Base-apex electrocardiographic examination in healthy cows of Chianina breed

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Abstract

Background: The electrocardiography is a useful diagnostic tool for the characterization of the cardiac rhythm in veterinary medicine. In cattle, standard electrocardiographic (ECG) exam is commonly performed using the base-apex lead system and reference values for ECG parameters have been reported for different breeds of cows. However, no ECG studies have been conducted in Chianina breed.

Aim: To determine the feasibility and normal values for standard base-apex electrocardiography in clinically healthy Chianina cows.

Methods: A standard base-apex ECG examination was acquired in 45 Chianina cows. All the cows were considered healthy based on history and physical examination. The following ECG parameters were evaluated: heart rate (HR); morphology of P wave, QRS complex, and T wave; amplitude and duration of P wave, QRS complex, and T wave; duration of PR and QT intervals. Correlations between ECG parameters and clinical variables were analyzed.

Results: Morphology of the ECG waves/complexes and values for all ECG parameters recorded in the 45 clinically healthy Chianina cows were reported. Correlations between HR and body weight (BW), QT interval and BW, QT interval and HR, P wave amplitude and HR, PR interval and HR, R wave amplitude and age were observed. Statistical difference between HR in pregnant and non-pregnant cows was also found.

Conclusion: Base-apex electrocardiogram is suitable for monitoring heart rhythm in clinically healthy Chianina cows and reference values for main ECG parameters have been reported for this breed. This study can be a useful contribution to the literature, updating current knowledge on the electrocardiography in cattle.

Keywords: Arrhythmias, Cattle, Electrocardiogram, Heart.

Introduction

The electrocardiography is a non-invasive and inexpensive diagnostic tool that can be useful for the characterization of the cardiac rhythm in human and veterinary medicine. In adult cattle, a standard electrocardiographic (ECG) examination is commonly performed using the base-apex lead system (Rezakhani *et al.*, 2004; Buczinski and Boerboom, 2010). This system allows to obtain clear waves/complexes and minimizes the effect of the animal movement during the recording (Deroth, 1980; Rezakhani *et al.*, 2004). Therefore, base-apex ECG exam can be readily available in farms and useful to confirm or rule out the presence of cardiac arrhythmias in cattle (Buczinski and Boerboom, 2010). Previous studies reported reference values for ECG parameters for different breeds of cows such as Holstein (DeRoth, 1980; Rezakhani *et al.*, 2004; Cedeno *et al.*, 2016; Bonelli *et al.*, 2019), Mithun (Sanyal *et al.*, 2010), and crossbreed (Reddy and Sivajothi, 2016; Mohapatra *et al.*, 2017; Areshkumar *et al.*, 2018). To the authors' knowledge, the feasibility and the reference values for ECG examination have not been previously reported in Chianina breed.

The Chianina is an Italian cattle breed selected for its high-quality meat and it is present in different territories of the world (Italy, North and South America, and Australia). This breed is the largest and one of the oldest cattle breeds in the world. However, the scientific literature about cardiovascular assessment and cardiac diseases in Chianina cows is scarce (Caivano *et al.*, 2021; Jacinto *et al.*, 2022).

Therefore, this study aims to establish the feasibility and normal values for base-apex ECG parameters in clinically healthy Chianina cows that could be different from normal range of other cattle breeds and useful to assess cardiac rhythm in this breed.

Materials and Methods

Animals

A total of 45 Chianina cows were recruited from four different farms of central Italy (Umbria). All the cows

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Table 1. ECG parameters in 45 clinically healthy Chianina cows.

ECG parameters	Median	Minimum	Maximum
HR (bpm)	68	48	94
P wave duration (seconds)	0.10	0.08	0.13
P wave amplitude (mV)	0.20	0.10	0.25
QRS complex duration (seconds)	0.08	0.07	0.12
R wave amplitude (mV)	0.10	0.05	0.45
S wave amplitude (mV)	0.70	0.40	1.10
T wave duration (seconds)	0.08	0.06	0.14
T wave amplitude (mV)	0.30	0.20	0.65
PR interval duration (seconds)	0.18	0.13	0.24
QT interval duration (seconds)	0.39	0.31	0.46

(ECG): electrocardiographic; (bpm): beats per minute; (mV): millivolts.

included in the study were considered healthy based on history and physical examination.

