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DETERMINATION OF BLOOD AND PERITONEAL LACTATE LEVELS AS A PROGNOSTIC MARKER IN HORSES WITH COLIC SYNDROME

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ABSTRACT

Colic syndrome is one of the main causes of mortality in horses, often generating clinical emergencies due to its severity and high fatality rate, being responsible for 50% of deaths in adult horses. Lactate, a byproduct of anaerobic metabolism, increases its concentration in situations of tissue hypoxia, such as intestinal ischemia, common in equine colic. The aim of this study was to analyze the correlation between lactate levels in the blood and peritoneal fluid of horses with colic syndrome in relation to strangulating diseases, the therapeutic strategies employed and the survival rate of the animals. The research demonstrated that elevated lactate in the peritoneal fluid is a more effective marker to identify ischemic lesions compared to blood lactate, which had lower specificity for these cases. In addition, blood and peritoneal lactate levels at the admission of horses with acute abdominal syndrome were considered predictors of both the therapeutic indication and the survival of patients. It has been observed that higher peritoneal lactate values at admission are associated with a higher risk of mortality for the horse.

Keywords: Acute Abdomen Syndrome. Survival. Diagnosis.

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INTRODUCTION

Acute abdomen syndrome is the main cause of mortality in horses, being responsible for several serious systemic alterations. Characterized by severe abdominal pain, this condition stands out as one of the most frequent emergencies in equine veterinary practice (Francelino *et al*., 2015). The severity of this syndrome is recognized by insurance companies, which identify it as the leading cause of death among horses, accounting for 50% of deaths in adult horses (Silva *et al*., 2021).

Such susceptibility of horses is largely due to the anatomical and functional particularities of their gastrointestinal tract. The small stomach and the presence of the cardia valve, which prevents food reflux and makes vomiting impossible, are factors that contribute significantly to this predisposition (Tadesse, 2018; Bland, 2016). In addition, among the most common causes of colic are compaction of the large intestine, spasmodic colic, intussusception, volvulus, and torsion (Tadesse, 2018).

Given the severity of the syndrome, the survival of affected animals is closely linked to the speed and precision of veterinary care, as highlighted by Paim *et al.* (2019). Prompt treatment is vital, especially in situations where obstruction of blood flow and intestinal ischemia occur, conditions that can quickly lead to loss of viability of bowel loops and, consequently, death. Therefore, the search for parameters and laboratory tests that help in the diagnosis and prognosis becomes essential for the effective clinical management of these cases (Paim *et al*., 2019).

Lactate, identified in the seventeenth century as a byproduct of anaerobic glycolytic metabolism, was initially associated with muscle fatigue during exercise (Botteon, 2012). Subsequent research has demonstrated its link to tissue injury, septicemia, and hemorrhages, elevating blood lactate levels as an indicator of tissue hypoxia and severe circulatory changes. In cases of equine colic, intestinal ischemia impairs cell membrane permeability, resulting in the release of intracellular byproducts, such as lactate, into the systemic circulation and peritoneal cavity (Miranda *et al*., 2014).

In this context, the evaluation of peritoneal fluid, especially the measurement of lactate levels, emerges as an essential tool for prognosis and clinical decision-making. Any significant change in peritoneal fluid, combined with clinical evaluation and persistence of pain, may indicate the need for surgical intervention. Blood hyperlactatemia has been associated with lower survival rates, as high lactate values indicate tissue hypoxia and suggest the presence of ischemic lesions, even if they do not specify the affected intestinal

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segment (Francelino *et al*., 2015).

Studies carried out at the Veterinary Hospital of the University of California, USA, corroborate this association. In a control group of 20 healthy animals and 189 horses with colic, it was found that the sick animals had significantly elevated levels of lactate in both the peritoneal fluid and blood, compared to the healthy ones. In addition, animals undergoing surgery, especially those with ischemic lesions that required resection and anastomosis, showed even higher levels. Another study, carried out with 74 horses, revealed that more than half (54%) of the animals affected by the syndrome did not resist, while 46% survived. The highest lactate levels were observed in the animals that died (Tennent-Brown, 2014; Paim *et al*., 2019).

Therefore, the analysis of lactate levels in the blood and peritoneal fluid proves to be a promising tool for the prognosis of equine colic syndrome, offering crucial information for clinical decision-making. The development and implementation of rapid and accurate methods for this evaluation are essential to improve diagnostic reliability and reduce mortality associated with the disease. Continuing studies in this area is vital to improve therapeutic approaches and promote the well-being, health, and longevity of horses. The objective of this study was to analyze the correlation between lactate levels in the blood and peritoneal fluid of horses with colic syndrome in relation to strangulating diseases, the therapeutic strategies employed and the survival rate of the animals.

