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MONITORING OF INTERSTITIAL GLUCOSE IN THE POSTOPERATIVE PERIOD OF ENTEROTOMY IN HORSES WITH ACUTE ABDOMEN SYNDROME

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ABSTRACT

The study evaluated the continuous monitoring of blood glucose in horses submitted to enterotomy in the postoperative period of acute abdomen syndrome, using the FreeStyle Libre sensor. Two Quarter Horse animals were analyzed: an adult and a foal. During the observation period, the adult horse had hyperglycemia, while the foal had persistent hypoglycemia. Hyperglycemia in adults was related to the severity of the clinical picture, as described in the literature, and was associated with complications such as sepsis and endotoxemia. Hypoglycemia in the foal, on the other hand, reflected energy dysregulation, commonly observed in critically ill foals. Continuous glucose monitoring has proven to be an

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effective tool for detecting these metabolic variations, providing real-time information that has allowed for precise adjustments in treatment, as well as reducing the discomfort caused by frequent blood draws. The reference range for blood glucose in horses varies between 83 and 114 mg/dL, and both hyperglycemia and hypoglycemia outside this range were identified during monitoring, proving the relevance of the technology in clinical follow-up. These data corroborate other studies that associate glycemic imbalances with the severity of critical diseases in horses, especially in postoperative situations. Thus, the continuous use of glycemic monitoring not only facilitates treatment management, but also improves survival in critically ill horses.

Keywords: Interstitial Blood Glucose. Hyperglycemia. Equine. Acute Abdomen Syndrome.

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INTRODUCTION

The regulation of glucose in the blood results from the interaction of several factors, such as the time interval since the last meal, the influence of hormones and the nervous system, and the use of glucose by peripheral tissues, such as skeletal muscle. The interval after the last meal is significant only in monogastric animals, in which food intake leads to an increase in blood glucose levels (Lassen, 2007).

Changes in blood glucose levels are relatively frequent in critically ill horses. Hyperglycemia in horses with acute abdomen syndrome has been associated with poor survival, and in foals neonate both hypoglycemia and hyperglycemia occur with a similar frequency, both associated with reduced survival (Hassel, Hill, Rorabeck, 2009). In addition, a strong positive correlation has been identified between plasma lactate, which is a marker of the severity of systemic diseases, and glucose levels, both in humans and animals, since these metabolites are interconnected in carbohydrate metabolism and each can contribute to the formation of the other (Dunkel, Mason, Chang, 2019).

The time of care for the patient with colic syndrome is crucial. In addition to the initial physical examination, laboratory tests, such as erythrogram, leukogram, and peritoneal fluid analysis, are important for the choice of treatment (Di Filippo et al., 2014). Other parameters have also been investigated, especially to differentiate strangulative from non-strangulative lesions (Peloso & Cohen, 2012). Lactatemia and glycemia stand out as useful tools in the clinical suspicion and prognosis of horses with acute abdomen (Allen & Holm, 2008).

Blood glucose is a common finding in horses admitted with colic and has been related to pain severity on admission, elevated heart rate, mortality, and referral for celiotomy. Although the role of blood glucose in these cases is not clear, this parameter can be used as one of the complementary tests in the formation of the prognosis, helping in decision making (Hassel et al., 2009).

According to Cohn (2000), the use of portable sensors to measure blood glucose is quite common in the practice of veterinary medicine, especially in small animals. Blood glucose measurement is crucial for both the diagnosis and follow-up of various diseases or conditions that can lead to hypoglycemia or hyperglycemia.

In order to avoid the need for repeated blood samples and the consequent discomfort to the patient, in addition to identifying variations between the regular collections used in traditional blood glucose monitoring, devices for continuous glucose measurement

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(CGM) in the interstitial fluid in human medicine were developed and evaluated (Vlkova et al., 2009; Wollersheim et al., 2016). A CGM system remains embedded for a longer period, thus allowing for a more comprehensive view through a larger number of glucose readings and the graphical presentation of glycemic trends (Freckmann et al., 2016).

According to the Food and Drug Administration (FDA), a federal agency of the United States Department of Health and Human Services, portable glucometers cannot present an error rate greater than 20% in blood glucose concentration for values between 30 and 400 mg/dL (Briggs and Cornell, 2004). The top three companies in this industry are Abbott Laboratories, Medtronic, and Dexcom Inc. (Olczuk et al., 2017).

