PhD THESIS

Clinical and Paraclinical Criteria for the Objective Assessment of Diagnosis and Prognosis in Equine Colic Syndrome

(SUMMARY OF THE PhD THESIS)

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INTRODUCTION

Equine colic syndrome represents a complex condition characterized by acute clinical manifestations that can rapidly progress to severe decompensation, constituting one of the leading causes of morbidity and mortality in horses (Freeman, 2017). Epidemiological data indicate that between 4% and 10% of horses will experience at least one episode of colic during their lifetime, with case severity ranging from mild, self-limiting forms to life-threatening conditions (Tinker et al., 1997). The complexity of the gastrointestinal tract, the particular sensitivity of horses, and various external factors-including feeding practices, workload, and meteoclimatic disturbances-explain the high incidence of colic and its often dramatic clinical presentation compared to other species. Colic, defined as a painful, violent, continuous or intermittent manifestation, can originate from a wide range of etiologies: gastric, hepatic, intestinal, urinary, vascular, peritoneal, cardiac, respiratory, or neurological. Consequently, in horses, colic should not be regarded as a disease per se but rather as a syndrome reflecting acute abdominal pain (Mircean, 2018). The most frequent causes of colic syndrome include disorders affecting the large colon or cecum, gas accumulation leading to intestinal distension or displacement, and topographic disturbances such as volvulus, torsion, or strangulation. Other potentially fatal conditions include intestinal intussusceptions, ileus, epiploic foramen entrapment, mesenteric positional or integrity disorders, hernia, neoplasia, or severe peritonitis (Barros et al., 2024; Parra-Moyano et al., 2025). Accurate and prompt diagnosis of colic syndrome in horses requires well-defined clinical and paraclinical criteria that allow for precise assessment of disease severity and guide appropriate therapeutic decisions. The clinical examination plan must be structured in a logical sequence encompassing anamnesis, objective clinical assessment, and documentation. Objective clinical assessment should be based on the main semiological examination methods: inspection, palpation, percussion, auscultation, and thermometry, supplemented by gastric intubation, transrectal palpation, and abdominocentesis (Papuc, 2017). Clinical signs, the degree of dehydration, and the response to initial treatment, corroborated with data obtained from paraclinical investigations, are essential for establishing prognosis and determining the therapeutic approach. The identification and use of ancillary diagnostic tools are critical to support the clinician in differentiating between cases amenable to medical treatment and those requiring surgical intervention (Li Radcliffe et al., 2022; Barton et al., 2021). The treatment of colic depends on etiology, symptom severity, the overall condition of the patient, and the owner's financial resources. Management may be either conservative or surgical, depending on case severity. Surgical therapy does not exclude medical treatment, which

remains indispensable for the patient's recovery after surgery. Ventral midline laparotomy is considered the gold standard interventional approach for both the diagnosis and treatment of equine colic syndrome, being primarily indicated in cases unresponsive to medical management (van den Boom et al., 2003; Cook, 2017). Clinical evaluation through observation of symptoms and close monitoring of physiological parameters - including heart rate, respiratory rate, body temperature, capillary refill time, and mucous membrane appearance - is essential for the early detection of colic syndrome in horses and the prompt initiation of therapy.

The aim of this research was to perform a detailed analysis and to establish the most relevant clinical and paraclinical criteria for the objective assessment of diagnosis and prognosis in equine colic syndrome, as well as to apply the most effective suture techniques for ventral abdominal wall closure during surgical treatment, both with respect to immediate postoperative outcomes and to the long - term functional and cosmetic integrity of the surgical site.

In this context, several objectives were defined to design the study, namely:

- To establish the diagnosis of colic syndrome in horses based on the evaluation and interpretation of clinical manifestations;
- To assess the diagnostic and prognostic value of paraclinical examination in equine colic syndrome;
- To apply conservative and surgical treatment strategies in equine colic syndrome.

STRUCTURE OF THE DOCTORAL THESIS

The doctoral thesis entitled "*Clinical and Paraclinical Criteria for the Objective Assessment of Diagnosis and Prognosis in Equine Colic Syndrome*" comprises a total of 158 pages, prepared in accordance with current academic and national editorial standards. The work is structured into two main parts, comprising eight chapters, and includes 109 bibliographic references.

