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Original Article

Computerized electrocardiography in adult Sulffolk sheep: a comparative study

Eletrocardiografia computadorizada em ovinos adultos da raça Sulffolk: estudo comparativo

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ABSTRACT

Computerized electrocardiography is a method widely used in veterinary medicine in several species and currently, with the availability of several devices in the market. In sheep, studies have shown variations in electrocardiographic values according to race, age, and methods of capture, but the values obtained in different computerized devices have not been compared. Thus, the present study sought to determine and compare the values of electrocardiographic variables between two computerized devices in healthy sheep. Fifty sheep (n = 50), Suffolk breed, female, launched, adult, non-pregnant, with average age and weight of two years and 50kg, respectively, were studied properly selected and clinically fit. The electrocardiographic tracings were obtained in two computerized electrocardiography devices (Apparatus A and B) individually and subsequently, with subsequent recording and interpretation of the tracings. The results showed a predominance of sinus rhythm in 78% (n = 39) and 22% (n = 11) with sinus arrhythmia in both devices. Significant differences among the devices (p <0.05) were identified in the duration variables (ms), such as P wave, P-R interval and segment, QRS complex, Q-T interval, S-T segment and T wave; and in the P-wave and R-wave amplitudes (mV). However, the values obtained were within the normal ranges recommended for the species, regardless of the capture method used. Thus, it is possible to conclude the presence of different values among the computerized electrocardiographs, suggesting variations in the tracking uptake sensitivity among the devices in released Suffolk sheep.

RESUMO

A eletrocardiografia computadorizada é um método muito utilizado na medicina veterinária em diversas espécies e atualmente, com a disponibilidade de vários aparelhos no mercado. Em ovinos, estudos demonstraram variações nos valores eletrocardiográficos conforme a raça, idade e métodos de captação, mas não foram comparados os valores obtidos em diferentes aparelhos computadorizados. Assim, buscou-se determinar e comparar os valores das variáveis eletrocardiográficas entre dois aparelhos computadorizados em ovinos hígidos. Para isso, foram estudados cinquenta ovinos (n=50), raça Suffolk, fêmeas, lanadas, adultas, vazias, idade média de 2 anos e peso corporal médio de 50kg; devidamente selecionadas e aptas clinicamente. Os traçados foram obtidos em dois aparelhos de eletrocardiografia computadorizada (Aparelho A e B) de forma individualizada e subsequente, com posterior gravação e interpretação dos traçados. Os resultados obtidos demonstraram o predomínio do ritmo sinusal em 78% (n=39) e 22% (n=11) com arritmia sinusal em ambos aparelhos. Diferenças significativas entre os aparelhos (p<0,05) foram identificadas nas variáveis de duração(ms), como Onda P, Intervalo e segmento P-R, Complexo QRS, intervalo Q-T, Segmento S-T e Onda T; e nas amplitudes (mV) de Onda P e Onda R. Contudo, os valores obtidos estavam dentro dos intervalos de normalidade preconizados para a espécie, independentemente do método de captação utilizado. Assim, pode-se concluir a presença valores diferenciados entre os eletrocardiógrafos computadorizados,

Franco et al. Acta Veterinaria Brasilica June 14 (2020) 77-84

78

sugerindo variações na sensibilidade de captação do traçado entre os aparelhos em ovinos Suffolk lanados.

INTRODUCTION

The electrocardiogram (ECG) is a complementary, non-invasive and low-cost exam that allows the detection of changes in the electrical conduction of the cardiac chambers (arrhythmias) and in the frontal plane axis (CAMACHO *et al.*, 2010; MENDES NETTO, 2014; TILLEY, 1992); widely used in domestic species such as canines, felines, equine and ruminants.

Sheep farming has gained a prominent role in the Brazilian territory due to the increase in farms and its use as a scientific experimental model (KOETHER *et al.*, 2016). According to Lavinsky; Seibel (2001) and Rabbani *et al.* (2008) when they studied the sheep species anatomically, concluded that some anatomical and physiological structures were similar to humans. Due to the findings, the species has become a model for research and experimental comparisons (LAVINSKY; SEIBEL, 2001), in addition to the great availability of animals, their low maintenance cost and favorable size.