Given the importance of blood glucose as an indicator of clinical severity in horses, especially in cases of acute abdomen syndrome, the use of technologies such as continuous glucose monitoring has proven to be a valuable tool to optimize the postoperative follow-up of these animals. Considering the frequent glycemic variations in horses submitted to surgical interventions, such as hyperglycemia and hypoglycemia, this study aims to monitor interstitial blood glucose in horses in the postoperative period of this syndrome, focusing on the determination of glycemic curves, breakfast control and identification of hypoglycemia during the fasting period.

METHODOLOGY

The study was carried out at the Hospital Veterinário Imperial Medicina Equina, located in the city of São Miguel do Tocantins, TO. Two female horses of the Quarter Horse breed were used, both diagnosed with acute abdomen syndrome. The animals underwent surgical intervention aimed at resolving the condition, after enterotomy the animals remained in water and solid fasting, being administered only fluid therapy with Lactated Ringer solution, being monitored for 3 days. During all stages of the study, from diagnosis to postoperative monitoring, strict ethics and animal welfare guidelines were followed, according to the protocols established by the veterinary hospital. The care for the comfort and health of the horses was a priority, seeking to minimize any discomfort associated with the surgical procedure and the use of the FreeStyle Libre sensor, ensuring the well-being of the animals and the accuracy of the results obtained.

To measure interstitial blood glucose, the FreeStyle Libre sensor was used, applied to the dorsolateral region of the initial third of the neck of the horses. For the application of the sensor, the trichotomy of the region and asepsis with 2% chlorhexidine degerming were

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performed, and for better fixation, ethyl-cyanoacrylate-based glue was used on the edges of the sensor structure, in addition to the use of a flexible tape with an adhesive part made of 100% cotton fabric to protect the sensor. The application of the sensor was performed immediately after the surgical intervention, and the measurements were initiated one hour after the animals returned from anesthesia, respecting the period necessary for the stabilization and calibration of the device. Interstitial blood glucose readings were recorded according to the recommended protocols to ensure the accuracy of the data collected.

Figure 1: Place of application of the Freestyle Libre sensor.

Source: Prepared by the author (2024).

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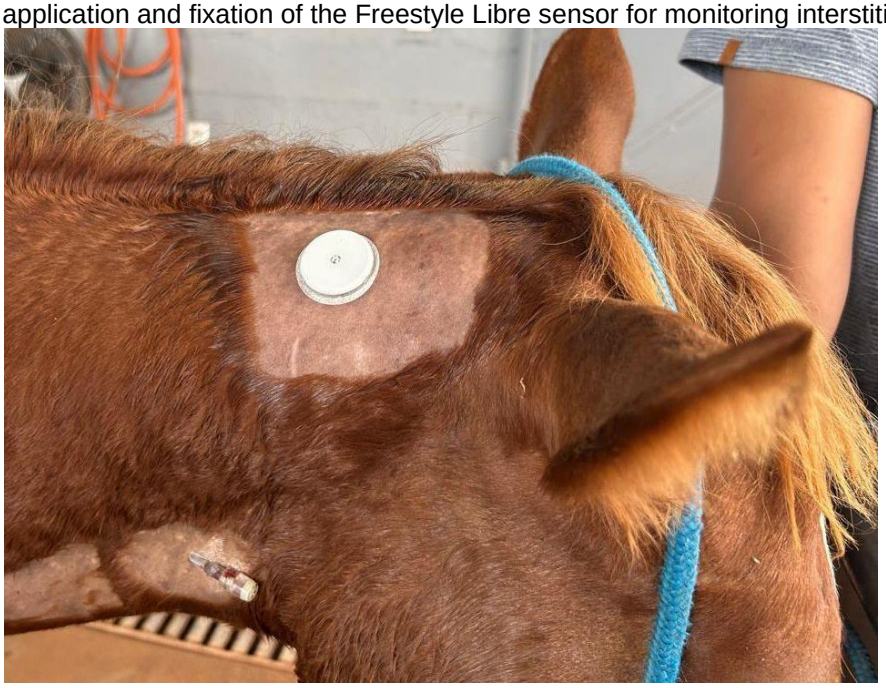
Figure 2: Point of application and fixation of the Freestyle Libre sensor for monitoring interstitial blood glucose.



Source: Prepared by the author (2024).

Figure 3: FreeStyle Libre sensor tracking and daily reading graph.

Source: Prepared by the author (2024).

