Prognostic factors assessed by blood analysis at the time of patient admission for horse colic

N. Brkljača Bottegaro*, J. A. Magoga, K. Bojanić, B. Beer Ljubić, K. Miljak, D. Grden and J. Gotić

Nika BRKLJAČA BOTTEGARO*, DVM, PhD, Associate Professor, (Corresponding author, e-mail: nikabb@vef.unizg.hr), Faculty of Veterinary Medicine, University of Zagreb, Zagreb, Croatia; Juliette Alexandra MAGOGA, DVM, De La Nouvetiere Clinique Veterinaire, la Nouvetiere, France; Krunoslav BOJANIĆ, DVM, PhD, Researcher, Mag. Med. Biochem., Laboratory for Aquaculture Biotechnology, Division of Materials Chemistry, Ruđer Bošković Institute, Zagreb, Croatia; Blanka BEER LJUBIĆ, PhD, Katarina MILJAK, DVM, Darko GRDEN, DVM, PhD Assistant Professor, Jelena GOTIĆ, DVM, PhD, Assistant Professor, Faculty of Veterinary Medicine, University of Zagreb, Zagreb, Croatia

Abstract

Colic in horses is an emergency frequently encountered by clinicians. Prompt and precise evaluation of each case is mandatory to determine the need for surgery. Prognosis evaluation is also a crucial part of the decision-making process regarding management options. The present study evaluates the relevance of routinely used haematology and biochemistry blood parameters at the time of patient admission as tools to determine the aetiology type and prognosis of colic cases. Clinical exams and blood analysis were drawn from 46 horses admitted with signs of acute abdominal pain. Horses were further divided into groups according to type of colic and survival. Heart rate, respiratory rate and temperature differed significantly between survivors and non-survivors. Serum albumin and lactate were also reliable prognostic factors. Similarly, heart rate, serum albumin and gamma-glutamyl transferase concentrations differed significantly between strangulating and non-strangulating colic types. Clinical exams and blood parameters can efficiently guide clinicians during the evaluation of horses with signs of abdominal pain.

Key words: *equine colic; strangulating lesion; survival; prognosis; blood analysis*

Introduction

Colic is a term for abdominal pain symptoms. In the equine medicine field, it may range from a short period of discomfort to a life-threatening condition, because it can be associated with various aetiologies. It is typically detected based on behavioural changes in the animal (Sutton et al., 2013) and later confirmed by clinical exam. However, the pathophysiologic processes involved can be challenging to identify. Consequently, new insights into colic diagnosis and prognosis are of high interest (Mair, 2009; Mair and White, 2010).

Colic horses represent an emergency frequently met in both first opinion and referral practice. White (2005) outlined that in a year in a group of 100 horses, 4–10% will have a colic episode. Of these, 80–85% have a non-specific aetiology and up to 4% of colic cases require surgical intervention. The diseases causing gastrointestinal illnesses can be classified in several ways, but the most important categorisation is based on whether surgical treatment is required or not. The late determination of a surgical case can negatively influence survival (Wheat, 1975).

It is extremely important to promptly and accurately distinguish the kind of pathology involved in a case. Multiple scanning and laboratory screening tools (Freeman, 2002; Beccati et al., 2011) are now accessible to complement the physical exam. Most clinical exam variables are subjectively interpreted (pain scoring, ultrasonography and rectal palpation findings) which can potentially lead to cognitive biases (Farrell et al., 2021). Identifying the exact cause of the presented colic, early on at the time of admission, would aid in the timely selection of the proper treatment strategy, resulting in better survival rates for horses.

The purpose of this study was to evaluate the relevance of routinely used haematology and biochemical blood parameters as tools to determine aetiology types and prognosis of colic cases. We hypothesised an increase in lactate and haematocrit would be associated with colic severity and non-survival of patients.

Material and methods

The study population was recruited from three different locations, two in France La Nouvetière clinic in Sonzay and Clinique de Conques in Saint-Aubin de Branne) and one in Croatia (Veterinary Teaching Hospital, Faculty of Veterinary Medicine, University of Zagreb). The study was performed over 10 months.

Ethical commitment

This research was approved by the Animal Ethics Committee of the Faculty of Veterinary Medicine, University of Zagreb (approval number: 640-01/22-17/46; 251-61-32-22-01). Written consent was received from the owners.

Horses

All horses presenting with signs of acute abdominal pain during the study period were considered eligible. Signalment, history and clinical exam at admission were recorded. Collected data were: heart rate (HR), respiratory rate (RR) and temperature (T), mucous membrane colour, peristalsis, skin turgor assessment, presence of reflux, and rectal and ultrasound findings. After case resolution, the clinical outcome of the horse was added to the record. Patients were further selected based on the availability and reliability of the following inclusion criteria: clinical examination findings, diagnosis and outcome. The diagnosis was made by the veterinarian attending the clinical exam, laboratory results and intra-surgical findings when available. In cases with several pathological findings, the most influential was used to assign the case to a diagnosis sub-group. The exclusion criteria were: missing history data, or samples not centrifuged and frozen within 24h.

