

Electrocardiographical Parameters in Alpacas Infected With *Sarcocystis lamacanis*

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ABSTRACT

The objective of this study was to determine if the presence of micro cysts of *Sarcocystis lamacanis* in the heart of alpacas (*Lama pacos*) produced any electrocardiographic changes. Fourteen alpacas were divided into a control group (n = 7) and a group of animals infected (n = 7) with the parasite *S lamacanis*. Electrocardiograms in non-sedated animals were performed 3 days in a row, by means of a bipolar and unipolar augmented system. Two alpacas were sacrificed and their hearts sent for histopathological analysis. The electrocardiographic parameters obtained did not differ from the normal parameters found in previous studies. Variable QRS complex morphology, low QRS voltage, and a variable mean electrical axis of the frontal plane was found. Histologically, the micro cysts were located in the myocytes and not in the cells of the conduction system. The micro cysts did not appear to cause any kind of alteration in the conduction of the electrical impulse through the myocardium.

INTRODUCTION

The increasing popularity of South American camelids worldwide is accompanied by the necessity to obtain information about this species that can be used to aid in the prevention, diagnostics, treatment, and con-

trol of certain diseases. The literature found regarding cardiac pathologies in South American camelids is scarce.

Cardiac rhythm abnormalities such as atrial premature complexes, second degree atrioventricular blocks, atrial fibrillation, and sinus bradycardia have been found in alpacas.¹ Congenital abnormalities like inter-ventricular septal defects have been diagnosed in South American camelids without the presence of any clinical signs. Acquired cardiac diseases are mainly of the inflammatory type and they involve the pericardium, epicardium, myocardium, and endocardium. Non-inflammatory pericardial effusions been diagnosed as well.²

It has been determined that the referential electrocardiographical values in llamas and alpacas, without sedation, are very similar to those found in ruminants.³ The variability of the QRS complex and the mean electrical axis are found to be poor indicators of ventricular enlargement in this species; however, the prolonged duration of the QRS complex can serve as an indicator of ventricular enlargement. The characteristics found in the electrocardiograms included: low voltage QRS complexes, a variable morphology of the QRS complex, a mean electrical axis oriented dorsocranially to the right, and a QT interval and ST segment negatively correlated to the heart rate.³ The heart rate varied between 50 and 110 beats per minute. All the electrocardiographi-

cal parameters were distributed normally, between the P wave positive and monophasic, with larger amplitude in males. The PR interval was shorter in animals younger than 6 months and the T wave morphology was variable.^{1,4,5} On the other hand, it has been reported that in the case of animals living at an altitude above 4400 m above sea level, the heart rate is lower and the QT interval is longer compared to those living at sea level.⁶ This can be attributed to a longer duration of ventricular diastole or to an adaptation response associated to polycythemia.

Three species of *Sarcocystis* have been found in South American camelids: *S tilopodi* in guanacos; *S aucheniae* in alpacas, llamas, and vicuñas producing macro cysts of slow growth and maturation in the skeletal muscle; and *S lamacanis* in alpacas, producing micro cysts of rapid growth and maturation in the cardiac muscle. *Sarcocystis lamacanis* initiates extensive hemorrhagic areas and necrosis of the cardiac muscle. The myocardium acquires a deep red colouring, and abundant serohemorrhagic fluid has been found in the thorax, pericardium, and peritoneum.⁷

The high prevalence (70%-100%) of micro and macro cysts found in the musculature of the alpaca, llama, guanaco, and vicuña reveals the high contamination index of the highland pastures with this coccidia.⁸ The structure and ultrastructure of the primary wall of *S aucheniae* macro cysts was evaluated through optic and electron microscopy, finding that 90% of the animals presented macro cysts in different organs, but none were found in the heart.⁹ In alpacas and llamas naturally infected with *Sarcocystis* spp, abnormalities within the myofilaments and myofibrils in the myocardial cells have been found.¹⁰

The objective of this study was to determine if the presence of micro cysts of *S lamacanis* in the heart of alpacas produces any change in the conduction of the electrical impulse, detected by the means of the electrocardiographic technique.

MATERIALS AND METHOD

Animal Care and Health

Alpacas were determined to be healthy by physical exam and cardiac auscultation. The animals were born in Lima at sea level in the research facility of the College of Veterinary Medicine of Cayetano Heredia University. Their body condition was good.

