Effect of Body Position on Feline Electrocardiographic Recordings

A.M. Harvey, M. Faena, P.G.G. Darke, and L. Ferasin

The aim of this study was to determine whether changes in body position alter feline electrocardiographic parameters. Forty-seven cats referred to the Feline Unit of the University of Bristol had electrocardiograms (ECGs) recorded. Only cats presenting in sinus rhythm were included in the study (n = 41). ECGs were recorded either as part of the investigation for potential cardiac disease (n = 38) or as a preanesthetic screen (n = 3). Standard 6-lead ECGs (leads I, II, III, aVR, aVL, and aVF) were recorded in 3 different recumbent positions in the 41 cats. Recordings were 1st made in right lateral (RL) recumbency, followed by sternal (ST) and then left lateral (LL) recumbency. Measurements were taken of the amplitude and duration of P waves and QRS complexes and of duration of PQ and QT intervals from lead II was taken in the 3 different positions. Mean electrical axis (MEA) also was calculated. Repeated measures analysis of variance was performed and identified a significant difference in R wave amplitudes (P = .009) and MEA (P = .037) among the 3 different body positions. Two-tailed paired t-tests demonstrated that the R wave amplitude differed significantly both in ST (P = .025) and LL recumbency (P = .009). The mean R wave amplitude was reduced in both ST and LL recumbency when compared with RL recumbency. The MEA only was significantly different in LL recumbency (P = .037). ST and LL recumbencies should not be used for recording ECGs in cats if amplitudes and MEA are to be compared with standard references.

Key words: Cardiac; Electrocardiogram; Electrocardiography; Heart; Lateral; Sternal.

Electrocardiography is an essential part of the evaluation of patients with cardiac disease. It is commonly used in small animal practice to diagnose and monitor cardiac arrhythmias and conduction disturbances and to assess heart rate when femoral pulses are not easily palpated or when counting the heart rate is made difficult by tachycardia or an abnormal rhythm. Furthermore, some electrocardiogram (ECG) variations can indicate cardiac chamber enlargement, pericardial or pleural effusion, or electrolyte disturbances. Increases in the amplitude and duration of complexes commonly are used as indicators of cardiac chamber enlargement. It is therefore important to know whether alterations in body position influence voltages on ECGs.

Standardized methods of recording ECGs have been described, and strict guidelines have been developed for recording ECGs in dogs, consisting of specific placement of recording electrodes on the limbs, placing the limbs in a specific position relative to the body, and placing the animal in right lateral recumbency.

Changes in forelimb position of dogs can significantly change the morphology of QRS complexes, and a more recent study investigating the effect of body position on the 6-lead ECG of dogs indicated that tracings recorded in right lateral (RL), left lateral (LL), and standing positions yielded significantly different results.

Normal values for feline ECGs also have been obtained from ECGs recorded in cats in RL recumbency. However, in cats, some clinicians might prefer to record ECGs in sternal (ST) recumbency because less restraint is required and cats can tolerate this position better, particularly if they are dyspneic. In this species however, the only published investigations into the effect of body position showed no significant differences in duration or amplitude of complexes between RL and ST recumbencies. Sternal recumbency subsequently was described as the position of choice for recording ECGs in cats.

Nevertheless, in the last few years, we have observed marked variations in feline ECG recordings among different recumbent positions, and this study was designed to evaluate the statistical significance of these changes. Previous comparisons of positions have examined ECGs from normal animals. However, in this study, cats with cardiac disease were included in addition to those without cardiac disease because ECGs often are performed when the clinician is unsure about the cardiac status of the patient. We also wanted to include in this study ECG recordings obtained in LL recumbency to investigate a previously proposed hypothesis that cardiac position within the thorax affects ECG variables.

Materials and Methods

Animals

Forty-seven cats referred to the University of Bristol Veterinary School in 2003 had ECGs recorded in 3 different recumbencies (RL, ST, and LL). Only cats presented in sinus rhythm were enrolled in the study (n = 41). The mean age of these cats at presentation was 6.1 ± 4.5 years (mean ± SD, range 0.4–18 years) and mean weight was 3.97 ± 1.1 kg (range 1.8–6.3 kg). Twenty-six cats were neutered males, 13 were neutered females, and 2 were intact females. Thirteen breeds were represented, the most common of which were Domestic Shorthair (n = 24), followed by Domestic Longhair (n = 3), and Persian (n = 2).

ECGs were recorded either as part of the investigation of a potential cardiac disease (n = 38) or for a preanesthetic screen (n = 3). The clinical reasons that prompted an ECG to be performed are listed in Table 1. Thirteen cats included in the study were diagnosed with primary heart disease, and 5 cats had left ventricular hypertrophy secondary to hyperthyroidism. A total of 14 of these cats had left ventricular hypertrophy.