In Veterinary Medicine, there is a difficulty in determining electrocardiographic values in sheep. According to Chiacchio *et al.* (2018) there are differences in the values of electrocardiographic variables according to race and age, highlighting the variations found when comparing the conventional method with the computerized one. Thus, further research in the area is necessary (KOETHER *et al.*, 2016). Electrocardiography is a non-invasive exam (MENDES NETTO, 2014; OLIVEIRA *et al.*, 2013) that promote the graphical visualization of linear segments showing the results of depolarization and repolarization of cardiac cells (NUNES *et al.*, 2014). According to Oliveira *et al.* (2008) the best results in relation to the capture of electrocardiographic tracing in cattle is the use of electrodes on the four limbs, with a similar indication for sheep. A fact that proves the theory of Tório *et al.* (1997) who affirmed Einthoven's principles for the placement of electrodes in sheep, with adequate anatomical positioning of the heart, generating less variation in the electrocardiographic tracing, improving the amplitude and the correct evaluation of all parameters.

The use of computerized electrocardiography has become frequent in veterinary medicine due to its handling, sensitivity in capturing traces and practicality when compared to conventional devices (PELTER; ADAMS; DREW, 1996; OLIVEIRA *et al.*, 2013). According to Pereira Neto *et al.* (2006) the test can be used for different diagnostic purposes, such as preoperative evaluation, electrocardiographic monitoring, recognition of arrhythmias, suggesting cardiac remodeling or the presence of chest effusions. In the veterinary market there are several brands and models available, and there may be variations and differences between them in relation to the sensitivity for the sheep species, requiring

attention to the parameters of normality for each equipment used (Oliveira *et al.*, 2013). In the equine species, studies have shown differences among the conventional and computerized methods in the quarter mile and mangalarga gait breed (Lázaro *et al.* 2015) as well as mini horses (Dantas *et al.* 2015), emphasizing the need for standardization of values. Oliveira *et al.* (2013) studied and compared computerized electrocardiography in healthy dogs, observing differences among the devices used and suggesting the need for further studies, aiming to exclude factors that led to the observed differences, such as the sensitivity and uptake of the electrocardiographic tracing.

In small ruminants, Samimi *et al.* (2017) studied the values of the S-T segment in order to identify the high variability of the index in relation to race, sex and age, with the results demonstrating the absence of interference in the variables in the S-T segment of sheep and goats. Chiacchio *et al.* (2018) studied the electrocardiography of sheep and reported the presence of significant differences in the duration of the PR and QT intervals and in the T wave, as well as in the decrease in the amplitude of the P, R and T waves at the evaluated moments. Heart rate and total QRS decreased progressively until 35 days of age with heart rate variability (HRV) indexes increasing in the same period. Regarding the configurations of the QRS complexes, Koether *et al.* (2016) identified a wide variety of configurations in sheep, with a predominant rS and qR pattern in leads I and aVF, in the first week of life and at 35 days. In addition, as age increased, a higher percentage of low voltage and complexes with a qs, qr and rs pattern was observed. Previously, Chalmeh (2015) using a single-channel electrocardiograph in sheep, had observed differences in the values and formation of the P-QRS-T complex in neonates when compared to adults.

Thus, due to the increase in the number of computerized electrocardiographs on the market, the use of the sheep species as an experimental model and the differences found in the electrocardiographic variables of the species, the present study sought to determine and compare the values of the electrocardiographic variables using two computerized devices in healthy Suffolk launched sheep.

MATERIAL AND METHODS

In the present study, as approved by university's ethics in animal use committee (CEUA) under the CIAEP-01.0218.2014 protocol, fifty sheep (n = 50), Suffolk breed, females, flips, adults, empty, aged average of two years, average weight of 50 ± 9.8kg, from the Ovine Culture sector at the Universidade de Marília - UNIMAR. All sheep were vaccinated and underwent a physical examination prior to the study, with the measurement of

heart and respiratory rates, ruminal movements, assessment of mucosal color (Famacha method), measurement of rectal temperature, nutritional status, as well as a complete blood count, complete and parasitological feces (OPG) (reference - maximum 500 eggs per gram of feces), aiming at the standardization of animal health and hygiene (FEITOSA, 2014).

