Prevalence of heart disease in symptomatic cats: an overview from 1998 to 2005

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Summary

A total of 408 cats with various cardiovascular problems has been presented to two investigational clinics during the last 8 years. The number of yearly examinations has steadily increased during this period. Definitive cardiovascular disease was diagnosed in 287 cats, whereby hypertrophic cardiomyopathy (HCM) was the most common diagnosis with 67.6%. Congenital cardiovascular malformations were found in 11.8% of the cases. Ventricular septal defect (VSD) was the most frequent anomaly, in contrast to previously published studies. The ECG was found to be relatively non-specific and insensitive for the diagnosis of heart disease. Its usefulness lies in the recognition and diagnosis of cardiac arrhythmias. The radiographically recognized changes were also non-specific for certain heart diseases. Radiographs of the thorax are especially useful in the evaluation of cardiomegaly, and secondary signs of congestion.

Keywords: cardiology, cardiomyopathy, congenital heart disease, cat

Prävalenz von Herzerkrankungen bei symptomatischen Katzen: Ein Überblick von 1998 bis 2005

Während der letzten 8 Jahre wurden insgesamt 408 Katzen mit den unterschiedlichsten Herzerkrankungen an zwei verschiedenen Kliniken vorgestellt. Die Anzahl der vorgestellten Katzen hat in dieser Zeit stetig zugenommen. Eine Herzmuskelerkrankung konnte bei 287 Tieren diagnostiziert werden, wobei die hypertrophe Kardiomyopathie (HCM) mit 67.6% die häufigste Form war. Eine Herzmissbildung konnte in 11.8% der Fälle gefunden werden. Der Ventrikel Septum Defekt war die am häufigsten festgestellte Anomalie, was im Gegensatz zu bisher publizierten Studien steht. Das Elektrokardiogramm hat sich als relativ unsepzifisch und unsensibel in der Diagnostik von Herzerkankungen erwiesen. Seine Bedeutung liegt vor allem in der Erfassung und Charakterisierung von Herzrhythmusstörungen. Die radiologisch festgestellten Veränderungen sind ebenfalls nicht sepzifisch für bestimmte Herzerkrankungen. Thoraxröntgen ist besonders in der Evaluation der Herzgrösse und sekundärer Anzeichen von Kongestion von Bedeutung.

Schlüsselwörter: Kardiologie, Kardiomyopathie, angeborene Herzmissbildung, Katze

Introduction

Myocardial diseases that affect cats encompass diverse idiopathic and secondary diseases affecting the myocardium, and the spectrum of anatomic and pathophysiologic characteristics of these diseases is broad. The number of cats presented for cardiac disease and cardiac screening prior to breeding has increased steadily over the last few years. This increase may be explained by the improvement of diagnostic methods and on the other hand with increased popularity of felines as pets. Hypertrophic cardiomyopathy has been diagnosed most frequently (Atkins et al., 1992; Kittleson et al., 1998; Rush, 2004). The aim of our study was to document the various cardiac diseases of felines from western Switzerland between 1998 and 2005, to document the recognized changes and diagnoses, and to compare them with previously published studies.

Animals, Material and Methods

The case records of cats with a cardiac examination at the Small Animal Clinic, University of Berne and Cabinet Vétérinaire Amberger-Philip in Geneva between January 1998 and October 2005 were reviewed retrospectively. Control examinations were excluded from the present study. Signalement (age, breed, and sex), serum taurine levels, electrocardiographic (ECG) findings, and radiographic and echocardiographic

 DOI 12.1024/0036-7281.149.02.65

findings were reviewed. A standard six-lead ECG was recorded with the patient in right lateral or sternal recumbency and ECG traces were examined by analysis of the rhythm and the morphology of the complexes and mean electrical axis according to Tilley (1992). The radiographic examination included a left lateral and a ventro-dorsal view of the thorax. The final diagnosis was based on B-mode, M-mode and Colour Doppler echocardiography. The examination was performed with the cat in lateral recumbency over a cut-out on the examination table and images were obtained by scanning from beneath the patient (Boon, 1998). Two-dimensional echocardiographic parameters following recommended standards were measured (Thomas et al., 1993). M-mode parameters were measured by using the leading-edge to leading-edge method advocated by the American Society for Echocardiography (Sahn et al., 1978). Cardiomyopathies were classified as hypertrophic cardiomyopathy (HCM), dilated cardiomyopathy (DCM), restrictive cardiomyopathy (RCM), arrhythmogenic right ventricular cardiomyopathy (ARVC), unclassified cardiomyopathy (UCM) and specific cardiomyopathy (SCM) according to Kittleson (2005).