ECG Recording

ECGs were recorded with a Cardiowaco ECG-9130K machine. Surface electrodes made of flattened alligator clips were attached to the skin at the level of the olecranon on the caudal aspect of the forelimb.
Table 1. List of clinical situations that prompted an electrocardiogram recording in the 41 cats included in the study.

<table>
<thead>
<tr>
<th>Presenting Problem</th>
<th>No. of Cats</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>Epilepsy of cyanosis</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>Heart murmur</td>
<td>20</td>
<td>49</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>22</td>
<td>54</td>
</tr>
<tr>
<td>Intermittent dysrhythm</td>
<td>2</td>
<td>4.9</td>
</tr>
<tr>
<td>Gallop sound</td>
<td>3</td>
<td>7.3</td>
</tr>
<tr>
<td>Episodic collapse</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>Preanesthetic</td>
<td>3</td>
<td>7.3</td>
</tr>
<tr>
<td>Coughing</td>
<td>1</td>
<td>2.4</td>
</tr>
<tr>
<td>Bradycardia (&lt;100 bpm)</td>
<td>1</td>
<td>2.4</td>
</tr>
</tbody>
</table>

Statistical Analysis

ECG measurements and heart rates in the 3 body positions were compared by repeated measures analysis of variance with commercially available statistical software. Where a difference was identified, a paired 2-tailed t-test was performed comparing values obtained in RL recumbency with those obtained in the other 2 recumbencies. Confidence intervals (CI; 95%) of the differences between RL and LL recumbency and RL and ST recumbency also were determined.

Sensitivities and specificities of increased R wave amplitude and left axis deviation in detecting left ventricular enlargement were determined together with 95% confidence intervals (Win Episcope 2.0. Available at: www.clive.ed.ac.uk/episcope). The statistical significance of the differences in these sensitivities and specificities between the body positions was determined by McNemars’ analysis.

Results

ECG recordings yielded good quality traces from all 41 cats in the 3 different recumbencies. Although heart rate varied when cats were moved from one position to another, this difference was not found to be statistically significant (P = .07). Similarly, no significant difference was observed in P wave duration (P = .406), P wave amplitude (P = .259), PQ interval (P = .222), QRS duration (P = .386), and QT interval (P = .056) among the 3 recumbencies. Although the differences in these parameters were not statistically significant, the sample size was relatively small. Measurements of R wave amplitude and MEA were significantly different in the 3 different recumbencies (P = .009 and .037, respectively).

In most of the ECG recordings, the R wave amplitude was reduced when cats were moved from RL to ST and LL recumbency. The difference in mean R wave amplitude between RL and ST recumbency was 0.07 mV (95% CI 0.01–0.13 mV, P = .025) and was 0.08 mV (95% CI 0.02–0.14 mV, P = .009) between RL and LL recumbencies. Similarly, the value of the MEA was significantly different between RL and LL recumbency (19.8°, 95% CI 1.28–38.32°, P = .037). No significant difference however was found between RL and ST recumbency (P = .283). The diagram in Figure 1 illustrates the mean and standard deviation of the MEA in the 3 different recumbencies.

Results (mean ± SD) of all ECG parameters measured in this study are shown in Table 2. Values recorded in ST...
Table 2. Mean (±SD) of electrocardiogram parameters recorded from 41 cats in the 3 different recumbencies. Significant differences compared with right lateral recumbency are marked in bold (* P < .05, ** P < .01).

<table>
<thead>
<tr>
<th></th>
<th>Right Lateral Recumbency</th>
<th>Sternal Recumbency</th>
<th>Left Lateral Recumbency</th>
</tr>
</thead>
<tbody>
<tr>
<td>R wave amplitude (mV)</td>
<td>0.54 ± 0.36</td>
<td>0.47 ± 0.38*</td>
<td>0.46 ± 0.31**</td>
</tr>
<tr>
<td>QRS duration (s)</td>
<td>0.03 ± 0.01</td>
<td>0.03 ± 0.01</td>
<td>0.03 ± 0.01</td>
</tr>
<tr>
<td>P wave amplitude (mV)</td>
<td>0.13 ± 0.05</td>
<td>0.14 ± 0.07</td>
<td>0.13 ± 0.06</td>
</tr>
<tr>
<td>P wave duration (s)</td>
<td>0.03 ± 0.01</td>
<td>0.03 ± 0.01</td>
<td>0.03 ± 0.01</td>
</tr>
<tr>
<td>PQ interval (s)</td>
<td>0.07 ± 0.02</td>
<td>0.07 ± 0.01</td>
<td>0.07 ± 0.01</td>
</tr>
<tr>
<td>QT interval (s)</td>
<td>0.17 ± 0.02</td>
<td>0.16 ± 0.03</td>
<td>0.16 ± 0.02</td>
</tr>
<tr>
<td>MEA (degrees)</td>
<td>26.1 ± 77.7</td>
<td>37.3 ± 71.6</td>
<td>45.9 ± 70.2*</td>
</tr>
</tbody>
</table>

and LL recumbency are compared with RL recumbency, which is commonly accepted as the standard reference.

