Changes in Dog’s Electrocardiography P-Wave During Anesthesia
Elektrokardiogrammas P-zoba raksturojums sunjiem anestezijā

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Abstract. The influence of premedication (Atropine Sulphate together with Acepromazine Maleate) followed by general anesthesia (Ketamine Hydrochloride together with Diazepam) on the amplitude (mV) of ECG P-wave in 34 German Shepherd and 32 Cocker Spaniel dogs has been investigated using electrocardiographical lead II. The data were statistically processed using analysis of variance (ANOVA), t-statistic, and P value (P < 0.05). The results showed that premedication and general anesthesia have an essential influence on P-wave amplitude changes in the selected dog breeds. Description of the dynamics of P-wave amplitude in premedication and general anesthesia to Cocker Spaniel and German Shepherd dogs differed. Premedication agent Atropine Sulphate in combination with Acepromazine Maleate caused a decrease in P-wave amplitude to German Shepherd dogs, but to Cocker Spaniels the P-wave amplitude was affected insignificantly. Under the summary influence of anesthetic agents Ketamine Hydrochloride and Diazepam, the amplitude of P-wave to Cocker Spaniel dogs sharply increased already during the first minute of administration and continued to increase for 30 more minutes; then started to decrease. As to German Shepherds, the increase in P-wave amplitude under general anesthesia after premedication was not distinctively expressed, and was statistically significant only in the 60th minute after the influence of general anesthesia. Investigation results confirmed the correlation between the changes in ECG P-wave amplitude and heart rate frequency dynamics influenced by both premedication and anesthetic agents. Key words: dogs, electrocardiography, breed and sex, general anesthesia, drug combinations.

Introduction
As it is known, warm-blooded mammals’ cardiac cycle begins with the atrial contraction represented as a P-wave in electrocardiogram (ECG).

ECG P-wave describes electrophysiological processes of the atrial chambers during the heart contraction: influx of Na+, Ca ++ ions into the cell causes depolarization that is an adequate irritant for generating contraction of cardiac myocytes. The action potentials travel from the sinoatrial node to the right atrium (upright part of P-wave), then to the left atrium (Ettinger and Suter, 1970; Miller, 1986; Tilley, 1992; Akhtar, 1990; Upeniece et al., 1999; Schrope et al., 1995; Покушина, 2001).

It is believed that P-wave amplitude and width depend upon the dog’s breed, heart rate frequency, regularity of the QRS complex, animal’s age, sex, as well as body characteristics – the differences between the heart weight and body weight (Nune et al., 1990; Rezakhani, 1990; Blumenthal et al., 1996).

P-wave of electrocardiogram before each QRS complex is an indication of a normal sinus rhythm before administration of drugs – both premedication and anesthesia. It is an essential element of assessing the process of premedication and general anesthesia.

Analysis of separate ECG parameters using 10 leads established that one of the most descriptive ECG leads is the second standard lead (Miller, 1986; Upeniece et al., 1999; Upeniece at al., 2002). Therefore, the separate elements of this lead for dogs have been researched most extensively (Eckenfeld and Trieb, 1979; Miller, 1986; Bernal et al., 1995; Blumenthal et al., 1996; Upeniece et al., 1999).

Analyzing P-wave, three characterizing parameters are considered most frequently – location, form, as well as deviations from normal positioning ECG (Покушина, 2001).

In general, very little research has been done on the changes of electrophysiological parameters in animals, including dogs, during general anesthesia. No uniform examination methodology has been developed – e.g., positioning of the animal under anesthesia during the electrocardiographic recording; comparison of dogs’ normal heart biopotentials from different ECG leads (before medication) and cardiophysiological parameters during the intravenous (IV) anesthesia.

However, this kind of research is essential to predict and prevent potential functional heart failures during different type of surgery (Muir, 1998; Hansen, 1998; Avdoško, Birģele, 1999, 2002a, 2002b; Lockwood, 2002).

Therefore the aim of our study was to investigate electrophysiological parameters of dogs’ heart during both premedication and general anesthesia, taking into consideration animal’s breed, sex, body weight, as well as the duration of anesthetic agents.

