Forty-four Hour Ambulatory Electrocardiography (Holter Monitoring) in Normal Unsedated Cats

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ABSTRACT

Background: Standard electrocardiogram (ECG) performed during a clinical examination has a limited ability to detect many arrhythmias. Holter or 24-h ambulatory electrocardiography (AECG) is the most sensitive non-invasive test for demonstrating transient arrhythmias, that allows continuous recording of cardiac electrical activity while the patient is engaged in normal daily activities. This study was undertaken to define 24-h AECG parameters, including variations in heart rate, and the types and incidence of arrhythmias in clinically normal adult cats to provide a baseline for comparison for cats suspected of having cardiac diseases.

Materials, Methods & Results: Twenty clinically normal adult cats, with an equal number of males and females, weighting from 2.8 to 7.6 kg (mean 4.10 ± 1.22), were used. All animals had no historical or clinical evidence of systemic diseases, with unremarkable physical examination, and with no alterations on either thoracic radiography, electrocardiographic, and echocardiographic evaluations, as well as on clinical pathology or blood pressure measurement. Ambulatory electrocardiographic recording was performed for 24-h, with a 3-lead, modified bipolar, transthoracic system. The owner was requested to keep a diary to record the time of exercising, feeding, and other behaviours. The records were analysed using a microprocessor. In the current study, regular sinus rhythm was predominant, there was no evidence of atrioventricular conduction block, or ST segment alterations and the minimum heart rate was 102 ± 23 bpm, while the maximum heart rate was 242 ± 17 bpm and the mean heart rate was 151 ± 26 bpm.

Discussion: The main disadvantage of routine clinical ECG is that it records only a short period of heart rhythm. Continuous 24-h AECG monitoring is an obvious way of circumventing this problem. The normal heart rhythm in felines is usually regular, varying from sinus rhythm to sinus tachycardia. Sinus arrhythmia is considered uncommon or abnormal, and when present, it is usually associated with respiratory disorders. Nonetheless, sinus arrhythmia occasionally occurs in cats when they are relatively relaxed. Consistently, it was noted that 95% (19/20) of the cats presented an apparent respiratory sinus arrhythmia with alternating periods of heart rate increase and decrease. Sinus arrhythmia has been previously observed in normal cats when they were calm and quiet in their home environment with either telemetry or Holter monitoring. In cats, sinus arrhythmia is commonly associated with bradycardia (sinus bradyarrhythmia). This finding may be an indication that the vagal tone is an important factor in the genesis of this rhythm. The heart rate variability parameters obtained through telemetry suggest that parasympathetic tone was higher (and sympathetic tone lower) when the cats were in their home environment. In the current study, the minimum heart rate was lower than that of hospitalized normal cats (102 ± 23 bpm versus 117 ± 15 bpm), while the maximum heart rate was higher (241 ± 17 bpm versus 241 ± 21 bpm) and the mean heart rate was lower (151 ± 26 bpm versus 151 ± 16 bpm), but without statistical significance. There were no gender differences in the mean values for minimum, mean and maximum heart rate, a finding that is in contrast to a previous study in which females presented with higher mean values for minimum and mean heart rates than males did. This study suggests that occasional ventricular (and supraventricular) ectopic activity may occur in healthy young cats. However, it is still unclear how many premature beats can be considered “normal” in cats.

Keywords: holter monitoring, feline, sinus arrhythmia, heart rate, unsedated cats.
INTRODUCTION

Given the short duration, standard electrocardiogram (ECG) is unreliable for consistently detecting even frequent arrhythmias, and they are likely to result in over- or underestimation of the severity of any identified rhythm disturbance [20]. A typical resting electrocardiogram of 5 min duration only samples 0.3% of a 24-h period [14]; consequently, Holter recording (a type of ambulatory electrocardiography, or AECG) was developed to overcome some of the limitations of the short period recorded by standard ECG [6].