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Figure 4: Daily reading of the FreeStyle Libre reader.

Source: Prepared by the author (2024).

RESULTS

Horses admitted to the intensive care unit of the Hospital Imperial Medicina Equina were monitored for 3 days. The first animal, registered as "Daily Record – Animal 1", is a Quarter Horse mare, 5 years old and weighing 468 kg. This animal underwent surgical resolution due to a 360º volvulus of the larger colon and entrapment of the nephro-splenic ligament (from caudal to cranial). The second animal, identified as "Daily Record – Animal 2", is a filly of the same breed, Quarter Horse, 10 months old and weighing 232 kg. She underwent surgery to resolve a displacement of pelvic flexure on the right, located in the diaphragm region on the left, accompanied by a non-strangled 180º volulus of the greater colon.

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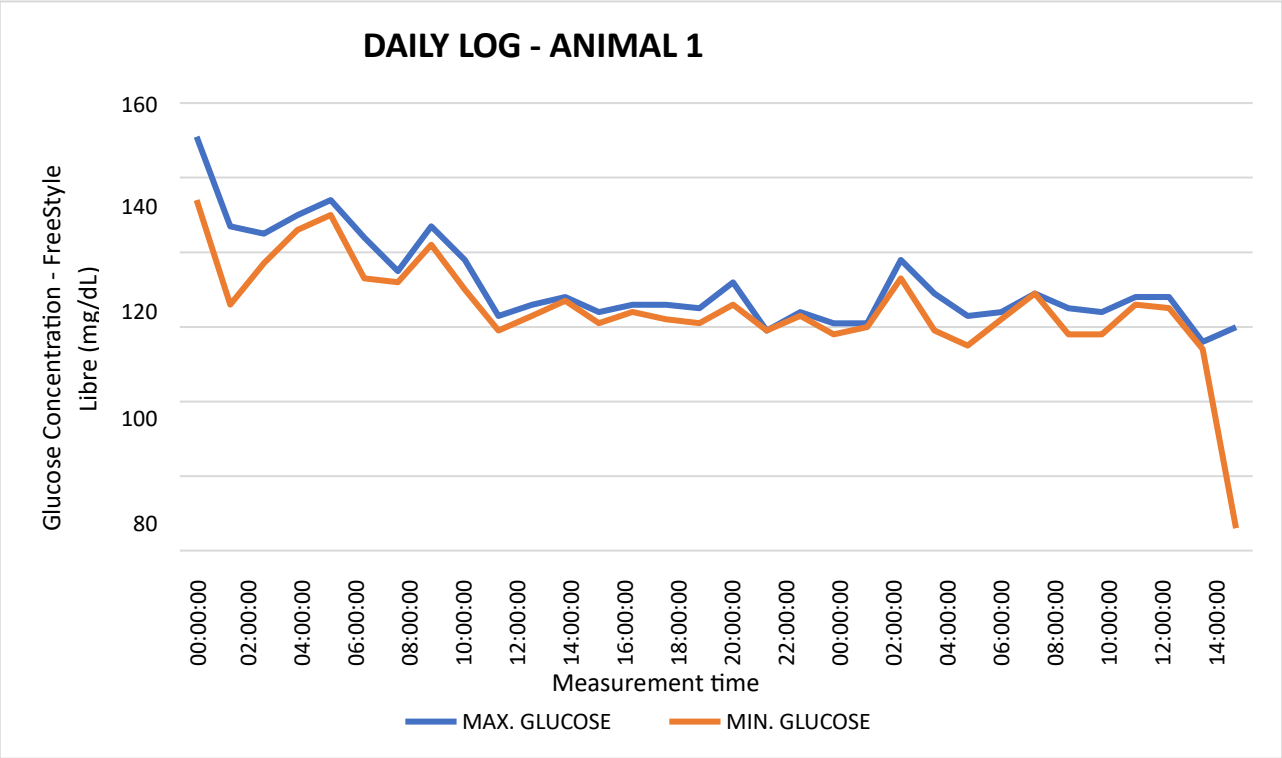
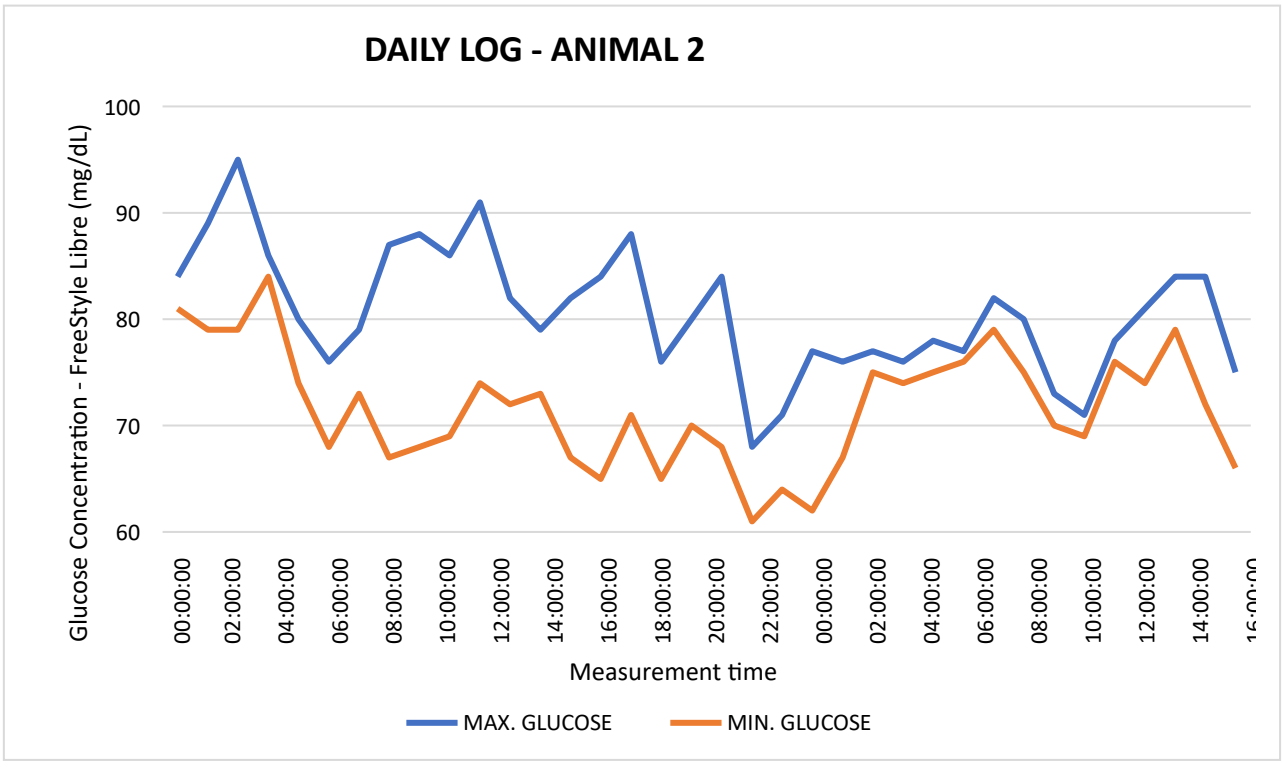
Graph 1: Daily recording of interstitial glucose monitoring for three days of animal 1.



