Ambulatory electrocardiographic evaluation of clinically normal adult Boxers

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Objective—To determine the prevalence of ventricular arrhythmias in clinically normal adult Boxers.

Design—Prospective cross-sectional study.

Animals—301 Boxers (181 females and 120 males) > 1 year old with echocardiographically normal systolic function and no history of syncope or congestive heart failure.

Procedures—Physical examination, which included echocardiography, was performed on all dogs. A 24-hour ambulatory ECG was performed on each dog, and results were evaluated to assess ventricular arrhythmias. Statistical evaluation was performed to determine correlations between the total number of ventricular premature complexes (VPCs)/24 h, grade of ventricular arrhythmia, and age of the dogs.

Results—Age of dogs ranged from 1 to 16 years (median, 4 years). Number of VPCs/24 h in each dog ranged from 0 to 62,622 (median, 6 VPCs/24 h). Grade of arrhythmias ranged from 0 to 3 (median, 1). Age was correlated significantly with number of VPCs/24 h (r = 0.43) and with grade of arrhythmia (r = 0.37). Number of VPCs/24 h was significantly correlated with grade of arrhythmia (r = 0.82).

Conclusions and Clinical Relevance—Clinically normal adult Boxers generally had < 91 VPCs/24 h and an arrhythmia grade < 2. Boxers with > 91 VPCs/24 h were uncommon and may have represented dogs with arrhythmogenic right ventricular cardiomyopathy or other disease processes that could have resulted in the development of ventricular arrhythmias. (*J Am Vet Med Assoc* 2010;236:430–433)

Boxers are one of the most commonly reported breeds of dogs in which ARVC is diagnosed.[1] Previously termed Boxer cardiomyopathy, ARVC in Boxers is inherited in an autosomal dominant pattern and may result in sudden death or the development of congestive heart failure.[1,2] There is no single test that provides a definitive diagnosis of ARVC. Instead, the diagnosis is defined by a combination of findings, which include postmortem histologic detection of fibrofatty replacement of myocardium in the right ventricle (and sometimes interventricular septum and left ventricle), ventricular tachyarrhythmias, syncope or exercise intolerance, and a possible history of familial disease.[1,3] Ventricular tachycardia and VPCs are hallmark features of ARVC. Electrocardiographic evaluation to detect and assess the severity of ventricular arrhythmias is one of the tests most commonly used in the diagnosis of ARVC.[3] Because ventricular arrhythmias can be quite intermittent, ECG screening to detect ventricular tachyarrhythmia is best performed by use of ambulatory ECG (Holter monitor), whereby analysis of number, morphology, and severity of ventricular arrhythmias can be quantified within a 24-hour period.[4–7] Clinicians use this information to make an antemortem diagnosis of ARVC in adult Boxers, although strict criteria for affected and unaffected status have not been determined.

Abbreviations

ARVC	Arrhythmogenic right ventricular cardiomyopathy
VPC	Ventricular premature complex

In other studies,[5,7,8] apparently healthy dogs of various breeds had infrequent, typically monomorphic VPCs in a 24-hour period. However, similar data for clinically normal Boxers has not been reported. The purpose of the study reported here was to determine the prevalence of ventricular arrhythmias in a population of clinically normal Boxers.

Materials and Methods

Animals—Boxers > 1 year old were prospectively recruited for participation in a study to evaluate the clinical aspects of ARVC. Physical examination and echocardiography were performed. Dogs with a history of syncope or signs consistent with congestive heart failure were ex-

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cluded. Additionally, dogs with echocardiographic abnormalities suggestive of congenital heart disease or dilated cardiomyopathy (ventricular dilation or fractional shortening < 20%) were excluded. This study was conducted under the guidelines of the Animal Care and Use Committee of The Ohio State University. Written consent authorizing study participation was obtained from each client.