The following criteria were used for echocardiographic diagnosis of *hypertrophic cardiomyopathy (HCM):* Size of the interventricular septum and / or the left ventricular free wall thickness in diastole ≥ 6mm, in a two-dimensionally guided M-mode scanning obtained from the right parasternal short axis view of the left ventricle just above the papillary muscles, abnormal papillary muscle thickening and/or left atrial dilation (Fox et al., 1995). *Restrictive cardiomyopathy (RCM)* was diagnosed based upon the presence of a marked left atrial or biatrial dilation without a concomittant myocardial hypertrophy (Kienle, 1998). *Dilated cardiomyopathy (DCM)* was diagnosed with the echocardiographic observation of left ventricular dilation (end systolic diameter ≥ 14mm) and a poor fractional shortening (≤ 28%) in a two-dimensionally guided M-mode scanning (Pion et al., 1992). *Unclassified cardiomyopathy (UCM)* was diagnosed by exclusion, upon evidence of myocardial abnormalities that did not fit to any of the recognised disease classifications (Kienle, 1998). *Arrhythmogenic right ventricular cardiomyopathy (ARVC)* was characterized by a markedly enlarged and hypokinetic right ventricle and right atrium, paradoxical interventricular septal motion and tricuspid regurgitation, and a normal looking left ventricle and left atrium (Fox et al., 2000). *Specific Cardiomyopathy (SCM)* describes heart muscle diseases associated with specific cardiac or systemic disorders, such as ischemic cardiomyopathy, metabolic cardiomyopathy, and others. Myocarditis was placed in the category of specific cardiomyopathy (Fox et al., 1998). *Secondary Cardiomyopathy (2°CMP)* has denoted heart muscle diseases resulting from an identifiable systemic, metabolic, or nutritional disorder (Fox et al., 1998). *Mitral valve dysplasia and tricuspid valve dysplasia* were defined as malformations of the mitral resp tricuspid valve apparatus, including the valve leaflets, chordae tendinea, or papillary muscles, that resulted in valvular insufficiency. The interventricular and atrial septum were screened for defects on two-dimensional echocardiography and colour-flow Doppler echocardiography. *Ventricular and atrial septum defects* were diagnosed only if shunting blood flow was identified. For the *echocardiographic criteria of peritoneopericardial diaphragmatic hernia (PPDH), arteriovenous canal (AVC), persistent right aortic arch (PRAA), Tetralogy of Fallot (TOF)* the interested reader is directed to specialised texts (Fox et al., 1998, Kittleson et al., 1998).

Results

Between January 1998 and October 2005, a total of 408 cats of 22 different breeds were examined. The mean age was 6.1 ± 4.5 years. 259 of the 408 cats were males (63.5%) and 149 (36.5%) females. The 408 cats were presented due to various cardiac as well as non-cardiac symptoms. In 306 of the 408 cats, a primary cardiac disorder was found. A summary of diagnoses findings is presented in Table 1. The number of cats with cardiac disease as well as the number of screening examinations has increased steadily over the last years (Fig. 1).

ECG's were recorded from 395 of the 408 symptomatic cats. 35.4% of the examined cats showed a normal ECG and 47.8% showed sinus tachycardia. Conduction abnormalities and morphologic changes were only found in 6.7% and 10%, respectively. The diagnosed ECG-abnormalities in general and a break-down of the most

Table 1: Summary of all diagnoses.

