

P-WAVE DISPERSION IN PREDICTION OF MAINTENANCE OF SINUS RHYTHM AFTER AN ELECTRICAL CARDIOVERSION OF ATRIAL FIBRILLATION IN DOGS

AGNIESZKA NOSZCZYK-NOWAK

Department of Internal Medicine and Clinic of Diseases of Horses, Dogs and Cats,
 Faculty of Veterinary Medicine, University of Environmental and Life Science, 50-366 Wrocław, Poland
 agnieszkann@poczta.onet.pl

Received: September 3, 2011

Accepted: January 27, 2012

Abstract

The aim of this study was to demonstrate the diagnostic accuracy of P-wave dispersion in predicting recurrence of atrial fibrillation in dogs with sinus rhythm restoration after external cardioversion. The study was performed on 15 dogs, which underwent electrical external cardioversion after atrial fibrillation. Nine-lead surface electrocardiogram of each dog was recorded 1 min after the cardioversion process to measure the P-wave duration. Dogs with recurrent atrial fibrillation had significantly higher P-wave dispersion compared to dogs that had a sinus rhythm lasting more than 3 months (9.26 ± 2.01 ms vs 20.9 ± 2.18 ms, $P=0.001$). This study suggests that P-wave dispersion analysis in dogs after a successful external electrical cardioversion has diagnostic accuracy to predict the recurrence of atrial fibrillation.

Key words: dog, P-wave dispersion, arrhythmia, atrial fibrillation, cardioversion.

Atrial fibrillation (AF) is the most common type of arrhythmia in dogs (2, 11, 14). AF is mainly recorded in dogs with organic heart diseases such as dilated cardiomyopathy and advanced degenerative valvular and congenital heart diseases (11). However in large dog breeds, atrial fibrillation is recognised without any existing organic heart disease (lone AF) (14). In such cases, atrial fibrillation will lead to a deterioration of the dog, will worsen its exercise endurance, and might contribute to tachycardiomyopathy and thrombo-embolic complications (13, 14). Among different methods to restore the sinus rhythm, pharmacological and electrical cardioversion are used although some AF recurrences may occur. It is well known that the longer atrial fibrillation lasts and the bigger the atrium, the smaller chances are that the sinus rhythm will be retained after cardioversion (2). However, dogs with short events of atrial fibrillation and with normal atrial size also show AF recurrences, therefore specific indicators are sought to predict the risk of AF recurrence after electrical cardioversion. P-wave dispersion (Pd) is a simple electrocardiographic marker, which has been reported to be associated with inhomogeneous and discontinuous propagation of sinus impulses (4, 10). Its usefulness as a predicting marker of AF recurrence after cardioversion has not been evaluated. The present study is a continuation of research done on P-wave dispersion in dogs (9, 10).

The aim of this study is to demonstrate the diagnostic usefulness of Pd in predicting recurrence of

atrial fibrillation in dogs with sinus rhythm restoration after external electrical cardioversion.

Material and Methods

An observational prospective study was performed on 15 dogs, of various breeds (five Bernardines, three German Sheppards, three Tatra Mountain Sheepdogs, one Great Dane, one Boxer, one American Stafford, and one mixed-breed dog), weighing 65 kg, and aged from 1 to 7 years. The group consisted of 12 males and three females. The animals were qualified based upon earlier investigation, preliminary clinical examination and morphological and biochemical blood analysis (AST, ALT, urea, creatinine, Na^+ , K^+ , Ca^{2+} , Mg^{2+} , Cl^-). All dogs underwent a routine transthoracic echocardiographic examination (Aloka 4000+), with a 5 MHz and 7.5 MHz sector probe. Left atrial (LA) diameter and LA/aorta ratio, left ventricular end-diastolic (LVIDd) and end-systolic diameters (LVIDs), left ventricular ejection fraction (LVEF) and left ventricular shortening fraction (FS) were determined before cardioversion. Dogs with normal size heart cavities and without disorders in morphological and biochemical blood tests were qualified for electrical cardioversion. A depression of the left ventricle's contractility (LVEF and FS) was acceptable due to lack of mechanical activity of the atria during AF. Electrical cardioversion was performed under general sedation

(infusion of butorphanol 1 mg/kg + metedomidine 25 µg/kg m.c.). Sinus rhythm was restored with a bi-phase impulse (70 -360 J).

