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THE ELECTROCARDIOGRAPHIC CURVE OF CLINICALLY HEALTHY DOGS OF SELECTED BREEDS

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ABSTRACT

The aim of this elaboration is an attempt to specify in detail the electrocardiographic curve for clinically healthy dogs representing 9 selected purpose breeds.
All examined dog breeds were subdivided into three purpose groups:
I. Defensive dogs (Rottweiler, German sheepdog, Bull terrier), II. Hunting dogs (German pointer, Bloodhound Dachshund) and III. Draught dogs (Alaskan malamut, Siberian husky, Samoyed). The following conclusions may be drawn:

1. Heart action frequency of examined dogs was on average 131 beats per minute.
2. The most significant factor influencing the electrocardiographic curve morfology is the dog breed.
3. Affiliation to the purpose group, age, conditions of examinations influenced only some of EKG curve components.
4. Effects of animal sex and size on the EKG curve parameters were not found.

Key words: Electrocardiographic curves, dogs

INTRODUCTION

Electrocardiography is a measurement method of heart action current used in medicine from 1912 and in veterinary medicine - from 1913 (12). Since that time, this method has been recognized as one of the basic and most valuable methods of heart diagnostics due to its numerous advantages such as an easiness and short duration of examination, its non-invasiveness, painless, stressless way of recording, comparability and objectiveness of obtained results, their accuracy and specificity.

At present, together with the development of techniques, new diagnostic methods are created and developed, such as vectorcardiography, stereocardiography, ballistocardiography, one- and two-dimensional echocardiography, echocardiography based on the Doppler effect, computer tomography, coronarography, magnetic resonance and cardiac catheterisation (19). However, these methods have not depreciated the importance of electrocardiography being the sole effective method enabling to state the presence and to determine the specific character of heart arrhythmia. The value of this kind of examination has even a broader range because this method enables to suspect the presence of other heart diseases, e.g. megalocardia or enlargement of particular heart parts, the presence of innate heart position and structure anomalies, the presence of transudates or exudates in pericardial or preural cavities and even systemic diseases, e.g. uraemia, thyroid gland dysfunction or electrolyte disturbances (29,30).Thus, it may be stated that this a useful examination allowing to recognize the character of the patient's disease quickly and at a relatively low cost, being totally irreplaceable in the diagnostics of circulatory system insufficient function.

The electrocardiographic record is a graphical record of heart electric action, performed on the base of the difference of potentials measured on the skin surface. Electrodes are placed on strictly determined body spots as it is described in "Standards for canine cardiography", The Academy of Veterinary Cardiology Committee Report, 1977 (32) which enables to compare the results. Electrocardiography is currently a very popular method used in the veterinary medicine, especially in the treatment of horses and small animals, where it also has the greatest economic justification.

The aim of this elaboration is an attempt to specify in detail the electrocardiographic curve for clinically healthy dogs representing 9 selected purpose breeds.

Besides, efforts were made to find out whether there exist characteristic features of the electrocardiographic record for particular breeds, purpose dog groups, generic lines, sex, age, kind of use and EKG record realisation conditions. It was also important to determine whether those differences influenced the record interpretation considerably, and whether they concerned the whole curve or only its components.

An attempt was also made to establish whether record changes were connected with anatomical anomalies, whether the records changed under the influence of physical exercise, or whether the changes occurred with the lapse of time, and if they abated under the influence of atropine..

MATERIALS AND METHODS

The investigation was planned and carried out in two stages:

I. The preliminary stage comprised the electrocardiographic examination of pure-bred dogs. In this part of the research, 369 determinations for dogs representing 44 breeds were conducted. After the preliminary analysis of obtained results, 9 dog breeds were selected to enter the second stage because they had demonstratedcharacteristic changes in the curve, e.g. in case of Samoyed breed, or the lack of supposed changes e.g. in case of the bull terrier or because of a specific body size, such as. in case of the German sheepdog and dachshund.

II. The basic stage included the electrocardiographic examination of 487 clinically healthy dogs of selected breeds: Alaskan malamut, Siberian husky, Samoyed, German sheepdog, rottweiler, bull terrier, German pointer, bloodhound, dachshund.