Sample collection and processing

At horse admission, blood was collected from the jugular vein. The samples were collected in duplicates into four vacutubes as follows: two serum tubes with gel (5 mL) and two haematology tubes (6 mL) coated with K2EDTA to obtain plasma. All tubes were from LT BURNIK d.o.o. (Vodice, Slovenia). Haematology analysis was performed on the sampling day at the Veterinary Teaching Hospital in Zagreb: complete cell count, including red blood cell count, haemoglobin, haematocrit, MCH, MCHC, RDW, MPV, MCV, platelet count and leukocyte count was performed using a cell counter analyzer Horiba Scil Vet abc Plus analyzer (Scil, Germany). Blood smears were stained using May-Grünwald stain (RAL diagnostics, RAL, France) for differential blood count and evaluated under a light microscope. Blood samples for serum biochemistry analysis were centrifuged at 1200 x g, 500 µL and analysed using the Abbot Architect Plus c4000 (Abbot, USA) to measure serum albumin, gamma-glutamyl transferase (GGT), and concentration.

Statistical analysis

Data analyses were performed using R v4.1.2. R Foundation for Statistical Computing, Vienna, Austria) in the integrated desktop environment RStudio v. 2023.03.1 (https://posit.co/). Analyses included exploratory and statistical data analyses. All statistical analyses used an alpha error of < 0.05 unless otherwise stated. Exploratory analyses included measures of central tendency (mean and median) and variability (standard deviation, interquartile range, overall range and coefficient of variation) for numerical variables; and counts and relative frequencies for categorical variables. Data included demographic and history data, clinical, and laboratory parameters. Dependent variables of interest were outcome status (survivor *vs.* non-survivor) and strangulation status (strangulated vs non-strangulated colic types). For these variables, preliminary statistical tests included Shapiro-Wilk's test of normality and F test of variance homogeneity to select the appropriate two-sample test according to their assumptions. Therefore, the evaluation of differences in numerical variables by horse outcome status and strangulation status was based on the normality of distribution, where the student t-test was used for normally distributed data with or without Welch correction according to results of the F-test, while non-normal data were analysed using the Wilcoxon rank sum test.

Grouping

Retrospectively, horses were divided into two groups based on the case outcome: survivor vs. non-survivors; where survivors were defined as successfully discharged from the clinic and/or complete resolution of clinical signs without recidivism in the following two weeks. Horses were also grouped based on two types of diagnosis: strangulating bowels or non-strangulating bowels. The non-strangulating cases group was further divided into two sub-groups: identified as inflammatory colic or others (without strangulation or inflammation).

Results

Of the 52 identified colic cases during the study period, 46 horses met the inclusion criteria. Twenty horses were treated by the team of La Nouvetière. Fourteen horses were transported and admitted to Conques, and 12 were admitted to the Veterinary Teaching Hospital in Zagreb. Of the total 52 horses included, 23 were male and 23 were female, 22 were warm-blood horses, 10 ponies, 6 Arabians and Anglo-Arabians, 4 standardbreds, 3 draft horses and 1 thoroughbred. The average age of horses was 13.9±8.8 years (from 3 months to 29 years old) (Table 4).

Most of the horses had occasional activity, defined as up to one exercise session per week (27). Fifteen horses were frequently exercised with more than one session per week. The majority were housed in paddocks (23) or turned out. Nineteen patients received regular deworming and 20 had an inadequate frequency of deworming (none or occasional).

Retrospective data of the study population

Before admission and sampling, 31 horses had been transported to facilities and 29 had already received therapy. The pre-admission duration of symptoms ranged from one hour to five days with an average of 13.9±20.5 hours (Table 4). For 30 horses, this was the first known colic episode, while 15 had already shown signs of colic in the past. Final diagnoses were proven in 13% of horses (6/46) by intra-operative findings or necropsy. Twenty-six horses (56%) received medical treatment and five (11%) underwent surgery. Of the 46 surviving patients, 28 (61%) were discharged, while 18 patients (39%) were euthanised, including three surgical cases. The details of survival according to diagnosis type and clinical management are presented in Tables 1 and 2.

Table 1. Survival outcome of horses showing colic signs, according to diagnosis group and clinical management.