Primary cardiac disorders	**n=306**
Cardiomyopathy (all forms)	252
Congenital heart disease	48
CVD-MR with CHF	1
Cardiac mass	5
Secondary cardiac disorders	**n=102**
Secondary cardiomyopathy	35
Traumatic myocarditis	3
CHF, myocarditis and myocardial failure due to seizures, pancreatitis, diabetic ketoacidosis, cholangiohepatitis	10
Myocardial changes due to pneumopathy and pleural abnormalities	16
Turbulent flow and myocardial changes due to anemia, dehydration, pregnancy, fever of unknown origin etc	35
Endocarditis	1
Pericardial effusion of unknown origin	2

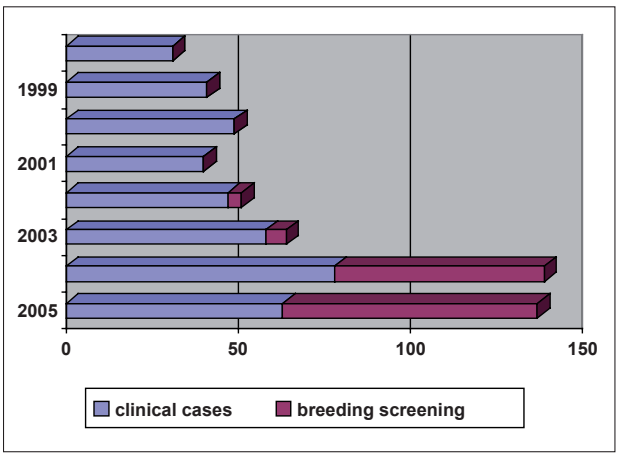

Figure 1: Number of cases presented at the two referral institutions from 1998-2005. The number of cats presented for cardiac disease and cardiac screening prior to breeding has increased steadily over the last few years.

common myocardial diseases are presented in Table 2. *Radiographs* of the thorax were taken in 374 of the 408 symptomatic cats. 21.1% had normal findings. Generalised cardiomegaly was diagnosed in 34.2% and pleural effusion was recognized almost twice as often as pulmonary oedema (58 and 27 cases), respectively. The radiographic abnormalities in general and a break-down of the most common congenital defects are presented in Table 3. The radiographic changes observed were not typical of any specific disorder.

Echocardiographic findings in congenital heart disease

A congenital cardiac defect was diagnosed in 48 of the 408 presented cats. This represents 11.8%. 28 of those 48 cats (58.3%) were males, the other 20 (41.7%) were females. VSD was the most frequently diagnosed malformation. Details of the congenital defects are presented in Table 4.

Echocardiographic findings in myocardial diseases

Cardiomyopathy was diagnosed in 287 cats of 19 different breeds. HCM was the most common form with

Table 2: Electrocardiographic findings in 395 cats with heart disease.

ECG findings	Total (n=395)	HCM (n=169)	DCM (n=11)	RCM (n=10)	ARVC (n=2)	UCM (n=6)	SCM (n=22)	2°CMP (n=33)	VSD (n= 25)
Normal ECG findings	140	35	3	2	0	0	9	8	9
Conduction abnormalities									
LAFB	9	9						1	
LBBB	5	2							
RBBB	1	1							
1° AV block	2	2							
3° AV block	1								
LGL.syndrome	2					1		1	
QRS notching	6	3		1					
Morphological changes									
LV enlargement pattern	21	10	2	1				3	1
LA enlargement pattern	3	1							
RV enlargement	3								1
pattern	5	2							
RA enlargement	7	2		2					
pattern									
Hypovoltage									
Rhythm disturbances									
VPC	39	14	4	2	2	3	7	2	
APC	2	1		1					
VT	2			1					
SVT	189	104	4	5		3	12	16	16
Afib	4	2	1	1					
Sinusbradycardia	2	1							
Escape rhythm	1	1							

LAFB, left anterior fascicular block; LBBB, left bundle branch block; RBBB, right bundle branch block; AV block, atrio-ventricular block; LGL, Lown-Ganong-Levine syndrome; LV, left ventricle; LA, left atrium; RV, right ventricle; RA, right atrium; VPC, ventricular premature complex; APC, atrial premature complex, SVT, supraventricular tachycardia; Afib, atrial fibrillation.
HCM, hypertrophic cardiomyopathy; DCM, dilated cardiomyopathy; RCM, restrictive cardiomyopathy; ARVC, arrhythmogenic right ventricular cardiomyopathy; UCM, unclassified cardiomyopathy; SCM, specific cardiomyopathy; 2° CMP, secondary Cardiomyopathy; VSD, ventricular septal defect.