All examined dog breeds were subdivided into three purpose groups:

Group I	Defensive dogs	171	1. Rottweiler	62
			2. German sheepdog	63
			3. Bull terrier	46
Group II	Hunting dogs	145	4. German pointer	44
			5. Bloodhound	49
			6. Dachshund	52
Group III	Draught dogs	171	7. Alaskan malamut	77
			8. Siberian husky	65
			9. Samoyed	29

Before commencing the electrocardiographic examination, data were collected with special attention paid to a dog breed, origin of dog, sex, age, kind and value of a physical load, past diseases and other symptoms having a potential influence on the circulatory system state. A short clinical examination was conducted in which conjunctiva and oral mucosa colors, possible protrusion or retraction of eyeballs and skin and its product condition were evaluated. The size and shape of the chest and abdominal cavity were determined. The behaviour of the animal was also taken into consideration. The rhythm, frequency and quality of pulse and respiration were examined. Noticeable heart beating was palpated, and heart ausculation and percussion were also conducted.

Then, EKG records were carried out by means of the Multicard E-30 apparatus. Dogs were examined without any use of violence or pharmacological preparations for animal calming because otherwise records could be disturbed. Dogs were examined in the sternal position, i.e. the standing position and the owner of the dog was holding his animal by the dog-collar during the examination and was calming his dog with his voice. The dogs were always examined in the dry state because wet hair and skin would make it impossible to obtain a legible record. EKG records were made during exhibitions of pure-bred dogs, during draught-dog-races, at the dog owner's place and in outpatient clinics. Instrument electrodes were fitted

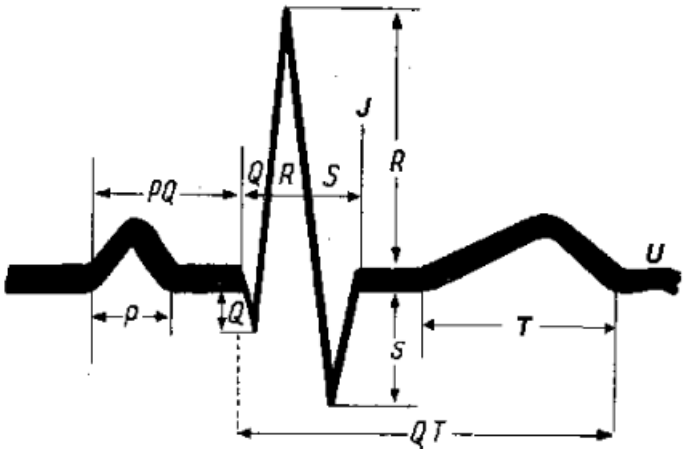
with crocodile clamps fastened at strictly determined spots of animal skin after its prior degreasing and wetting with denatured alcohol. It was not necessary to shave dogs in any case because the way of fastening with clamps described above ensured a clear record. Electrodes were fastened in accordance with international standards. In most cases, the tape speed of 50 mm/s was applied. A lower speed was applied only in cases where changes in a record required a longer period of registration. In suchsituations, the speed of 25 or 10 mm/s was applied. Such relatively high recording speed enabled an accurate evaluation of the curve shape and a more detailed analysis than at lower speeds (16). The most frequently used sensitivity of the instrument amounted to 1 mV = 10 mm, and only in cases when the legibility of the record required it, the sensitivity of 1 mV = 5 or 1 mV = 15 mm was used. In all cases, an additional filter was connected in order to suppress noises from a supply network. All examined dogs were at least 0.5 year old because younger dogs show changes in a record connected with the growth period (20, 33). The resting examination was always carried out, and in selected cases the exercise tests were also conducted. In cases where exercise test records were necessary, dogs were examined after several-kilometre run (5-6 km) with a load. In several selected cases, the EKG record was repeated in several-month intervals. In three cases an effort was made to liquidate the observed changes by means of pharmacological agents. Dogs submitted to pharmacological tests had received atropin intramuscularly in the amount of 0.03 mg / kg of body mass and then, after a quarter of an hour a series of records were carried out at 10-minute intervals for 40 minutes. A diagnosis was established on the base of records obtained from all outlets.

