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Analysis of base apex lead electrocardiograms of normal dairy cows

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ABSTRACT

Electrocardiographic parameters of 600 normal dairy cows ranging in age from 1 to 14 years (4.97 ± 2.06 years old) were analyzed in this study. None of the cows used for this study had cardiac problems or heart sound abnormalities. Data analysis showed that heart rate was 75.73 ± 9.13 (47-90 beats per minute), P wave amplitude was 0.12 ± 0.04 (0.05-0.3 mV), r-wave amplitude was 0.15 ± 0.13 (0.05-0.95 mV), S-wave amplitude was 0.77 ± 0.27 (0.12-1.90 mV) and T-wave amplitude was -0.12 ± 0.10 (0.05-0.80 mV and +0.25 ± 0.14 (0.05-1.10 mV). P-wave duration was 0.08 ± 0.01 second (0.05-0.12 sec.), QRS duration was 0.06 ± 0.01 (0.04-0.10 sec.), T-wave duration was 0.09 ± 0.01 (0.05-0.16 sec.) and P-R and Q-T intervals were 0.20 ± 0.02 (0.12-0.26 sec.) and 0.37 ± 0.03 (0.22-0.48 sec.), respectively. Age and pregnancy were found to influence some of these values. This study showed that lead base apex is suitable as a standard and monitoring lead for adult Holstein cows.

Key words: cow, dairy, electrocardiogram, base apex, leads

Introduction

Since the first report on normal electrocardiographic values of cattle by NORR (1921), various publications on ECG parameters and cardiac rhythm of different breeds of beef and dairy cattle have appeared in the veterinary literature (ALFREDSON and SYKES, 1942; BROOJMANS, 1957; VAN ARSDEL III et al., 1959; UPADHYAY et al., 1976; McGUIRK et al., 1983; CLAXTON, 1988; MACHIDA et al., 1991; REZAKHANI and PAPAHN, 2002.)

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A review of the literature indicates that the ECGs recorded using the limb leads in cattle have low polarities and great variability. This could be due to the position of electrodes relative to the position of the heart in the thoracic cavity, and also to the distribution of the conduction system in the myocardium (ABRAMSON and MARGOLIN, 1936) which causes cancellation of wave fronts. To overcome these problems different lead systems have been tried in cattle in order to establish a standard lead such as the lead II used in human and small animal cardiology (SCHULTZ and PRETORIUS, 1972; DEROTH, 1980). Base apex lead have been used by several researchers and have been shown to be an appropriate lead as the ECGs recorded by them have clear and large waves and complexes and animal movement has a minimum effect on the recording (DEROTH, 1980; REZAKHANI and MOAFPOURIAN, 1993; REZAKHANI et al., 1994.)

As this lead system is now used routinely for large animals, then it is prudent to present the normal ECG values of this lead in normal cattle. Therefore, this study was undertaken to record ECG from a large number of adult Holstein cows in order to provide ECG parameters of base apex lead of this species of cattle.

Materials and methods

The animals studied were from four provinces of Iran. Animals were included in this study if they met the following criteria: they were more than one year old; they had no arrhythmias or abnormal heart sounds, and heart rate was between 47 and 90 beats per minute.

The ECG was recorded on a bipolar base apex lead using limb lead I. Animals were kept in a standing position in a stock without any tranquilizer or sedative. No clipping or shaving was carried out for electrodes attachment. The ECG was recorded when animals were thought to be in a quiet state using alligator-type electrodes which were attached to the skin after cleaning it with ethanol and applying electrocardiographic jelly. The positive electrode of lead I (left arm) was attached to the skin of the fifth intercostal space just caudal to the olecranon, and the negative electrode (right arm) on the jugular furrow about lower 1/3 of the left side of the neck. These sites are commonly used in this school as our previous research showed that there is no significant difference when attaching this electrode on the right or left side of the neck in the horse and cattle (REZAKHANI et al., 1994) and the earth was attached away from these two electrodes. All ECGs were obtained

on a single channel ECG machine (Cardiostat, Siemens, Germany) with the paper speed 25 mm/ sec. and calibration of 10 mm equal to 1 mV.

For measuring ECG parameters the traces were analyzed using a magnifying glass. By this method of measuring the precision of duration was 0.02 sec. and amplitude was 0.05 mV. Heart rate was calculated by measuring the average last six R-R intervals of each trace as the animals were more relaxed at the end of recording.