Table 3: Radiographic findings in 374 cats with heart disease.

Radiographic findings	Total	VSD	ASD	TVD	MVD	PPDH	TOF	AVC
Normal radiographic appearance	79							
Generalised cardiomegaly	128	11	1	2		3	1	1
Pleural effusion	58	2		2				
Pulmonary oedema	27				2			
Left atrial dilation	75				6			
Right atrial dilation	22	4	1	1				
Increased bronchial density	33	1						
Ascites	9			1				

VSD, ventricular septal defect; ASD, atrial septal defect; TVD, tricuspid valve dysplasia; MVD, mitral valve dysplasia; PPDH, peritoneopericardial diaphragmatic hernia, TOF, Tetralogy of Fallot; AVC, arteriovenous canal.

Table 4: Congenital feline cardiac disease.

Cardiac disease	Total (n=48)	%
VSD	27	56.3
MV dysplasia	7	14.6
TV dysplasia	5	10.4
ASD	3	6.3
PPDH	3	6.3
Tetralogy of Fallot	1	2.1
AV-canal	1	2.1
PRAA	1	2.1

VSD, ventricular septal defect; MV, mitral valve; TV, tricuspid valve; ASD, atrial septal defect; PPDH, peritoneopericardial diaphragmatic hernia, AV, arteriovenous; PRAA, persistent right aortic arch.

67.6%, followed by DCM with 4.5%, RCM with 3.8%, ARVC with 0.7%, UCM with 2.8%, SCM with 8.4%, and secondary cardiomyopathy with 12.2%. Male cats (65.2%) were more frequently affected than females (34.8%). Hyperthyroidism, hypertension, chronic renal insufficiency and chronic pulmonary disease were the most common causes for secondary cardiac changes. Details including breed, age and sex distribution of cats with cardiomyopathies are presented in Table 5.

Feline arterial thromboembolism (FATE)

Thromboembolisations were recognized in a total of 21 cats with cardiac disease (15/21) and non-cardiac disease (6/21). The following diseases had lead to FATE: Hypertension, acromegaly, surgery, FIP and unknown causes. Male cats were affected twice as often with cardiac diseases (10/15) as well as with non-cardiac diseases (4/6). The left atrium-to-aortic-ratio of cats with HCM was 1.96 ± 0.55cm, of cats with non-cardiac diseases only 1.46 ± 0.36cm.
Systolic anterior motion (SAM) of the mitral valve was recognized in 17 of 194 cats (8.8%) with HCM.
Serum taurine levels were measured in 3 of the 13 cats diagnosed as having DCM and were found to be within normal limits. One of these cats with DCM responded well to dietary substitution although taurine level had been within normal limits.

Discussion

Our study provides information about the relative frequency of congenital and myocardial heart diseases in sick cats from western Switzerland. There are limitations to any retrospective study. During period time required to collect all these cases, there were improvements of the training level of the echocardiographers involved, amelioration of the equipment and changes of diagnostic criteria of some (cardiac) diagnoses. Because all data originated from two referral institutions, the highly selective nature of patient referral patterns affects how the diseases are perceived. This may result in overestimation of disease prevalence in the general population. Despite these limitations, the present study provides valuable information to cardiologists and interested practitioners.
In comparison to a study of Electrocardiography (ECG): ECG-abnormalities in feline idiopathic HCM (Ferasin et al., 2003), we found fewer conduction abnormalities (6.7% vs. 30%) and morphological changes (10% vs. 47.1%). However, we found more cardiac rhythm disturbances (60.5% vs. 21.7%). Most striking was the difference with sinus tachycardia (47.82% vs. 6.6%). This could be due to differences in the study design (idiopathic CMP vs. various cardiac disorders), therapy, duration of therapy prior to referral, excitement during the examination, use of sedatives and differences of the severity of the underlying cardiac disease. Overall, 35.4% of the cats showed no electrocardiographic abnormalities. With specific cardiac disorders a normal ECG was observed in HCM with 20.7%, DCM with 27.3%, SCM with 40.1%, secondary CMP with 24.2%, and VSD with 36% respectively. The ECG therefore seems to have a rather

Table 5: Signalement (age, sex and breed) in 287 cats with cardiomyopathy.