The sensitivity of R wave amplitude in detecting left ventricular enlargement (R wave amplitude > 0.9 mV) was 43% (95% CI 17–69%), 36% (95% CI 11–61%), and 29% (95% CI 5–52%) for RL, ST, and LL recumbencies, respectively. The specificity of increased R wave amplitude indicating left ventricular enlargement was 85% (95% CI 72–99%) for RL and ST recumbencies and 93% (95% CI 83–100%) for LL recumbency. These differences between the sensitivities (RL versus ST P = 1, RL versus LL P = .480) and specificities (RL versus ST P = 1, RL versus LL P = .480) were not statistically significant.

The sensitivity of left axis deviation in detecting left ventricular enlargement (< 90° < MEA < 0°, reference range 0°–160°) was 7% (95% CI 0–21%), 29% (95% CI 5–52%), and 14% (95% CI 0–32%) for RL, ST, and LL recumbencies, respectively. The specificity of MEA in detecting left ventricular enlargement was 74% (95% CI 58–91%), 78% (95% CI 62–93%), and 81% (95% CI 67–96%) for RL, ST, and LL recumbencies, respectively. Similarly, these differences between sensitivities (RL versus ST P = .248, RL versus LL P = 1) and specificities (RL versus ST P = 1, RL versus LL P = .480) were not found to be statistically significant.

Discussion

Good quality electrocardiographic recordings were successfully obtained in all 3 recumbencies, suggesting that body position does not affect the quality of the ECG trace. However, the mean R wave amplitude decreased when ECGs were recorded in ST and LL recumbency when compared with RL recumbency. This result differs from those of a similar study performed in dogs, in which R wave amplitudes were increased when dogs were moved from RL to standing and LL recumbency.4 These results also are in contrast to previous observations in cats that did not identify a significant change in ECG parameters between RL and ST recumbencies.6,8

ECGs usually are recorded when a cardiac condition is suspected, and performance of additional diagnostic tests (e.g., radiography, echocardiography) often is prompted by ECG abnormalities. In particular, increased amplitude of the R wave might indicate left ventricular enlargement, and, in this study, the specificity of this finding in RL recumbency was 85%. Consequently, if the R wave amplitude is decreased in a different position, an important finding suggesting left ventricular enlargement can be missed. However, the sensitivity of the R wave amplitude to detect left ventricular enlargement was rather low in this study (43%), confirming that ECG recordings should not be used as the only method to assess cardiac chamber enlargement. Mean R wave amplitude was lower in ST and LL recumbencies when compared with RL recumbency, and the sensitivity of ECG in providing an indication of left ventricular enlargement is therefore reduced even further (36% for ST, 29% for LL).

Therefore, not only normal cats but also cats with heart disease were included in this study because ECG changes may be more pronounced in the latter group.8 The difference in sensitivities, however, was not found to be statistically significant.

A significant difference also was observed between MEA in RL and LL recumbency (Fig 1; Table 2). The MEA would be expected to shift to the left in ST recumbency and even further to the left in LL recumbency because of the position of the heart moving toward the left side of the chest with these changes in position.4 In this study, however, MEA moved to the right in both ST and LL recumbencies. The sensitivity of left axis deviation detecting left ventricular enlargement was very low in all 3 recumbencies, with no statistical difference among them. Similarly, clinical interpretation of these results should take into account that data were derived from a small population of cats.

External electrical interference, the use of different ECG machines, and the use of different frequency filters also can affect voltages of complexes on the ECG.13 In this study, these potential effects were ruled out by recording all of the ECGs in the same quiet room and with the same ECG machine and the same frequency filter in each instance.

In dogs, changes in forelimb position significantly affect ECG parameters.3,14 This possibility was not investigated in this study. During the recordings, however, attempts were made to keep the position of the forelimbs consistent among the different cats to eliminate this variable. Recording ECGs in ST recumbency could provide more reliable measurements because there is less freedom of forelimb movement than in lateral recumbency.3 This hypothesis, however, has not been investigated, and further studies must be performed in cats to investigate the effects of changes in forelimb positions.

On the basis of the results of this study, ST recumbency still can be considered an acceptable position for recording ECGs to assess rhythm or conduction disturbances in cats. However, when accurate measurement and interpretation of
complex amplitudes and MEA is required, recording ECGs in RL recumbency is preferable.

Footnotes

a Cardiofax ECG-9130K, Nihon Kohden, Tokyo, Japan
b Statistical Package for the Social Sciences 12.0 for Windows (2003); SPSS Inc, Chicago, IL
c Excel, Microsoft Office 2000, Microsoft Corp, Redmond, WA
d Win Episcope 2.0, CLIVE, University of Edinburgh, Edinburgh, Scotland
e Graphpad Quickcalcs, GraphPad Software Inc, San Diego, CA

Acknowledgments

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References