Long-term ECG recording is the most sensitive non-invasive test for demonstrating transient arrhythmias [17]. In human medicine, it is the most useful non-invasive test for evaluating patients with arrhythmias [15] and establishing possible correlations with clinical signs [6,14,15,19].

Holter monitoring is a form of AECG that allows continuous recording of cardiac electrical activity while the patient is engaged in normal daily activities. The indications for Holter monitoring are as follows: the evaluation of symptoms that may be related to rhythm disturbances (the classic indication) [3,13,19], the detection of myocardial ischemia [14], the assessment of risk and prognosis in patients with or without symptoms [3], the assessment of rhythm in patients with or without symptoms [18,21], and the determination of antiarrhythmic therapy efficacy [6,11,19].

There are few reports of AECG in cats [5,8,20].

The present study was undertaken to define 24-h AECG parameters, including variations in heart rate, and the types and incidence of arrhythmias in clinically normal adult cats to provide a baseline for comparison for cats suspected of having cardiac diseases.

MATERIALS AND METHODS

Animals

Twenty clinically normal adult cats, with an equal number of males and females, weighting from 2.8 to 7.6 kg (mean 4.10 ± 1.22), were used. The animals were either from the cattery of Department of Internal Medicine of School of Veterinary Medicine and Animal Science of University of São Paulo or were selected at the Cardiology Service at the Veterinary Hospital of University of São Paulo. In the latter case, they were housed in their home environment.

Radiography and Echocardiographic evaluation

The thoracic radiography were evaluated qualitatively, and quantitatively (using the “Vertebral Scale System”) [2]. Echocardiographic evaluation indicated no chamber enlargement, and diastolic left ventricular wall and interventricular septal thickness were ≤ 5 mm [7].

In animals with normal results (no historical or clinical evidence of systemic diseases, with unremarkable physical examination, and with no alterations on either thoracic radiography, electrocardiographic, and echocardiographic evaluations, as well as on clinical pathology or blood pressure measurement), the ambulatory electrocardiographic recording was performed for 24-h, with a 3-lead, modified bipolar, transthoracic system, using an analogic recorder or a digital recorder, respectively recorded on cassette tape, or on fleshcard. For this, hair was shaved from an area of approximately 6.0 cm wide and 8.0 cm height on either side of the precordium, just behind the front legs. The electrodes were placed fairly close together because of small size of the thorax. Self adhesive disposable electrodes were applied to the prepared areas of skin and the adhesion reinforced by adhesive tape strips. The leads were attached to the electrodes patches. An adhesive tape was wrapped around the chest, over the electrodes and leads wires. An auto-adhesive elastic bandage was wrapped around the chest, to cover the lead wires and recorder.

Record data

The record starting time was noted and then the cat was taken home or to the cattery where a normal daily routine was encouraged. The owner was requested to keep a diary to record the time of exercising, feeding, and other behaviours.

The records were analysed using a cassette tape recorder microprocessor or a Fleshcard recorder microprocessor.

Full-disclosure printouts and standard report parameters were obtained. The authors examined all the full-disclosure reports to ensure that the reported heart rhythm and hourly counts of ectopic complexes were as accurate as possible.

Data evaluated included hourly and 24-h summaries of minimum, mean and maximum heart rate; heart rhythm, and hourly counts of ectopic complexes. Any abnormalities of sinus node function or atrioventricular conduction was also noted.
Regarding the rhythm, the presence of sinus arrhythmia was defined as more than 10% difference between RR intervals or more than 0.10 s difference between consecutive PP intervals. Measurements of the total time duration of sinus arrhythmia was not attempted. Calculation of the degree of sinus arrhythmia was done by the formula (RR-rr)/rr whilst the arrhythmia was most marked. The largest difference between consecutives RR intervals was also calculated.

**Data and Statistical analysis**

All data analysis was performed using the Minitab statistical analysis program. Results are presented as mean ± standard error of the individual groups means. A statistically significant difference was defined as $P < 0.05$.

The parametric data were analysed by Student $t$-test, with the gaussian distribution confirmed by Kolmogorov-Smirnov method. The non-parametric data were analysed by Friedman method.

