

Original Study

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Electrocardiographic examination in calves: a preliminary study

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Abstract

This study aims to describe and evaluate normal electrocardiographic parameters in calves. Twenty healthy male Holstein calves were included and divided into two groups of 10 animals each. Calves aged between 25 and 30 days have been enrolled in the Group 1. Calves aged between 177 and 183 days have been included in Group 2. The electrocardiogram were recorded with minimal restraint and without any sedation. Standard bipolar (I, II, and III) and augmented unipolar limb (aVR, aVL, and aVF) leads were recorded using 50 mm / sec paper speed and 10 mm = 1 mV for at least 5 minutes. QRS complexes, T and P waves were evaluated for duration and amplitude. The duration of the PR, QT and ST intervals was also measured. The analysis of the electrocardiography traces showed that the morphology of the QRS complex was of type Qr, QS or rS in both groups. The duration and amplitude of P, T waves and QRS complex showed minimal variations between two groups. The duration of the QT and RR intervals was higher in the Group 1 than the Group 2, instead the heart rate was decreased.

Key Words: ECG, calf, cattle, leads

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Introduction

The electrocardiogram (ECG) examination is a non-invasive method for assessing the cardiac electrical activity in both human and veterinary medicine (1). Electrodes register the potential differences that occur over the surface of the body for the electrical activity of the heart (1). All the parameters of the ECG examination are recorded in the bipolar standards (I, II and III) and augmented limb leads (aVR, aVL, and aVF). The P wave represents the atrial depolarization followed by the isoelectric PR interval, which is caused by the conduction delay at the AV node. The depolarization of the ventricles is recorded as QRS complex which is followed by the ST segment and finally by the T wave, which represents the ventricular repolarization (1).

Calves can be affected by cardiac (pericardial effusion, traumatic pericarditis, congenital malformations), or metabolic disease (digestive disorders, respiratory diseases, electrolyte imbalances) that can affect the heart function (2,3,4,5,6). Calves can also be develop myodystrophy due to deficiency in vitamin E and selenium (7). All these conditions cardiac or extra-cardiac may

cause changes in ECG parameters (2,8).

The ECG examination is an important practical tool for the veterinarian of large animals. In fact, many diagnostic techniques are not available in farms. Instead, the electrocardiograph is easily transportable, cheap, fast and provides a lot of data (16). In horses, clinical studies support the use of the ECG for diagnosis and evaluation of cardiovascular disease (9), while few studies are reported on ECG in cattle (1,9,10,11,12,13,14,15). For this reason, the interpretation of ECG in cattle are more difficult and less sensitive.

Therefore, the aim of this study is to improve the knowledge of the normal ECG parameters of calves, for increase their sensitivity in the diagnosis and prognosis of cardiac or extracardiac diseases involving the cardiovascular system.

Materials and Methods

All procedures were conducted in two farms located in the municipality of Reggio Calabria (Southern Italy), between May 2018 and June 2018. For the study, 20 clinically healthy male Holstein calves were enrolled and divided into two groups of 10 animals each. Group 1 were included calves aged between 25 and 30 days, fed only with cow's milk. The Group 2 was formed by calves of aged between 177 and 183 days, weaned and fed dry food for over three months.

All ECG traces were recorded using a three-channel electrocardiograph (Cardioline, Delta 3 plus, Italy) in a quiet place. The calves were placed in standing position, with minimal manual restraint. Each calf was stand next to his mother to minimize stress that could affect the ECG recording. The application of 96% ethanol improved a good clip-to-skin contact and electric conductivity. Electrodes were placed on the skin behind the left olecranon, at the inguinal fold region on the left side and at the inguinal fold region on the right side, respectively (14).

Standard bipolar (I, II, and III) and augmented unipolar limb (aVR, aVL, and aVF) leads were recorded using 50 mm / sec paper speed and 1 cm = 1 mV for at least 5 minutes. All analyzes and measurements refer to lead II. The mean heart rate was calculated by mean of 10 consecutive RR intervals. The amplitude and duration of P, Q, R, S and T waves and and the duration of PR, QRS, QT and ST intervals, were measured and analyzed according to the average of five consecutive beats. The morphology of P, T waves and QRS complexes was also classified according to standard methods (1,8).

For each parameter (waves, intervals and axis) the average value was calculated. The analysis of variance was applied in order to examine the effect of age on each parameter ($P < 0.05$).

Results

The results of the ECG examination are summarized in Table 1. All animals showed a normal sinus rhythm. The heart rate in Group 1 was 140 bpm (beats per minute), with a range between 110 and