EKG data were collected in a computer data base by recording results from outlet II. The gathered data were submitted to a statistical elaboration. Then, an average value of median, modal value, variance, minimum value, maximum value, standard deviation and standard error were calculated. Depending on the number of compared groups, either the t-Student test or multi-factor analysis of variances with the use of the Tukeya rank test were applied, if they complied with the following assumptions: their distribution was normal and variances were equivalent. The examinations were carried out at the significance level of $\alpha = 0.05$.

The following criteria were taken into consideration at the evaluation of the curve:

1. The following symbols were accepted for particular curve components:

Graph № 1. Correct electrocardiographic curve:



PRINT

Wave P: maximum 0.04 s at 0.4 mV PQ space:0.06-0.13 s
Wave Q: maximum 0.5 mV QRS complex – maximum 0.06 s
Wave R: maximum 3.0 mV Wave S: maximum 0.35 mV
ST section lowered no more than by 0.2 mV and increased no more than to 0.15 mV
Wave T: maximum 25 % of break R height (acc. to 14, 29, 32)

Frequency. After the calculation of an average heart beat frequency, the extreme values, i.e. maximum and minimum excitation frequencies were calculated on the base of at least 10 combinations. Values within the range of 60 – 120 / min (1.00 – 2.00 Hz) were treated as a standard. Respiratory arrhythmia was permissible, i.e. such arrhythmia, at which accelerated heart action was always connected with inspiration, and slowed heart action - with expiration. Frequency higher than 120 / min was considered as tachycardia.

Rhythm. A hearth rhythm was determined as a sinus rhythm when each chamber unit was preceded by wave P of the same shape and correct size, and section PQ did not exceed standard limits. A sinus arrhythmia not connected with respiratory movements was treated as a non-physiological one and called a sinus arrhythmia.

When P waves were different in shape and the remaining record components did not exceed standard limits, a wandering excitation centre within a sinus node was recognised.

When waves P and QRS unit were correct and PQ time was prolonged over 0.13 s, then an atrioventricular block was noted. A temporary sudden slowing heart action demonstrated a long P-P space, being at least a double value of the node cycle, was diagnosed as an atrioventricular block, or as a sinusal inhibition. The presence of F waves instead of the break P was determined as an atrial flutter. The presence of extrasystolic beats was noted when the sinus rhythm was disturbed by prematurely occurring, widened and deformed, QRS units with secondary changes in the ST and T wiev. Usually, after an additional examination complex an equalising pause occurred, and the time of extrasystolies coupling with the preceding complex was stable.

Features proving the presence of the block:

- of the right branch of the Hiss bundle were the following: wide QRS complex above 0.07 s and its positive values in aVR, CV_1outlets, the presence of R' in CV_1, shifting of an average electric vector value to the right, wide and deep S break in the outlets: I, II, III, aVF, CV_2, CV_4.
- of the left branch of the His bundle were as follows: not widened QRS complex, high wave R and small wave in outlet I, deep S in III and aVF, shifting of an average electric vector value to the left.

Analysis of particular curve components: Break P, having non-prolonged duration time reaching maximum 0.04 s and having a large amplitude above 0.4 mV occurring in outlets II and III, was preliminarily recognised as P-pulmonale, i.e. an overloading of the right vestibule. Variable voltage of breaks of several subsequent sets varying within a small range and changing in a regular way was determined as an electric variation. High amplitude slightly exceeding a permissible standard with simultaneous correct times of QRS set duration recognised at lean animals was considered as a permissible variant of the nomogram and was determined as a hypervoltage. The state of correct break P, the PQ section and QRS set (of amplitudes and durations of breaks creating it) with a simultaneous shifting of an average