The selected and fit sheep were separated and grouped in the management pen in the afternoon, beginning the 90-minute adaptation period, prior to the electrocardiographic evaluation. Subsequently, they were individually contained in a wooden containment trunk, being stationed under rubber plates fixed to the floor as contact insulators. Two computerized electrocardiography devices (Device A - Computerized Electrocardiograph Model: ICAV1.2 - Incardio Agile - 6 leads / Device B- DL660 - Computerized Electrocardiograph - 12 leads) were used to capture the electrocardiographic traces individually, with each electrocardiographic capture lasting two minutes, using the methodology cited by Oliveira *et al.* (2008), with subsequent recording and interpretation of the traces. For this, four electrodes were attached, both moistened with 70% alcoholic solution, two in the axillary region and two close to the patella, aiming to capture and record the electrocardiographic tracings and derivations D1, D2, D3, aVF, aVL and aVF, in the speed of 50m/s and calibrated to a centimeter equal to 1 mV.

The electrocardiographic tracings obtained were interpreted based on an electrocardiographic section chosen at random and absent of interference, aimed at measuring the following variables using derivation D2: Evaluation in time (ms) P Wave, PR Interval, QRS Complex and QT; in amplitude (mV) the values of P waves, Q wave, R wave, S wave and T were obtained. Subsequently, the cardiac axis was calculated using the QRS Complex, using the values obtained in leads D1 and D3.

After the interpretation of the obtained data, the Student t test method was used, paired at 5% probability for analysis and comparison of electrocardiographic variables. Previously, the hypothesis of normality of the variables was checked using the Shapiro-Wilk normality test also at 5% probability. For the comparison of the normality values of devices A and B with the authors Schultz; Pretorius; Terblanche (1972) and Kumar *et al.* (2017), the 95% confidence interval was used. Emphasizing that all data were analyzed using the software R (R CORE TEAM, 2017).

RESULTS

With the electrocardiographic tracings and subsequent interpretation, the predominance of sinus rhythm can be characterized in 78% (n = 39) of sheep and 22% (n = 11) presented sinus arrhythmia; bradyarrhythmias or tachyarrhythmias were not identified during the electrocardiographic tracing capture period.

Regarding the patterns in the configuration of the QRS complexes in the evaluated sheep, it was observed in both devices (A and B), the predominance of the Qrs pattern in 46% (n = 23), QRs pattern with 36% (n = 18) and the qR standard without 18% (n = 9) (Figure 1).

After the capture and interpretation of electrocardiographic tracings by the same professional, the values obtained were compared statistically between the devices A and B used, with the results showing significant differences (p <0.05) in the derivations analyzed over time (ms), such as P Wave duration, PR interval and segment, QRS Complex duration, QT interval, ST segment and T wave duration. In the study of amplitudes (mV), significant differences were also observed in P wave and R wave, with the other variables showing no changes. The values and standard deviations are shown in Table 1.

Figure 1 – Different configurations of the QRS complex obtained in healthy, female Suffolk sheep, using different computerized electrocardiography devices. A) Qrs standard; B) Standard qrs; C) QRS standard.
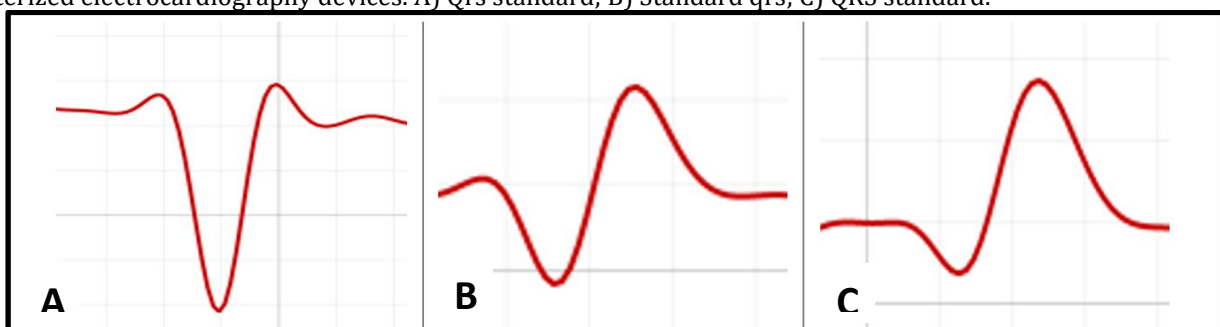
Table 1 – Mean values and standard deviation (SD) of the electrocardiographic leads obtained in healthy Suffolk sheep, using different computerized electrocardiography devices.