The main task of this project was:
1. to investigate the changes of ECG P-wave amplitude (mV) during premedication and general
anesthesia for two breeds of dogs using second standard ECG lead;
2. to determine most essential factors that influence ECG P-wave dynamics in second standard lead for dogs during premedication and general anesthesia.

Materials and methods
Data about 32 one to eight years old Cocker Spaniel and 34 German Shepherd dogs have been collected and analyzed in this paper.

Dogs’ heart biopotentials were registered using German made AT–I V electrocardiography SCHILLER, which allows recording 10 simultaneous leads.

We used alligator type electrodes that were previously applied with electrode paste and attached directly to animal’s skin in a place designated for each specific lead. Location points of electrodes were as follows: standard leads I, II, and III, and amplified Goldberger leads aVR, aVL, and aVF, where electrodes were attached to the corresponding front extremity directly above the elbow. Electrodes on hind legs were attached above the knee of the corresponding leg.

During the electrocardiography, animals under examination were positioned on right lateral recumbency. Front legs were positioned parallel to each other and perpendicularly to lengthwise axis of the body (Hill, 1968; Rezakhani, 1990; Tilley, 1992; Avdoško, Birgele, 1999; Upeniece et al., 1999).

General health condition of the animal was determined by anamnesis, weight, clinical examination (inspection, palpation, auscultation), as well as laboratory tests (hematological and biochemical blood tests). Besides the main method – electrocardiography, X-raying as an additional method was applied, that was performed by positioning the dog in lateral and dorsoventral position.

For animals’ premedication we used 0.054% solution of Atropine Sulphate (calculated by 0.02 mg/kg) combined with 1% Acepromazine Maleate solution (0.06 mg/kg) by intramuscular injection.

For noninhalation general anesthesia we used 5% Ketamine Hydrochloride solution (6 mg/kg) combined with 0.5% Diazepam solution (correspondingly 0.6 mg/kg).

ECG recording was performed within one minute after IV injection of general anesthetic agent, as well as within 15, 30, 45, and 60 minutes. Therefore, seven 10m lead electrocardiograms were obtained that allow to make conclusions regarding the impact of this combination of drugs on heart biopotentials, as well as the overall dogs’ cardiovascular system’s reaction during general anesthesia.

ECG recording speed was 50 mm/second. Heart rate frequencies, length of separate ECG parameters in miliseconds (ms), as well as ECG waves amplitude in millivoltes (mv) were recorded automatically.

It must be stressed that this paper analyzes P-wave dynamics for ECG standard lead II only.

The following statistical methods were applied to process the numerical values of ECG P-wave:
1. analysis of variance (ANOVA) where “factors” such as animal’s breed, sex, and duration of anesthesia were taken into consideration;
2. descriptive statistical indicators (mV: mean value ± standard deviation) basing the credibility (P < 0.05) or the results on t-test related data.

Results
We will begin the discussion of the results by looking at dogs’ electrocardiogram P-wave dynamics during premedication and general noninhalation anesthesia in correlation with two “factors” – dog’s breed and sex.

Two factor dispersion analysis clearly showed that dog’s breed is a significant “factor” related to alterations in P-wave in ECG standard lead II for animals during general noninhalation anesthesia (Table 1).

Table 1 shows that the relation of the second

<table>
<thead>
<tr>
<th>Significance of correlation between dog’s breed and sex and P-wave during the initial state, premedication, and general anesthesia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial state, premedication, various durations of general anesthesia</td>
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<tr>
<td>---------------------------------------------------------------</td>
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<tr>
<td>F-statistic</td>
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<tr>
<td>Initial state</td>
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<td>---------------------------------------------------------------</td>
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<tr>
<td>10 min. after premedication</td>
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<tr>
<td>1 min. after general anesthesia</td>
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<tr>
<td>15 min. after general anesthesia</td>
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<tr>
<td>30 min. after general anesthesia</td>
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<td>45 min. after general anesthesia</td>
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<tr>
<td>60 min. after general anesthesia</td>
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* – the differences against the initial state are statistically significant (P < 0.05).
Sigificance of differences in P-wave (mV) for German Sheperd and Cocker Spaniel dogs during premedication and general anaesthesia in comparison to the initial state