Study Design

Fourteen 1.5-year-old alpacas were divided into 2 groups: control and infected (infected orally at the age of 1 month with a 30,000 *S lamacanis* sporocysts dose). The groups were kept separate, each in a 50-m² yard, where they were offered daily water ad libitum and food in the morning and afternoon.

Sporocysts

To obtain the sporocysts for the experimental infection, a group of dogs was fed with meat contaminated with micro cysts. Twenty days later, the alpacas' feed was contaminated with 30,000 sporocysts of *S lamacanis*. The number of sporocysts was determined by the means of a Neubauer chamber.

Serum Analysis

A blood sample was taken weekly from all the animals to determine the presence of *S lamacanis* through the polymerase chain reaction test (PCR). Starting 45 days after birth, all the alpacas in the control group, 4 females and 3 males, were found PCR negative every time, whilst all the animals in the infected group (6 females and 1 male) were found to be PCR positive every time.

Electrocardiograms

An electrocardiography machine, ESAOTE P80, regulated at a velocity of 25 mm/s, voltage 10 mV, baseline filter of 0.05 Hz, 60 Hz net filter, and 35 Hz myogram filter was used. The electrocardiograms were registered in the bipolar and unipolar augmented leads.

All the electrocardiograms were performed with the animals in a standing position, without any type of sedation, being manually held by an assistant. The electrodes were connected with pins to the

Table 1. Electrocardiographical parameters in the control and infected group of alpacas

| | P | | PQ Interval (sec) | QRS Duration (sec) | QT Interval (sec) | ST Segment (mV) | HR |
|----------|----------------|----------------|-------------------|--------------------|-------------------|-----------------|---------------|
| | Duration (sec) | Amplitude (mV) | | | | | |
| Control | 0.06 ± 0.01 | 0.19 ± 0.02 | 0.120 ± 0.02 | 0.06 ± 0.01 | 0.21 ± 0.04 | -0.01 ± 0.09 | 98.57 ± 17.73 |
| Infected | 0.07 ± 0.01 | 0.21 ± 0.06 | 0.13 ± 0.01 | 0.06 ± 0.02 | 0.25 ± 0.03 | 0.05 ± 0.08 | 60.00 ± 11.55 |

4 extremities, 2 cm above the olecranon and 4 cm above the proximal insertion of the patellar ligament. The fibre in the skin was exposed at the connection points and it was saturated with alcohol to facilitate the electrical conduction. Six electrocardiograms were taken per animal (2 electrocardiograms per day, 1 in the morning and 1 in the afternoon) during 3 consecutive days. Each reading was taken at a velocity of 25 mm/s for 1 minute.

Data Analysis

The electrocardiograms were analysed on the basis of 3 common characteristics found in previous studies^{2,3,5,8}: high variability in the morphology of the QRS complex, low voltage of the QRS complex, and a mean electrical axis oriented dorsocranially to the right.

The number of animals required for this study was determined using the formula to calculate the size of the sample for different proportions. The mean and the standard deviation for every parameter evaluated were obtained.