ECG examination

All ECG examinations were recorded at the farms, the cows were kept in standing positions with helping of the owners and without sedation. The standard base-apex ECG examinations (ECG-1101G VET 5-lead, Carewell health care, Shenzhen, China) were acquired by positioning the positive electrode caudally to the olecranon, at the level of the fifth left intercostal space, and the negative electrode on the left jugular furrow in the lower 1/3 of the neck, as previously described (Rezakhani *et al.*, 2004). The other electrodes were attached near the positive electrode. To obtain a good quality of the ECG tracings, a small amount of alcohol was used to optimize the contact. When the animals were quiet, ECG recording was acquired for 2 minutes and printed at 25 mm/second with a gain of 10 mm/mV.

ECG parameters

All ECG tracings were analyzed, and the following parameters were assessed: heart rate (HR) (beats for minute, bpm), the morphology of P wave, QRS complex, and T wave (DeRoth, 1980; Rezakhani *et al.*, 2004); amplitude (millivolts, mV) and duration (seconds) of P wave, amplitude (mV) and duration (seconds) of QRS complex, amplitude (mV) and duration (seconds) of T wave, and duration (seconds) of PR and QT intervals. Each parameter was calculated using five randomly selected heartbeats, and the mean of these five measurements was used for statistical analyses.

Statistical analysis

Distribution of the data was evaluated using the Shapiro–Wilk test. Because most of ECG parameters were not normally distributed, descriptive data regarding the ECG measurements were reported as median and range (minimum and maximum). Next, correlations of all ECG parameters with body weight (BW), HR, and age were examined by Spearman's correlation test (Mukaka, 2012). Finally, the Mann–Whitney test was

Fig. 1. ECG tracing recorded in a clinically healthy Chianina cow. Positive and "bifid" P waves, QRS complexes with "rS" configuration and "biphasic" T waves are evident in the electrocardiogram. HR is 60 bpm. Paper speed = 25 mm/second; gain = 10 mm/mV.

used to verify the difference between ECG parameters in pregnant and non-pregnant cows. Statistical analysis was performed using a commercial software (GraphPad Prism 5, La Jolla, CA) and statistical significance was set at $p < 0.05$.

Ethical approval

The study was approved by the Ethical Committee of the University of Perugia (19/2022), according to the D.L.116/92 and D. Lgs. 26/14. An owner's written consent was obtained for ECG recording for all cows included in the study.

Results

Cows were aged between 3 and 11 years (median age 6 years) and BW ranged between 710 and 980 kg (median 830 kg). All the cows have had at least one parturition and 24 of 45 cows were pregnant.

ECG examination was carried out in all cows for a total of 45 ECG tracings and all animals tolerated the procedure well. All the ECG tracings were considered adequate for interpretation and no baseline artifacts were identified. All cows enrolled in the study showed sinus rhythm without presence of arrhythmias.

ECG tracing analysis showed HR values between 48 and 94 bpm with a median of 68 bpm. Median, minimum, and maximum values for all ECG parameters are reported in Table 1.

All cows showed a positive P wave with a "bifid" morphology in 10 of these. A QRS complex with "rS" morphology was recorded in 43 cows (Fig. 1), whereas

Fig. 2. ECG tracing recorded in a clinically healthy Chianina cow. Positive and "bifid" P waves, QRS complexes with "RS" configuration, and positive T waves are evident in the electrocardiogram. HR is 60 bpm. Paper speed = 25 mm/second; gain = 10 mm/mV.

the other 2 cows showed an "RS" morphology (Fig. 2). T wave polarity was positive in 38 cows and "biphasic" in 7 animals.