heart electric vector to the left (sinistrogram) was assessed as an enlargement of the left heart chamber. On the other hand, the state of correct break P in limb outlets, the PQ section at a QRS set magnitude , the shifting of an average heart electric vector to the right (dextrogram) and the presence of a two-phase or negative break P in the CV, RL outlet was assessed as an enlargement of the right heart chamber. The state of a correct break P and the PQ section preceding the enlarged QRS set and a correct value of the average heart electric vector suggested an enlargement of the heart. A volvulus or a notch in the QRS break without other significant changes in the chamber set appearance was determined as depolarisation disturbances of a heart chamber muscle. The curve spot where the S break - ascending arm end comes into contact with the starting point of ST section is point J. Repolarisation disturbances were determined when nonspecific record changes concerned the ST and T sections.

The presence of additional waves e.g. R? were noted in single outlets but no special diagnostic significance was attributed to it.

The average heart chamber electric vector was calculated by summing algebraically calculated chamber vectors from outlets I and III. The record was evaluated as a nomogram in case when the average heart chamber electric vector value was within specified limits. A vector value lower than 40° was determined as a sinistrogram and a value higher than 100° - as a dextrogram.

RESULTS AND DISCUSSION

The first examined parameter was the heart action frequency measured as a number of beats per minute. This parameter was calculated in at least 10 complexes in order to reduce the respiration arrhythmia influence on the calculation result. Physiological deviation limits are not univocal and it is the reason why the authors have different opinions on provided value ranges for grown dogs. These ranges are the following: 60 – 120 (26), 60 – 160 (5), 70 – 160 (1, 23), 70 – 180 (14, 29, 32), 100 – 130 (25). Some authors introduce divisions into small and big dogs but even then there are some differences in proposed standards: big dogs 60 – 80, small dogs 80 – 120 (17), small dogs 100 – 120, big dogs 80 – 100 (18). My own investigations concerning dog heart beating frequency gave an average result of 131 / min. No significant influence of the dog size on the investigated parameter was observed, as it was indicated by some other authors (14, 17, 18, 29, 32); such an opinion may be caused by the fact that respective examinations were carried out on one breed of small dogs only, i.e. dachshunds. The comparison of the dachshund heart beating frequency of 142 (± 4.4) and the dog heart beating frequency of 139 (± 3.5) did not show significant differences. The lowest heart beating frequency was noted in cases of working dogs: pointers 121 (± 4.7), rottweilers 122 (± 3.1), huskies 124 (± 3.0), malamuts 127.5 (± 3.3), Samoyeds 130 (± 5.5) and bloodhounds 133 (± 4.1). Dogs not commonly used for work such as great Dane and dachshund show the highest average heart beating frequency. This dependence complies with the well known phenomenon consisting in the fact that training causes the growth of heart muscle mass and the growth of heart eruptive left chamber volume, which, in consequence, leads to a decrease of heart beating frequency at resting (3). Bull terriers demonstrate a surprisingly high heart beating frequency, on average 146 (± 4.4) per minute and it is very difficult to explain this fact univocally. It is possible that the innate sympathetic system superiority plays some role here influencing the parasympathetic system suppressing action, which may be connected with the character and temperament of bull terriers and the fact of destining them for fights. From the statistical point of view, a significant frequency difference

(specificity level = 0.0287) was noted between draught-dog group and the remaining two dog groups. There are no considerable differences between the defensive and the hunting dog groups in the examined frequency. The influence of sex on the heart action frequency was not noted (specificity level = 0.3623), while the influence of age was present (specificity level = 0.0875). Dogs submitted to examination were divided into two groups: dogs not older than 1.5 year, determined as young dogs, and dogs older than 1.5 year - determined as adult dogs. Young dogs showed a higher heart beating frequency: 135 (± 1.92) than older dogs: 129 (± 1.85). The influence of examination conditions on the heart beating frequency was also analysed. Dogs were examined in various surroundings: at the owner's place, in a clinic ambulatory, during bred-dog exhibitions and during draught-dog races. An assumption was made that various outer conditions might influence the heart beating frequency, even though the examination itself was carried out at a calm and friendly atmosphere. No significant difference was observed (specificity level = 0.449) among these four formed groups of dogs, what seems to indicate that the examination itself is always the same experience for an animal, irrespective of examination conditions. Taking into consideration the fairly large number of particular groups amounting to: 96 dogs examined in the ambulatory, 265 - dogs in exhibitions, 72 - dogs in draught-dog races and 54 – dogs at home, the examinations of these dogs were not repeated in other conditions.

