

# Comparison of in-hospital versus 24-hour ambulatory electrocardiography for detection of ventricular premature complexes in mature Boxers

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**Objective**—To evaluate the use of in-hospital electrocardiography (ECG) for detection of ventricular premature complexes (VPC), compared with 24-hour ambulatory ECG.

**Design**—Original study.

**Animals**—188 Boxers > 9 months old; 31 had a history of syncope, and 157 were healthy (no history of syncope).

**Procedure**—In-hospital ECG was performed on all Boxers for at least 2 minutes. Within 7 days after the in-hospital ECG was completed, 24-hour ambulatory ECG was performed.

**Results**—The specificity of in-hospital ECG was 100% for the detection of at least 50 VPC in a 24-hour period in dogs with syncope and 93% in healthy dogs. In-hospital ECG had poor sensitivity, although sensitivity increased as the number of VPC per 24 hours increased.

**Conclusions and Clinical Relevance**—Use of in-hospital ECG is highly specific for detection of at least 50 VPC during a 24-hour period. However, in-hospital ECG is insensitive, and a lack of VPC does not suggest that the dog does not have a substantial number of VPC during that same period. The use of in-hospital ECG appears to be inadequate for screening purposes and therapeutic evaluations in mature Boxers with ventricular arrhythmic disease. (*J Am Vet Med Assoc* 2001;218:222–224)

**E**lectrocardiography (ECG) is a commonly performed technique that is used in many veterinary practices for the detection of arrhythmias. Applications of this technique include peri-anesthetic evaluations, as well as a screening tool for animals with syncope and those suspected of having inheritable arrhythmias and cardiomyopathies.<sup>1-4</sup> In most instances, ECG is performed for only a brief period (1 to 5 minutes), because the animal has to remain restrained and attached to electrodes the entire time. However, many arrhythmias are intermittent and may not be observed when brief in-hospital ECG is performed. It has been proposed that 24-hour ambulatory electrocardiography (AECG), also termed Holter monitor, is more sen-

sitive for detection of intermittent arrhythmias because it allows for evaluation of longer periods and is portable enough that the dog may be returned to its normal environment.<sup>2,5-7</sup> Unfortunately, this technique requires equipment that may be unavailable to many veterinarians or may be too expensive for some clients. Therefore, in some instances, brief in-hospital ECG is performed even though the validity of this technique for detecting intermittent ventricular arrhythmias has not been well evaluated in dogs.

Mature Boxers are often affected with ventricular tachyarrhythmias secondary to familial ventricular arrhythmias (Boxer cardiomyopathy).<sup>1,8-10</sup> In this study, we evaluated the use of in-hospital ECG to detect ventricular premature complexes (VPC) in a large group of Boxers. A 24-hour AECG was obtained after lead-II ECG was performed. The purpose of the study reported here was to determine the ability of in-hospital ECG to detect VPC, compared with 24-hour AECG.

## Materials and Methods

**Dogs**—One hundred eighty-eight mature Boxers were evaluated for the presence of ventricular tachyarrhythmias. Evaluation included a physical examination, in-hospital ECG, and 24-hour AECG, using a 3-channel transthoracic system.<sup>a</sup> Histories were obtained for each dog to determine whether syncopal episodes had been previously detected.

**Electrocardiography**—Dogs were positioned in right lateral recumbency, ECG was performed according to standard technique, and electrical activity was recorded for not < 2 and not > 3 minutes.<sup>11</sup> The presence or absence of VPC was recorded. Ambulatory ECG was performed either immediately after performing in-hospital ECG or within the next 7 days. Each dog was released from the hospital to allow for monitoring of the dog's electrical activity in its normal environment. The monitor was removed after 25 hours.

Analysis of the tapes was performed by a technician under the guidance of a veterinary cardiologist, using a Holter analysis system.<sup>a</sup> Any tapes that did not have at least 20 hours of readable data were excluded. Total number of VPC were tabulated.