HR showed a moderate positive correlation ($r = 0.60$, $p < 0.0000$) with BW, whereas the QT interval showed a moderate negative correlation ($r = 0.58$, $p < 0.0000$) with BW and a high negative correlation with HR ($r = 0.86$, $p < 0.0000$). Moreover, HR showed a low positive correlation with P wave amplitude ($r = 0.41$, $p < 0.0052$) and a low negative correlation with PR interval duration ($r = 0.32$, $p < 0.0312$). Finally, R wave amplitude showed a low positive correlation with age ($r = 0.30$, $p < 0.0431$). All other ECG parameters showed no correlations with BW, HR, and age. Significant difference in HR was found between pregnant and non-pregnant cows ($p = 0.03$): pregnant cows showed higher HR (median 72.5 bpm, range 52–94 bpm) than non-pregnant cows (median 63 bpm, range 48–90 bpm). All other ECG parameters did not differ between pregnant and non-pregnant cows ($p > 0.07$).

Discussion

Our study demonstrates the feasibility of recording the cardiac rhythm by base-apex ECG examination in Chianina breed cows at the farms. We have also established the normal values for ECG parameters in clinically healthy cows of this breed. Chianina breed is an Italian cattle breed selected for producing top-quality beef, specifically the famous "Florentine steak", and it is the largest cattle breed in the world (cows weigh 800–900 kg with a withers height >165 cm) (*http://www.anabic.it/index_uk1.htm*). However, few data about the cardiovascular assessment in this cattle breed have been reported in veterinary literature (Caivano *et al.*, 2021; Jacinto *et al.*, 2022).

ECG examination was well tolerated in all Chianina cows included in the study and the quality of the ECG tracings was considered adequate for interpretation. As demonstrated in this study, this diagnostic tool can be easily performed with helping of the owners using a portable ECG machine in farms and can allow a rapid evaluation of the cardiac rhythm. Therefore, ECG examination could be useful to confirm the presence of cardiac arrhythmias suspected on the base of the clinical findings in Chianina cows.

HR in Chianina cows showed values between 48 and 94 bpm with a median of 68 bpm. In previous studies, HR assessed by electrocardiography in cows showed values slightly higher: HR of 79 ± 12.9 bpm (Cedeno *et al.*, 2016), 75.73 ± 9.13 bpm (Rezakhani *et al.*, 2004) and 75 ± 7 bpm (DeRoth, 1980) has been reported in Holstein cows; similarly, Bonelli *et al.* (2019) recorded HR with a median of 80 bpm. We speculate that HR values recorded in Chianina cows could be due to inverse correlation between HR and BW in mammalian species (Noujaim *et al.*, 2004): being Chianina cows larger than Holstein cows included in the previous studies (DeRoth, 1980; Rezakhani *et al.*, 2004; Cedeno *et al.*, 2016; Bonelli *et al.*, 2019), their HR values are lower.

Concerning the morphology of ECG waves and complexes, P wave was positive in all cows (in some animals were also "bifid"), in accordance with previous studies (DeRoth, 1980; Rezakhani *et al.*, 2004; Cedeno *et al.*, 2016; Bonelli *et al.*, 2019). P wave duration was similar between Chianina and Holstein cows (DeRoth, 1980; Rezakhani *et al.*, 2004; Cedeno *et al.*, 2016; Bonelli *et al.*, 2019), whereas a slight difference was recorded in P wave amplitude that was higher in Chianina cows (DeRoth, 1980; Rezakhani *et al.*, 2004; Cedeno *et al.*, 2016). P waves represent the atrial depolarization, and tall or wide P waves could indicate atrial enlargement. Therefore, we can only speculate that Chianina cows have a larger size of the heart, specifically the size of the atria, than Holstein cows. The QRS complex showed mostly a negative polarity with "rS" configuration (43 cows), whereas an "RS" configuration was found in two animals. Our results are in accordance with previous studies, even if we have not found "QS" configuration of QRS complex that has been previously recorded in Holstein cows (DeRoth, 1980; Rezakhani *et al.*, 2004). Duration and amplitude of the QRS complex showed similar values reported in previous studies on Holstein cows (DeRoth, 1980; Rezakhani *et al.*, 2004; Cedeno *et al.*, 2016; Bonelli *et al.*, 2019). The T wave was positive in most of Chianina Cows and "biphasic" in seven animals. Our results are somewhat consistent with some previous studies (DeRoth, 1980; Rezakhani *et al.*, 2004), although also negative T waves have been recorded (Cedeno *et al.*, 2016; Bonelli *et al.*, 2019). Duration and amplitude of