All dogs underwent ECG in right lateral position using a BTL SD08 equipped with net filter and different frequencies of muscular filters. A nine-lead (I, II, III, IV, aVR, aVL, aVF, V₁, V₂, V₄) surface electrocardiogram was recorded for each dog 5 min after the effective external cardioversion to measure the P-wave duration. The onset of the P-wave was defined as the junction between the isoelectric line and the beginning of the P-wave deflection and the offset of the P-wave as the junction between the end of the P-wave deflection and the isoelectric line. Pd was defined as the difference between maximum and minimum P-wave duration. The assessment was done by means of electronic markers on the computer screen after a 200 times enlargement of the ECG recording. In every evaluated lead the duration of P-wave was measured as a distance between the onset and the offset with precision up to 1 ms. The dispersion of P-waves was calculated as the difference between P max and P min and then the average from five measurements was obtained (9, 10). The study period was limited to 3 months after conversion to a sinus rhythm. Control electrocardiograms were performed routinely once

during every month. ECGs were used to document AF recurrence.

Statistical analysis was performed using a Mann-Whitney U test. Pearson correlation analysis was used to analyze the relationship of AF recurrence with Pd and echocardiographic variables. Differences were considered statistically significant if the P value was <0.05. Statistical analysis was based on STATISTICA programme, version 7.1.

Results

Recurrent AF was observed in nine dogs (60%) between 2 and 35 d. There was no difference between groups of dogs with and without AF recurrence in terms of gender, lone AF and LA/aorta ratio, LVEF and FS. There was no significant difference between the two groups in terms of the type of medications used after cardioversion (Table 1).

Pd of dogs with recurrent AF was found to be significantly higher (20.9 ± 2.18 ms) than in those, which continued to have a regular sinus rhythm (9.26 ± 2.01 ms) ($P=0.001$) (Fig. 1). There was a positive correlation between the increase in Pd and the risk of AF recurrence ($r=0.85$, $P<0.05$). No correlations between AF recurrence and echocardiographic variables were noted.

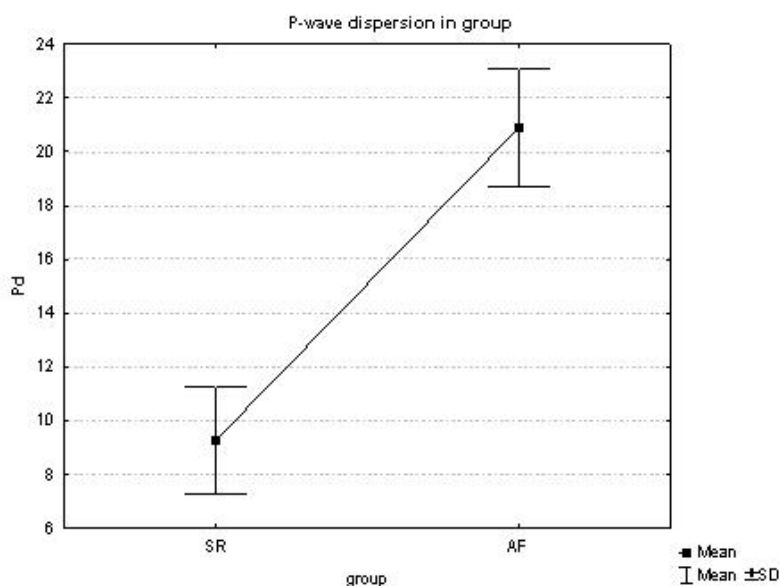


Fig. 1. Mean of P-wave dispersion in observed group of dogs ($P=0.001$). Pd - P-wave dispersion, SR-sinus rhythm, AF-atrial fibrillation recurrence.