Source: Prepared by the author (2024).

Graph 2: Daily record of interstitial glucose monitoring for three days of animal 2.



Source: Prepared by the author (2024)

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DISCUSSION

In the monitored horses, discrepant variations in interstitial glucose levels were observed. In the adult horse, episodes of hyperglycemia were recorded, while the foal had persistent hypoglycemia. The reference range for blood glucose in horses ranges from 83 to 114 mg/dL. Values above this range indicate hyperglycemia, a condition that may be associated with factors such as stress, excitability, and pain (PUSTERLA; HIGGINS, 2018). Di Fillipo et al. (2007) report that hyperglycemia is common in the early stages of colic syndrome, caused by increased catecholamines that stimulate glycogenolysis, with glucose levels returning to normal after glycogen stores are depleted. Hypoglycemia, according to Pusterla and Higgins (2018), is rare in adult horses, but may indicate septicemia, poor milk/colostrum intake or, rarely, liver failure in foals.

The adult horse presented hyperglycemia during the first day of monitoring and postoperatively. According to the study by Hollis, Boston and Corley (2007), in human patients, the degree of hyperglycemia is directly related to the severity of the disease, and this correlation seems to apply to horses with colic as well. Hyperglycemia has been linked to elevated heart and respiratory rates, which may indicate a more severe clinical picture. In addition, it was associated with surgical, strangulating and intestinal lesions, as well as those requiring resection. Horses that require bowel resection tend to be more severely compromised, with greater damage to the gut and an elevated risk of translocation of bacteria and endotoxins, which can result in sepsis, endotoxemia, and worsening of the clinical condition.