The first part of the thesis, entitled "Current State of Knowledge," is organized into two chapters and spans 29 pages. This section synthesizes information regarding equine colic syndrome (**Chapter 1**). The majority of intestinal disorders in horses are clinically expressed through dramatic manifestations, commonly referred to as "colic" or "colic syndrome." Narrowly defined, the term colic derives from the Latin dolor coli, meaning "pain of the colon," reflecting pain originating from the abdominal viscera. In a broader sense, this symptom complex extends to all types of pain affecting internal organs, with a distinction made between true colic, expressing gastrointestinal pain, and

false colic, reflecting pain originating from other organs such as the peritoneum, biliary system, kidneys, urinary tract, uterus, or pleura. It is essential to clearly differentiate between colic, which is a syndrome signifying abdominal pain, and ileus, which is a severe condition characterized by the absence of normal gastrointestinal motility, resulting in the stagnation of intestinal contents. Ileus is always an emergency requiring prompt intervention, as the accompanying symptoms can deteriorate rapidly, leading to severe compromise of the animal's health and potentially resulting in death due to shock (**Chapter 2**).

The second part of the thesis is dedicated to the author's original research and is structured into six chapters, comprising 99 pages.

Chapter 3 describes the working hypothesis and the objectives of the research. Based on these objectives, the study design was developed and organized.

Chapter 4 presents **Study 1**, entitled "*Clinical Diagnosis of Colic Syndrome in Horses*," which aimed to evaluate and interpret the clinical manifestations observed in a representative cohort of horses affected by colic syndrome. The analysis focused on physiological parameters recorded at the time of clinical examination to determine whether the case constituted a medical emergency and to guide the appropriate treatment approach (conservative or surgical). Another aim of this study was to explore potential associations between natural cosmic factors - including lunar phases, days of the week, and variations in the geomagnetic Kp index - and the onset of colic manifestations within the study population. The biological material comprised a total of 116 horses (n=116), including males (n=62) and females (n=54), of various breeds, aged between 1 day and 21 years, and weighing between 70 kg and 840 kg.

Chapter 5 includes **Study 2**, entitled *"Diagnostic and Prognostic Value of Paraclinical Examination in Equine Colic Syndrome".* The primary aim of this study was to identify, apply, and highlight the value of the most relevant paraclinical methods for establishing the diagnosis and prognosis in equine colic syndrome. A secondary objective was to provide a comprehensive scientific synthesis regarding the role of peritoneal fluid in the diagnosis of colic syndrome, with a particular focus on the pathophysiological mechanisms that lead to changes in its normal and abnormal composition, the methodologies for sample collection, and the main analytical techniques. Special emphasis was placed on the clinical significance of the lactate-glucose ratio as a predictive marker guiding medical decision-making. By integrating these concepts, the analysis aimed to contribute to improving diagnostic and prognostic accuracy and to more effective disease management. Paraclinical examination is not mandatory; however, when performed, it provides critical information for accurately defining health status and, in the case of illness, for establishing a definitive diagnosis and prognosis. Among the wide range of currently available paraclinical methods, only

those relevant to equine colic syndrome were selected and applied. These methods included: hematological examination, biochemical analysis, inflammatory markers, blood gas analysis, peritoneal fluid sampling and analysis, ultrasonography, endoscopy, and abdominal radiography. Peritoneal fluid collection was performed via abdominocentesis. The main objectives of abdominocentesis were to determine disease etiology, assess disease severity, monitor the patient's clinical evolution, and evaluate treatment response. This procedure represents a critical component of clinical examination, particularly in severe cases of colic or cases unresponsive to medical therapy. Abdominocentesis is a vital procedure in evaluating horses with colic syndrome, as it provides precise information about the state of the abdominal cavity and assists in differentiating medical from surgical colic. For accurate diagnosis and the prevention of complications, it is essential that this procedure be performed by an experienced veterinarian. After the procedure, the collected peritoneal fluid was analyzed to provide valuable diagnostic information and to determine the etiology of the disease.