<table>
<thead>
<tr>
<th>Initial state, premedication, various durations of general anesthesia</th>
<th>German Sheperds</th>
<th>Cocker Spaniels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial state compared to 10 min. after premedication</td>
<td>t-statistic  = 1.981</td>
<td>t-statistic  = 0.159</td>
</tr>
<tr>
<td>Initial state compared to 1 min. after anesthesia</td>
<td>P-value    = 0.0579</td>
<td>P-value    = 0.8759</td>
</tr>
<tr>
<td>Initial state compared to 15 min. after anesthesia</td>
<td>t-statistic  = 0.699</td>
<td>t-statistic  = 3.179</td>
</tr>
<tr>
<td>Initial state compared to 30 min. after anesthesia</td>
<td>P-value    = 0.4907</td>
<td>P-value    = 0.0067*</td>
</tr>
<tr>
<td>Initial state compared to 45 min. after anesthesia</td>
<td>t-statistic  = 0.921</td>
<td>t-statistic  = 3.648</td>
</tr>
<tr>
<td>Initial state compared to 60 min. after anesthesia</td>
<td>P-value    = 0.3662</td>
<td>P-value    = 0.0026*</td>
</tr>
<tr>
<td>Initial state compared to 60 min. after anesthesia</td>
<td>t-statistic  = 0.7291</td>
<td>t-statistic  = 4.537</td>
</tr>
<tr>
<td>Initial state compared to 45 min. after anesthesia</td>
<td>P-value    = 0.1571</td>
<td>P-value    = 0.0005*</td>
</tr>
<tr>
<td>Initial state compared to 60 min. after anesthesia</td>
<td>t-statistic  = 1.463</td>
<td>t-statistic  = 4.254</td>
</tr>
<tr>
<td>Initial state compared to 60 min. after anesthesia</td>
<td>P-value    = 0.0348*</td>
<td>P-value    = 0.0008*</td>
</tr>
<tr>
<td>Initial state compared to 60 min. after anesthesia</td>
<td>t-statistic  = 2.250</td>
<td>t-statistic  = 2.815</td>
</tr>
<tr>
<td>Initial state compared to 60 min. after anesthesia</td>
<td>P-value    = 0.0348*</td>
<td>P-value    = 0.0146*</td>
</tr>
</tbody>
</table>

* - the differences against the initial state are statistically significant (P < 0.05).

Fig. 1. P-wave of German Sheperd (●) and Cocker Spaniel (○) dogs in ECG standard lead II during:
1 – premedication (Atropine Sulphate 0.02 mg/kg and Acepromazine Maleate 0.06 mg/kg);
2 – general anesthesia (Ketamine Hydrochloride 6 mg/kg and Diazepam 0.6 mg/kg).

“factor” animal’s sex to P-wave dynamics in ECG standard lead II was not significant.

Analysis of ECG P-wave dynamics in standard lead II during premedication and general anesthesia in correlation with the breed of the specific animal (Table 2) showed that this correlation was significantly distinct for Cocker Spaniel dogs – even within one minute of IV injection of general anesthetic agents 5% Ketamine Hydrochloride (6mg/kg) combined with 0.5% Diazepam (0.6 mg/kg).

Graphical depiction of ECG P-wave dynamics in German Shepherd and Cocker Spaniel dogs is seen in Fig. 1.

Firstly, animals of both breeds displayed different P-wave dynamics after administration of premedication agents Atropine Sulphate (0.02 mg/kg) and Acepromazine Maleate (0.06 mg/kg). While German Shepherds displayed a decrease of ECG P-wave amplitude in standard lead II, quite the opposite was observed in Cocker Spaniel dogs – P-wave amplitude had a tendency to slightly elevate.

Secondly, even within the first minute after IV injection of anesthetic agents, Cocker Spaniel dogs displayed a very distinct elevation of ECG P-wave amplitude (P = 0.0067), while German Shepherds’ P-wave amplitude in standard lead II during the same time period elevated only slightly. Compared to the prior to drug administration state, it was not statistically significant (Fig. 1 and Table 2).