Wave P

The P wave duration did not change in a significant way in any of the analysed variants (specificity level = 0.1731) but the amplitudes were different among purpose groups (specificity level = 0.0001) and breeds (specificity level = 0.0001). The highest average amplitude was noted in case of hunting dogs: 0.235 (± 0.0067) and the breeds of: dachshund - 0.266 (± 0.011) and German pointer - 0.227 (± 0.012). The wave P expresses the depolarisation of atria, which consist of a thin muscular coat and, therefore, the electric pulses coming from the atria are not very strong. In five cases out of 487 of examined dogs, P pulmonale was noted, when the amplitude in outlets II and III exceeded 0.4 mV and the duration was within standard limits. The examinations of Maeda *et al.* performed on people did not show a univocal connection between P pulmonale and the right atrium size determined through dissection. According to Hawrylkiewicz and Murphy, the presence of P pulmonale in the EKG record is connected at a smaller extent with the actual atrium size, while it depends more significantly on pulmonary emphysema, on phrenoptosia and on a heart vertical position. Wrabec *et al.* confirmed this phenomenon proving that the considerable dependence at the intravital examination of the right heart part size was obtained only in the echocardiographic examination (22). In the light of these examinations, it is difficult to state univocally whether, at the examined dogs, we can talk about actual overloading and enlargement of the right atrium, or a slight vertical position of the heart.

Section PQ

The PQ section duration does not depend on sex (specificity level = 0.1591) but depends on animal age (specificity level = 0.013). In the adult dog group longer times were noted - PQ = 0.0596 s (± 0.0012) than in the young dog group: 0.0578 s (± 0.00132). A similar phenomenon of PQ section elongation due to age was noted earlier (36). Significant differences among purpose dog groups were recognised (specificity level = 0.0001), the hunting dog group had shorter PQ time - 0.1516 s (± 0.00132) than the defensive dog groups - 0.0614 s (± 0.00136) and the draught-dog ones 0.0628 s (± 0.00174). The last two groups do not demonstrate considerable differences when compared to each other. Breed has a

considerable influence on the examined parameter (specificity level = 0.0001). The longest duration of the PQ section was noted in case of bull terriers: 0.0686 (± 0.0026) and malamuts: 0.073 (± 0.00028) . An incorrect heart position was suspected when rhythm disturbances were not recorded, and the electrocardiographic changes did not meet the requirements for blocks of intrachamber conductivity and enlargements of particular heart parts. Relatively frequent disturbances in production and conduction of stimuli from a sinus node led to a suspicion that they were caused by an excessive tension of the vagus nerve (1, 6, 29, 32, 36). The changes mentioned above concerned particularly dogs used in sport competitions and trained for them. The phenomenon of vagotonic superiority in trained animals is known and described by numerous authors (11, 15, 21). However, it always abates during and after an exercise and after applying atropine. If blocks or bradycardia still remain, it is presumed that they are caused by anatomic incorrectness of the heart stimulus system (3). Investigations carried out by Strausser, Hochleitner and Bubna-Littitz show that the PQ section becomes longer at stress in case of police-dogs working hot on the trail, what was attributed to hyperventilation. (31). In three cases the owners of malamuts with a first grade atrioventricular block agreed on the performance of the the atropine test according to the procedure described above. Yet, no change in the curve shape was noted, i.e. the existing block remained in the unchanged form, and only the increase of heart action frequency was recorded. Similarly, it was impossible to change the block after pressing eyeballs and after making an exercise test. It confirms the hypothesis that the noted irregularities are of regular change character (not functional).