Chapter 6 was dedicated to **Study 3,** entitled "*Conservative and Surgical Treatment of Colic Syndrome in Horses*." The aim of this study was to apply and evaluate conservative treatment methods for equine colic syndrome to alleviate pain, restore normal gastrointestinal function, and prevent complications. Additionally, a retrospective study was conducted based on a representative clinical sample to comparatively assess the efficacy and complications associated with the use of three distinct abdominal suture techniques in the surgical management of equine colic, through rigorous methodology and detailed statistical analysis. The biological material consisted of 146 cases diagnosed with colic syndrome, of which 116 cases received conservative treatment, and 30 cases underwent surgical therapy. Horses treated surgically were adults aged between 3 and 20 years (mean age 11.7 ±4.9 years), comprising 47% males and 53% females, weighing between 300 kg and 800 kg (mean weight 575 ±145 kg), including both purebreds and crossbreeds. The diagnosis of colic was confirmed based on medical history, thorough clinical examination, and paraclinical investigations. The experimental design involved allocating horses into three groups subjected to surgical treatment using three different abdominal suture techniques to highlight the structural differences between the methods. The groups were organized according to the complexity of the applied suture techniques—from simple to combined - in order to demonstrate the progressive complexity of the techniques, starting with interrupted sutures (Group 1), followed by continuous suture patterns (Group 2), and concluding with the hybrid suture technique (Group 3). This progression of suture types reflects the working hypothesis of the study, namely that increasing suture complexity improves healing outcomes and provides greater mechanical strength to the abdominal

wall. The visual segmentation of experimental groups contextualizes the healing process, particularly the superior outcomes observed in Group 3 compared to the other two groups. The inclusion of key terms such as "interrupted," "continuous," and "hybrid" facilitates rapid association between each group and the applied suture technique. The experimental design serves not only as a descriptive tool but also as a didactic element that reinforces methodological clarity and the comparative nature of the three suture techniques. All surgical interventions were performed under standardized general anesthesia, consisting of sedation with xylazine (0.5 mg/kg IM), induction with ketamine (2.2 mg/kg IV), and maintenance with isoflurane in oxygen. Patients were positioned in dorsal recumbency on the operating table, with strict aseptic preparation of the abdominal area. The ventral midline laparotomy incision, measuring on average between 25 and 45 cm, was performed by sequentially dividing the skin, subcutaneous tissue, and abdominal fascia. A rigorous layered closure protocol was implemented to achieve hermetic and efficient sealing of the abdominal cavity and to optimize tissue healing across all surgical planes. The suture material was uniformly represented by polyglycolic acid (PGA), selected according to the anatomical layer: PGA 2.0 (USP 2) for the peritoneum and subcutaneous connective tissue and PGA 4 (USP 4) for skin closure. These absorbable sutures were chosen for their biocompatibility, mechanical strength, and low inflammatory profile.

Chapter 7 presents the conclusions and recommendations formulated based on the research results, while **Chapter 8** describes the originality and innovative contributions of the thesis.

RESULTS OF THE ORIGINAL RESEARCH

Chapter 3. The analysis of physiological parameters revealed significant variability reflecting the severity and heterogeneity of colic syndromes. The interpretation of these physiological parameters in the context of equine colic is essential for establishing prognosis and selecting the appropriate therapeutic approach. To improve understanding and interpretation of the results obtained in the study, statistical analysis was performed using both descriptive and inferential statistical methods. The statistical analysis of the cohort of horses included in the study showed that the most frequently diagnosed gastrointestinal pathologies were the following: coprostasis (23.3%), colon displacements (18.1%), and colitis/enterocolitis (15.5%). Together, these three pathological entities accounted for over 57% of all analyzed cases, indicating a high prevalence of simple obstructive disorders and inflammatory processes. This distribution reflects a well-established reality in equine medicine: the most common forms of colic are not necessarily those requiring immediate surgical

intervention but rather those involving non-strangulating obstructions and diffuse intestinal inflammation, which can worsen rapidly if not treated promptly. The analysis of the results demonstrated that the physiological parameters recorded at the time of presentation provided essential information for patient triage and establishing therapeutic priorities. Dynamic monitoring of vital parameters, correlated with a thorough clinical examination and response to initial therapy, is critical for the early detection of disease progression and timely surgical decision-making.