Ambulatory ECG—A 24-hour ambulatory ECG was obtained by use of a 3-channel transthoracic system.[a] The monitor was placed, and the dog was discharged to the owner to allow monitoring of the dog's cardiac electrical activity in its home environment. The owners were encouraged to maintain the dog's typical amount of activity, and the monitor was removed after 25 hours. A technician using a prospective, user-interactive method[b] analyzed the monitor tapes under the guidance of a veterinary cardiologist, who used a Holter analysis system.[b] Any tapes that did not have at least 20 hours of readable data were excluded. The total number of VPCs/24 h was tabulated, and ventricular arrhythmias were graded as follows: 0 = none; 1 = single, monomorphic VPCs; 2 = couplets, bigeminy, trigeminy, and multiform VPCs; and 3 = triplets, R-on-T, or ventricular tachycardia. The highest grade detected was the grade assigned.

Statistical analysis—Ranges and medians were determined for the number of VPCs/24 h, grade of arrhythmia, and age of the dogs. The 25th, 75th, 90th, 95th, and 99th percentiles of VPCs/24 h and the 25th and 75th percentiles of arrhythmia grade were calculated. Nonparametric analysis was performed because the data were not normally distributed. A Spearman correlation was performed by use of commercial software[c] to determine relationships between number of VPCs/24 h and age, arrhythmia grade and age, and number of VPCs/24 h and arrhythmia grade. Results were considered significant at $P < 0.05$.

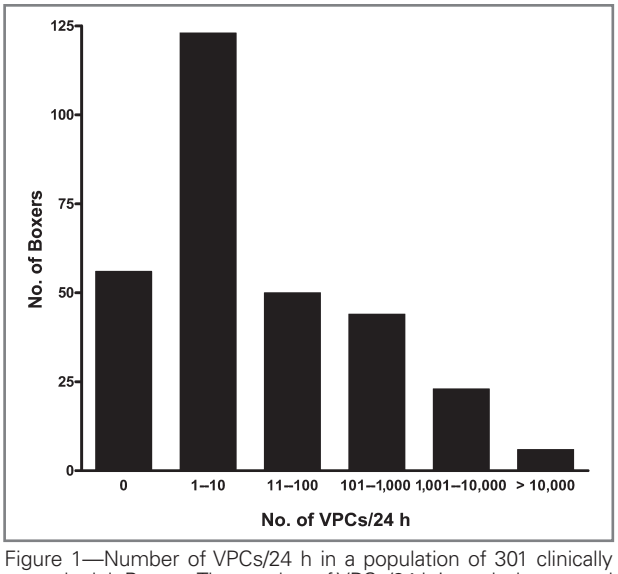


Figure 1—Number of VPCs/24 h in a population of 301 clinically normal adult Boxers. The number of VPCs/24 h in each dog ranged from 0 to 62,622.

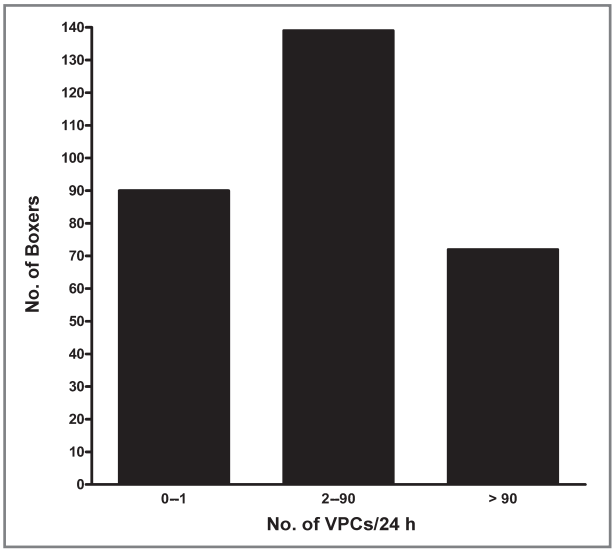
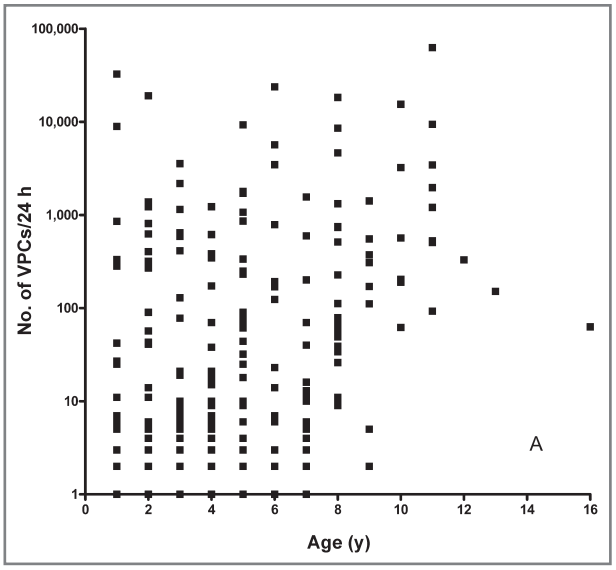


