Journal of Veterinary Cardiology (2010) **12**, 1—16

ELSEVIER

Journal of Veterinary Cardiology ESVC

www.elsevier.com/locate/jvc

Echocardiographic assessment of left ventricular geometry and the mitral valve apparatus in cats with hypertrophic cardiomyopathy☆

Karsten Schober, DVM, Dr med vet, Dr habil*, Amanda Todd, BS

Department of Veterinary Clinical Sciences, College of Veterinary Medicine, The Ohio State University, 601 Vernon L Tharp Street, Columbus, OH 43210, USA

Received 23 February 2009; received in revised form 1 September 2009; accepted 13 September 2009

KEYWORDS
Feline;
Hypertrophic obstructive cardiomyopathy;
Papillary muscles;
Systolic anterior motion;
Mitral valve leaflet

Abstract *Objectives:* This retrospective study addressed the general hypothesis that abnormalities of the mitral valve apparatus are common in cats with idiopathic hypertrophic cardiomyopathy (HCM) and contribute to dynamic obstruction of the left ventricular outflow tract (LVOT).
Animals, materials and methods: 106 cats (28 controls and 78 with HCM) had transthoracic two-dimensional and Doppler echocardiography performed with quantification of 33 variables. Three groups of cats (control [Group-1], HCM without obstruction [Group-2], and HCM with obstruction [Group-3]) were identified and compared by analysis of variance, χ^2 analysis, and correlation analysis.
Results: Cats in Group-3 had more LV and papillary muscle hypertrophy, increased length of the anterior mitral valve leaflet, and a higher prevalence of false tendons in the LVOT compared to cats in Group-2 ($P \leq 0.05$). The length of the anterior mitral valve leaflet was correlated to the severity of dynamic obstruction ($P \leq 0.05$) and the magnitude of LV hypertrophy ($P \leq 0.001$). Systolic anterior motion of chordae tendineae (CAM) was observed in 16% of control cats and >50% of cats with HCM ($P \leq 0.05$).
Conclusions: Abnormalities of the mitral valve are common in cats with HCM suggesting a possible role in the pathogenesis of dynamic outflow tract obstruction.

Introduction

Hypertrophic cardiomyopathy (HCM) is the most common cardiac disorder in the domestic cat and is regarded as a disease of cardiac muscle with

☆ Presented in part at the Annual Forum of the ACVIM, San Antonio, TX, June 2008.

* Corresponding author.
E-mail address: schober.4@osu.edu (K. Schober).

1760-2734/$ - see front matter © 2010 Elsevier B.V. All rights reserved.
doi:10.1016/j.jvc.2009.09.004