The investigation into potential correlations between natural cosmic factors, such as lunar phases, day of the week, and geomagnetic variability expressed by the Kp index, and the onset of clinical manifestations in horses revealed several noteworthy findings. Notably, Sundays and Thursdays were associated with increased Kp index values, suggesting a possible weekly cyclic pattern in the context of geomagnetic fluctuations and clinical presentations.

Chapter 4. The statistical analysis of paraclinical blood parameters in the study cohort (n=116) highlighted considerable inter-individual variability, reflecting both the diverse etiopathogenesis of the cases and the severity of pathological states diagnosed upon admission. Hematological analysis showed mean erythrocyte parameters generally falling within the known physiological ranges for this species. Specifically, the mean red blood cell count (RBC: 8.60 $\pm$1.54 x10^{12}/L) and hemoglobin concentration (HGB: 13.7 $\pm$2.6 g/dL) were consistent with the normal hematologic status of adult horses. Although mean erythrocyte values remained within physiological limits, the broad amplitude of these values indicated substantial heterogeneity within the study population. The mean leukocyte count (WBC: 10.7 $\pm$5.1 x10^{9}/L) fell within the generally accepted physiological reference ranges for adult horses (approximately 5–12 x10^{9}/L), but the distribution analysis revealed significant variability, with extremes ranging from 2.84 to 30.03 x10^{9}/L. Regarding platelets (PLT: 168.6 $\pm$64.3 x10^{9}/L), the reported mean was within the physiological range (150–250 x10^{9}/L), but the wide variation, particularly the very low minimum value (5.6 x10^{9}/L), raised concerns about the occurrence of severe thrombocytopenia in certain subgroups of the analyzed population. The analysis of leukocytes and platelets thus revealed a complex hematological profile characterized by marked variability, reflecting the heterogeneous immune and inflammatory status of the patients. Serum total protein levels (6.3 $\pm$1.2 g/dL) were on average within reference intervals for adult horses (approximately 5.5–7.5 g/dL), but the broad range (2.2–10.2 g/dL) suggested significant variability in protein status among individuals. Serum urea levels (42.6 $\pm$18.2 mg/dL) also spanned a wide interval, with maximum values up to 110.2 mg/dL, indicating the possibility of renal or pre-renal pathological processes. Serum creatinine (1.5 $\pm$0.6 mg/dL), generally considered a more specific marker of renal function than urea as it reflects glomerular

filtration and is less influenced by extrarenal factors, further supported these findings. In conclusion, the combined evaluation of the hemogram, biochemical markers, and tissue enzymes provided a comprehensive picture of the health status of the studied patients and allowed for individualized therapeutic management and monitoring of clinical evolution, reinforcing the role of laboratory diagnostics in modern equine medicine. Overall, the integrated interpretation of peritoneal fluid parameters alongside clinical and imaging data contributed to improved diagnostic accuracy and timely, evidence-based therapeutic decision-making. This multifactorial approach enables earlier intervention, reduces the risk of irreversible damage, and improves postoperative management in horses diagnosed with colic syndrome.

Chapter 5. The results of **Study 3** demonstrated that conservative treatment is applied in mild to moderate colic cases without severe complications or strangulating obstructions, while adhering to fundamental principles to increase the chances of success and recovery. At any point, conservative management can be replaced by surgical intervention if specific symptoms indicate their necessity. Therapeutic objectives should primarily focus on early shock treatment, pain control, correction of fluid and electrolyte imbalances and acid-base disturbances, restoration of gastrointestinal patency, management of endotoxemia, infection prevention, and appropriate hygiene and dietetic regimens. If the patient's condition does not allow transport, therapy should be administered on-site, and the horse should be relocated to a safe environment as soon as it becomes transportable. In severe colic cases, neurogenic, hypovolemic, septic, and endotoxic shock may occur simultaneously. The pathogenesis of shock involves multiple factors, including altered cardiovascular function, circulating volume loss, systemic inflammation, and metabolic complications (Parry and Gay, 2004). In equine colic syndrome, shock can be classified as hypovolemic, endotoxic, cardiogenic, extracardiac obstructive, septic, distributive, or anaphylactic. The main goals of shock therapy include stabilization of circulating fluid volume through intravenous fluid replacement, reduction of inflammation and interruption of the inflammatory cascade, and treatment of endotoxemia. Fluid therapy is a central and arguably the most important step in the treatment of colic in horses, with the primary goal of restoring homeostasis through various mechanisms. This is essential in cases of hypovolemic shock, endotoxemia, or massive fluid losses through the gastrointestinal tract. Complementary therapies may also be considered to stimulate intestinal motility.