To describe the QRS complex in this lead, the first positive wave was named R and the negative deflection after R was designated S. If the QRS complex was only a negative wave then it was designated QS. If the amplitudes of waves were small then lower case letters were used to name them. The Q-T interval was not corrected in this study.

Mean and standard error (SEM), standard deviation and minimum and maximum values were computed for statistical analysis. Statistical treatment was carried out using SSPS software package, with independent t-test and Pearson correlation test to confirm the presence or absence of significant differences between two age groups (one to three years of age, and more than 3 years) and pregnant and non-pregnant cows, and to find the correlation between ECG components.

Results

The heart rate of 600 cows was in the predetermined range of 47 to 90 beats per minute, with a mean and standard deviation of 75.73 ± 9.13

Analysis of the morphologies of P, QRS and T are presented in Table 1. The P wave was positive in all cases and was peaked in most cases, although a few notched waves were observed. Wandering pacemaker was very rare. The main component of the QRS complex was negative. Amplitude of ECG waves and duration of P, QRS, and T and intervals of P-R and Q-T are presented in Table 2.

Statistical analysis showed that P wave ($P = 0.001$), negative T wave ($P= 0.007$) amplitudes were taller and QRS ($P = 0.037$) duration was longer in older cows as compared to younger ones. The values for P wave ($P = 0.018$) amplitude, P ($P = 0.021$) duration and Q-T ($P = 0.005$) were higher in older, pregnant cows as compared to non- pregnant cows of this age group. There was a positive correlation between age and p amplitude ($r = 0.17$, $P = 0.000$), P ($r = 0.09$, $P = 0.033$) and QRS

Table 1. Electrocardiographic patterns of base-apex lead of Holstein cattle

ECG configuration	P-Wave	QRS Complex				T-Wave		
ECG patterns	+	RS	Rs	rS	QS	+	-	+/-
Number	600	2	5	270	323	374	28	198
Percent	100%	0.33%	0.83%	45%	53.83%	62.33%	4.66%	0.33%

Table 2. Electrocardiographic values of base-apex lead of Holstein cattle

ECG parameters	Number	Minimum	Maximum	Mean ± SD
Heart rate/min	544	47	90	75.73 ± 9.13
P amplitude (mV)	600	0.05	0.32	0.12 ± 0.04
QRS R	274	0.05	0.95	0.15 ± 0.13
(mV) S	600	0.12	1.90	0.77 ±0 .27
T Negative	226	0.05	0.80	-0.12 ± 0.10
(mV) Positive	572	0.05	1.10	+0.25 ± 0.14
P duration (sec.)	600	0.05	0.12	0.08 ± 0.01
P-R (sec.)	600	0.12	0.26	0.20 ± 0.02
QRS (sec.)	600	0.04	0.10	0.06 ± 0.01
Q-T (sec.)	600	0.22	0.48	0.37 ± 0.03
T (sec.)	600	0.05	0.16	0.09 ± 0.01

($r = 0.14$, $P = 0.001$) duration. There was also a positive correlation between heart rate and P ($r = 0.17$, $P = 0.002$) and S ($r = 0.12$, $P = 0.003$) amplitudes and negative correlation between heart rate and Q-T ($r = -0.58$, $P = 0.000$) interval and T ($r = -0.14$, $P = 0.001$) wave duration.

Discussion

Electrocardiography, a non-invasive technique, is a method of choice for evaluating electrical activity of the heart and determining irregularities of cardiac rhythm, which may be caused by several factors. In small animals and human beings it can also be used for detecting cardiac hypertrophy and dilatation (TILLEY, 1985; ROSENDORFF, 2001). However, in large animals, because of deep penetration

of Purkinje fibres in the myocardium, the ECG is not very helpful for detecting cardiac chambers enlargement (HAMLIN and SMITH, 1965). Therefore, in horses and cattle the ECG is mostly used for detection of cardiac arrhythmias. In order to use a trace for this purpose it should have clear electrocardiographic waves and complexes. So a base apex lead seems to be the best and standard lead for monitoring large animals for cardiac arrhythmias. Accordingly, it is prudent to present electrocardiographic parameters of this lead in Holstein cows as standard values.