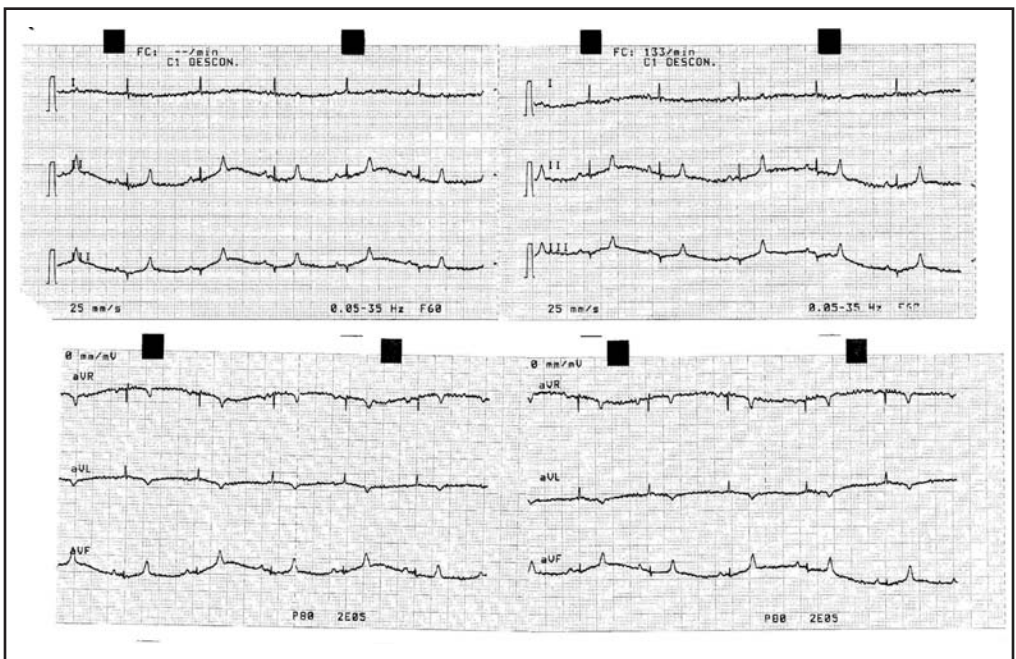
Histopathology

Once the electrocardiographical recordings were completed, 2 animals from the infected group were sacrificed. Samples were obtained from the right atrium, AV node, interventricular septum (right and left peripheral Purkinje fibres), and the heart apex. The micro cysts count was determined per cm² from the histopathological sample.

RESULTS

Arrhythmias or murmurs were not detected during cardiac auscultation in any of the

Figure 1. Electrocardiogram of an alpaca infected with *S. lamacanis*. Note the low voltage QRS complexes.



alpacas used in this study (Table 1). There is no difference in the duration and amplitudes of the different waves between the control and the infected groups of alpacas. Although the control group has a more rapid heart rate, this is still under the normal parameters.

The morphology of the QRS complex on the bipolar and the unipolar augmented limbs varied widely between the animals, detecting up to 8 variations in the control group and 16 variations in the infected group of alpacas (Figure 1). In the control group, the QRS morphology was less variable in aVF and more variable in aVL with a predominating qR pattern. In the infected group, the morphology of the QRS complex was less variable in I and more variable in III with a predominating Rs pattern (Table 2).

In the control group, an absence of the S wave was found in III and aVF. A low voltage of R and S waves was shown in I, aVR, and aVL, whilst in the infected group a low voltage was shown in all the leads. The control group shows a mean electrical axis oriented ventrally and caudally, while the infected group shows a mean electrical axis with a variable orientation and a ventrocaudal tendency (Figure 2).

Table 2. R and S voltages found in the control and infected group of alpacas.

| | Control (n = 7) | | Infected (n = 7) | |
|-----|-----------------|---------------|------------------|-------------|
| | R (mV) | S (mV) | R (mV) | S (mV) |
| I | 0.21 ± 0.20 | 0.13 ± 0.11 | 0.43 ± 0.25 | 0.16 ± 0.16 |
| II | 0.90 ± 0.83 | 0.014 ± 0.038 | 0.30 ± 0.17 | 0.26 ± 0.23 |
| III | 0.67 ± 0.61 | 0 ± 0 | 0.086 ± 0.15 | 0.50 ± 0.68 |
| aVR | 0.086 ± 0.12 | 0.39 ± 0.23 | 0.14 ± 0.17 | 0.31 ± 0.20 |
| aVL | 0.086 ± 0.12 | 0.27 ± 0.16 | 0.34 ± 0.26 | 0.11 ± 0.21 |
| aVF | 0.69 ± 0.61 | 0 ± 0 | 0.19 ± 0.13 | 0.23 ± 0.26 |

There was an average of 43 micro cysts per cm², localized on different areas of the heart (Table 3). A larger population was found on the right atrium and ventricle. A slight mononuclear infiltration was found in all the samples; however, this was not associated with the micro cysts. No micro cysts were found in the conduction fibres and there was no fibrotic tissue.

DISCUSSION

The control group showed electrocardiographical parameters found within the normal values determined in previous studies,^{2,3,5,8} but 1 of the parameters (mean electrical axis) corresponds to values found less frequently in this species. However, they are still normal. Because of this reason, the parameters found in the previously mentioned studies were taken as a reference value.

Electrocardiographic differences between the infected alpacas and the normal alpacas were not found. The micro cysts tend to locate in the myocardial muscle cells and not in the conduction tissue, which may be a reason why interference in the transmission of the electrical impulse through the cardiac muscle does not occur. The cardiac impulse travels rapidly through the conduction fibres because these have a lower depolarization threshold than the myocardial cells. Once they arrive to the cardiac muscle, the impulse generates the mechanical contraction of the ventricular myocardium. The ventricular contraction in this species occurs almost simultaneously, which may be a reason why the global force of contraction