Surgical treatment is indicated in severe cases or when conservative therapy fails to produce the desired results. Surgical intervention is typically applied in colic caused by mechanical obstructions, including foreign bodies, enteroliths, fecal impactions, intestinal torsions, strangulated hernias, volvulus, or intussusceptions, as well as any other pathological unresponsive to conservative management. In the third

experimental group, the surgical technique applied was developed by our team with the aim of optimizing abdominal cavity sealing and reducing the risk of postoperative complications. The parietal peritoneum was sutured using a continuous suture technique with 2.0 PGA absorbable material, applied at short intervals of 0.5 cm to ensure tight and uniform closure of the peritoneal cavity. Postoperative wound assessment was performed daily, evaluating local inflammatory signs, presence of seroma, dehiscence, herniation, and abdominal muscular diastasis over a minimum period of three months. Healing was assessed clinically and by abdominal ultrasonography, evaluating wound thickness, presence of serous fluid, and fascial integrity.

Statistical analysis of the obtained data was performed using SPSS v.25 software. The Chi-square test was used to compare complication frequencies, while ANOVA with Tukey's post-hoc test was applied to analyze differences in mean healing times. The significance threshold was set at $p < 0.05$.

Retrospective analysis of postoperative outcomes across the three experimental groups revealed statistically and clinically significant disparities in complication rates, healing patterns, and the overall quality of outcomes.

In experimental Group 1, which utilized interrupted suture techniques, no fascial dehiscence was observed; however, this group exhibited a high incidence of seroma formation (70%), which frequently progressed to cutaneous dehiscence with serous exudation and healing by secondary intention.

Experimental Group 2, which used continuous suture techniques, showed the highest rate of severe postoperative complications, raising concerns regarding the structural durability of the continuous model under physiological load.

Experimental Group 3, which employed the combined suture technique, achieved the best results in terms of both mechanical integrity and aesthetic healing.

The results of this study corroborate previous findings in the literature regarding the delicate balance between suture mechanics and the biological response of tissues (Gialletti et al., 2021; Freeman, 2017). The combined suture technique offers a promising alternative for ventral abdominal wall closure in horses, warranting further investigation through prospective studies and biomechanical testing.

The selection and application of abdominal wall suture techniques in the surgical management of equine colic clearly demonstrate their critical importance for both immediate postoperative outcomes and the long-term functional and aesthetic integrity of the intervention site.

The combined suture technique evaluated rigorously in this study transcends traditional methods by synergistically integrating the mechanical advantages of

continuous and interrupted sutures with strategically placed reinforcement sutures, such as X-pattern sutures.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

In **chapter 7** the general conclusions of the thesis are presented, formulated based on the results obtained.

1. The analysis of the results demonstrated that the physiological parameters recorded at the time of presentation provided essential information for patient triage and for establishing therapeutic priorities in equine colic syndrome.
2. The integrated assessment of blood parameters in equine emergency medicine yields valuable data regarding acid-base balance and oxygenation status-elements that are critical for determining the severity of colic, the degree of tissue hypoxia, and the most appropriate therapeutic approach.
3. Inflammatory markers used in paraclinical evaluations of colic in horses provide essential information for both diagnosis and monitoring of this pathology. C-reactive protein (CRP) and serum amyloid A (SAA) are the most sensitive indicators of acute inflammation, fibrinogen and haptoglobin are relevant in chronic inflammatory processes, while D-dimer reflects abnormal coagulation and tissue ischemia. Interpreting these markers in their clinical context improves prognostic accuracy and guides treatment decisions.
4. Diet plays a key role in the management of colic in horses by supporting gastrointestinal function, preventing complications, and contributing to the recovery process. Feed must be tailored to the type of colic and the horse's general condition, and reintroduction of normal alimentation should be performed gradually. Careful monitoring of the animal's condition is essential to ensure an appropriate nutritional approach.
5. Based on the results obtained, it is recommended that the management of equine colic syndrome should be holistic and prompt, integrating traditional methods of examination and treatment with innovative techniques.

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