Signalement	**Total** (n=287)		**HCM** (n=194)		**DCM** (n=13)		**RCM** (n=11)		**ARVC** (n=2)		**UCM** (n=8)		**SCM** (n=24)		**2°CMP** (n=35)	
Age (yrs)	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std	Mean	Std
	6.8	4.6	5.6	4.1	7.4	3.9	10.7	4.5	13	0	5.07	4.2	6.8	3.6	12.0	4.5
Sex	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Male	187	65.2	128	66.0	9	69.2	8	72.7	2	100	5	62.5	13	54.2	22	62.9
Female	100	34.8	66	44.0	4	30.8	3	27.3	0		3	37.5	11	45.8	13	37.1
Breed	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
DSH	124	43.2	67	54.0	8	6.5	9	7.3	1	0.8	2	1.6	16	12.9	21	16.9
Persian	51	17.8	43	84.3	2	3.9	0		0		1	2.0	1	2.0	4	7.8
Maine Coon	48	16.7	44	91.7	0		0		1	2.1	1	2.1	2	4.2	0	
DHL	12	4.2	7	58.3	0		1	8.3	0		0		1	8.3	3	25.0
Sphinx	10	3.5	10	100.0	0		0		0		0		0		0	
Cartesian	8	2.8	8	100.0	0		0		0		0		0		0	
Siamese	6	2.1	3	50.0	0		0		0		1	16.7	1	16.7	1	16.7
Birman	5	1.7	1	20.0	0		0		0		1	20.0	2	40.0	1	20.0
Scottish fold	5	1.7	3	60.0	0		0		0		2	40.0	0		0	
Abyssinian	4	1.4	0		2	50.0	0		0		0		0		2	50.5
British blue	3	1.0	3	100.0	0		0		0		0		0		0	
Siberian	3	1.0	2	66.7	0		0		0		0		1	33.3	0	
Ex shorthair	2	0.7	0		0		1	50.0	0		0		0		1	50.0
Burmese	1	0.3	1	100.0	0		0		0		0		0		0	
Devon Rex	1	0.3	0		1	100.0	0		0		0		0		0	
Am shorthair	1	0.3	1	100.0	0		0		0		0		0		0	
Norwegian	1	0.3	1	100.0	0		0		0		0		0		0	
Oriental	1	0.3	0		0		0		0		0		0		1	100.0
Singapur	1	0.3	0		0		0		0		0		0		1	100.0

HCM, hypertrophic cardiomyopathy; DCM, dilated cardiomyopathy; RCM, restrictive cardiomyopathy; ARVC, arrhythmogenic right ventricular cardiomyopathy; UCM, unclassified cardiomyopathy; SCM, specific cardiomyopathy; 2° CMP, secondary Cardiomyopathy.

low sensitivity for recognizing cardiac diseases with morphologic changes. On the other hand, the ECG was very helpful in recognising and characterising of cardiac arrhythmias.

Thoracic radiographs were helpful for recognising the enlargement of one or several cardiac chambers and the presence of congestive heart failure. Our radiographic results, although including various cardiac disorders, match those of a study with feline idiopathic cardiomyopathies performed by Ferasin (2003). Pleural effusion and pulmonary oedema were recognized in 22.5% of the cases. Frequently, however, the cats had been stabilised in hospital with furosemide, oxygen therapy and cage rest prior to taking radiographs. The observed radiographic changes were not typical of any specific cardiac disorder. The radiographs therefore do not seem helpful in narrowing down a diagnosis of suspected specific cardiac disease. Because of the retrospective nature of our study, it was not possible to compare the radiographic findings of congestion to the clinical findings.