**Statistical analyses**—The likelihood of observing VPC detected by use of in-hospital ECG was compared with the likelihood of observing VPC detected by use of AECG. Dogs were grouped on the basis of presence or absence of syncope and according to the number of VPC on the AECG: at least 1 VPC,  $\geq 10$  VPC,  $\geq 50$  VPC,  $\geq 100$  VPC,  $\geq 500$  VPC, and  $\geq 3,000$  VPC/24 hours. The prevalence of dogs with VPC within each group was determined, as well as the positive predictive value of in-hospital ECG, the negative predictive value, and the sensitivity and specificity of the technique for each group. Positive predictive value was determined by dividing

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the number of dogs that had VPC observed on both the in-hospital electrocardiogram and the ambulatory electrocardiogram by the total number of dogs that had VPC observed on the in-hospital electrocardiogram for that group ( $\geq 1$ ,  $\geq 10$ ,  $\geq 50$ ,  $\geq 100$ ,  $\geq 500$ ,  $\geq 3,000$ ). Negative predictive value was determined by dividing the number of dogs that had no VPC detected by use of either technique by the total number of dogs that had no VPC observed on the in-hospital electrocardiogram for that group. Sensitivity was calculated by dividing the number of dogs that had VPC observed on the in-house electrocardiogram by the total number of dogs that had VPC observed on the ambulatory electrocardiogram for that group. Specificity was determined by dividing the number of dogs in which no VPC were observed on the in-hospital electrocardiogram by the total number of dogs that had no VPC observed on the ambulatory electrocardiogram for that group.

## Results

One hundred eighty-eight mature Boxers were evaluated. One hundred fifty-seven Boxers were apparently healthy (no history of syncope), and 31 Boxers had a history of syncope. The age of the dogs ranged from 9 months to 12 years, including both sexually intact and neutered males and females.

The in-hospital ECG had a positive predictive value that ranged from 23 to 100% and a negative predictive value of 26 to 99%. Specificity and sensitivity of the technique were 76 to 100% and 36 to 92%, respectively (Table 1).

Table 1—Comparison of use of in-hospital electrocardiography (ECG) versus ambulatory electrocardiography (AECG) to detect ventricular premature complexes (VPC) in 157 healthy Boxers (ie, no history of syncope)

Variable	No. VPC/24 hours					
	$\geq 1$	$\geq 10$	$\geq 50$	$\geq 100$	$\geq 500$	$\geq 3000$
Prevalence	81%	50%	36%	31%	22%	0.4%
PPV	100%	98%	87%	80%	62%	23%
NPV	26%	70%	84%	87%	95%	99%
Specificity	100%	98%	93%	90%	86%	76%
Sensitivity	36%	58%	68%	75%	82%	92%

Prevalence was defined as the percentage of dogs in the population with the given number of VPC on the AECG. PPV = Positive predictive value, calculated as number of dogs with VPC observed on the in-hospital electrocardiogram and the ambulatory electrocardiogram divided by total number of dogs that had VPC on the in-hospital electrocardiogram for that group. NPV = Negative predictive value, calculated as number of dogs that had no VPC on either electrocardiogram divided by the total number of dogs that had no VPC observed on the in-hospital electrocardiogram for that group. Specificity = Number of dogs in which no VPC were observed on the in-hospital electrocardiogram divided by the total number of dogs that had no VPC observed on the ambulatory electrocardiogram for that group. Sensitivity = Number of dogs that had VPC observed on the in-house electrocardiogram divided by the total number of dogs that had VPC observed on the ambulatory electrocardiogram for that group.

Table 2—Comparison of use of in-hospital ECG versus AECG to detect VPC in 31 Boxers with syncope

Variable	No. VPC/24 hours					
	$\geq 1$	$\geq 10$	$\geq 50$	$\geq 100$	$\geq 500$	$\geq 3000$
Prevalence	94%	81%	74%	55%	39%	19%
PPV	100%	100%	100%	93%	64%	36%
NPV	13%	35%	47%	76%	82%	94%
Specificity	100%	100%	100%	93%	74%	64%
Sensitivity	48%	56%	61%	76%	75%	83%

See Table 1 for key.

The in-hospital ECG had a positive predictive value that ranged from 36 to 100% and a negative predictive value of 13 to 94%. Specificity and sensitivity of the technique were 64 to 100% and 48 to 83%, respectively (Table 2).