	Survivors (n)	Non-survivors (n)	Total (%)
Diagnosis (groups)			
Non-Strangulating	27	6	33 (71.7)
Strangulating	1	12	13 (28.3)
Clinical management			
Medically treated	26	15	41 (89.1)
Surgically treated	2	3	5 (10.9)

Table 2. Details of the survival outcome of horses with colic signs, according to diagnosis sub-groups (inflammation, strangulating or other).

Variable	Survivors (*n*)	Non-survivors (*n*)	Total (%)
Diagnosis (sub-groups)			
Other	23	4	27 (58.7)
Strangulating	1	12	13 (28.3)
Inflammation	4	2	6 (13.0)

The diagnosis sub-group "other" included patients with gastric distension, large colon displacement, nephrosplenic ligament entrapment, colon obstipation, prepubic tendon rupture with associated colic, pelvic flexure impaction/obstipation, gaseous ileus of the colon and non-specific colic findings. The sub-group "strangulating" gathered cases of mesenteric abscess, strangulating lipoma, small intestine torsion, colonic torsion, epiploic foramen hernia, mesenteric laceration with concurrent large colon torsion, and gastric rupture. The sub-group "inflammatory" included colitis, gastric ulcers, and parasitism (*Gasterophilus spp*.). The descriptive values of the history and clinical parameters are summarised in Tables 3 and 4.

Table 3. Descriptive values of the numerical parameters of horses with colic signs, from the anamnesis, admission clinical exam and laboratory analyses

Numerical variables	*n*	Mean	±SD	CV (%)	Median	IQR	(min – max)
Age (year)	46	13.9	±8.8	0.6	13.5	16	0.2 – 29
Pre-admission duration (hour)	45	13.9	±20.5	1.5	6	15	1 – 120
HR (bpm)	45	62.2	±23.5	0.4	52	24	32 – 120
RR ($b_r$pm)	31	26	±13.4	0.5	20	19	12 – 64
Temperature (°C)	31	37.5	±0.7	0	37.4	0.7	36 - 39.5
WBC count (M/mm^3)	39	10.4	±4.5	0.4	10.9	5	1.2 - 24.3
Neutrophils count (%)	38	71.9	±12.2	0.2	70.8	17.6	47.5 - 94
Haematocrit (%)	40	41	±12.7	0.3	36.9	13.3	26.4 - 85.3
Lactate (mmol/L)	32	2.7	±2.4	0.9	2	1.5	0.8 - 12

SD: standard deviation; CV: coefficient of variation; IQR: interquartile range

Table 4. Descriptive values of the categorical parameters of horses with colic signs, from the admission clinical exam and laboratory analyses.

Categorical variables	n	%
Mucous membranes colour	*45*	
Normal	33	73.3
Abnormal	12	26.7
Dehydration %	*45*	
None to mild	22	48.9
Mild to moderate	8	17.8
Moderate to severe	15	33.3
Peristalsis (auscultation)	*46*	
Normal	11	23.9
Abnormal	35	76.1
US findings	*34*	
Normal	12	35.3
Abnormal	22	64.7
Rectal palpation findings	*40*	
Loops of small intestine	10	25.0

Categorical variables	n	%
Tight tenias	9	22.5
Obstipation	9	22.5
Normal palpation	13	32.5

There were significant differences in HR between survival and non-survival statuses (W=387.5, *P*=0.001). The average HR in survivors was 53.1 bpm and 75.9 bpm in non-survivors. According to colic type, HR was also significantly different between cases (W= 87.5, *P*=0.003). It was on average 80.2 bpm in bowel strangulation and 54.9 bpm in non-strangulating cases. There were significant differences in RR between survival and non-survival of horses (*W*=169, *P*=0.005). The average RR in survivors was 22.6 bpm and 33.2 bpm in horses that died. However, it was not significantly associated with colic type (W=38.5, *P*=0.06). Temperature was significantly different between survivors and non-survivors (W= 31.5, *P*= 0.003). It was on average 37.7°C in survivors and 37°C in horses that did not survive. On the other hand, temperature was not significantly different between colic types (W=105.5, *P*=0.13).

Out of the tested laboratory parameters, albumin was on average 6g/L (95% CI= [2.0, 9.9]) lower in survivors, showing a significant difference between survival outcomes (t= 3.25, dF= 14, P=0.006). The mean albumin concentration was 26±3.3g/L in survivors and 32±1.4g/L in horses that died. Concerning strangulation status, although albumin was on average 5.17 g/L (95% CI = [-10.4, 0.1]) higher in strangulated than in non-strangulated cases, it did not significantly differ between horses (*t*=-2.12, *dF*=14, *P*=0.05). The mean albumin concentration was 32.5±5.6g/L in strangulated bowels and 27.3±3.8g/L in non-strangulated colic. The GGT concentration was significantly different between strangulating and non-strangulating bowel cases (W=39, P=0.031). It was on average 16.2 U/L in strangulating colic and 67.2 U/L in non-strangulated ones. GGT was not significantly different between survivors and non-survivors (W= 18.5, *P*= 0.34).