Table 1
Characteristics of the studied group of dogs

Parameter	Sinus rhythm group (n=6)	Atrial fibrillation recurrence group (n=9)
Age (years)	4.0±1.4	4.2±2.1
Body mass (kg)	47.8±16.2	49.0±12.65
Males	5	7
LA/aorta	1.25±0.11	1.3±0.16
LVIDd (mm)	53.0±5.2	54.0±4.9
LVIDs (mm)	38.9±3.6	39.8±4.6
LVEF (%)	36.5±14.2	34.1±16.2
FS (%)	21.0±8.9	22.0±11.2

LA/aorta- left atrium/aorta ratio, LVIDd- left ventricular end-diastolic diameter, LVIDs left ventricular end-systolic diameter, LVEF - left ventricular ejection fraction, FS- left ventricular shortening fraction, Pd- P-wave dispersion.

Discussion

Electrical cardioversion is a non-pharmacological way of treating AF. It was introduced to human medicine by Lown *et al.* (8) in 1962. Six years later, Zoll *et al.* (15) performed the first electrical defibrillation. In the 90's, electrical cardioversion started to be used in veterinary medicine (2). External electrical cardioversion is based on the liberation of an electrical impulse that is synchronised with the internal heart activity based on recordings of the R wave in ECG by the cardioverter defibrillator. This method brings certainty that the electrical stimulus will not occur during the rapid repolarisation phase, 60-80 ms before and 20-30 ms after the peak of the T-wave. The procedure in humans and animals is always performed under general anesthesia (2, 12). In veterinary medicine, in spite of the availability of electrical cardioversion, the strategy of controlling the ventricles' rhythm during AF is selected more often, because most affected animals show numerous other concurring problems associated with the underlying heart disease (6). However, there is a group of dogs, especially of large and giant breeds, that show atrial fibrillation without any coexisting heart disease (lone AF). These are good candidates for electrical cardioversion, especially if the atrial fibrillation does not last for a long time and no heart cavern enlargement is noticed. Bright *et al.* (2) concluded that along with the duration of AF in dogs, the risk of arrhythmia recurrence after cardioversion increases due to electrical remodelling that is initiated by AF, one of the self maintaining mechanism of the arrhythmia (1, 13). The rapid atrial rate during AF decreases the ionic current density of transient outward K^+ current, L-type Ca^{2+} current, and Na^+ current, thereby altering cardiac electrophysiology, and promoting arrhythmia maintenance (16). Based on the performed studies, 60% of dogs that had no organic heart diseases and lack of left atrium enlargement had an AF recurrence after electrical cardioversion, similar to humans (5).

Pd in dogs that had an AF recurrence was significantly higher than in dogs that had a sinus rhythm longer than 3 months. Pd in dogs that had an AF recurrence was also higher than in healthy dogs (16.8 ± 3.51) (10). Similarly people that had an AF recurrence after cardioversion had a higher Pd compared to people with a normal sinus rhythm (5, 12). Pd is more dependent on the disturbances in the inter and intra ventricular conduction and inhomogeneous impulse propagation, and independent on atrium enlargement (5, 10). Inhomogeneous impulse propagation within the atria favours the recurrence of AF and its maintenance (1). The presence of pulmonary vein potentials is also important (3, 7). Pulmonary veins have arrhythmogenic ability through spontaneous activities or high-frequency irregular rhythms. The higher incidence of spontaneously occurring high-frequency irregular rhythms in dogs may account for the increased risk of atrial fibrillation in these dogs (3).

Pulmonary vein potentials are detectable only during an invasive electrophysiological examination. Electrophysiological studies performed by Hocini *et al.* (7) on perfused dog hearts showed that zones of activation-delay correlating with histological assessment of myofiber arrangement and distribution are prominent in canine pulmonary veins. These results suggest that a microreentry mechanism could occur or promote the exit of activation from a focal source.

In humans, P max plays a major role as a predictive index in AF recurrence; however, in dogs P max depends on the body mass. Along with the enlargement of the heart caverns, the size of the atria also increases leading to an increase in P max and P min, although the P max/P min ratio stays constant. For this reason there are no significant differences in Pd in spite of differences in body mass of healthy dogs (10). Despite information that the increased size of the atrium significantly increases the risk of atrial fibrillation recurrence, in the present study no correlation between the size of the left atrium and AF recurrence was noted.

The results of this study suggest that the size of the atrium in dogs without organic heart disease has little meaning in the recurrence of AF after electrical cardioversion in comparison to the inhomogeneous intraatrial conduction, which is visualised by high values of Pd. The presented results suggest that P-wave dispersion has diagnostic accuracy for predicting the recurrence of atrial fibrillation after cardioversion in dogs without organic heart diseases. The small sample size and the unavailability of data about definite duration of an AF before external cardioversion are the main limitations of the study.