METHODOLOGY

The research was conducted in the municipality of São Miguel-TO, at the Imperial Equine Medicine Clinic, using clinical data and blood and peritoneal fluid samples from 22 Quarter Horse horses (10 males and 12 females) that presented symptoms of abdominal pain, over a period of 12 months. Both samples were collected in the same period of time, being collected as soon as the animal was admitted to the clinic.

Peritoneal fluid was collected through abdominocentesis, after trichotomy and asepsis of the linea alba, 10 cm caudal to the xiphoid pituitary, with the horse in the quadrupedal position. The collection was carried out with the operator using sterile gloves and a sterile 40x12 needle where it was slowly introduced into the skin at an inclination of approximately 90° until the peritoneal fluid came out, being stored in a tube without anticoagulant, later the tip of the needle was checked to confirm that there had been no contamination by the piercing of the loops, If contamination with the digestive contents

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occurred, the needle should be removed and the puncture performed in a new location, adjusting the position of the paracentesis to the caudal or cranial region.

In addition, to obtain venous blood, the venipuncture technique was performed. After trichotomy and cleaning of the jugular region, a 3 ml syringe was inserted to collect the blood, which was also stored in a tube without anticoagulant, and the concentration of lactate in the blood and peritoneal fluid was immediately measured after collection, using a portable biochemical analyzer, Accutrend® Plus, from COBAS.® From a fluid sample, lactate levels were analyzed. The sample was placed on a tape, which was inserted into the device to perform the reading; This tape contained an identification code for the exam, which was registered on the equipment.

For the statistical analysis of the collected data, the SAS OnDemand version 9.3 program was used, the normality of the data was evaluated by the Shapiro-Wilk test as a decision criterion for the use of parametric and non-parametric tests. Thus, the non-parametric tests Wilcoxon test and Kruskal-Wallis test were chosen.

RESULTS

The study involved 22 Quarter Horses, 10 males and 12 females, diagnosed with colic syndrome attended between September 2023 and August 2024 at the Imperial Equine Medicine Clinic. Horses in which it was not possible to obtain a diagnosis or samples of peritoneal fluid were excluded. Data such as name, race, gender, blood and peritoneal lactate levels, affected gastrointestinal segment, presence of strangulative process, type of treatment applied, survival, and associated complications were recorded.

Of the 22 cases analyzed, 45.45%(10) required surgery, with a survival rate of 40%(4) for surgical cases and an overall survival rate of 59.09%(13) for all cases attended, in addition, among the 9 deaths, 4 of them were euthanized, due to complications such as rupture that occurred during surgery. Table 1 shows the number of animals treated that had problems in each digestive segment and how many were strangulative or not, the number of survivors and deaths, and the complications found before, during, or after surgical or clinical treatment. It was found that among the complications presented, the most recurrent was laminitis, with a total of 4 cases.

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Table 1: Presentation of cases with the number of cases that obtained or did not obtain strangulating lesions, number of alive or dead, and complications that were presented during the course of the animal's case.

Digestive segment	Number of horses	Type of obstruction	Survival	Number of complications
Stomach	2	Strangling=0 Non-strangler=2	Alive=1 Dead=1	No
Small intestine	2	Strangler=1 Non-strangler=1	Alive=1 Dead=1	1 Enterogastric reflux
Large intestine	17	Strangling=2 Non-strangler=16	Alive=11 Dead=7	4 Laminite 2 Rupture 1 Diarrhea 1 Enterogastric reflux 1 Sepsis

Source: The authors, 2024.

In addition, the data revealed that 13.6%(3) of the cases were stranglers, with a survival rate of 00.0%(0), while 86.3%(19) of the cases were non-stranglers, with a survival rate of 63.1%(12). Among the gastric disorders found, gastric overloads were observed. In the small intestine segment, cases of entrapment of the epiploic foramen and compaction were identified. In the large intestine, 8 cases of compaction in different segments (pelvic flexure, smaller colon, transverse colon and ileum), 1 case of cecum tympanism, 5 major colon displacements, 2 ruptures (mesocolon and minor colon), 3 incarcerations (two in the epiploic foramen and one nephrosplenic), 4 larger colon volvuli and 1 case of sablosis.

Among the diseases presented, the large intestine was the one that presented the most alterations, with 82%(17). When analyzed individually, survival rates were 50% for the gastric segment, 50% for the small intestine and 61.1% for the large intestine.

