



Prognosis indicators of equine acute abdomen in south Brazil

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ABSTRACT: Acute abdomen cases are among the most prevalent and challenging illnesses in equine medicine. The diagnosis includes anamnesis and detailed clinical evaluation of the patient, allowing the gathering of several important information and, additionally, the use of complementary exams helps to define the diagnosis and prognosis of each case. This research applied the multiple correspondence analysis (MCA) in data referring to clinical examination information and outcome of horses with colic referred to a hospital in Rio Grande do Sul, Brazil. Fifty eight horses were included in the analysis and, it was possible to identify significant differences between the groups, survivors and non-survivors. Related to clinical signs, non-survivor cases are distinguished by severe pain, lack of motility, mucosal alteration, capillary refill time greater than 2sec, heart rate more than 48bpm and presence of nasogastric reflux. As complementary exams, hematocrits and blood lactate demonstrate significant difference among the groups. The cardiovascular parameters, including heart rate, mucosal color and capillary refill time, were the variables with the greatest contribution to discriminate animals that non-survive from those that were discharged. Thus, clinical evaluation should not be underestimated and complementary exams should be used in conjunction to seek a better prognosis. The MCA allowed to visualize the data and predict the outcome of the patients.

Key words: colic, clinical evaluation, horse, statistics, survival.

Indicadores prognósticos de abdome agudo em equinos no sul do Brasil

RESUMO: Os casos de abdome agudo estão entre as doenças mais prevalentes e desafiadoras na medicina equina. O diagnóstico inclui a realização de anamnese e avaliação clínica detalhada do paciente, permitindo a coleta de diversas informações importantes e, adicionalmente, a utilização de exames complementares ajuda a definir o diagnóstico e prognóstico de cada caso. O objetivo principal deste trabalho foi aplicar a análise de correspondência múltipla (ACM) em dados referentes ao exame clínico e desfecho de cavalos com cólica encaminhados para um hospital no Rio Grande do Sul, Brasil. Foram incluídos 58 cavalos na análise e foi possível identificar diferenças significativas entre os grupos, sobreviventes e não sobreviventes. Relacionado aos sinais clínicos, os casos de óbito distinguem-se por dor intensa, falta de motilidade, alteração da mucosa, tempo de preenchimento capilar maior que 2seg., frequência cardíaca maior que 48bpm e presença de refluxo nasogástrico. Como exames complementares, o hematócrito e o lactato sanguíneo demonstraram diferença significativa entre os grupos. Os parâmetros cardiovasculares, como batimento cardíaco, coloração de mucosas e tempo de preenchimento capilar, foram as variáveis com maior contribuição para diferenciar animais que não sobreviveram dos que receberam alta hospitalar. Assim, a avaliação clínica não deve ser subestimada e os exames complementares devem ser utilizados em conjunto para buscar um melhor prognóstico. A ACM permitiu visualizar os dados e prever o desfecho dos pacientes.

Palavras-chave: cólica, avaliação clínica, cavalo, estatística, sobrevivência.

INTRODUCTION

The equine acute abdomen have a multifactorial nature and it is characterized by variable intensity of abdomen pain generally caused by gastrointestinal diseases. It is one of the conditions that most affect horses, causing economic and animal welfare losses, besides being one of the main causes of death in horses (ASHDOWN et al., 2011; PIEREZAN et al., 2009; REEVES, 1997; TINKER et al., 1997).

When the animal has colic syndrome, the approach must be carried out quickly, seeking to avoid greater damage to the health of the animal

and, thus, facilitating the success of the treatment. For this, a careful and detailed diagnosis is of paramount importance, seeking to elucidate the cause of the clinical presentation of colic through a set of observations and analyses, carried out concurrently during care. The definition of the diagnosis and precise therapeutic approach, clinical or surgical, are crucial for the patient's recovery and prognosis (BACH & RICKETTS, 1974; LINDEN et al., 2003; YAMOUT et al., 2011).

The definition of an exact diagnosis in case of acute abdomen are difficult, so, many times it is just possible with a laparotomy surgery. The main

challenge to the clinician is to provide a clear view of possible complications and prognoses to the owner (VAN DER LINDEN et al., 2003). Thus, some studies are focusing on correlated preoperative variables, clinical and clinicopathologic features, with the risk of mortality in equine colic using multivariable models (HACKETT et al., 2015; KELLEHER et al., 2013; PROUDMAN et al., 2002).

Multiple correspondence analysis (MCA) is a multivariate exploratory technique, which makes it possible to summarize, visualize and identify relations of interdependence for a data set (DI FRANCO, 2016; NENADIC & GREENACRE, 2005). MCA is a method similar to principal component analysis (PCA), but that works with only categorical variables. MCA and PCA are approaches to reduce the data set dimensionality by obtaining a new system of coordinates associated with estimated axes that capture the existing variability in the data. This simplification allows for identifying unobservable patterns in separate variables and providing insights into similarities and differences.