Thirdly, animals of both breeds in general displayed differences in P-wave dynamics during general anesthesia. Cocker Spaniel dogs’ ECG P-wave
amplitude elevated until the 30th minute of examination and then lowered for the next 30 minutes.

During the first to fifteenth minute after the administration of general anesthetic agents, P-wave amplitude in German Shepherd animals decreased, then it began to raise and continued to raise until the sixtieth minute of examination when, compared to the prior to drug administration state, P-wave amplitude elevation was statistically significant – $P = 0.0348$ (Fig. 1 and Table 2).

Thus, the present research is indicative of the impact that premedication and general anesthetic agents that we applied (Atropine Sulphate 0.02 mg/kg combined with Acepromazine Maleate 0.06 mg/kg and Ketamine Hydrochloride 6 mg/kg together with Diazepam 0.6 mg/kg) leave on the P-wave dynamics in ECG standard lead II. Besides, this impact depends upon the dog’s breed. Correlation between the animal’s sex and changes in P-wave during the premedication and general anesthesia in ECG standard lead II is not significant.

**Discussion**

One of the main tasks of this study was to examine the dynamics of electrocardiogram’s P-wave in II standard lead for German Shepherd and Cocker Spaniel dogs during the noninhalation anesthesia where Atropine Sulphate (0.02 mg/kg) combined with Acepromazine Maleate (0.06 mg/kg) was used as a premedication agent, and Ketamine Hydrochloride (6 mg/kg) combined with Diazepam (0.6 mg/kg) – as an anesthetic.

It turned out that both premedication and anesthetic agents leave an impact on P-wave dynamics in ECG standard lead II for dogs of both breeds, however this impact was quite different.

We already mentioned that premedication agents Atropine Sulphate and Acepromazine Maleate induced the P-wave amplitude decrease for German Shepherds, but Cocker Spaniel dogs’ P-wave amplitude at the same time slightly increased. However, these changes were not statistically significant.

Comparing the results of the current research with those of our previous research regarding heart rate frequency dynamics during premedication for dogs of both breeds (Avdoško, Birgele, 2002c, d), it is seen that German Shepherds display a very typical correlation between the P-wave amplitude dynamics and the heart rate frequency. Decrease in heart rate frequency coincided with the decrease in P-wave amplitude. Cocker Spaniel dogs showed a less marked correlation between the two during the premedication. It can be explained by a comparatively lower P-wave amplitude in ECG standard lead II for Cocker Spaniel dogs prior to drug administration (or normal state) (Upeniecie, Birgele, 2002).

After intravenous induction of anesthetic agents Ketamine Hydrochloride (6 mg/kg) and Diazepam (0.6 mg/kg), P-wave amplitude statistically significantly elevated for Cocker Spaniel dogs. Besides, the elevation was the sharpest within the first minute of anesthetic agents induction. It has to be pointed out that this first minute elevation coincides with a simultaneously sharp increase of heart rate frequency for Cocker Spaniel dogs happening within the first minute of anesthetic agent administration (Avdoško, Birgele, 2002c, d).

During the further course of the investigation, P-wave amplitude changes for Cocker Spaniel dogs induced by anesthetic agents corresponded to the heart rate frequency dynamics observed in these animals after the induction of Ketamine Hydrochloride and Diazepam (Avdoško, Birgele, 2002c, d). Within 30 minutes of intravenous administration of anesthetic agents, Cocker Spaniel dogs’ heart rate frequency started to decrease, coinciding with the simultaneous lowering of ECG P-wave amplitude.

The fact that P-wave amplitude of ECG standard lead II significantly depends upon the dog’s heart rate frequency has been confirmed by other studies on the changes of dogs’ ECG parameters in relation to their breed, age, and sex (Upeniecie, Birgele, 2002).

As regards our studies related to ECG P-wave changes for German Shepherd dogs induced by the Ketamine Hydrochloride and Diazepam’s summary affect, it has to be concluded that animals of these breeds did not display a statistically significant P-wave amplitude elevation influenced by anesthetic agents until the 45th minute of their administration. Only within 60 minutes after induction of the anesthetic agents the P-wave amplitude elevation became statistically significant ($P = 0.0348$).