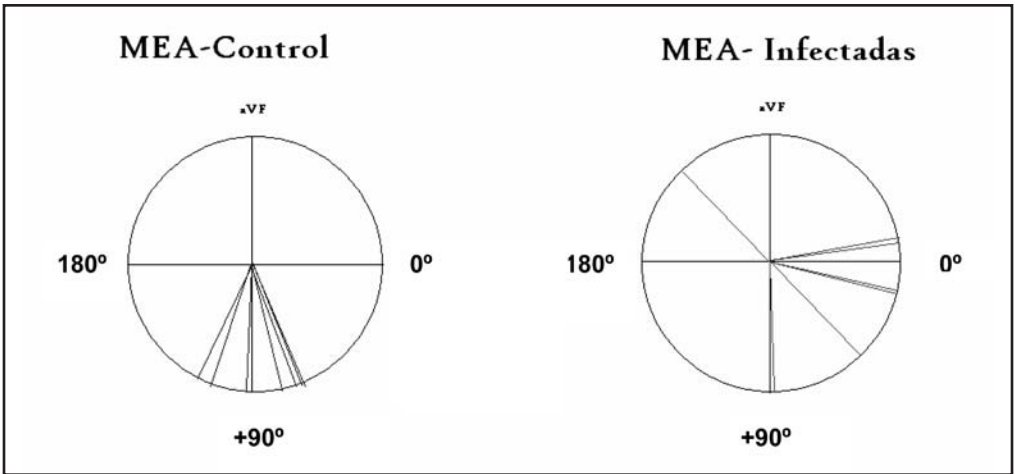
will hide any interference produced in a certain region. This would not show in an electrocardiogram, nor will it originate any detectable electrical alteration.

The presence of heart murmurs, gallops, and first and second abnormal heart

sounds is low in those animals studied by Boon et al,¹ but none of these abnormalities was found in the present study. Arrhythmias also were not found.

Many variations in the morphology of the QRS complex were found. These variations were also found in the studies performed to obtain the normal parameters in this species.³ It is understood that small

Figure 2. Mean electrical axis (MEA) of the control and infected group of alpacas. MEA-Control: angles from right to left: 60°, 60°, 63°, 71°, 92°, 113°, 120°; MEA-Infected: angles from right to left: -19°, -15°, 11°, 12°, 43°, 87°, -135°.



deviations in the placement of the leads may originate slight changes in the morphology of the QRS complex.¹¹ The deep penetration of the Purkinje fibres results in the almost simultaneous depolarization of the myocardium. This induces small deviations detected by the extremity leads resulting in high variations of the morphology of the QRS complex.¹ Normally, the R and S wave voltages do not exceed 1.0 and 0.7 mV, respectively.³ In this study, similar results were obtained. In ruminants and horses, the deep penetration of the Purkinje fibres to almost every area of the myocardium results in the almost simultaneous depolarization of all its regions, which may be why the movement barriers are minimal and the differences between the voltage potentials from one region to another obtain low voltage QRS complexes.⁶

Table 3. Micro cysts population in the hearts of alpacas infected with *S. lamacanis*.

| Area of the Heart | Number of Micro Cysts/cm ² |
|-------------------|---------------------------------------|
| Right atrium | 59 |
| Right ventricle | 49 |
| Left ventricle | 25 |
| Septum | 53 |
| Apex | 29 |
| Mean value | 43 |

A third characteristic of the electrocardiogram of alpacas is the dorsocranial orientation of its mean electrical axis. In previous studies, the electrical axis was obtained in 3 planes: frontal, sagittal and transversal. In the last 2 planes, the electrical axis was dorsocranial, being the most frequent axis. In the frontal plane, the electrical axis was very variable, due to the almost simultaneous depolarization of the ventricular myocardium, which induces small differences in voltage, producing short vectors detected by the frontal plane leads (I to aVF). The high variability in the morphology of the QRS complex in these leads produces the variations in the mean electrical axis on this plane.³ In the present study, the electrical axis was obtained only in the frontal plane. This was oriented ventrocaudally.

Due to the location of the micro cysts, it can be said that the right side of the heart is more compromised than the left side, since the microcyst population in the right side almost doubles the population of the left side.

CONCLUSIONS

No electrocardiographic difference was found between normal and infected alpacas. Variations on the morphology of the QRS complex were found in both groups due to the simultaneous depolarization of the myocardium. The mean electrical axis in the

frontal plane was oriented ventrocaudally in both groups. The micro cysts of *S lamacanis* were found in the myocardial cells and not in the conduction tissue. No evidence was shown that the micro cysts of *S lamacanis* produce any alteration in the conductance of the cardiac impulse.

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