As far as we aware, no studies using MCA in equine colic cases were published in Brazil. In view of this and the great economic impact caused by disorders in the gastrointestinal system, early and accurate exam allow identifying the possible disease and facilitating the diagnosis, providing a better prognosis. Therefore, the use of statistical methods, through parameters easily obtained in the clinical evaluation, which help the veterinarian in determining the prognosis and scientifically based feedback to the owner is of extreme practical applicability.

This study applied a Multiple correspondence analysis (MCA) in equine acute abdomen cases correlated to the history, anamnesis, clinical signs, and complementary exams with the outcome.

MATERIALS AND METHODS

Design

A prospective observational study of clinical data was applied. The medical records of 70 horses treated for colic syndrome between December 2021 and February 2022 at the Guadalupe Veterinary Clinic, located in Rio Grande do Sul, Brazil, were used. The inclusion criteria for the study were adult horses presented with clinical signs of colic.

Clinical form

For each animal collected, an evaluation form was completed at admission, including information regarding horse demographics (sex, breed, travel time to the hospital, weight and date),

anamnesis (duration of clinical signs, level of pain, other concomitant diseases) and clinical evaluation (abdominal auscultation, gastric reflux, mucous membranes, capillary refill time [CRT], heart rate [HR], respiratory rate [RR] and rectal temperature), complementary exams (ultrasound evaluation, measurement of lactate, fibrinogen, hematocrit/packed cell volume [PCV], total protein and serum amyloid A [SAA]), final diagnosis and outcome of the case.

Complementary exams

All horses referred to the veterinary clinic are submitted to blood collection by jugular venipuncture at admission. The measurement of lactate, fibrinogen, hematocrit and total protein were carried out in the own laboratory, as a standard routine in care and the results included in the clinical form. For SAA analysis, the serum was frozen and forwarded to the university (UNIPAMPA) where the SAA was mensurated using ELISA kits.

The ultrasound was carried out using the FLASH technique and the observations described in the clinical form.

Statistical analysis

Data were tabulated in excel and submitted to statistical analysis in the R software (R CORE TEAM, 2021). Initially, the variables were evaluated based on their association with the outcome. For quantitative variables, the Mann-Whitney test was used, due to the deviation from normality, and for qualitative variables, the Chi-Square test was calculated, thus selecting the significant indicators for multiple analysis. Subsequently, MCA (DI FRANCO, 2016; NENADIC & GREENACRE, 2005) was performed to evaluate the simultaneous association of the set of clinical signs observed in the study with the patient's outcome in order to characterize the different profiles. MCA was performed with FactoMineR and factoextra R packages (ALBOUKADEL & FABIAN, 2017; LÊ et al., 2008). To enable the MCA, the quantitative variables were categorized into two groups: HR ≤ 48 or >48 ; CRT ≤ 2 or >2 ; and hematocrit <40 or ≥ 40 (SOUTHWOOD, 2013). Qualitative variables followed the description as follows: absent/mild, moderate or severe pain; absent or present gastric reflux; normal or altered mucous; and absent or present motility. These factors were considered active variables in the analysis. The lactate variable entered in MCA analysis as a supplementary variable because it has an elevate number of no responses.

Initially, the data set is transformed into an indicator matrix with individuals in rows and

categories placed in columns. Then, the method of singular decomposition of values is applied to obtain the eigenvalues and eigenvectors. These quantities inform the variability captured by each new orthogonal axis, called inertia, and the coordinates of the objects that will be displayed in the correspondence graph (HUSSON & JOSSE, 2014).

Variables, categories, and individuals are represented as a cloud of points arranged in a plane delimited by increasing variability axes. The position of the categories on the plane represents the association of each with the axes, so there will be more discrimination in greater category distances concerning the graph origin. The proximity between individuals means they have similar profiles related to the study variables.

RESULTS

Data were available from 70 adult horses that underwent abdominal pain. From that, twelve were excluded due to lack of information, leaving 58 that were used in the study, among them 24% (14) died while 76% (44) were discharged after hospitalization. The predominant gender was stallion (41%), followed by female (31%) and geldings (28%). The middle weight was 431 (± 43.9 sd) and almost the totality was breed crioulo 76% (44), reflecting the veterinary clinic geographic location. The other breeds included: Brazilian Sport Horse (8%), American trotter (5%), Arabian horse (3%) and Mangalarga, Thoroughbred, American Quarter Horse, no defined breed with 2% each. The surgical colic cases included 36 animals (61%) and the clinic cases 23 horses (39%), with several different conditions. All variables included were described in the table 1.