Table 2 shows that, in strangulating lesions, the mean lactate levels are higher than in non-strangulating lesions, revealing a relationship between lactate and obstructive processes. For the animals that did not survive, the mean blood lactate was 8.13 mmol/L, ranging from 4.20 mmol/L to 14.50 mmol/L, while in the peritoneal fluid the mean was 9.36 mmol/L, ranging from 1.10 mmol/L to 17.50 mmol/L. In contrast, the surviving animals had a mean blood lactate of 4.28 mmol/L, ranging from 0.60 mmol/L to 13.30 mmol/L, and an average peritoneal lactate of 3.47 mmol/L, ranging from 0.70 mmol/L to 12.30 mmol/L. This comparison reveals that, in the animals that did not survive, the mean lactate levels, both in

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the blood and in the peritoneal fluid, were higher than in the animals that managed to survive.

Table 2: Presentation of the means of the general value of blood and peritoneal lactates according to each intestinal segment and the mean in cases of simple and strangulating obstructions

Digestive Segment	Mean blood and peritoneal lactate values	Mean lactate values in simple obstructions	Mean values in strangulating obstructions
Stomach	LS=5.5 mmol/L LP=2.15 mmol/L	LS=5.5 mmol/L LP=2.15mmol/L	-
Small intestine	LS=2.4 mmol/L LP=7 mmol/L	LS=0.6 mmol/L LP=2.0 mmol/L	LS=4.2 mmol/L LP=12 mmol/L
Large intestine	LS=6.27 mmol/L LP=6.17 mmol/L	LS=5.5 mmol/L LP=5.0 mmol/L	LS=10.5 mmol/L LP=15.5 mmol/L

** LS= Blood lactate/**LP=Peritoneal lactate/Source: Authorship, 2024.

According to the statistical analyses using the non-parametric Wilcoxon test, there were significant differences ($p<0.05$) between lactates when considering the therapy (clinical and surgical) and the outcome (discharge and death) (Tables 3 and 4), which when related to the concentrations of blood lactate and peritoneal fluid with the clinical or surgical referral, there were very marked differences, being ($p<0.05$), mainly in relation to blood lactate related to clinical or surgical referral (Tables 3 and 4).

Table 3: Statistical analysis regarding the relationship between clinical or surgical referral associated with blood lactate and peritoneal fluid levels

	THERAPY		
Lactate	Clinical	Surgical	*P-value*
Blood Lactate	3.89 ± 3.87	8.21 ± 3.73	*0,0177*
Peritoneal Lactate	3.51 ± 4.68	8.72 ± 5.31	*0,044*

Source: The authors, 2024

In addition, the peritoneal lactate values measured in relation to the outcome (discharge or death) (Table 4) were highly significant ($p<0.01$). Showing that the values found both in the blood and in the peritoneal fluid of animals referred for surgery and those that died are higher than those that were discharged and only clinical treatment, revealing that these

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values are predictors and associated with a higher risk of death and surgical indication.

Table 4: Statistical analysis evaluating blood lactate concentrations and peritoneal fluid associated with survival of patients treated with symptoms of abdominal pain

	RESULT		
Lactate	Discharge	Death	*P-value*
Blood Lactate	4.28 ± 3.97	8.13 ± 3.93	*0,0147*
Peritoneal Lactate	3.47 ± 3.89	9.36 ± 5.87	*0,0091*

Source: The authors, 2024

In the obstructive processes, in the analysis performed together with the measurement of blood lactate, there was no difference with (P>0.05), having no relationship with the presence of strangulant obstruction, and in the analysis of peritoneal lactate, there was statistical significance with (P<0.05), showing that the presence of peritoneal lactate is linked to the presence of strangulating processes, as shown in Table 5.

Table 5: Statistical analysis relating peritoneal fluid lactate measurements to intestinal ischemia in horses

	STRANGLING PROCESS		
Lactate	No (Average)	Yes (Average)	*P-value*
Blood Lactate	5.45± 3.55	8.40± 6.45	*0,2834*
Peritoneal Lactate	4.54 ± 3.29	14.47 ± 7.75	*0,0318*

Source: The authors, 2024

DISCUSSION

Based on data obtained from 22 horses with colic syndrome followed up over 12 months, it was observed that cases involving strangulating processes did not result in survival. All these animals died or were euthanized during surgery due to the poor prognosis, evidencing the severity of the condition. In these cases, the absence of tissue viability or rupture of the intestinal segment led to euthanasia, since the survival rate was extremely low (Oliveira, 2010).

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Among the complications identified, laminitis was the most frequent. This complex and multifactorial condition is associated with systemic alterations that include colic syndrome and endocrine dysfunctions in horses. The etiopathogenesis of laminitis is closely linked to metabolic and inflammatory disorders that affect blood circulation in the hooves of animals (Frank, 2009). Horses with colic or that have undergone surgery, especially intestinal surgery, have a high risk of developing laminitis, due to the possibility of endotoxemia. Colic and surgical manipulation of the gut can cause a microbial imbalance, resulting in the death of Gram-negative bacteria that release endotoxins (lipopolysaccharides-LPS) into the bloodstream. The presence of these endotoxins in the circulation triggers a severe systemic inflammatory response, an important predisposing factor for laminitis. This phenomenon justifies the high incidence of this complication observed in the study (Laskoski, 2016).