Haematocrit and lactate values were only significantly different between survivors and non-survivors (W=273.5, *P*=0.03 for haematocrit; W=182, *P*=0.04 for lactate). Haematocrit was on average 37% in survivors and 46.8% in non-survivors. The average lactate concentration was 1.9 mmol/L in survivors and 3.7 mmol/L in horses that died. Haematocrit and lactate concentrations were not significantly different between strangulation statuses (W=116, *P*=0.13 for haematocrit; W=78, *P*=0.2 for lactate).

Neutrophil and WBC counts were not significantly associated with outcome (W=160, *P*=0.57 for WBC count; t=0.99, dF=36, *P*=0.33 for neutrophil count), or with strangulation statuses (W=179, *P*=0.62 for WBC count; t=-0.89, dF= 36, P= 0.38 for neutrophil count).

Similarly, pre-admission duration was not significantly different within survival groups (W= 298, *P*=0.21) and diagnosis groups (W=174, *P*=0.40).

In general, few parameters showed a significant difference associated with outcome. The average values of HR, RR, albumin, haematocrit and lactate were lower in survivors compared to horses that did not survive a colic episode, while the average temperature was higher. Regarding colic types, only HR averages were significantly higher while GGT averages were lower during bowel strangulation. The values of numerical parameters are presented in Tables 5 and 6 according to outcome and type of colic.

Table 5. Summary of statistical results, tendencies and interpretations concerning outcome

Variable	Overall Mean ±SD Median (IQR, min-max)	According to outcome			
		Survivors Mean ±SD Median (IQR, min-max)	Non-survivors Mean ±SD Median (IQR, min-max)	Tendency in survivors	Tests Details
Age (year)	13.9±8.8 13.5 (0.2 – 29) 16	12.1±8.3 10 (0.5 – 29) 13.5	16.8±9.1 16 (0.2 – 28) 13.8	4.7 years younger 95% CI= [-0.5, 9.9]	*t*= 1.81, *dF*= 44 *P*= 0.077
Pre-admission duration (hour)	13.9±20.5 6 (15, 1 – 120)	13.8±23.9 5 (14, 1 – 120)	14.1±14.6 7.5 (16, 2 – 48)	-	*W*= 298 *P*= 0.205
HR (bpm)	62.2±23.5 52 (24, 32 – 120)	53.1±16.8 48 (17, 32 – 100)	75.9±25.9 71 (33.5, 40 – 120)	***	*W*= 387.5 ***P*= 0.001**
RR (b.pm)	26±13.4 20 (19, 12 – 64)	22.6±13.2 16 (7, 12 – 64)	33.2±11.2 30 (16.5, 16 – 50)	**	*W*= 169 ***P*= 0.005**
Temperature (°C)	37.5±0.7 37.4 (0.7, 36 – 39.5)	37.7±0.5 37.7 (0.6, 36.7 – 38.5)	37±1 36.8 (0.7, 36 – 39.5)	**	*W*= 31.5 ***P*= 0.003**
Albumin (g/L)	28.6±4.7 28.5 (5.5, 20-38)	26±3.3 26 (4, 20 – 31)	32±1.4 32 (3.5, 25 – 38)	6g/L lower 95% CI= [2.0, 9.9] **	*t*= 3.25, *dF*= 14 ***P*= 0.006**
GGT (U/L)	53.6±58.3 24 (56.5, 11 – 172)	60.7±60.8 24 (91, 15 – 172)	43±58.1 21 (20.2, 11 – 160)	-	W= 18.5 *P*= 0.344

Haematocrit (%)	41±12.7 36.9 (13.3, 26.4 – 85.3)	37±9.5 35.1 (9.4, 26.4 – 60.1)	46.8±14.9 41.5 (22.1, 32.3 – 85.3)	*	*W*= 273.5 ***P*= 0.025**
Lactate (mmol/L)	2.7±2.4 2 (1.5, 0.8 – 12)	1.9±1.3 1.6 (1.3, 0.8 – 6.2)	3.7±3 2.7 (3.3, 1 – 12)	*	*W*= 182 ***P*= 0.041**
Neutrophils count (%)	71.9±12.2 70.8 (17.6, 47.5 – 94)	70.4±10.6 68.8 (12.1, 47.5 – 90.2)	74.4±14.7 79 (21.3, 51 – 94)	4.07 % lower 95% CI= [-4.3, 12.4]	*t*= 0.99, *dF*= 36 *P*= 0.329
WBC count (M/mm^3)	10.4±4.5 10.9 (5, 1.2 – 24.3)	11.1±4.5 10.5 (4.9, 5.7 – 24.3)	9.3±4.5 10.9 (4.7, 1.2 – 15.6)	-	*W*= 160 *P*= 0.573