Thus, ECG P-wave amplitude increase in standard lead II for German Shepherds influenced by the summary effect of anesthetic agents Ketamine Hydrochloride and Diazepam is not as much distinctive as it is for Cocker Spaniel dogs.

It is believed the ECG P-wave amplitude elevation is related to the enlargement of the right atrium, which forms the so-called P-pulmonale or P-dextroatriale in ECG (Tilley, et al., 1990). This kind of ECG P-wave can be observed in cases of very fast heartbeat (Ivall et al., 1979; Waxman et al., 1980; Bohn, 1993) also caused by the summary effect of anesthetic agents Ketamine Hydrochloride and Diazepam (Avdoško, Birgele, 2002c, d).

In our previous experimental research in vitro we proved the direct impact on isolated frog’s heart by both premedication agents – Atropine Sulphate and Acepromazine Maleate as well as Ketamine Hydrochloride and Diazepam (Avdoško, Birgele, 2002a, b). Since the frog’s heart was isolated, it could not react to various secondary impacts conducted in
animal’s organism by its central nervous system (CNS). Therefore we can assume that the above general anesthetic agents cause certain direct changes in heart’s conductive system and functions of the contractile elements of the heart muscle that during premedication and anesthesia for dogs are reflected in separate ECG parameters – in this case, ECG P-wave amplitude dynamics in standard lead II.

It should be taken into consideration that the impact of the premedication and anesthetic agents we studied on ECG P-wave changes is closely related to dog’s breed but not to dog’s sex. Besides, during the different stages of anesthesia, this correlation manifests itself quite differently in dogs of German Shepherd and Cocker Spaniel breeds.

In conclusion, the close correlation between the ECG P-wave dynamics in standard lead II and heart rate frequency during the general anesthesia must be stressed.

Conclusions

1. Premedication agents Atropine Sulphate (0.02 mg/kg) and Acepromazine Maleate (0.06 mg/kg) followed by anesthetic agents Ketamine Hydrochloride (6 mg/kg) combined with Diazepam (0.6 mg/kg) impact the P-wave dynamics in ECG standard lead II for German Shepherd and Cocker Spaniel dogs. Besides, this impact depends upon the dog’s breed but doesn’t depend upon dog’s sex.

2. Premedication agent Atropine Sulphate in combination with Acepromazine Maleate causes tendency of decrease of P-wave amplitude for German Shepherds, but the P-wave amplitude for Cocker Spaniel dogs is influenced very insignificantly.

3. Summary effect of anesthetic agents Ketamine Hydrochloride and Diazepam caused a sharp elevation of ECG P-wave amplitude for Cocker Spaniel dogs already within the first minute of induction and continued to raise for 30 more minutes, then started to lower. For German Shepherds who received both premedication and anesthesia, the elevation of P-wave amplitude was not so sharply distinct and only within the 60th minute of administration became statistically credible.

4. The results of the study confirm the correlation between the changes in ECG P-wave amplitude and heart rate frequency induced by premedication and anesthetic agents.

References


Anotācija

Darbā ir izpētīta P–zoba amplitūdās (mV) dinamika 34 Vācu atu un 32 Kokerspanielu šķīrnes suņiem premedikācijas (atropīna sulfāts kombinācijā ar acepromazīna maleātu) un vispārējās anestēzijas (ketaminā hidroholīda kombinācijā ar diazeperamu) ietekmē. Dati ir statistiski apstrādāti, izmantot daudzfaktoru dispersijas analīzes (ANOVA), t–tests saistītiem datiem un aprakstošās statistikas rādītāju (mV: vidējās vērtības ± standartklūda) pamatojot rezultātu ticamību P<0,05. Iegūtie rezultāti parādija, ka premedikācijai un vispārējai anestēzijai ir būtiska ietekme uz P zoba amplitūdas izmaiņām mūsu izvēlēto šķīnā suņiem. P–zoba amplitūdas dinamikas raksturojums premedikācijā, vispārējā anestēzijā Kokerspanieliem un Vācu atu šķīrnes suņiem ir atšķirīgs.