Derivações ECG	Aparelho A (Média e DP)	Aparelho B (Média e DP)	p
Duração P (ms)	30,4±5,7	37,2±5,51	0,0001*
Intervalo PR (ms)	90,8±14,1	119,8±18,9	0,0001*
Duração QRS (ms)	70,4±15,5	84,1±11,7	0,0007*
Segmento PR (ms)	75,4±13,2	94,1±17,8	0,0003*
Intervalo QT (ms)	51,6±4,0	70,1±8,9	0,0011*
Segmento ST (ms)	168,4±39,6	138,7±42,7	0,037*
Duração T (ms)	52,9±16,1	66,9±22,7	0,009*
Amplitude P (mv)	0,05±0,01	0,07±0,03	0,0002*
Amplitude Q (mv)	0,1±0,12	0,23±0,22	0,095
Amplitude R (mv)	0,09±0,04	0,12±0,04	0,045*
Amplitude S (mv)	0,03±0,03	0,05±0,11	0,549
Amplitude T (mv)	0,14±0,1	0,14±0,1	0,801
Infradesnivelamento ST (mV)	0,04±0,07	0,02±0,03	0,381
Frequência Cardíaca (bpm)	89±1	95±20	0,360
Eixo Cardíaco QRS	163±25	147±28	0,095

*Presence of significant difference to the Student's t test paired at 5%;

The values and confidence intervals obtained from the electrocardiographic variables were compared with normal values previously established in sheep by Schultz *et al*. (1972) using conventional electrocardiograph and with Kumar *et al*. (2017) who used a computerized electrocardiograph. The results of device A showed differences only in the variable QRS Axis° and in device B, differences were identified in the variables QRS duration (ms), Q wave (mV) and QRS axis, when compared with the values described by Kumar *et al*. (2017). Regarding the values obtained by Schultz *et al*. (1972), only the variables P wave (ms) and R wave (mV) of device A demonstrated different values, but in device B were the variables P wave (ms), QRS (ms), P wave (mV) and Wave R (mV) that presented values outside the confidence interval (Figures 2 and 3).