## Discussion

Ventricular tachyarrhythmias are one of the cardinal findings in Boxers with familial ventricular arrhythmias.<sup>1,8-10</sup> Clinical signs of affected dogs include those without any signs, those with a history of syncope, and those with congestive heart failure. Some dogs die unexpectedly without evidence of clinical signs. Detection of ventricular arrhythmias that lead to development of clinical signs is important for diagnostic, therapeutic, prognostic, and screening purposes, because there is increasing evidence that the disease is familial.<sup>1,9,12</sup> Documentation of ventricular arrhythmias in an individual dog may be challenging because of the intermittent nature of ventricular arrhythmias. Therefore, AECG has been suggested as the optimal test for detecting ventricular arrhythmias; however, availability and expense of this technique may preclude its use in many dogs.<sup>9</sup> Consequently, many veterinarians may base diagnostic and therapeutic decisions on lead-II ECG performed for only a brief period while the dog is in the hospital.

In many clinical practices, in-hospital ECG is used for detection and evaluation of ventricular arrhythmias caused by acquired cardiac disease, myocarditis, and cardiomyopathy. The importance of ECG for interpretation of arrhythmias is without question. Unfortunately, by their nature, ventricular arrhythmias are intermittent. It has been estimated that a typical 3-minute rhythm strip records approximately 0.2% of total depolarizations that occur during the day; therefore, an arrhythmia would need to occur frequently for detection on a 3-minute rhythm strip.<sup>6</sup> Results of our study suggest that performing brief in-hospital ECG is an insensitive technique for detection of intermittent ventricular arrhythmias. Although it is possible that these findings are specific to the detection of ventricular arrhythmias in Boxers, we believe that these findings are not unique and can be extrapolated to other ventricular arrhythmic diseases. The insensitivity of in-hospital ECG has been suggested previously. In humans, the ability of ECG to detect arrhythmias has been compared with that of AECG in a similar fashion. Electrocardiography performed for < 1 minute was inadequate for detecting an arrhythmia in 30 of 55 humans with syncope in which an arrhythmia was detected by use of AECG.<sup>13</sup> A study in which ventricular arrhythmias were evaluated in dogs after undergoing splenectomy found in-hospital ECG readings to be normal in 100% of dogs that had between 10 and 3,000 VPC/hour and 29% of dogs with > 3,000 VPC/hour when ECG was performed for 1 minute every 6 hours.<sup>3</sup> In another study, performing in-hospital ECG was useful for detection of a causative arrhythmia in only 6% of dogs with syncope.<sup>2</sup>

The goal of our study was to compare 2 methods of arrhythmia detection, but we did not attempt to identify the importance of the arrhythmia relative to

clinical signs. Because the sensitivity of the technique was higher for detection of dogs with a higher number of VPC (> 70% for dogs with  $\geq 500$  VPC/24 hours) and those that were syncopal, it may be argued that the technique may be useful for screening dogs that are severely affected. However, it should be remembered that it has not yet been demonstrated that the number of VPC correlate with severity of disease or risk of unexpected death. Additionally, we did not attempt to evaluate the relationship between detection of VPC by use of ECG and grade of arrhythmia (ie, bigeminy, trigeminy, paroxysms of VPC, etc). Although sensitivity of in-house ECG did increase for dogs with a history of syncope, evaluation of dogs with syncope remains difficult and may also include evaluation with a cardiac event monitor and evaluation for other possible reasons for collapse.

We evaluated the use of in-hospital ECG to detect notable ventricular tachyarrhythmias in Boxers. Performing brief in-hospital ECG has reasonable specificity but poor sensitivity. The presence of VPC on the electrocardiogram should be a strong indication for additional evaluation of the dog. However, the lack of VPC on an electrocardiogram does not imply that VPC do not occur during the rest of the day. Sensitivity of the technique does increase as the prevalence of VPC increases (92% for dogs with > 3,000 VPC/24 hours, compared with 58% for dogs with > 50 VPC/24 hours) or when dogs with syncope are evaluated (61% for dogs with syncope with > 50 VPC/24 hours).

<sup>a</sup>Delmar Accuplus 363 Holter analysis system, Delmar Medical Systems, Irvine, Calif.

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