a diverse morphological and clinical spectrum.[1–8] Dynamic obstruction of the left ventricular (LV) outflow tract (LVOT) is frequently observed in cats with HCM[9,10] [a,b] (referred to as hypertrophic obstructive cardiomyopathy [HOCM]). This is due to systolic anterior motion (SAM) and mid to late systolic contact of the mitral valve with the interventricular septum (IVS) or to hypertrophy of the dorsal IVS that protrudes into the LVOT during systole.[b,4,10,11] Functional and intrinsic abnormalities of the mitral valve are common in people with HCM[12–16] and may favor obstruction of the LVOT.[17,18] Such abnormalities include, but are not limited to an increased area of one or both mitral valve leaflets;[13,14] elongated and distorted mitral valve leaflets[13,14,17,19] and chordae tendineae (referred to as ''chordal slack'');[18,20,21] restrictive chordae and leaflets;[17] proximal shift of the coaptation point of the mitral valve leaflets;[18,22] mitral valve thickening[4,5,13,14] and prolapse;[22] direct insertion of the heads of papillary muscles into the ventricular aspect of the anterior mitral valve leaflet;[13,14,20,23] anteriorly displaced leaflets[18,24] and papillary muscles;[14,15,19,22,23] reduced interpapillary muscle distance;[15,22] giant single, bifid, multi-element, or increased number of papillary muscles[15,22] and increased number of leaflet scallops.[13] They all may contribute to redirection of blood flow in the LVOT leading to flow drag and ultimately SAM.[18,21] However, congenital malformations of the mitral valve mimicking HOCM due to obstruction of the LVOT and secondary LV hypertrophy have also been observed in some human patients with unexplained LV hypertrophy.[24–27] Although there is anecdotal evidence that the mitral valve and papillary muscles are abnormal in a subset of cats with HCM,[4,5,9] the morphology of the mitral valve apparatus and the LVOT in relation to other abnormalities of LV geometry and the contribution of these to outflow tract obstruction has not yet been systematically studied in a large number of affected cats. With the event of high-quality, two-dimensional echocardiography (2DE) with high temporal resolution (frame rates $>$ 100 frames per second), such investigations are feasible. This study addresses the general hypothesis that abnormalities of the mitral valve and the LVOT are common in cats with HCM and can be characterized by transthoracic 2DE. Specifically, we hypothesized that cats with HOCM have more hypertrophy of the LV, elongated mitral valve leaflets and chordae tendineae, an anteriorly displaced mitral valve leaflet coaptation point, and a higher prevalence of papillary muscle abnormalities compared to cats with non-obstructive HCM.

Animals, materials and methods

Echocardiograms from all cats seen by the cardiology service at the Veterinary Teaching Hospital of The Ohio State University between November 2004 and July 2006 and diagnosed with either ''normal cardiovascular findings'' or HCM were reviewed. To be included, echocardiograms had to be of appropriate quality to allow for accurate measurements; complete with regard to standard imaging views[28] and number of images and cine loops captured to allow for confirmation of the previously made diagnosis and to comprehensively assess the geometry and function of the LV, the mitral valve apparatus, and the LVOT; and were required to have a simultaneously recorded single-lead electrocardiogram (ECG) visible on the screen. Sector transducers with an array of 7 MHz or 10 MHz nominal frequency and a digital high-end ultrasound system[c] were used for all echocardiographic studies. Cats were manually restrained in lateral recumbency and imaged from underneath. Right and left parasternal long and short-axis views were used for data acquisition, and studies were performed as recently described (Figs. 1–4).[29] Sweep speed and frame rate during recordings was 100–200 mm/s and 62 to 198 fps, respectively. Prior to the echocardiogram cats had undergone a thorough physical examination, measurement of systolic blood pressure using the Doppler method[d] ($<$160 mmHg in all cats), and determination of plasma T4 concentration in cats older than six years of age or younger if clinical signs suggestive of hyperthyroidism were observed ($T4 < 4.0$ μg/dL in all cats).

Control group (Group-1) — Cats were included if they were clinically healthy with a normal physical examination. A soft systolic heart murmur heard in some cats was not considered abnormal. The maximum LV wall thickness measured at end-diastole was $<$6 mm[10] and the maximum left atrial dimension was $<$16 mm.[6] Control cats did not have SAM of the mitral valve, and did not have 2DE, M-mode, or

[a] DeFrancesco TC, Gebhardt K, Atkins CE, Moore DT, Keene BW. Clinical outcome of feline hypertrophic cardiomyopathy with and without concurrent left ventricular outflow tract obstruction (abstract). *J Vet Intern Med* 2005; 19:406.

[b] Meurs K, Kittleson MD, Towbin J, Ware W. Familial systolic anterior motion of the mitral valve and/or hypertrophic cardiomyopathy is apparently inherited as an autosomal dominant trait in a family of American shorthair cats (abstract). *J Vet Intern Med* 1997; 11:138.

[c] Vivid 7 Vantage™, GE Medical Systems, Milwaukee, WI.

[d] Ultrasonic Doppler flow detector, Model 811-B, Parks Medical Electronics Inc, Aloha, OR.