Figure 2 – P wave electrocardiographic variables in ms and mV, according to the comparison between devices A and B and the normal values obtained in the sheep species.
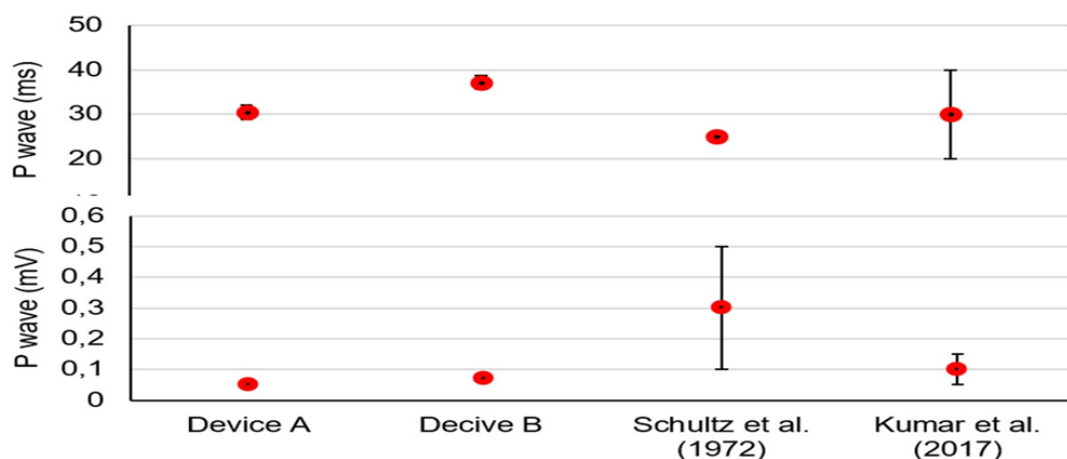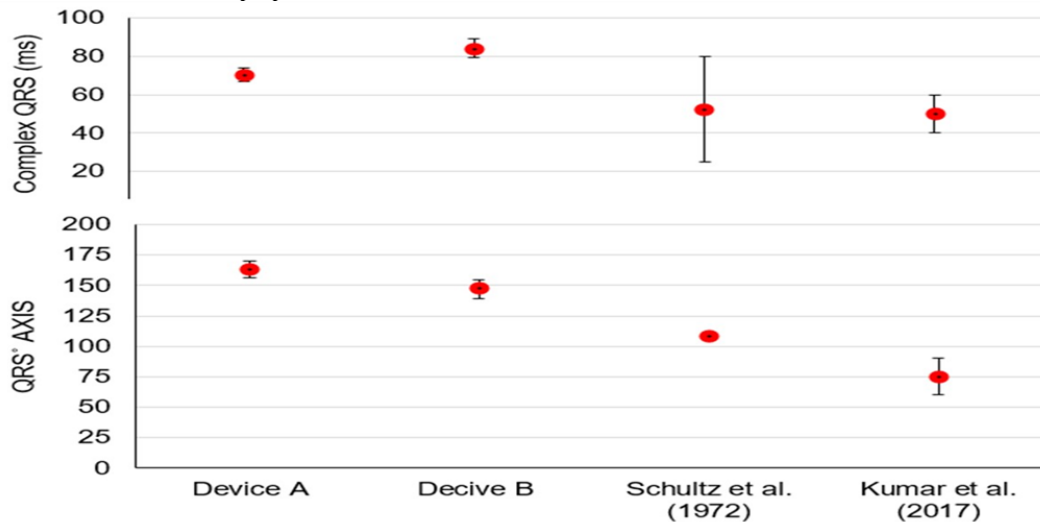
Figure 3. Electrocardiographic variables Complex QRSms and QRS° AXIS, in comparison between devices A and B and the normal values obtained in the sheep species.

DISCUSSION

The computerized electrocardiographs used in the present study demonstrated the applicability of the method in the sheep species, according to the previous studies described (CHIACCHIO *et al.*, 2018; OLIVEIRA *et al.*, 2013; SAMIMI *et al.*, 2017).

Sinus rhythm was predominant in the animals evaluated in 78% (n = 39) while 22% (n = 11) presented sinus arrhythmia. Similar results were found in lambs by Chiacchio *et al.* (2018) and adult goats by Pogliani *et al.* (2013), demonstrating the predominance of sympathetic autonomic activity in the animals evaluated and the reduction of parasympathetic activity; due to the identification of sinus arrhythmia, this rhythm is usually related to respiratory movements promoting variations in heart rate values (RADOSTITS *et al.*, 2007). We emphasize that no bradyarrhythmias or tachyarrhythmias were identified during the electrocardiographic study. The adult Gallega ewes, when evaluated, showed a predominance of sinus rhythm as described by Tório *et al.* (1997) in 66.7% of cases and respiratory sinus arrhythmia in 23.3% of sheep between two and seven years of age; justifying that adult animals showed rhythmic pattern and lower HR.

In relation to HR, no differences were observed among the devices with the predominance of values within the normal range for adult sheep (KUMAR *et al.*, 2007), which suggests the minimization of stress with the method adopted in the evaluation of sheep, as well as the period of the day adopted for the execution of the present study (SZABUNIEWICK; CLARK, 1967). Data regarding the increase in HR in obtaining electrocardiography due to stress and its relationship with neonates up to 35 days of age were described by Chiacchio *et al.* (2018) and Koether *et al.* (2016) in sheep. Differences in HR values in different breeds of goats were also reported by Atmaca; Simsek; Emre (2014) and Pogliani *et al.* (2013), justified by the stress

of contention and chest format. Results that were not observed in the present study, with the HR values obtained remaining stable with a predominance of sympathetic activity (KEUNEN *et al.*, 2000).