P value is expressed as level of significance ($P<0.05$, ** $P<0.01$ and *** $P\leq0.001$)*

Table 6. Summary of statistical results, tendencies and interpretations concerning diagnosis

Numerical variable	**Overall** Mean ±SD Median (IQR, min-max)	**According to colic type**			
		Strangulated Mean ±SD Median (IQR, min-max)	**Non-strangulated** Mean ±SD Median (IQR, min-max)	**Tendency in strangulated**	**Tests Details**
Age (year)	13.9±8.8 13.5 (0.2 – 29) 16	16.6±9.6 16 (0.2 – 28) 13	12.9±8.4 12 (0.5 – 29) 14	3.66 years older 95% CI= [-9.4, 2.1]	*t*= -1.28, *dF*= 44 *P*= 0.208
Pre-admission duration (hour)	13.9±20.5 6 (15, 1 – 120)	20.5±32.7 7 (18, 2 – 120)	11.2±12.5 5.5 (13.8, 1 – 48)	-	*W*= 174 *P*= 0.400
HR (bpm)	62.2±23.5 52 (24, 32 – 120)	80.2±28.1 80 (40, 40 – 120)	54.9±17 49 (16, 32 – 105)	**	*W*= 87.5 ***P*= 0.003**
RR (b$_r$pm)	26±13.4 20 (19, 12 – 64)	33.7±12.6 35 (16, 16 – 50)	24.2±13.1 16 (12, 12 – 64)	-	*W*= 38.5 *P*= 0.061
Temperature (°C)	37.5±0.7 37.4 (0.7, 36 – 39.5)	37.3±1.1 37 (0.5, 36.4 – 39.5)	37.5±0.6 37.5 (0.7, 36 – 38.5)	-	*W*= 105.5 *P*= 0.132
Albumin (g/L)	28.6±4.7 28.5 (5.5, 20-38)	32.5±5.6 33.5 (5.5, 25 – 38)	27.3±3.8 27.5 (4.8, 20 – 33)	5.17g/L higher 95%CI= [-10.4, 0.1]	t= -2.12, dF= 14 **P= 0.052**

GGT (U/L)	53.6±58.3 24 (56.5, 11 – 172)	16.2±9.2 12 (4.8, 11 – 30)	67.2±63 33 (100.5, 15 – 172)	*	*W*= 39 ***P*= 0.031**
Haematocrit (%)	41±12.7 36.9 (13.3, 26.4 – 85.3)	43.9±11.2 41.5 (18.1, 32.3 – 63)	39.7±13.3 36.1 (10.5, 26.4 – 85.3)	-	*W*= 116 *P*= 0.128
Lactate (mmol/L)	2.7±2.4 2 (1.5, 0.8 – 12)	3.1±1.9 2.6 (2.6, 1 – 6.5)	2.6±2.6 1.7 (1.6, 0.8 – 12)	-	*W*= 78 *P*= 0.199
Neutrophil count (%)	71.9±12.2 70.8 (17.6, 47.5 – 94)	74.6±15 79.2 (23, 51 – 94)	70.7±11 68.8 (12.6, 47.5 – 91.2)	3.98 % higher 95% CI= [-12.8, 5]	*t*= -0.89, *dF*= 36 *P*= 0.381
WBC count (M/mm^3)	10.4±4.5 10.9 (5, 1.2 – 24.3)	9.3±4.5 10.7 (4.5, 1.2 – 15.6)	108±4.6 10.9 (5, 2.6 – 24.3)	-	*W*= 179 *P*= 0.616

P-value is expressed as a level of significance (P<0.05, ** P<0.01, *** P≤0.001)*

Discussion

We aimed to identify one or several clinical examination findings and blood analysis parameters that would assist in the determination and decision-making processes related to equine colic cases.

The results indicate that in the settings of our study population, HR, RR, T, haematocrit, serum albumin and lactate were reliable prognostic factors. Similarly, HR, serum albumin and GGT concentration were reliable diagnostic indicators for differentiation of colic types. Interestingly, in our population, neither lactate nor haematocrit was a valuable diagnostic indicator.