T wave did not differ from values reported in previous studies (DeRoth, 1980; Rezakhani *et al.*, 2004; Cedeno *et al.*, 2016). The ECG interval duration (PR and QT intervals) showed similar values reported in previous studies (DeRoth, 1980; Rezakhani *et al.*, 2004; Cedeno *et al.*, 2016; Bonelli *et al.*, 2019).

When we evaluated the correlations between ECG parameters and BW, HR, or age, we found a moderate correlation between HR and QT interval with BW; a high correlation between QT interval and HR was also observed. HR showed a moderate positive correlation with BW, this means that heavier cows showed higher HR. If HR is inversely correlated with BW (Noujaim *et al.*, 2004), opposite results should be expected: lower HR should be recorded in heavier cows. However, some authors have already described this correlation in dairy cows: mean HR was higher in animals with higher BW (Hagen *et al.*, 2005). Authors speculated about the reasons for their results, suggesting that BW could not be proportional to heart volume in the cows (Hagen *et al.*, 2005). Further studies are needed to evaluate the relationships between BW and ECG parameters in cows in order to assess species-specific characteristics. Concerning the QT interval, this showed a high negative correlation with HR and a moderate negative correlation with BW. The QT interval is routinely used to measure the ventricular repolarization in human and veterinary medicine (Al-Khatib *et al.*, 2003; Pedersen *et al.*, 2013; Oliveira *et al.*, 2014). In humans and animals, QT interval is negatively correlated with HR, leading to a decrease in the interval when the HR increases (Davey, 2002; Al-Khatib *et al.*, 2003; Moss, 2003; Rajappan *et al.*, 2003, Rezakhani *et al.*, 2004). We have demonstrated similar correlation in Chianina cows. However, our results differ from those of previous studies with regard to the association between QT interval and BW (Bartlett *et al.*, 2009; Schwarzwald *et al.*, 2012; Oliveira *et al.*, 2014). Indeed, a positive correlation has been reported between QT interval and BW in other animal species (Oliveira *et al.*, 2014; Bartlett *et al.*, 2009; Schwarzwald *et al.*, 2012). Conversely, in this study, we have found a moderate negative correlation between QT interval and BW: to the authors' knowledge, no relationships between QT interval and BW were previously reported in cattle. Therefore, further studies could be useful in order to have more information about normal QT interval in relation to body size in cows. With regard to low positive correlation between HR and P wave amplitude, our results are consistent with a previous study on Holstein cows (Rezakhani *et al.*, 2004). In our study, we have also described a low negative correlation between HR and PR interval duration: although this correlation has never been described in cattle, a significantly negative relationship has been reported in humans and horses (Schwarzwald *et al.*, 2012; Soliman and Rautaharju, 2012). Finally, a low positive correlation between age and R wave amplitude was found in Chianina cows and it has never been described in cattle. If this correlation is related to increased ventricular dimensions in older cows, remains undetermined.

A similar number of pregnant and non-pregnant cows (24 *vs.* 21 animals) were included in our study. We have analyzed these subpopulations and we have found a significant difference only for HR. This is not surprising because higher HR has been previously reported in pregnant dairy and beef cows (Brosh *et al.*, 2002; Trenk *et al.*, 2015).

In conclusion, we have demonstrated that base-apex ECG examination is suitable for monitoring heart rhythm in clinically healthy Chianina cows. We have also reported the reference values for ECG parameters and some specific ECG characteristics for this breed. Our study can be a useful contribution to the literature, updating current knowledge on the electrocardiography in cattle.

Acknowledgments

Conflict of interest

The authors declare that there were no conflicts of interest.

Authors' contribution

All authors conceived and performed the study, analyzed the data, and wrote the paper. All authors read and approved the final manuscript.

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