Variations in HR and rhythm values can occur in normal animals due to autonomic influence or involvement by myocardial disorders. As there were no electrocardiographic changes with the ECG, we assume that the variations in frequency and rhythm in the present study are normal (RADOSTITS *et al.* 2007). However, we emphasize that environments with high temperatures can influence the electrocardiographic tracings, as described by Mendes *et al.* (2010) when they mentioned that the temperature of the environment influences the electrocardiographic parameters, leading to R values close to 0.160 mV in goats at 60 days of age and lambs at birth. Results justified due to the reduction of peripheral vascular resistance, the occurrence of inotropism and positive compensatory chronotropism (MENDES *et al.*, 2010). Facts probably minimized in the present study due to the adaptation period and the experimental act to be carried out at the end of the day and in the month of June, when the room temperatures are lower when compared to midday and early morning, aiming at greater thermal comfort to the evaluated sheep.

Regarding the patterns in the configuration of the QRS complexes, the predominance of the Qrs pattern was observed in both devices (A and B) in 46% (n = 23) of the animals, QRs pattern with 36% (n = 18) and QRs in 18% (n = 9). The morphology of the qRS complex depends on the waves that predominate in the tracing (Tilley, 1985) and according to Reed *et al.* (2010) the morphologies of the QRS complex are variable in the sheep species, justified due to the variation in the penetration and conduction of the impulses in the ventricular walls, the can generate several QRS patterns, such as "Qr" (large Q wave and small R wave); "qR" (where the Q wave is small and the R wave is large); "qrs" (presence of the three small waves); "Q" (only large

Q wave); "Rs" (large R wave and small S wave); "R" (only large R wave); "rS" (small R wave and large S wave); "Q" (small Q wave only); and "r" (only small R wave) in conventional and computerized methods. In conventional and computerized exams, the most common pattern was "qR" (48.78%) in both methods, followed by "Qr" with 14.63% for conventional and 19.51% for computerized; which was also observed in our study.

Tório *et al.* (1997) studying conventional electrocardiography in adult Galician sheep, described several QRS patterns found, with 60% of QS, 20% of Qr and 8% QR. Results that are not consistent with those identified in the present study. Kumar et al. (2017) obtained QR patterns in computerized electrocardiography in 50%, rSr in 30% and qRs with 20%. These results, more similar to those obtained in the present study, justified due to the use of the same electrocardiographic method in sheep, adults and of the launched breed, favoring the standardization of the results.

Significant differences were identified in the electrocardiographic variables in time (ms) and amplitude (mV) between devices A and B, with practically all the values above estimated in device B. These results show the possibility of differences in the sensitivity of the capture of electrocardiographic impulses among the devices in the sheep species, since the values of both devices were interpreted by the same professional, captured individually and on the same experimental day. Factors such as the anatomy of the species, rumen, body mass and the presence of wool can interfere with the capture of the tracings, possibly favoring the differences observed between the devices studied. In the sheep species, studies already show differences between neonates in the conformation of the P-QRS-T complex, as mentioned by Chiacchio *et al.* (2018). In horses, Lázaro *et al.* (2015) also identified differences in the values of electrocardiographic variables in a comparative study of conventional and computerized electrocardiography in horses of the quarter mile and mangalarga gait races. Also promoting the differences in ECG values in horses of different races, Mantovani *et al.* (2013) described that cardiovascular function can vary according to the racial and functional characteristics of horses and previously, Morgan (2012) highlighted the main factors that affect the electrocardiographic tracing in the species, such as body size, chest conformation and cardiac positioning in the cavity thoracic, justifying the variations in the amplitudes of durations observed between the studied breeds. Facts seen in small ruminants, with differentiated electrocardiographic values in different races, ages and sizes, as described by Chiacchio *et al.* (2018) and Samimi *et al.* (2017) in sheep, as well as Pradhan *et al.* (2017) in goats. Differences among sheep species in relation to body mass and gastrointestinal tract volume can influence the distribution of electrical potentials on the body surface (SANTAMARINA; ESPINO; SUAREZ, 2001) and this may explain the differences in

the ST segment duration between sheep and goats cited by Samimi *et al.* (2017). Data that further reinforces the differences obtained in the present electrocardiographic study when we compare the values obtained between devices A and B, as well as the comparison of their confidence intervals with those previously published (KUMAR *et al.*, 2017; SCHULTZ; PRETORIUS; TERBLANCHE, 1972).