Considering the limited availability and commercialisation of point-of-care tests, decision-making processes were previously mostly based on physical exam findings of colic patients. The addition of laboratory parameters to the diagnostic process improved diagnostic accuracy. More than 30 years ago, Orsini et al. (1988) emphasised that the most useful strategy is to use a combination of parameters. They conclude that combined lactate levels in serum and haematocrit were accurate tools for prognostic survival. Later on, capillary refill time (CRT) and the blood anion gap were added to the previous parameters by Ebert (1995). Improving strategies to predict outcomes, based on routine examination of colic horses, has often been a subject of research. Elevated HR, elevated haematocrit, prolonged CRT, poor mucous membrane colour and abnormal blood pH have all been defined as poor prognosis indicators (Parry et al., 1983; Reeves et al., 1989).

Although numerous studies have been published on this challenging topic, the use of subjective evaluations from physical exams is still a matter of discussion. Van der Linden et al. (2003) analysed the prognosis power of combined white blood cell count (WBC), haematocrit, blood pH and mucous membrane colour parameters. Their findings countered the previously cited studies as the combination of clinical parameters tested in their study was not significantly correlated with the outcome of horses. Other values like the duration of colic signs, quality of peristalsis and bowel motility, degree of skin tenting, HR, pain level and PF appearance, proved to be useful in identifying survival potential.

Similarly, Thoefner et al. (2003) questioned the reliability of parameters from the physical exam as their model of decision tree turned out to be non-significant. It featured rectal exam findings, haematocrit, rectal temperature and estimated pain level, which is partially in contradiction with our results. Farrell et al. (2021) were able to find relevance in the same base of parameters. The combination of HR, RR, high blood lactate and the identification of abnormal rectal and ultrasound findings, gives a significantly poor prognosis. Beccati et al. (2011) proved that abdominal screening can accurately discern pathologies like strangulations, nephrosplenic entrapment, and differentiate small from large bowel involvement. Visualisation of the mesenteric vasculature can also determine the type of large colon involvement (Manso-Diaz et al., 2020).

While nowadays, lactate, albumin and creatine kinase are the only parameters available to foresee ischemic lesions (Ludwig et al., 2023), a few other clinical parameters were quantified to assess their diagnosis potential. In this research, HR was significantly higher in cases of bowel strangulation. This result is in agreement with the studies of Ihler et al. (2004) and Kos et al. (2022), which both determined a significant elevation of HR in colic cases needing surgery. Although they analysed the parameter in combination with haematocrit values, we can highlight that HR could be valuable in differentiating diagnosis types.

In the present study, albumin showed significant differences between concentrations in strangulating and non-strangulating colic cases. This could be explained because albumin tends to shift to ischemia-modified albumin under hypoxic conditions (Gunduz et al., 2008).

Also, GGT concentrations differed between colic types, and was significantly decreased in strangulating cases. This result was expected, considering the conclusions obtained by Gardner et al. (2005). They determined that horses with large colon dorsal displacement to the right had higher blood concentrations than in cases of dorsal displacement to the left. They explain this as by the potential anatomic compression of the bile duct in cases with colonic displacement to the right, causing occlusion of the channel, followed by elevation of GGT in blood. In our study, regardless of horses suffered from left or right displacement, we can extrapolate that a shift leading to the compression of the bile duct would be mostly related to strangulation as time passes. Thus, it appears rational that GGT could differentiate colic cases, although this requires further study.

The skin tent test and dryness of mucous membranes are used to assess the level of patient dehydration, together with CRT. Colic horses are often dehydrated and this test is empirically done during the regular exam, with fluid therapy as the primary step of drug administration. However, Pritchard et al. (2008) showed that these parameters are not reliable since the duration of the skin tent and the mucosa tackiness are cancelled by the plasma osmolality of the subjects.

Considering the need for prompt therapy in colic cases, Ihler et al. (2004) distinguished medical and surgical management. They emphasised the use of packed cell volume (PCV) as a single parameter that orientates towards medical treatment, while the combination of elevated HR and abnormal mucous membrane colour are indicators of the need for surgical procedures. They did not obtain valuable results from the incorporation of D-Dimer blood concentrations, and hypothesised that therapies given before sampling interfered with their results.

Southwood and Lindorg (2021) detected that the association of PCV, blood glucose, blood lactate, decreased rectal temperature and first-time colic at an advanced age are parameters associated with strangulating episodes. Kos et al. (2022) confirmed that elevated PCV and HR are most common in horses in need of surgical treatment.

In the present study, several limitations need to be mentioned. The study population was quite heterogeneous given the multiple clinics and breeds involved, and the age range of animals. Some horses had previously received therapy before admission which could have influenced the results. The duration of transport to the clinic was not evaluated. Transportation was not included in the analysis because Carvalho Filho et al. (2022) showed that a distance of less than 300 km did not significantly change the blood analysis.