In the present study, the monitored adult mare also presented hyperglycemia, which is in agreement with previous reports of hyperglycemia in horses affected by colic syndrome. Initially, this condition was explained by the presence of cortisol and norepinephrine, hormones that can raise blood glucose levels. However, more recent studies suggest that hyperglycemia in horses with colic may also be related to a dysfunction in glucose homeostasis, as a result of peripheral insulin resistance, hyperinsulinemia, and increased gluconeogenesis (HASSEL; HILL; RORABECK, 2009). In addition, high blood glucose concentrations were associated with a lower survival rate, with horses showing hyperglycemia during colic being five times less likely to survive (BERTIN; RUFFIN-TAYLOR; STEWART, 2018).

Monitoring of interstitial blood glucose in horses in the postoperative period of colic syndrome is essential to understand the interrelationships between glucose and lactate in

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carbohydrate metabolism, especially in contexts of physiological stress. According to Meyerhof (1927), the physiological roles of glucose and lactate are strongly interconnected as part of carbohydrate metabolism. The production of lactate from glucose is a reflection of stress-induced changes, and the subsequent conversion of lactate to glucose by the liver illustrates the complexity of this metabolism. The hyperglycemia observed in postoperative adult horses can be understood as a result of the activation of the Cori cycle and gluconeogenesis, processes that are exacerbated during periods of pain and stress, such as those faced by horses after colic surgeries (CORI & CORI, 1946).

Regarding hypoglycemia, the 10-month-old foal showed persistence in low interstitial blood glucose levels during the three days of monitoring and postoperatively. According to Rings (2019), energy dysregulation problems often occur in critically ill foals, with up to 70% of foals presenting to a neonatal intensive care unit having a blood glucose concentration outside the reference range. Both hypoglycemia and hyperglycemia were associated with non-survival in young horses in critical clinical conditions.

According to Jorge et al., 2017, changes in lactate and glucose levels are often observed in critically ill patients, reflecting metabolic imbalances that can directly influence the prognosis of these individuals. These two metabolites are closely connected through crucial biochemical pathways such as glycolysis and gluconeogenesis, which are part of the Cori cycle. In this process, the lactate produced in the tissues is converted back into glucose by the liver and kidneys, ensuring the maintenance of energy homeostasis. However, when these organs are compromised, gluconeogenesis can be impaired, resulting in mild hypoglycemia.

The liver is the main organ responsible for the production of glucose through gluconeogenesis and glycogenolysis, essential processes to maintain normal glycemic levels in a healthy organism (TAYEK; KATZ, 1997). This state of hypoglycemia may be indicative of renal or hepatic dysfunction, conditions that have been associated with worse clinical outcomes and higher mortality in critically ill patients, in addition, chronic renal failure has a negative impact on glycogenolysis. (KRINSLEY et al., 2011; CANO, 2001).

The variations in interstitial glucose levels observed in this study, both in the adult horse and in the foal, corroborate the literature that associates these metabolic alterations with the severity of the clinical picture. The hyperglycemia recorded in the adult mare during the postoperative period is in line with studies that indicate an association between this condition and complications resulting from colic, such as sepsis and endotoxemia, which

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aggravate the clinical condition of the animal. Persistent hypoglycemia in the foal, on the other hand, may reflect a metabolic dysregulation common in young horses with severe diseases, as described in previous studies. These findings reinforce the importance of close blood glucose monitoring in hospitalized horses, especially in postoperative and critically ill situations, as a way to predict prognosis and adjust therapeutic interventions to improve the chances of survival.

CONCLUSION

The analysis of interstitial blood glucose in horses in the postoperative period of acute abdomen syndrome revealed significant variations among the monitored individuals, highlighting hyperglycemia in the adult horse and persistent hypoglycemia in the foal. These findings corroborate the existing literature, which associates hyperglycemia with serious clinical complications, such as sepsis and endotoxemia, and suggests that hypoglycemia in foals may reflect energy dysregulation common in critical situations. The use of continuous glucose monitoring sensors has proven to be a valuable tool, providing real-time data that enables the early detection of metabolic alterations, adjusting therapeutic interventions effectively. Thus, the practice of monitoring blood glucose is essential to predict prognosis and improve survival in horses with critical conditions, contributing significantly to the veterinary clinic.

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