Figure 2—Number of VPCs/24 h in a population of 301 clinically normal adult Boxers as determined by the 25th (1 VPC/24 h) and 75th (91 VPCs/24 h) percentiles.



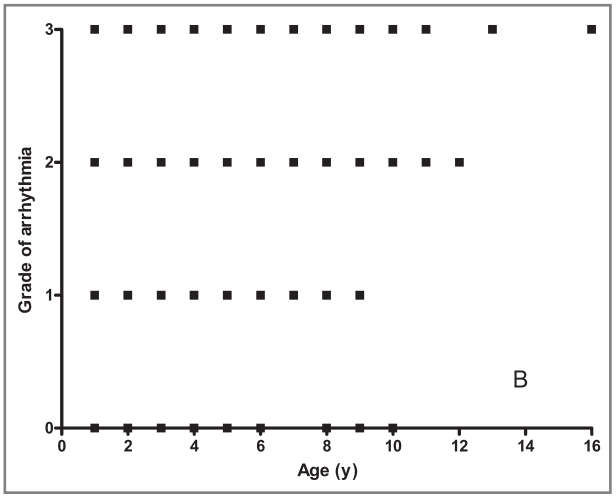


Figure 3—Graphs depicting the age of dogs and number of VPCs/24 h (A) and age of dogs and grade of arrhythmia (B) for 301 clinically normal adult Boxers. Age was significantly ($P < 0.001$) correlated with number of VPCs/24 h ($r = 0.43$) and with grade of arrhythmia ($r = 0.37$). Grade of arrhythmia was scored on a scale of 1 to 3 (0 = none; 1 = single, monomorphic VPCs; 2 = couplets, bigeminy, trigeminy, and multiform VPCs; and 3 = triplets, R-on-T, or ventricular tachycardia).

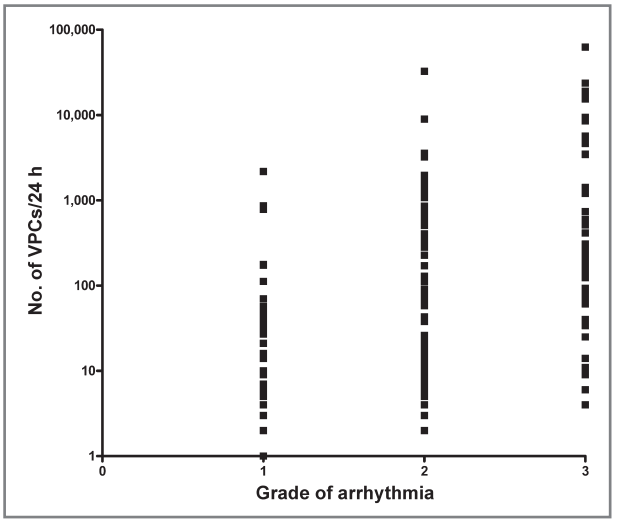


Figure 4—Semilogarithmic graph depicting the number of VPCs/24 h and the grade of arrhythmia for 301 clinically normal adult Boxers. Number of VPCs/24 h was significantly ($P < 0.001$) correlated with grade of arrhythmia ($r = 0.82$). *See* Figure 3 for remainder of key.

Results

Of 410 Boxers evaluated, 301 met the inclusion criteria for the study. This included 181 females (132 sexually intact and 49 spayed) and 120 males (91 sexually intact and 29 neutered). Age ranged from 1 to 16 years (median, 4 years). Number of VPCs/24 h in each dog ranged from 0 to 62,622 (median, 6 VPCs/24 h; 95% confidence interval, 363 to 1,432 VPCs/24 h; **Figure 1**). The 25th and 75th percentiles were 1 and 91 VPCs/24 h, respectively **(Figure 2)**. The 90th, 95th, and 99th percentiles were 854, 3,444, and 19,037 VPCs/24 h, respectively. Grade of arrhythmia ranged from 0 to 3, with a median score of 1 (single, monomorphic VPCs). The 25th and 75th percentiles of arrhythmia grades were 1 and 2, respectively.