150, while the Group 2 showed an average of 95.2 with a range between 84 to 120 bpm. The morphology of the QRS complex was of type Qr in 7/10 (70%), QS in 1/10 (10%) and rS in 2/10 (20%) animals in Group 1, while Group 2 instead recorded 5/10 (50%) Qr, 2/10 (20%) QS and 3/10 (30%) rS. The mean P wave amplitude was 0.5 (SD \pm 0.01) in the Group 1 and 0.6 (SD \pm 0.01) mV in the Group 2. In 2/10 (20%) animals belonging to Group 1 the T wave was biphasic, it was negative in 1/10 (10%) while the remaining 7/10 (70%) calves showed a positive T wave. Group 2 recorded biphasic T wave only in 1/10 (10%) calves, all other subjects had a positive T wave. The mean duration of P wave was 0.04 (SD \pm 0.01) and 0.06 (SD \pm 0.01) seconds (sec) in Group 1 and 2, respectively. The mean duration of the PR segment was 0.12 sec (SD \pm 0.01) in the Group 1 and 0.14 sec (SD \pm 0.09) in the Group 2. The morphology of the QRS complexes was mostly Qr or rS, in fact there were large negative Q and S waves, while the positive R wave was small. The RR interval was 0.4 sec (SD \pm 0) and 0.76 sec (SD \pm 0.05) in the Group 1 and 2, respectively. The T wave had mean amplitude of 0.2 mV in both groups and duration of 0.06 ± 0.05 mV in the Group 1 and 0.08 ± 0.05 mV in the Group 2. The duration of QT and ST segments was 0.24 ± 0.05 sec and 0.12 ± 0.02 sec in the Group 1 and 0.28 ± 0.04 and 0.18 ± 0.03 sec in the Group 2, respectively. Overall, the calves averaged a heart rate of 117 bpm. The ECG traces of the two groups also always had a positive P wave with an average amplitude and duration of 0.55 mV and 0.05 sec respectively. The QRS complexes of both groups were nearly isoelectric or weakly positive, with 0.04 sec of mean amplitude and duration. The T wave overall had variable morphology, with an average amplitude of 0.2 mV with a duration of 0.02 sec.

Table 1. The amplitude and duration of P, T waves, QRS complex and their intervals in calves recorded in lead II

		Heart rate (bpm)	P wave		PR interval	QRS complex	Q wave	R wave	S wave	RR interval	T wave		QT interval	ST segment
			Amp	Dur	Dur	Dur	Amp	Amp	Amp	Dur	Amp	Dur	Dur	Dur
GROUP 1	MEAN	140	0.5	0.04	0.12	0.04	-0.43	0.04	-0.01	0.4*	0.2	0.06	0.24	0.12
	SD	11	0.05	0.01	0.01	0	0.18	0.02	0.01	0	0.02	0.01	0.05	0.02
GROUP 2	MEAN	95.2	0.6	0.06	0.14	0.04	-0.38	0.04	-0.02	0.72*	0.2	0.08	0.28	0.18
	SD	8	0.05	0.01	0.09	0	0.11	0.01	0.01	0.05	0.02	0.02	0.04	0.03

Bpm= beats per minute; **SD** = Standard Deviation; **Amp** = Amplitude (mV); **Dur**= Duration (sec); ***P Value**<0.05

Discussion

This study divides calves into two very different growth stages. In fact, Group 1 had very young animals, fed only with cow's milk and with incomplete somatic and digestive tract development. While in Group 2 there are older calves that have been weaned and achieved good somatic development.

According with previous ECG studies performed with calves, we have observed an higher heart rate in younger animals, compared to older calves (11,13,14). In fact, the Group 1 showed an average of 140 bpm, while the group 2 recorded an average of 95.2 bpm. In adult cattle the heart rate decreases further, reaching mean values of 75 bpm according to DeRoth and 71 bpm in the most recent study conducted by Areshkumar (12,17). The decrease in heart rate from young animals to adults, is a gradual process that also occurs in other mammals, including humans (1,8). The Group 2 shows higher values in the duration of RR and QT interval and, of the ST segment comparing with the Group 1. Overall, both groups of calves have lower duration values of RR, QT interval and ST segment than the adult animals (17). It is possible that the decrease in the heart rate may also explain the variations in the other ECG parameters between the two groups.

QRS complexes show always low voltages with a large negative component. This is probably a feature due to the particular functioning of the bovine heart (12). Conversely to the other species, the depolarization occurs simultaneously for both ventricles, therefore a depolarization front with a recordable direction is not formed (12). Furthermore, the ECG recording could also be influenced by the large gastrointestinal tract of ruminants (12).

This study shows negative or biphasic T wave in 4/20 calves. According to De Roth et al. and Rezakhani et al., in the bovine species the T wave can change morphology with increasing heart rate (9,13).

This study diverges in few points with the study conducted by Kumari et al. (15), which reports a lower P amplitude with 0.17 mV on average, while our results show an average value of 0.55 mV (0.5 mV in group 1 and 0.6 mV in group 2). A possible explanation for these differences could be related to the different ages and races of the animals examined. Also Kumari et al. recorded a slightly longer duration of PR interval which had a duration of 0.18 s, while in this study the duration ranged from an average of 0.12 s in group 1 and 0.14 s in group 2. The ST segment in this study had a mean duration of 0.17 sec (0.12 sec in group 1 and 0.18 sec in group 2) while in the study conducted by Mendes et al. (11), it was 0.12-0.14 sec. The duration of the T wave ranged from 0.06 to 0.08 sec, that are lower values than that reported by Mendez et al. (0.08 and 0.10 sec). These variations could be due to the placement of the electrodes using different techniques, or to variability related to races and ages of the subjects enrolled in the studies.

Conclusions

The heart rate is negatively correlated with the age of calves, while the QT, RR and ST show increasing values with advancing age of the animals. In contrast, ECG parameters related to P waves, T waves and QRS complexes, and PR interval may be present small or not changes relating to the age. This study has a limitation, the number of animals enrolled is low. Further studies, with a greater number of subject, are needed to establish the physiological ranges of the ECG parameters

in calves

Conflicts of Interest: There is no potential conflict of interest, and the authors have nothing to disclose. This work was not supported by any grant.

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