**RESULTS**

Auscultation revealed no murmur, gallop sound, or arrhythmia. The resting ECG showed sinus rhythm or sinus tachycardia with no ectopic complexes.

The results about AECG are presented on Figure 1 and Table 1.

Regular sinus rhythm was predominant, there was no evidence of atrioventricular conduction block, or ST segment alterations and the minimum heart rate was $102 ± 23$ bpm, while the maximum heart rate was $242 ± 17$ bpm and the mean heart rate was $151 ± 26$ bpm.

Regular sinus rhythm was predominant; however, periods of sinus arrhythmia were evident in almost all of the animals (95% (19 of 20)), especially when the heart rate was lower, resulting in sinus bradyarrhythmia at times.

There was no evidence of atrioventricular conduction block, or ST segment alterations.

Six cats (30%; 3 females and 3 males) had single ventricular ectopic complexes (Table 2). Single supraventricular premature complexes occurred only in 2 animals (1 female with 3 supraventricular extrasystoles and 1 male with 4 supraventricular extrasystoles). The female presented with 3 events/h and the male with 1 event/h.

![Figure 1](image-url). Hourly mean values for minimum, mean, and maximum heart rates from 20 healthy cats are depicted over a 24-h period. HOVET/FMVZ/USP. São Paulo, 2013. *Beats per minute.*
DISCUSSION

The main disadvantage of the routine clinical ECG is that it records only a short period of heart rhythm. Continuous 24-h ambulatory ECG monitoring is an obvious way of circumventing this problem. One great utility of ambulatory ECG monitoring in cats is the analysis of heart frequency and rhythm in the environment.

In very small or debilitated cats, direct attachment of the recorder is not desired. So, the animal should be placed in a cage with the recorder on the top of it [5]. Obviously, direct attachment of the recorder can cause some stress, and should be taken into consideration during interpretation.

The normal heart rhythm in feline is usually regular [1,9,13,17] varying from sinus rhythm to sinus tachycardia. Sinus arrhythmia is considered uncommon [13,17] or abnormal [10], and when present is usually associated with respiratory disorders. Even though, occasionally sinus arrhythmia occurs in cats that are more relaxed [9].

Sinus arrhythmia is defined as an irregular rhythm originating in the sinoatrial node. It presents as a variation in heart rate in a cyclic mode with respiratory movements (respiratory sinus arrhythmia) or irregularly with no relation with respiratory movements. Sinus arrhythmia tends to disappear with increases of heart rate. Electrocardiographically, it is characterized by 0.10 s or greater variability between successive P waves [13,17] or greater than 10% variability between RR intervals [4]. Thus, it was noted that 95% (19/20) of the cats presented an apparently respiratory sinus arrhythmia, with alternated periods of increase and decrease of heart rate. Sinus arrhythmia has been

<p>| Table 1. Results of ambulatory ECG recording in 20 healthy cats. HOVET/FMVZ/USP. São Paulo, 2013. |</p>
<table>
<thead>
<tr>
<th>Number of QRS(1)</th>
<th>Exam Duration(2)</th>
<th>HR min.(3)</th>
<th>HR mean(4)</th>
<th>HR max.(5)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>bpm(6)</td>
<td>bpm</td>
<td>bpm</td>
</tr>
<tr>
<td>Minimum</td>
<td>128,187</td>
<td>1,235</td>
<td>75</td>
<td>100</td>
</tr>
<tr>
<td>Maximum</td>
<td>288,970</td>
<td>1,438</td>
<td>174</td>
<td>203</td>
</tr>
<tr>
<td>Mean</td>
<td>210,178</td>
<td>1,385</td>
<td>102</td>
<td>151</td>
</tr>
<tr>
<td>Median</td>
<td>210,979</td>
<td>1,413</td>
<td>95</td>
<td>153</td>
</tr>
<tr>
<td>SD(7)</td>
<td>40,180</td>
<td>61</td>
<td>23</td>
<td>26</td>
</tr>
</tbody>
</table>

(1)Total number of QRS complexes in 24 h; (2)Duration of exam in minutes; (3)Minimum heart rate; (4)Mean heart rate; (5)Maximum heart rate; (6)Beats per minute; (7)Standard deviation.