Age of dogs was significantly ($P < 0.001$) correlated with number of VPCs/24 h ($r = 0.43$) and significantly ($P < 0.001$) correlated with grade of arrhythmia ($r = 0.37$; **Figure 3**). Number of VPCs/24 h was significantly ($P < 0.001$) correlated with grade of arrhythmia ($r = 0.82$; **Figure 4**).

Discussion

The objective of the study reported here was to determine the prevalence of ventricular arrhythmias in a population of clinically normal adult Boxers. Assessment of the results indicated that some clinically normal Boxers have high degrees of arrhythmia with regard to both frequency and grade. However, this appears to be uncommon because < 25% of the Boxers evaluated had > 91 VPCs/24 h or a grade 3 arrhythmia.

Twenty-five percent of the population had > 91 VPCs/24 h, and an increase in the number of VPCs/24 h was correlated with an increase in grade. It is possible that these findings revealed a normal breed variation, but this appears unlikely given that a study[5] of 50 (body weight, 18.2 to 40.9 kg [40 to 90 lb]) dogs of a variety of breeds identified a mean of 2 VPCs/24 h. None of the dogs in that study had more than 24 VPCs/24 h. Therefore, it may be more likely that dogs in the present study that had > 91 VPCs/24 h may have had an occult form of ARVC or some other myocardial or systemic disease that resulted in the development of VPCs. Both number of VPCs/24 h and grade of arrhythmia were correlated with age. These findings are also supportive of the possibility that these dogs had an occult form of ARVC because this is an adult onset disease and the likelihood of clinical signs (ie, VPCs) may be higher in older dogs.

Unfortunately, without a myocardial sample from each dog for histologic analysis, it is not possible to confirm the diagnosis of ARVC. The Boxers selected for the study were clinically normal and client-owned dogs, and it was difficult to justify the risk associated with performing an endomyocardial biopsy in this population. However, the lack of histologic information on these dogs is a limitation of the study. The arrhythmias in these dogs could have been from some other underlying cause; older dogs are more likely to have age-associated diseases, such as cardiac or splenic neoplasia, that could result in cardiac arrhythmias.

Another limitation of the study is the lack of complete information on the clinical outcome of the dogs. However, long-term follow-up monitoring of the dogs in this study is ongoing.

The relative difficulty of diagnosing the occult form of ARVC places high clinical utility on any single test that can aid in inclusion or exclusion of ARVC from the list of differential diagnoses. Screening tests are of particular importance when considering the potential for breeding Boxers that may have this familial disease. Although at least some cases of ARVC in Boxers appear to be of familial origin, a genetic mutation responsible for the development of ARVC in Boxers has not been identified, and many breeders have become reliant on annual screening of adult Boxers via an ambulatory ECG.[2] However, strict criteria for the diagnosis of ARVC in Boxers are lacking, particularly in clinically normal dogs. Analysis of the results of this study suggests that it is uncommon for clinically normal adult Boxers to have > 91 VPCs/24 h or grade 2 or higher arrhythmia grades (ie, couplets, triplets, ventricular tachycardia, or R-on-T phenomenon). This does not mean that any adult Boxer with > 91 VPCs/24 h, higher grades of arrhythmia, or both has overt ARVC. It does suggest that Boxers with > 91 VPCs/24 h should be carefully evaluated to determine the cause of the ventricular arrhythmias, which may include a diagnosis of ARVC.

This study was not intended to develop strict ECG criteria for the diagnosis of an overt form of ARVC. Instead, it was intended to provide baseline information on the number and severity of ventricular arrhythmias in a population of clinically normal adult Boxers. Further analysis of the clinical outcome of the dogs in the study reported here is ongoing and may eventually provide specific ECG criteria that could be used for a more definitive diagnosis of the occult form of ARVC.

a. Delmar Reynolds CardioCorder, model 459, Delmar Medical Systems, Irvine, Calif.
b. Delmar Avionics software for Accuplus 363 Holter analysis system, Delmar Medical Systems, Irvine, Calif.
c. Prism 4, GraphPad Software Inc, La Jolla, Calif.

