ao ratio was calculated in both 2D- and M-mode, and the LVFWd: IVSDd ratio was calculated from M-mode measurements (Brizard et al., 2009). Color Flow Doppler and Pulsed wave Doppler investigations were performed to exclude the presence of turbulences in both ventricular outflow tracts, as well as mitral valvular regurgitation. The following classification was used according to Kittleson's advice to breeders (Winn Feline Foundation 2005, updated in 2006, 2009 and 2011) HCM positive: Clinical suspicion of HCM/HOCM by clinical examination (heart murmur, gallop rhythm, tachycardia), familial screening of the disease in first or second degree parents, mild to moderate LV thickening (cut off limit of 5.5 mm), LVIDd < 15 mm and subjective increase of the size of Left Atrium (or LA/Ao < 1.3), abnormal motion and relaxation.
Equivocal: all M-mode measurements of LV thickness and internal dimension were normal (between 3 and 5 mm for LVDDd and IVSDd) but subendocardioal hyperechogenicity was present, particularly at the level of papillary muscle and/or presence of systolic anterior motion (SAM) associated to LA dilation (LA/Ao > 1.2 both

in 2D and M-mode). Isolated abnormal measurement or motion/relaxation is present, but the rest of the heart was absolutely normal. These patients were checked again within the 6 months to confirm abnormal heart structure, or the reversion to normal size and kinesis.
Normal: all the measured dimensions within normal limits (compared to the normal DSH population and values available in the published literature). The papillary muscles were are subjectively normal and symmetric, atrioventricular and semilunar valves were subjectively normal, left ventricular outflow tract (LVOT) and pulmonary flow were laminar, the size of LA and pulmonary artery were normal (1:1 ratio compared to aorta).
Incomplete recordings, in which a dimension was not taken from an average, are occasionally present and result in a final population less than 89 for some values. This is due to either non cooperation of the patient (a cat who moved too much or was too stressed) or technically unsatisfactory views for the measurements. Only technically satisfactory echocardiographic measurements were included in the study.

Statistical analyses

The data were stored in MS Excel (www.microsoft.com) and analyzed with the statistical software NCSS 2007 (www.ncss.com). Means, medians and proportions of the various characteristics (age, weight, echocardiographic measurements) were calculated. Normality of interval-measured data within groups was assessed using a Komolgorov Smirnov test. Means, medians and proportions were compared between Sphynx and DSH cats using the appropriate two-sample tests (unpaired T test, Mann Whitney U Test, ChiSquare and Fishers Exact test). To describe the relation between the various numeric (interval and score) parameters for age and body weight, a Spearman's rank correlation test was used. P-values < 0.05 were considered statistically significant.

Results

132 Sphynx cats were examined during the study period and 89 cats fulfilled the selection criteria. 35 cats with anomalies that could lead to HCM, 6 cats with other cardiac diseases such as mitral valve dysplasia and 2 cats with a heart rate > 250 were excluded from the study. 61 % (54) Sphynx cats were female and 39 % (35) were male. The median age of all cats in the study was 25.6 months (range 12 to 72 months). The median age of Sphynx cats was significantly less than that of the DSH. The mean weight of the Sphynx population was 3.62 kg (4.30 kg for males and 3.19 kg for females). The mean weight of males was significantly higher than that of females. Mean heart rate of the 89 Sphynx was 187 beat/min; significantly higher than the mean heart rate of the DSH (156 beat/min).

Table 1: Measurements and p-values for echocardiographic parameters, age, weight and heart rate in Sphynx and non sedated healthy adult DSH cats examined between 2005 and 2009. DSH = Domestic Shorthair

	DSH cats				Sphynx cats				Comparison
	N	Mean	95 % CI (SEM)*	Median	N	Mean	95 % CI (SEM)*	Median	P-value
Age (months)	30	59.2	42.47 – 75.92	48	88	25.6	22.75 – 28.45	20.50	< 0.0001
Weight (kg)	30	3.97	3.59 – 4.34	4	89	3.62	3.45 – 3.79	3.60	0.1104
Heart rate (beat/min)	30	156	149.04 – 163.28	149	87	187	183.27 – 191.71	185	< 0.0001
LA (2D) (mm)	30	11.70	11.09 – 12.3	11.60	86	11.45	10.95 – 11.94	12	0.9419
Ao (2D) (mm)	30	9.79	9.51 – 10.06	9.80	86	9.97	9.74 – 10.20	9.95	0.3373
LA:Ao ratio (2D)	30	1.18	1.14 – 1.21	1.19	86	1.15	1.10 – 1.20	1.15	0.6772
LA (mm)	30	11.02	10.55 – 11.48	10.75	72	12.08	11.72 – 12.44	12	< 0.0001
Ao (mm)	30	9.33	9.12 – 9.54	9.20	72	9.73	9.47 – 9.99	9.80	0.0463
LA:Ao ratio	30	1.17	1.13 – 1.21	1.16	72	1.24	1.21 – 1.28	1.25	0.0082
LVIDd (mm)	30	14.96	14.24 – 16.67	14.50	89	16.29	15.88 – 16.70	16.30	0.0014
LVIDs (mm)	30	7.80	7.23 – 8.37	7.60	89	8.07	7.64 – 8.49	7.90	0.5383
FS (%)	30	47.77	45.49 – 50.03	48.50	89	50.68	48.54- 52.82	51	0.1006
IVSd (mm)	30	3.98	3.70 – 4.26	4	89	3.98	3.82 – 4.15	3.80	0.4074
LVFWd (mm)	30	4.19	3.93 – 4.45	4.20	89	4.13	4.00 – 4.25	4.10	0.6279
IVSd : LVFWd Ratio	30	0.96	0.88 – 1.03	0.97	89	0.97	0.93 – 1.01	0.95	0.9511