QRS complex

The QRS complex is a picture of ventricle depolarisation and usually contains three breaks: negative break Q, positive break R and negative break S. No influence of examined parameters such as the purpose group, breed, age, sex and examination conditions on the Q break duration was recognised. However, there was an influence of the purpose group - specificity level = 0.048 and the breed - specificity level = 0.00001, on the break depth (amplitude). A lack of one or both negative breaks in limb outlets is acceptable except the aVR outlets. The influence of breed and affiliation to the purpose group on the size of R and S breaks, i.e. their duration periods and amplitude were observed. A significantly longer R break duration period and its higher amplitude took place in the defensive dog group: 0.033 s (± 0.00084) and 1.787 mV (± 0.055). As for the animal sex and age, they had no influence. In literature one can come across a differentiation of the R break permissible amplitude depending on dog size: small dogs – up to 2.5 mV, big dogs – up to 3.0 mV (14, 29, 32). Within the carried examinations, such differences were not noted, similarly as in Weppler investigations, who initially introduced a division into: small dogs, medium dogs and big dogs but due to lack of differences he abandoned it (34). The difficulty in the evaluation of, among others, the R break is caused by the fact that its form depends not only on the thickness and position of the heart muscle but also many other out-heart factors, such as the distance of the heart from a chest wall, the presence of liquid or air in the chest or in subcutis (10). An average R break amplitude of examined dogs amounts to 1.562 mV and is very similar to the average value obtained in Eckenfel's investigations - 1.6 mV carried out on 118 Beagle breed dogs (13).

ST section

The following factors influence the ST section length: affiliation to the purpose group (specificity level = 0.0001) and dog breed (specificity level = 0.0007). The influence of sex

(specificity level = 0.3553) and age (specificity level = 0.8482) on its duration was not observed.

T break

The T break is quite difficult to interpret due to a broad range of permissible changes and the difficulty in the statistical elaboration of such a changing value. The T break of dogs can be positive, negative, two-phase (positive-negative) or can be linked with the S break and the ST section without any clear boundary between them (27, 32). The increase and most frequently the positive polarisation of the T break and the frequency and duration disturbances of the PQ section may be an expression of the vagus nerve excitation (21).

QT space

It is the time of ventricle depolarisation and re-polarisation. Its length depends on heart action frequency; tachycardia is accompanied by the shortening of the QT time and heart action slowing - by elongation of this space. An excessive elongation of the QT time space is considered as a factor leading to arrhythmia. The shortening of the QT space is regarded as a feature of heart muscle training (3). Another feature of heart muscle training is a correct reaction to exercise. An interesting phenomenon noted in the group of draught-dogs submitted to 11 examinations before and after the exercise was the fact that the post-exercise heart action frequency increase was not always observed. The heart action was on the same level and sometimes, paradoxically, heart action frequency decrease was observed. The phenomenon might be explained in the following way: dogs of this group seem to be very satisfied when they can run. It is difficult to control their impatience and force them to wait for their turn when they see the start of another carriage. The observed resting heart action is an effect of such “before-start fever”. Among the examined animals, none demonstrated heart rhythm disturbances. Another equally interesting phenomenon noted at Samoyed dogs after exercise was the direction shift of a heart axis average electric vector towards normal values, of resting condition - a levogram record. However, the inconsiderable quantity of observations does not allow us to state whether it is a characteristic phenomenon for this breed. The effect of effort to the EKG record and the possible use of exercise tests for the evaluation of a circulatory system state require further systematic tests.