Since the samples were taken in three different locations, they were also processed by different clinicians and with different blood analysers. Although a detailed protocol was provided, variability originating from sample collection and handling until freezing cannot be excluded. Given the reality of field conditions and owner compliance, some horses that had to be humanely euthanised were not necropsied. Consequently, objective diagnoses were not available in cases not treated surgically. Additionally, the fact that a horse survived or did not survive a colic episode could be affected by several biases. Despite the experience of veterinarians handling the cases, there is a possibility of cognitive biases influencing clinical evaluations (Farrell et al., 2021). Moreover, the final decision belongs to the owner and there are possible financial restrictions that could influence this choice and horse survival outcome.

Conclusions

In conclusion, during the admission of colic cases, both the clinical examination and laboratory blood analysis can assist in establishing the type of colic and survival prognosis. Reliable indicators of survival prognosis were HR, RR, T, haematocrit, serum albumin and lactate. In establishing the correct diagnosis in colic cases, valuable factors were HR, serum albumin and GGT concentrations.

References

1. BECCATI, F., M. PEPE, R. GIALLETTI, M. CERCONE, C. BAZZICA and S. NANNARONE (2011): Is there a statistical correlation between ultrasonographic findings and definitive diagnosis in horses with acute abdominal pain? Equine Vet. J. Supplement. 39, 98-105. 10.1111/j.2042-3306.2011.00428.x
2. CARVALHO FILHO, W. P., P. C. DE SOUTO, A. M. O. OROZCO, A. K. A. JIMÉNEZ, F. M. GIRARDI, L. D. BENTOL and A. DA FONSECA (2022): Influence of Short and Medium Distance Road Transport on the Acute Phase Proteins in Horses. J. Equine Vet. Sci. 117, 104061. 10.1016/j.jevs.2022.104061
3. EBERT, R. (1995): Differentiated prognosis in the colicky horse. Tierarztl. Prax. 23, 475-480.
4. FARRELL, A., K. KERSH, R. LIEPMAN and K. A. DEMBEK (2021): Development of a Colic Scoring System to Predict Outcome in Horses. Front. Vet. Sci. 8, 697589. 10.3389/fvets.2021.697589
5. FREEMAN, S. (2002): Ultrasonography of the equine abdomen: findings in the colic patient. In Practice 24, 262-273. 10.1136/inpract.24.5.262
6. GARDNER, R. B., D. V. NYDAM, H. O. MOHAMMED, N. G. DUCHARME and T. J. DIVERS (2005): Serum Gamma Glutamyl Transferase Activity in Horses with Right or Left Dorsal Displacements of the Large Colon. J. Vet. Intern. Med. 19, 761-764. 10.1111/j.1939-1676.2005.tb02758.x
7. GUNDUZ, A., S. TUREDI, A. MENTESE, S. C. KARAHAN, G. HOS, O. TATLI, I., TURAN, U. UCAR, R. M. RUSSELL and M. TOPBAS (2008): Ischemia-modified

albumin in the diagnosis of acute mesenteric ischemia: a preliminary study. Am. J. Emerg. Med. 26, 202-205. 10.1016/j.ajem.2007.04.030

8. IHLER, C. F., J. LARSEN VENGER and E. SKJERVE (2004): Evaluation of Clinical and Laboratory Variables as Prognostic Indicators in Hospitalised Gastrointestinal Colic Horses. Acta Vet. Scand. 45, 109. 10.1186/1751-0147-45-109
9. KOS, V. K., P. KRAMARIC and M. BRLOZNIK (2022): Packed cell volume and heart rate to predict medical and surgical cases and their short-term survival in horses with gastrointestinal-induced colic. Can. Vet. J. 63, 365.
10. LUDWIG, E. K., K. J. HOBBS, C. A. MCKINNEY-AGUIRRE and L. M. GONZALEZ (2023): Biomarkers of Intestinal Injury in Colic. Animals 13, 227. 10.3390/ani13020227
11. MAIR, T. (2009): Clinical Governance, Clinical Audit, and the Potential Value of a Database of Equine Colic Surgery. Vet. Clin. N. Am-Equine 25, 193-198. 10.1016/j.cveq.2009.04.009
12. MAIR, T. S. and N. A. WHITE (2010): Improving quality of care in colic surgery: time for international audit? Equine Vet. J. 37, 287-288. 10.2746/0425164054529490
13. MANSO-DÍAZ, G., D. M. BOLT and J. LÓPEZ-SANROMÁN (2020): Ultrasonographic visualisation of the mesenteric vasculature in horses with large colon colic. Vet. Rec. 186, 491-491. 10.1136/vr.105468
14. ORSINI, J. A., A. H. ELSER, D. T. GALLIGAN, W. J. DONAWICK and D. S. KRONFELD (1988): Prognostic index for acute abdominal crisis (colic) in horses. Am. J. Vet. Res. 49, 1969-1971.
15. PARRY, B. W., G. A. ANDERSON and C. C. GAY (1983): Prognosis in equine colic: A comparative study of variables used to assess individual cases. Equine Vet. J. 15, 211-215. 10.1111/j.2042-3306.1983.tb01768.x
16. PRITCHARD, J. C., C. C. BURN, A. R. S. BARR and H. R. WHAY (2008): Validity of indicators of dehydration in working horses: A longitudinal study of changes in skin tent duration, mucous membrane dryness and drinking behaviour. Equine Vet. J. 40, 558-564. 10.2746/042516408X297462
17. REEVES, M. J., C. R. CURTIS, M. D. SALMAN and B. J. HILBERT (1989): Prognosis in Equine Colic Patients Using Multivariable Analysis. Can. J. Vet. Res. 53, 87.
18. SOUTHWOOD, L. L. and S. LINDBORG (2021): Early identification of horses with strangulating lesions: can we do better with point-of-care evaluation? Equine Vet. Educ. 33, 21. 10.1111/eve.33_13534