*95 % confidence interval (CI) based on mean + /- 1.96*SEM

All comparisons of echocardiographic dimensions are summarized in Table 1. The mean values of LA, LA:Ao and LVIDs of the Sphynx population were significantly higher than those of the DSH population. The Spearman rank correlation coefficients between the body weight and the following parameters were: LA (r_S = 0.30, P = 0.00416) and Ao (r_S = 0.43, P < 0.0001) in 2 D, LA (r_S = 0.53, P < 0.0001), Ao (r_S = 0.56, P < 0.0001) and LVFWd (r_S = 0.29, P = 0.00456) in M-mode . The following measurements differed significantly between male and female cats: LA and Ao in 2D, and LA, Ao, LVIDd, LVWFd in M-mode (Tab. 2).

Discussion

All the values in this study are normally distributed with the exception of age. The population of Sphynx cats was younger than that of the control group because the Sphynx cats were involved in a breeding program. The Sphynx cats' heart rates were significantly higher than those reported for the DSH. This elevated heart rate is most likely related to the young age of the Sphynx cats, as young felines have higher heart rates than adults (Schille and Skrodzki, 1999). Young cats may also be more easily stressed by the echocardiographic examination (Hamlin, 1999). Only a few echocardiographic parameters differed from those of the DSH. LA dimension in 2D and M-mode, the LA/Ao ratio and LVIDs measured in M-mode were slighty higher in the Sphynx population. The Sphynx breed is the result of crossbreeding between the DSH and the Devon Rex (Carville, 1995), thus further crossing of a Sphynx with a Devon Rex or a DSH should not modify the cardiac shape or size. As LA size is generally considered to be a good indicator of preload alteration in the early development of hypertrophic cardiomyopathy, the slight elevation of LA size (as well as the consecutive elevation of LA/Ao ratio) should be considered in the cardiac evaluation of normal Sphynx cats before breeding. The increased LVIDs in the Sphynx population, another important parameter in the assessment of early hypertrophic cardiomyopathy, can be explained by the age difference between the two populations. Diastolic relaxation and elasticity has been shown to be enhanced in younger cats (Santilli et al., 1998; Simpson et al., 2009). LVIDs, as well as LVIDd, is an essential measurement for the assessment of many functional cardiac indices (LV fractional shortening, End Systolic and Diastolic Volume Index, ejection fraction and mean velocity of circumferential fiber shortening) (Mattoon and Nyland, 2002).
Differences between males and females were present. The male Sphynx cats weighed more than the females and several echocardiographic parameters were greater in males than in females, such as LA in 2D, LA:Ao and LVFWd in M-mode. The Spearman-test revealed a high correlation between some echocardiographic parameters and body weight for the Sphynx cat. The Spearman test indicated

Table 2: Comparison of echocardiographic parameters, age, weight and heart rate between healthy adult male and female Sphynx cats examined between 2005 and 2009.