References

1. Basso C, Fox PR, Meurs KM, et al. Arrhythmogenic right ventricular cardiomyopathy causing sudden cardiac death in Boxer dogs. *Circulation* 2004;109:1180–1185.

2. Meurs KM, Spier AW, Miller MW, et al. Familial ventricular arrhythmias in Boxers. *J Vet Intern Med* 1999;13:437–439.
3. Harpster NK. Boxer cardiomyopathy. In: Kirk RW, ed. *Current veterinary therapy VIII: small animal practice*. Philadelphia: WB Saunders, 1983;329–337.
4. Meurs KM, Spier AW, Wright NA, et al. Comparison of in-hospital versus 24-hour ambulatory electrocardiography for detection of ventricular premature complexes in mature Boxers. *J Am Vet Med Assoc* 2001;218:222–224.
5. Meurs KM, Spier AW, Hamlin RL, et al. Use of ambulatory electrocardiography for detection of ventricular premature complexes in healthy dogs. *J Am Vet Med Assoc* 2001;218:1291–1292.
6. Spier AW, Meurs KM. Evaluation of spontaneous variability in the frequency of ventricular arrhythmias in Boxers with arrhythmogenic right ventricular cardiomyopathy. *J Am Vet Med Assoc* 2004;224:538–541.
7. Hall LW, Dunn JK, Delaney M, et al. Ambulatory electrocardiography in dogs. *Vet Rec* 1991;129:213–216.
8. Ulloa HM, Houston BJ, Altrogge DM. Arrhythmia prevalence during ambulatory electrocardiographic monitoring of Beagles. *Am J Vet Res* 1995;56:275–281.

From this month's *AJVR*

Evaluation of the analgesic effect of intracameral lidocaine hydrochloride injection on intraoperative and postoperative pain in healthy dogs undergoing phacoemulsification

Shin Ae Park et al

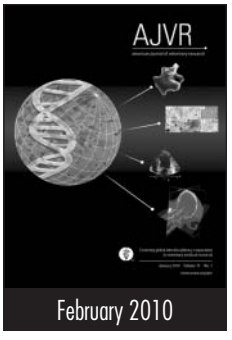
Objective—To evaluate the intraoperative and postoperative analgesic effects of intracameral lidocaine hydrochloride injection in dogs undergoing phacoemulsification.

Animals—12 healthy Beagles with healthy eyes.

Procedures—Dogs were randomly assigned to receive 1 of 2 intracameral injections: 2% lidocaine hydrochloride solution (0.3 mL) or an equivalent amount of balanced salt solution (BSS). All dogs were treated with acepromazine (0.05 mg/kg, IV) and cefazolin (30 mg/kg, IV), and tropicamide drops were topically applied to the eyes. Anesthesia was induced with propofol and maintained with isoflurane. The initial end-tidal isoflurane concentration was maintained at 1.2%. Heart rate, respiratory rate, arterial blood pressure, esophageal temperature, inspired and end-tidal isoflurane concentrations, and oxygen saturation were recorded every 5 minutes. The allocated agent was injected intracamerally after aspiration of the same volume of aqueous humor. Ten minutes after injection, phacoemulsification was performed. After surgery began, the isoflurane concentration was adjusted according to heart rate and mean arterial blood pressure. Pain scores were recorded before surgery and at 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 6, 8, 16, and 24 hours after extubation.

Results—Isoflurane requirements were significantly higher in the BSS group than in the lidocaine group. Mean ± SD time to administration of supplementary analgesia was significantly shorter in the BSS group (1.4 ± 1.2 hours) than in the lidocaine group (4.9 ± 1.2 hours).

Conclusions and Clinical Relevance—Intracameral lidocaine injection had significant analgesic effects in dogs undergoing cataract surgery. Results of this study suggest the value of intracameral lidocaine injection as an analgesic for intraocular surgery in dogs. (*Am J Vet Res* 2010;71:216–222)



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