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Heart rate turbulence after ventricular premature beats in healthy Doberman pinschers and those with dilated cardiomyopathy

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Abstract *Objectives:* To describe the measurement of heart rate turbulence (HRT) after ventricular premature beats and compare HRT in healthy Doberman pinschers and those with dilated cardiomyopathy (DCM), with and without congestive heart failure (CHF).
Animals: Sixty-five client-owned Dobermans: 20 healthy (NORMAL), 31 with preclinical DCM and 14 with DCM and CHF (DCM + CHF).
Methods: A retrospective study of data retrieved from clinical records and ambulatory ECG (Holter) archives, including data collected previously for a large-scale prospective study of Dobermans with preclinical DCM. Holter data were reanalysed quantitatively, including conventional time-domain heart rate variability and the HRT parameters turbulence onset and turbulence slope.
Results: Heart rate turbulence could be measured in 58/65 dogs. Six Holter recordings had inadequate ventricular premature contractions (VPCs) and one exhibited VPCs too similar to sinus morphology. Heart rate turbulence parameter, turbulence onset, was significantly reduced in DCM dogs, whereas conventional heart rate variability measures were not. Heart rate variability and HRT markers were reduced in DCM + CHF dogs as expected.
Conclusions: Heart rate turbulence can be measured from the majority of good quality standard canine 24-hour Holter recordings with >5 VPCs. Turbulence onset

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is significantly reduced in Dobermans with preclinical DCM which indicates vagal withdrawal early in the course of disease. Heart rate turbulence is a powerful prognostic indicator in human cardiac disease which can be measured from standard 24-hour ambulatory ECG (Holter) recordings using appropriate computer software. Further studies are warranted to assess whether HRT may be of prognostic value in dogs with preclinical DCM and in other canine cardiac disease.

Abbreviations

ANS	autonomic nervous system
BRS	baroreflex sensitivity
CHF	congestive heart failure
CIPA	Cardiac Index of Parasympathetic Activity
DCM	dilated cardiomyopathy
ECG	electrocardiogram
HRT	heart rate turbulence
HRV	heart rate variability
LV	left ventricle
LVIDd	left ventricular internal dimension at end-diastole
LVIDs	left ventricular internal dimension at end-systole
RMSSD	square root of the mean of the sum of the squares of differences between adjacent NN intervals
SDANN	standard deviation of the averages of NN intervals in all 5 min segments of the entire recording
SDNN	standard deviation of all intervals between normal beats (NN intervals)
SMOD	Simpson's method of discs
TI	triangular index
TO	turbulence onset
TS	turbulence slope
VPC	ventricular premature complex
VVTI	vasovagal tonus index

Introduction

The autonomic nervous system (ANS) and its influence on cardiovascular health has been extensively studied in recent years. This has led to a shift in the understanding of the pathophysiology of the heart failure syndrome, particularly the neurohumoral response which becomes abnormally activated in heart disease. It has become widely accepted that there is a relationship between ANS dysfunction and cardiovascular disease [1], which in humans manifests as a progressive withdrawal of parasympathetic tone and stimulation of sympathetic activity. This has provoked significant interest in quantitative estimates of autonomic tone to provide risk stratification for stroke and cardiac mortality in humans including sudden cardiac death.

Various markers of ANS function have been proposed, the simplest of which are derived from changes in heart rate in response to various stimuli. In resting humans and dogs, the heart rate is predominantly under parasympathetic control, mediated through reflex baroreceptor stimulation. Sympathetic influence affects the heart more slowly, both by direct effect on heart rate and by changes in peripheral vascular resistance [2]. Heart rate alone indicates the net effect of the sympathetic and parasympathetic nervous systems at any one time but does not disclose the two components of the ANS individually.

Heart rate variability (HRV) is the collective term for changes in instantaneous heart rate, measured by beat-to-beat (RR interval) changes on an electrocardiogram (ECG) [3]. Different HRV parameters reflect either predominantly sympathetic or parasympathetic activity and hence can more accurately quantify the interaction between the two systems than measurement of heart rate alone. Statistical calculations on direct measurements of intervals between normal beats (NN intervals) or differences between NN intervals are known as time-domain measures of HRV. In humans, HRV can predict severity of myocardial failure [4] as well as risk of cardiac mortality in both ischaemic and non-ischaemic cardiomyopathy [5,6]. Attempts have been made to demonstrate a similar relationship in dogs. Whilst this has improved the understanding of autonomic dysfunction in canine cardiac disease, these studies have thus far failed to identify conventional HRV techniques as clinically useful tools before the onset of congestive heart failure (CHF) [7–9]. This has been attributed to the predominance of vagal withdrawal in dogs rather than the accompanying sympathetic activation observed in humans [10,11]. It has been concluded that better non-

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