	Male				Female				Comparison
	N	Mean	95 % CI (SEM)*	Median	N	Mean	95 % CI (SEM)*	Median	P-value
Age (months)	35	28.45	23.46–33.45	26	53	23.71	20.27–27.15	19	0.1395
Weight (kg)	35	4.30	4.06–4.54	4.25	54	3.18	3.03- 3.33	3.20	< 0.0001
Heart rate (beat/min)	35	184.94	178.60–191.28	182	52	189.21	183.46–194.95	189.50	0.3468
LA (2D) (mm)	33	12.23	11.39–13.08	13	53	10.96	10.35–11.56	11	0.0090
Ao (2D) (mm)	33	10.37	9.99–10.75	10.30	53	9.71	9.44–9.99	9.80	0.0083
LA:Ao ratio (2D)	33	1.18	1.10–1.27	1.18	52	1.13	1.07–1.20	1.14	0.4118
LA (mm)	29	12.99	12.44–13.54	12.60	43	11.46	11.07–11.85	11.40	< 0.0001
Ao (mm)	29	10.39	10.01–10–76	10.20	43	9.29	8.99–9.59	9.10	< 0.0001
LA:Ao ratio (mm)	29	1.25	1.20–1.30	1.23	43	1.24	1.19–1.28	1.26	0.8273
LVIDd (mm)	35	16.93	16.26–17.60	17	54	15.87	15.37–16.37	15.80	0.0175
LVIDs (mm)	35	8.04	7.35–8.73	7.90	54	8.08	7.52–8.65	7.85	0.9798
FS (%)	35	52.41	48.61–56.22	51.20	54	49.56	46.98–52.13	51	0.3091
IVSd (mm)	35	4.10	3.82–4.37	4	54	3.91	3.71–4.11	3.80	0.3808
LVFWd (mm)	35	4.36	4.13–4.59	4.30	54	3.97	3.83–4.11	4	0.0066
IVSd: LVFWd Ratio	35	0.94	0.89–0.99	0.93	54	0.99	0.04–104	0.97	0.2069

*95 % confidence interval (CI) based on mean + /- 1.96*SEM

either a non-existent or only a weak correlation between the measured echocardiographic parameters and the age of the Sphynx cat. Litster and Buchanan (2000) reported no significant differences between the 2D-echocardiographic values from obese cats and cats with standard body weights. Our results are more consistent with the data published in 1985 (Jacobs and Knight, 1985) and in 2003 (Brown et al., 2003), where a direct correlation between weight and echocardiographic values was observed. Lister and Buchanan measured the echocardiographic values in 2-D, whereas the other authors obtained the measurements in M-mode. In the future, measurements in 2-D mode only should be used.

Our study had several limitations. The population of Sphynx cats was quite young. A complete collection of all data points was not always possible, which may generate some variations. The most useful parameters, however, were always consistently recorded. According to our personal experience, hypertrophic cardiomyopathy in the Sphynx cat progresses slowly with time. It is also feasible that some Sphynx cats are classified negative at age 2 and may go on to develop HCM later. Several cases of Sphynx cats who developed HCM at the age of 6 or 7 + years without any other concomitant disease have been seen (unpublished observation, 2011).

In conclusion, only a few echocardiographic values of normal Sphynx cats differ significantly from those of healthy DSH cats. Echocardiographic examination before breeding should be recommended in order to reduce the prevalence of this disease.

Paramètres échocardiographiques chez de jeunes chats sphynx adultes et en bonne santé

Le but de la présente étude rétrospective était de déterminer des valeurs normales pour les paramètres échocardiographiques en mode 2-D et M chez de jeunes chats sphynx adultes et en bonne santé non sédaté et de comparer ces valeurs avec celles des chats européens. 131 sphynx ont été examiné du point de vue cardiologique avant leur mise à la reproduction. Le groupe de contrôle se composait de 30 chats européens adultes en bonne santé. L'examen cardiaque complet a été fait en tenant compte des axes parasternaux droits, longs et courts. Quelques paramètres échocardiographiques diffèrent entre les sphynx et les européens. La valeur LA en mode 2-D et en mode M, le rapport LA /Ao et la mesure interne du ventricule gauche en systole (LVIDs) en mode M présentent des différences. Notre étude montre que des valeurs mesurées chez les sphynx en mode M sont semblabes à celles des chats européens alors que l'aspect en 2-D diffère entre ces deux races.

Parametri ecocardiografici nei gatti sfinge giovani, sani e adulti

Scopo di questo studio retrospettivo è di definire i valori normali dei parametri ecocardiografici, per gli esami M-mode (motion-mode) e 2D-mode, in gatti sfinge sani, giovani, adulti e non sedati e di paragonarli ai valori ottenuti con quelli di gatti a pelo corto europei. A 131 gatti sfinge, prima della prima riproduzione, è stato effettuato un esame cardiologico. Il gruppo di controllo era formato da 30 gatti domestici sani e adulti. È stato eseguito un esame cardiologico completo che prendeva in considerazione l'asse destro parasternale, lungo e corto. Alcuni parametri ecocardiografici nei gatti sfinge si differenziavano da quelli dei gatti sani a pelo corto europei. I valori LA in 2D-mode e M-mode, il rapporto LA/Ao e la dimensione interna del ventricolo sinistro in sistole (LVIDs) in M-mode, divergono le une dalle altre leggermente. Il nostro studio indica che i valori misurati nei gatti sfinge in M-mode sono simili a quelli dei gatti europei a pelo corto mentre la visualizzazione 2D tra le due specie di gatti è diversa.

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Received: 22 November 2010
Accepted: 14 October 2011