Among the causes of colic, a high incidence of compaction was observed, with 9 of the 22 cases (40.9%). According to Nunes *et al.* (2017), this condition is the second leading cause of colic in horses, behind only simple obstructions. This prevalence is attributed to anatomical and physiological factors of horses, such as small gastric capacity, the impossibility of regurgitation, and narrowing at specific points in the intestine, such as pelvic flexure. In addition, changes in dietary management, irregular physical activity, dehydration, intestinal parasites (such as *Strongylus vulgaris*), sand or soil ingestion, use of medications that reduce intestinal motility, dental problems, and environmental factors also contribute to the development of this condition. Compaction occurs in areas of the large intestine with a reduced diameter, leading to obstruction and accumulation of contents, which results in abdominal pain and possible severe complications. Thus, the combination of these factors makes compaction a common occurrence in horses with colic (Nunes *et al.*, 2017).

When statistically analyzing the values of blood lactate (SL) and peritoneal lactate (PF) in relation to the type of obstructive process, it was not significant ($P>0.05$) in relation to SLN, showing no association with the presence of spoiling processes. However, there was a statistical difference between LP lactate ($P<0.05$), which corroborates the study by Pye *et al.* (2019) that in strangulating lesions only the PL had an increase and significance in its statistical analysis, with SL having no relationship with the types of ischemic lesions and not being a good marker in this type of lesions. Furthermore, this is well explained by the physiology of the glycolysis method in anaerobic medium where in these lesions it

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increases due to lack of blood flow or poor tissue perfusion that leads to lack of oxygen in the loops.

However, Shearer et al. (2018) observed that in their study there was no difference in relation to SL and PF in strangulating and non-strangulating lesions, because in cases of abdominal distension it can reduce oxygen supply, resulting in anaerobic metabolism leading to increased lactate and but there can also be an increase in these two fluids due to poor venous drainage and damage to the intestinal mucosa. Thus, all these mechanisms, according to the researchers, can contribute to the increase in peritoneal lactate in horses with colic, not just the factor of ischemic lesions.

Regarding the results obtained from SLN and PL correlated with the type of therapy applied and outcome (discharge or death), there was a significant difference in both, especially in relation to death with ($p<0.01$), which was highly significant, thus relating the need for surgery in animals with high levels of peritoneal lactate and decreased chances of survival with this increased lactate. This can be explained because once lactate is released into the peritoneal space by any circulatory disorder that is going on, this substance is quickly absorbed by the peritoneum and can cause increased blood concentrations.

However, in clinical treatments and in cases of medical discharge, the mean blood lactate values were higher in relation to peritoneal lactate, with the latter only increasing in surgical, obstructive or death-progressing cases, which according to Paim (2019) the increase in SLN may also be related to the onset of systemic shock and occur due to several other causes, such as circulatory hypoperfusion, mitochondrial dysfunction, or hypermetabolic state.

Therefore, persistent elevation of blood lactate indicates a worsening of the clinical condition and is an important factor in the decision about treatment, such as the need for surgical intervention. Therefore, continuous lactate monitoring is essential to guide clinical management and determine the prognosis of horses affected by colic. In addition, liver disease can result in increased production or less metabolization of lactate, contributing to its elevation in the blood. In the study by Barros *et al.* (2024) says that there is a relationship between the increase in SL and PF in animals that died and higher values compared to animals that were discharged, indicating a decrease in survival and an increase in the need for surgery, corroborating the results of the present study.

Therefore, from this study, the relationship between SLN and PL values was verified, with the indication of therapy and with a good prognostic aid, and PL being one of the

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evaluators of possible strangulating processes, not excepting other types of disorders that may lead to its increase.

However, although this type of measurement is an aid in decision-making, it does not replace the evaluation of a good clinician and his decision and the need for other complementary tests for a better elaboration of therapy. The limitations of the study were the sample size used, requiring a larger sample size, and the need for serial measurements for better evaluation and follow-up of the case, as persistent elevation may be more indicative of a worse prognosis in horses with colic than a single evaluation (Radcliffe *et al.,* 2012). Serial measurement can promote a broad analysis of the severity of the condition, guiding the clinician to more accurate decisions (Tennent-Brown, 2014).

CONCLUSION

The present study demonstrated that elevated lactate in the peritoneal fluid is a more effective marker to identify ischemic lesions compared to blood lactate, which presented lower specificity for these cases. In addition, blood and peritoneal lactate levels at the admission of horses with acute abdominal syndrome were considered predictors of both the therapeutic indication and the survival of patients. It has been observed that higher peritoneal lactate values at admission are associated with a higher risk of mortality for the horse.

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