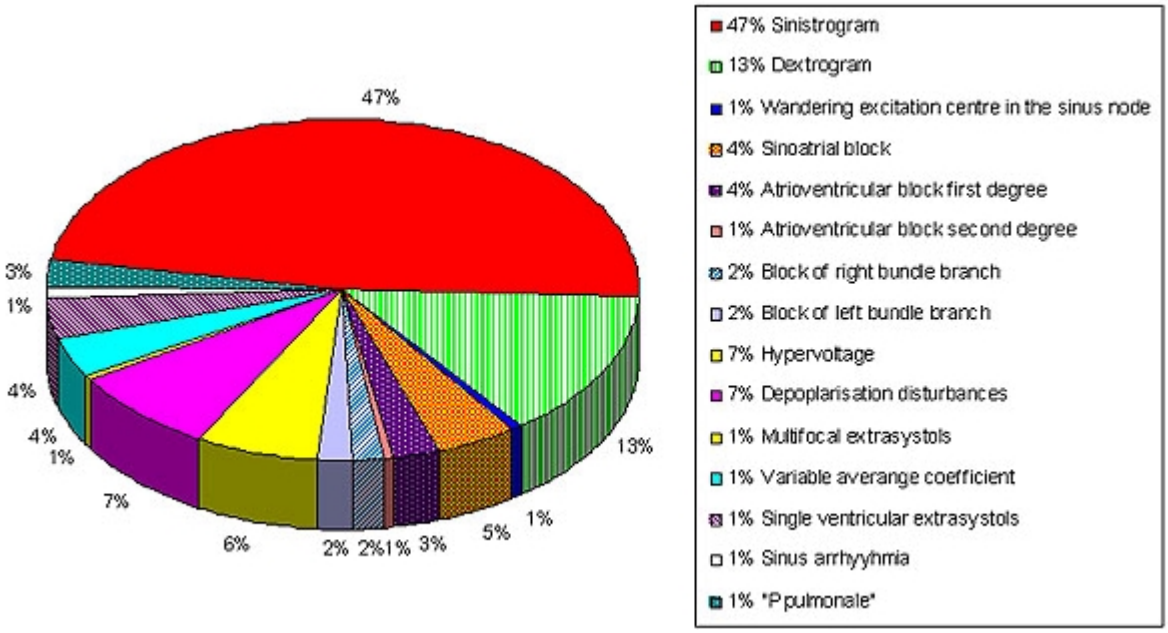
As it has already been mentioned, in case of Samoyed dogs, the levogram record dominates: 29.39 (± 7.52). Having no other pathological features of record, i.e. the prolongation of QRS complex duration, additional breaks, incorrectness of the ST section or predominance of dextrogram records in precordial leads, there are no grounds for attributing pathological importance to this phenomenon, but it should rather be treated as a physiological feature characteristic of this breed in Poland. The remaining breeds do not exceed standard limits despite existing deviations.

Record evaluation

According to the literature (2, 4, 5, 6, 7, 8, 9, 14, 23, 24, 28, 29, 32), there are breed predispositions to various irregularities in the circulatory system, and these are: congenital anomalies, predispositions to specific arrhythmias or cardiomyopathies but the respective knowledge is still insufficient. It is imperfect to such an extent that it made it difficult to evaluate Holter records conducted on dogs. C.Calvert performing this examination stated: “We know relatively little about the occurrence frequency of arrhythmia and pause

concerning clinically healthy dogs" (23). The breeds selected for this elaboration were not earlier examined in such a systematic way. Limited reports concern great Danes suffering from atrial fibrillation with slow ventricular tachycardia (120 – 160 beats per minute) without symptoms of circulatory inefficiency and without a heart enlargement in an X-ray picture. This state was considered as an early form of cardiomyopathy. In case of dogs, also classic dilated cardiomyopathy with extrasystolic beats and ventricular tachycardia (23) were recognised. M. Wronna, in investigations concerning predispositions to diseases of German dog breeds, noted the following predispositions to circulation system diseases: mitral insufficiency and progressive idiopathic cardiomyopathy of unknown etiology in case of German dogs, tricuspid insufficiency in case of dachshunds, and did not observe any predispositions to circulatory system diseases in case of bloodhounds, rottweilers and German pointers (35).

Circle diagram № 1 Percentage distribution of noted irregularities



CONCLUSIONS

As a summary of the examined material analysis, the following conclusions may be drawn:

1. Heart action frequency of examined dogs was on average 131 beats per minute.
2. The most significant factor influencing the electrocardiographic curve morfology is the dog breed.
3. Affiliation to the purpose group, age, conditions of examinations influenced only some of EKG curve components.
4. Effects of animal sex and size on the EKG curve parameters were not found.

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