In our study we found more congenital heart defects (9.8% vs. 0.2–1%) when unpared to other studies (Oyama et al., 2005). Older investientions (Bolton et al.,1977; Liu 1977) revealed congenital defects in about 15% of feline heart disease. At that time, echocardiography was not available and anomalies were diagnosed by angiography and necropsy. In comparison to the cited studies, VSD's seemed overrepresented in our study. This may be explained either by our study design (referral institutions) or different incidences of VSD's in other countries. We do not know of any previously published prevalence and types of congenital heart defects in Swiss cats. As cited, male cats have more malformations than females (Oyama et al., 2005).

Echocardiographic findings in myocardial diseases revealed hypertrophic cardiomyopathy the most common form of feline cardiomyopathy (67.6%), which is in accordance with previous published studies (Atkins et al., 1992; Kittleson et al., 1998; Rush, 2004). The age of cats diagnosed with cardiomyopathy was extremely variable, as previously observed by Bright et al. (1992). In the overall evaluation of the different cardiomyopathies, males were more affected than females. This corresponds with the literature (Bright et al., 1992).

The incidence of Feline arterial thromboembolism (FATE) as a complication of an HCM was 7.7% in our study. This is less than 12-28% mentioned in the literature (Atkins et al., 1992; Peterson et al., 1993; Rush et al., 2002). The lower number may be explained by the fact that cats with FATE don't even get referred to the study centers, but are often euthanized by practitioners without any further investigations because of the poor prognosis. In accordance with the literature, male cats were twice as likely affected than female cats (Smith et al., 2004).

Measurement of blood taurine levels is only possible in a few specialized laboratories in Switzerland and is costly. Therefore, taurine blood levels were most often dismissed, and an oral taurine substitution was begun without prior measurement of the levels depending upon the compliance of the owner. One cat responded very well to substitution despite initially normal taurine blood levels. In that particular case, a relative taurine deficiency was suspected.

Prévalence des affections cardiaques chez des chats symptomatiques: une rétrospective de 1998 à 2005

Durant les 8 demières années, 408 chats souffrant de diverses affections cardiaques ont été présentés dans 2 cliniques différentes. Le nombre de chats présentés a régulièrement augmenté durant cette période. Une affection du myocarde a pu être diagnostiquée chez 287 animaux, la cardiomyopathie hypertrophique étant la forme la plus fréquente avec 67.6%. Des malformations cardiaques ont été trouvées dans 11,8% des cas. Un défaut du septum interventriculaire était l'anomalie la plus fréquemment constatée, ce qui contredit les études publiées à ce jour. L'électrocardiogramme s'est révélé relativement peu spécifique et peu scnsible dans le diagnostique des affections cardiaques. Son utilité réside principalement dans la détection et la caractérisation de troubles du rythme. Les altérations constatées radiologiquement nc sont pas non plus spécifiques et les clichés du thorax sont particulièrement utiles pour évaluer la taille du cceur et les signes secondaires de congestion.

Prevalenza delle malattie cardiache in gatti sintomatici., uno sguardo tre il 1998 e il 2005

Negli ultimi 8 anni è stato fatto un esame ecocardiografico preventivo a 408 gafti in due differenti cliniche. Il numero dei gatti presentati è aumentato in questo periodo continuamente. In 287 animali è stata diagnosticata una malattia del muscolo cardiaco e nel 67.6% la forma più frequente è stata la cardiomiopatia ipertrofica (HCM). Una malformazione cardiaca è stata riscontrata nell'11.8% dei casi. AI contrario degli studi pubblicati finora, l'anomalia maggiormente constatata è stata un difetto septale ventricolare. L'elettrocardiogramma si è dimostrato nella diagnosi delle malattia cardiache come relativamente non specifico e non sensibile. Il suo significato si situa in particolare sulla registrazione e la caratterizzazione dei disturbi del ritmo cardiaco. 1 cambiamenti costatati radiologicamente sono anche non specifici a certe malattie cardiache. Radiografie al torace sono in particolare significative nella valutazione delle dimensioni cardiache e di segni secondari di congestioni.

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Received: 7 February 2006
Accepted: 5 September 2006