In conclusion, the obtained results suggest that P-wave dispersion analysis after external electrical cardioversion in dogs is an inexpensive, noninvasive, and simple method, which has diagnostic accuracy to predict the recurrence of atrial fibrillation after the restoration of the sinus rhythm.

References

1. Allesie M., Boyden P., Camm A., Kleber A., Lab M., Legato M., Rosen M., Schwartz P., Spooner P., van Wagoner D., Waldo A.: Pathophysiology and prevention of atrial fibrillation. *Circulation* 2001, **103**, 769-777.
2. Bright J.M., zumBrunner J.: Chronicity of atrial fibrillation affects duration of sinus rhythm after transthoracic cardioversion of dogs with naturally occurring atrial fibrillation. *J Vet Intern Med* 2008, **22**, 114-119.
3. Chen Y.J., Chen S.A., Chang M.S., Lin C.I.: Arrhythmogenic activity of cardiac muscle in pulmonary veins of the dog: implication for the genesis of atrial fibrillation. *Cardiovasc Res* 2000, **48**, 265-273.
4. Dilaveris P.E., Gialafos E.J., Andrikopoulos G.K., Richter D.J., Papanikolaou V., Poralis K., Gialafos J.E.: Clinical and electrocardiographic predictors of recurrent atrial fibrillation. *Pacing Clin Electrophysiol* 2000, **23**, 352-358.
5. Dogan A., Kahraman H., Ozturk M., Avsar A.: P wave dispersion and left atrial appendage function for predicting recurrence after conversion of atrial fibrillation

- and relation of P wave dispersion to appendage function. Echocardiography. 2004, **21**, 523-530.
6. Gelzer A.R., Kraus M.S.: Management of atrial fibrillation. Vet Clin North Am Small Anim Pract 2004, **34**, 1127-1144.
 7. Hocini M., Ho S.Y., Kawara T., Linnenbank A.C., Potse M., Shah D., Jaïs P., Janse M.J., Haïssaguerre M., De Bakker J.M.: Electrical conduction in canine pulmonary veins: electrophysiological and anatomic correlation. Circulation 2002, **105**, 2442-2448.
 8. Lown B., Amarasingham R., Neuman J.: New method for terminating cardiac arrhythmias. J Am Med Assoc 1962, **182**, 548-555.
 9. Noszczyk-Nowak A., Paławska U., Szałas A., Nicpoń J.: P-wave dispersion in healthy dogs. A preliminary study. Bull Vet Inst Pulawy 2008, **52**, 683-688.
 10. Noszczyk-Nowak A., Szałas A., Paławska U., Nicpoń J.: Comparison of P-wave dispersion in healthy dogs, dogs with chronic valvular disease, and dogs with disturbances of supraventricular conduction. Acta Vet Scand 2011, **53**, 18.
 11. Noszczyk-Nowak A., Paławska U., Zyśko D., Gajek J., Nicpoń J., Hebel M.: Atrial fibrillation in dogs. Medycyna Wet 2008, **64**, 686-689.
 12. Perzanowski C., Ho A.T., Jacobson A.K.: Increased P-wave dispersion predicts recurrent atrial fibrillation after cardioversion. J Electrocardiol 2005, **38**, 43-46.
 13. Shi Y., Ducharme A., Li D., Gaspo R., Nattel S., Tardif J.C.: Remodeling of atrial dimensions and emptying function in canine models of atrial fibrillation. Cardiovasc Res 2001, **52**, 217-225.
 14. Takemura N., Nakagawa K., Hirose H.: Lone atrial fibrillation in a dog. J Vet Med Sci 2002, **64**, 1057-1059.
 15. Zoll P., Linenthal A., Gibson W.: Termination of ventricular fibrillation in man by externally applied electric countershock. N Engl J Med 1956, **254**, 727-732.
 16. Yue L., Melnyk P., Gaspo R., Wang Z., Nattel S.: Molecular mechanisms underlying ionic remodeling in a dog model of atrial fibrillation. Circ Res 1999, **84**, 776-784.