Regarding the results obtained when comparing the normal ranges of the electrocardiographic variables described by Schultz; Pretorius; Terblanche (1972) in sheep of the merino-launched breed performed by conventional electrocardiograph, with the computerized A device, only two variables (Onda Pms and Onda RmV) did not fall within the normal ranges. Device B, on the other hand, showed differences in four variables (Pms wave, PmV wave, QRSms, RmV wave). Both the applied methods and the results of the present study confirm the data described by Wolf; Camacho; Souza (2000) and Camacho *et al.* (2010) in dogs and cats, respectively, where they pointed out the accuracy of the computerized technique in relation to the conventional method. Results also previously documented by Lázaro *et al.* (2015) and Dantas *et al.* (2015) in horses, comparing the two electrocardiographic methods. Still according to the medical literature, the human being has less precision in the perception of electrocardiographic reading when compared to the computer, as mentioned by Pelter; Adams; Drew (1997) when they described that man can measure unevenness from 0.05mV, while the computer detects from 0.01mV; what can justify the differences of the devices A and B for the values obtained by Schultz; Pretorius; Terblanche (1972) on conventional paper electrocardiographs. However, we emphasize that Oliveira *et al.* (2013) studying the comparison between computerized devices in healthy dogs, observed differences between the devices studied.

When we compare the results of the present study with the confidence intervals of the variables obtained by Kumar *et al.* (2017) in female, adult, muzaffarnagari sheep - released by means of computerized electrocardiography, it was observed that 91% of the variables in device A showed similar intervals to the comparative study. Emphasizing that the breeds of sheep and the brands of electrocardiographs were different, however both studies were carried out on females, adults, empty and launched, which may have favored the results due to standardization. With device B, 73% of the compared variables had similar intervals, with only the duration of the QRSms and amplitudes of the QmV wave with values above estimated. The duration of the QRS complex reflects left ventricular depolarization (TILLEY *et al.*, 2008) and differentiated values between the conventional method and the computerized method were described by Wolf; Camacho; Souza (2000) and Camacho *et al.* (2010) in other species. Thus, its interpretation must be cautious, since misinterpretations of left ventricular overload may occur. Regarding the Q Wave intervals, the differences observed are related to the different formats of the QRS

complex observed in the present study, making the variation in amplitude (mV) evident. owever, the results obtained corroborate those obtained by Oliveira *et al.* (2013) in healthy dogs, when they observed differences between the devices studied and concluding the need for further studies, aiming to exclude the factors that lead to the differences observed in the sensitivity and uptake of the electrocardiographic tracing.

The values of the cardiac axis obtained showed values greater than the range estimated by Kumar *et al.* (2017) and Schultz; Pretorius; Terblanche (1972), indicating the presence of a displacement of the cardiac axis to the right in the species, with the values in the third quadrant. The values were higher, but approximate to those obtained by Schultz; Pretorius; Terblanche (1972) when they performed the electrocardiographic study by the conventional method with the animals in season. Given that it can justify the identification of the displacement of the cardiac axis to the right in the species, when the animals are in adulthood. This fact corroborates with Dönmez; Cinar (2003) who confirmed that the heart of an adult sheep is directed from left to right. However, it is worth mentioning that according to the method used to obtain the electrocardiographic tracing in relation to the placement of the electrodes to the heart, the modification of the axis may occur, as observed in Gallega ewes where the axis is turned to the right (−165 a −137 °) (TORIO *et al.*, 1997). Differences suggest the presence of a non-consensus on the values of the cardiac axis in sheep, justified by several factors such as the position of the electrode, the technique used, size of the animal, breed and age. Variations in the amplitude of the QRS complex suggest a high degree of synchronized ventricular depolarization (MOHAN *et al.*, 2005), which can attribute variations in the cardiac axis, as observed in black cane goats with values 115 ° to 192 ° described by Ahmed ; Sanyal (2008). However, Chiacchio *et al.* (2018) studying sheep neonates characterized a variation in the cardiac axis in relation to the age development of the species, with values ranging from the first to the third quadrant.

CONCLUSIONS

After analyzing the data obtained in the present study, it is possible to observe the presence of different values in certain electrocardiographic variables when comparing the two computerized electrocardiographs, which may suggest variations in the sensitivity of capturing the trace between the devices. However, the values obtained remained within the confidence intervals for the computerized method in adult and released sheep.

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