The heart rate reported for cattle is very variable and it is difficult to arrive at a definite conclusion regarding minimum and maximum heart rate. The values chosen for this study are from our experience and from those reported by other workers (DEROTH, 1980; REZAKHANI and MOAFPOURIAN, 1993). Animals younger than one year old were not included in this study because younger animals are not accustomed to handling and the stress of ECG recording would increase heart rate. A heart rate higher than 90 per minute is considered as sinus tachycardia in our institution, and so those cows with a heart rate higher than 90 beats per minute were excluded. The mean heart rate reported in this study is in agreement with the value reported by DEROTH (1980) and lower than the rate reported by SCHULTZ and PRETORIUS (1972) and higher than that found by LANK and KINGREY (1959), although the minimum heart rate in their study and the present one was the same. The heart rate is related to various factors which should be taken into consideration at the time of ECG recording.

The P wave was only positive in this lead with no variability as seen in the limb leads ECG. Wandering pacemaker was very rare and there was no isoelectric or negative wave, as has been reported by DEROTH (1980). In the present study the placement of the electrodes was consistent from case to case, which may have reduced the variations in P wave morphology seen in our recordings when compared to others.

The QRS complex was mainly negative, either in the form of rS or QS. Other forms on the basis of the size of amplitude of QRS complex were observed (Table 2). Only monophasic (n-323) and biphasic (n-277) forms of the QRS complexes were observed, which is completely different to those which have been reported for the ECG of limb leads of cattle and other ruminants (REZAKHANI and SZABUNIEWICZ, 1977). The main part of the QRS complex was negative in 98.5%

of cases and showed much less variability than the QRS complexes recorded from limb leads.

The T wave was positive, negative or biphasic (-/+). The polarity of T wave is partly related to heart rate. It was observed on some traces that the T wave at the beginning of recording, when the heart rate was high, was different from the end of trace, in which the animal was more relaxed. Variability in polarity of the T wave has been shown in the horse and is often rate related (HOLMES and REZAKHANI, 1975). In the study reported by DEROTH (1980) no negative T wave was observed in the base apex lead ECG of cattle. This may be because of the relatively small number of animals (32) in that study compared to the present study (600). Generally speaking, the T wave is more variable in large animals than in small animals and therefore it cannot be used as an index for cardiac problems.

Statistical analysis revealed that the values of P wave amplitude and duration of QRS complex were significantly higher in older animals than younger ones, which could probably be due to the size of the heart in older cows. In pregnant cows the amplitude of the P wave was significantly ($P<0.01$) higher than in non-pregnant cows. This may be due to the fact that in pregnant cows the distension of the abdominal cavity may push the diaphragm forward and place the heart in a more vertical position in relation to the base apex lead. The Q-T and T intervals were significantly ($P<0.05$) higher in non-pregnant cows as compared to pregnant ones. This could be due to the higher heart rate in pregnant cows. Correlation coefficient between heart rate and Q-T and T intervals were negative in this study which confirms the above statement. It has been shown in various animals that there is a reverse relationship between heart rate and Q-T interval (UPADHYAY et al., 1976; TILLEY, 1985).

In conclusion, this study showed that the base apex lead is a suitable lead for monitoring heart rhythm of adult Holstein cows, and these values can be accepted as normal values for Holstein dairy cattle.

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SAŽETAK

Analizirani su elektrokardiografski parametri 600 zdravih mliječnih krava u dobi od 1-14 godina (4,97 ± 2,06 godina starosti). Ni u jedne krave nisu ustanovljeni srčani poremećaji ni abnormalni šumovi na srcu. Dobiveni podaci su pokazali da je broj otkucaja srca u minuti bio 75,73 ± 9,13 (47-90), amplituda P-vala iznosila je 0,12 ± 0,04 (0,05-0,3 mV), amplituda R-vala 0,15 ± 0,13 (0,05-0,95 mV), amplituda S-vala 0,77 ± 0,27 (0,12-1,90 mV) i T-vala -0,12 ± 0,10 (0,05-0,80 mV i +0,25 ± 0,14 (0,05-1,10 mV). Trajanje P-vala iznosilo je 0,08 ± 0,01 sekundi (0,05-0,12 s), QRS kompleksa bilo je 0,06 ± 0,01 (0,04-0,10 s), T-vala 0,09 ± 0,01 (0,05 - 0,16 s), a P-R te Q-T intervala iznosilo je 0,20 ± 0,02 (0,12-0,26 s) i 0,37 ± 0,03 (0,22-0,48 s). Ustanovljeno je da je starost i steonost utjecala na neke od ovih vrijednosti. Istraživanje je pokazalo da je bazalno-apikalni odvod prikladan za standardizaciju elektrokardiografije krava holštajnske pasmine.

Ključne riječi: krava, mliječnost, elektrokardiogram, bazalno-apikalni odvod