19. SUTTON, G. A., O. PALTIEL, M. SOFFER and D. TURNER (2013): Validation of two behaviour-based pain scales for horses with acute colic. Vet. J. 197, 646-650. 10.1016/j.tvjl.2013.04.007
20. THOEFNER, M. B., B. K. ERSBØLL, N. JANSSON and M. HESSELHOLT (2003): Diagnostic decision rule for support in clinical assessment of the need for surgical intervention in horses with acute abdominal pain. Can. J. Vet. Res. 67, 20.
21. VAN DER LINDEN, M. A., C. M. LAFFONT and M. M. S. OLDRUITENBORGH-OOSTERBAAN (2003): Prognosis in Equine Medical and Surgical Colic. J. Vet. Intern. Med. 17, 343-348. 10.1111/j.1939-1676.2003.tb02459.x
22. WHEAT, J. D. (1975): Causes of colic and types requiring surgical intervention. J. S. Afr. Vet. Assoc. 46, 95-99.
23. WHITE, N. A. (2005): Prevalence, Demographics, and Risk Factors for Colic. Proceedings of the American Association of Equine Practitioners Focus Meeting. Québec, Canada.

Prognostički čimbenici procijenjeni analizom krvi u trenutku prijema pacijenata-konja zbog kolika

Dr. sc. Nika BRKLJAČA BOTTEGARO, dr. med. vet., izvanredna profesorica, Veterinarski fakultet Sveučilišta u Zagrebu, Zagreb, Hrvatska; Juliette Alexandra MAGOGA, dr. med. vet., De La Nouvetiere Clinique Veterinaire, la Nouvetiere, Francuska; Dr. sc. Krunoslav BOJANIĆ, istraživač, Mag. Med. Biochem., Laboratorij za biotehnologiju akvakulture, Zavod za kemiju materijala, Institut Ruđer Bošković, Zagreb, Hrvatska; Dr. sc. Blanka BEER LJUBIĆ, Katarina MILJAK, dr. med. vet., dr. sc. Darko GRDEN, dr. med. vet., docent, dr. sc. Jelena GOTIĆ, dr. med. vet., docentica, Veterinarski fakultet Sveučilišta u Zagrebu, Zagreb, Hrvatska

Kolike u konja predstavljaju hitno stanje s kojim se kliničari često susreću. Brza i precizna procjena svakog slučaja obvezna je da bi se donijela odluka za kirurško liječenje. Procjena prognoze je i ključni dio u odluci o načinu liječenja. Ovo istraživanje procjenjuje važnost hematoloških i biokemijskih krvnih parametara koji se redovito koriste u trenutku prijema konja kao alata za određivanje etiološkog tipa i prognoze kod kolika. Podatci kliničkog pregleda i analize krvi uzeti su od 46 konja koji su primljeni sa simptomima kolike. Konji su dalje podijeljeni u skupine prema etiologije kolika i preživljavanju. Vrijednosti bila (HR), frekvencija disanja (RR) i temperature (T) bili su različiti između preživjelih i onih koji nisu preživjeli ($P<0,01$; $P<0,005$; $P<0,003$). Serumski albumin i laktat su bili pouzdani kao i prognostički čimbenici ($P<0,006$; $P<0,041$). Slično tome, HR, serumski albumin i koncentracija GGT bili su različiti između strangulirajućih i nestrangulirajućih tipova kolike ($P<0,003$; $P<0,52$;

P<0,51). Klinički pregled i krvni parametri mogu učinkovito pomoći kliničarima tijekom procjene konja s kolikom.

Ključne riječi: *kolike konja, strangulacijske lezije, preživljavanje, prognoza, analiza krvi*