<p>| Table 2. Presence of ventricular extrasystoles in healthy cats. HOVET/FMVZ/USP. São Paulo, 2013. |</p>
<table>
<thead>
<tr>
<th>Animal</th>
<th>Gender</th>
<th>VE(1)</th>
<th>Morphology of QRS complex</th>
<th>Maximum frequency of occurrence(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>female</td>
<td>18</td>
<td>monomorphic</td>
<td>4 VE/min at 2:34 AM</td>
</tr>
<tr>
<td>4</td>
<td>female</td>
<td>3</td>
<td>polymorphic</td>
<td>1 VE/h at 7:00 AM, 8:00 AM, 3:00 PM</td>
</tr>
<tr>
<td>5</td>
<td>female</td>
<td>6</td>
<td>polymorphic</td>
<td>2 VE/min at 4:36 PM</td>
</tr>
<tr>
<td>12</td>
<td>male</td>
<td>7</td>
<td>polymorphic</td>
<td>2 VE/h at 08:00 AM</td>
</tr>
<tr>
<td>14</td>
<td>male</td>
<td>1</td>
<td>monomorphic</td>
<td>1 VE/h at 9:00 PM</td>
</tr>
<tr>
<td>19</td>
<td>male</td>
<td>5</td>
<td>polymorphic</td>
<td>2 VE/h at 7:00 PM</td>
</tr>
</tbody>
</table>

(1)Total ventricular extrasystoles; (2)Maximum frequency of occurrence (per minute or per hour).
previously observed in normal cats when they were calm and quiet in their home environment, by either telemetry [1] or holter monitoring [20].

As in human beings, sinus arrhythmia was commonly associated with bradycardia (sinus bradycardia). This can be an indication that the vagal tone is an important factor on this rhythm genesis. The heart rate variability parameters obtained through telemetry suggested that parasympathetic tone was higher (and sympathetic tone lower) when the cats were in their home environment [1].

The mean values for minimum (102 ± 23 bpm), mean (151 ± 26 bpm versus 157 ± 3.7 bpm) and maximum (242 ± 17 bpm versus 267 ± 5.4 bpm) heart rate for all animals were very similar, but slightly inferior, to those determined by Ware [20].

In the current study, minimum heart rate was lower (102 ± 23 bpm versus 117 ± 15 bpm) and maximum heart rate was higher (279 ± 17 bpm versus 241 ± 21 bpm), with mean 24-h mean heart rate similar (151 ± 26 bpm versus 151 ± 16 bpm) to that found in hospitalized normal cats [5].

There were no gender differences in mean values for minimum, mean, and maximum heart rate, that is in contrast to a previous study [20] where females presented with higher mean values for minimum and mean heart rate than males.

Single ventricular premature complexes may occur in normal cats [8,20] normal dogs [12,18] and human beings [15]. In this study, the animals presented with fewer ventricular premature complexes than in Ware’s study [20]; this may be because the animals in this study were younger and the incidence of ventricular arrhythmias increases with age in cats [8,20] in dogs [16], and in humans [15].

Supraventricular premature complexes are rare, as in the younger cats from the previous study [8,20]. The incidence of supraventricular extrasystoles might be related to age; the two animals that showed supraventricular arrhythmia were the oldest of the study, but no statistically significant conclusions can be drawn from these two cases.

This study suggests that occasional ventricular (and supraventricular) ectopic activity may occur in healthy young cat. However, it is still unclear how many premature beats can be considered “normal” in cats.

CONCLUSIONS

It was concluded that 24-h ambulatory electrocardiography can be readily obtained in cats. Sinus arrhythmia was common, occurring in 95% of cats. Ventricular extrasystoles were uncommon, whereas supraventricular extrasystoles were rare.

REFERENCES