Non-survivor animals showed different conditions when compared to discharged animals. Among the non-survivor cases, there were more frequent events of gastric reflux, altered mucous, lack of motility, and higher levels of HR, CRT, hematocrits, and lactate. The outcome was not statistically associated with the demographics of the animals. In the same way, the duration of the signals also did not show significant differences. The clinical and clinicopathologic parameter without distinction between animals are the RR and total protein, respectively (Table 1).

After analyzing the association between the outcome and the investigated variables, MCA was performed to assess how variables are related to creating different outcome profiles. In MCA, seven animals without complete data for all significative

variables for the outcome were excluded, thus 51 animals participated in this analysis. In addition, lactate was not included as an active variable in MCA, as this presented a percentage of 20% of missing information. However, this variable enters as a supplementary variable in MCA.

The first axis obtained by MCA presented inertia of 0.3757, while the second axis accounted for 0.1799, it corresponds to an explained variance of 33.4% and 16%, respectively, with a total of 49.4% of data variability. In this sense, there is better discrimination of individuals with variables more related to the first axis (Figure 1). The MCA identified the most prevalent clinical signs for each outcome, as shown in figure 2. The first dimension divided the plane into two regions: one on the left, formed mostly by cases of discharge (survivors), and the other, on the right, with a concentration of non-survivors cases.

Analysis of the position categories in the reduced space indicates different profiles for each outcome. Non-survivors cases are distinguished by severe pain, lack of motility, mucosal alteration, CRT greater than 2sec, HR greater than 48bpm, hematocrits equal to or greater than 40%, and presence of reflux. Typically discharge cases exhibit motility, normal mucous, CRT of 2sec. or less, hematocrits less than 40%, and HR equal to or less than 48 bpm. The manifestation of pain in discharge cases was mild or moderate, or even non-existent.

Lactate levels above 2.5 mmol/L were frequently found in animals that non-survive, while animals with lower levels were located in the discharge category region. For the animals that it was not possible to collect this information, it is noted that there was no more defined position concerning the outcome. The measurement of SAA, performed on blood samples upon arrival of the animal at the hospital, did not show positive results and, therefore, cannot be included in the statistical analysis. The same occurred with fibrinogen, which, due to equipment breakage, was performed on a few animals and did not allow for analysis.

The correspondence graph also reveals that there is not a complete separation between cases of non-survivors and survivors in terms of clinical signs investigated. It is possible to note the presence of discharge cases close to the characteristics that predominated in non-survivors. These cases can be analyzed from the point of view of moderate pain. Although they were discharged, they were cases that showed gastric reflux and changes in cardiac function, hematocrit, and lactate.

Table 1 - Initial data analysis to define the P value and choose the parameters to be used in the multiple correspondence analysis. It is possible to observe the variables (observed parameters), level (classification in groups), overall (total of animals in each group), death (number of equine who non-survive), discharge (number of animal who survive) and P value.

| Variable | Level | ----Overall---- | -----Death----- | ---Discharge--- | -----P value----- |
|--------------------------------|------------------|-----------------|-----------------|-----------------|-------------------|
| | | 58 | 14 | 44 | |
| sex (%) | Female | 18 (31.0) | 3 (21.4) | 15 (34.1) | 0.385 |
| | Geldings | 16 (27.6) | 3 (21.4) | 13 (29.5) | |
| | Stallion | 24 (41.4) | 8 (57.1) | 16 (36.4) | |
| breed (%) | Crioulo | 44 (75.9) | 11 (78.6) | 33 (75.0) | 1.000 |
| | Others | 14 (24.1) | 3 (21.4) | 11 (25.0) | |
| travel time | median | 100.00 | 95.00 | 100.00 | 0.837 |
| weight | Median | 400.00 | 400.00 | 400.00 | 0.983 |
| pain (%) | Absent/mild | 17 (30.4) | 2 (15.4) | 15 (34.9) | 0.022 |
| | Moderate | 25 (44.6) | 4 (30.8) | 21 (48.8) | |
| | Severe | 14 (25.0) | 7 (53.8) | 7 (16.3) | |
| | Absent | 11 (19.3) | 7 (50.0) | 4 (9.3) | |
| gastrointestinal motility (%) | Diminished | 38 (66.7) | 7 (50.0) | 31 (72.1) | 0.002 |
| | Normal/increased | 8 (14.0) | 0 (0.0) | 8 (18.6) | |
| nasogastric reflux (%) | Absent | 38 (66.7) | 5 (35.7) | 33 (76.7) | 0.012 |
| | Present | 19 (33.3) | 9 (64.3) | 10 (23.3) | |
| mucous (%) | Altered/aded | 13 (23.2) | 7 (53.8) | 6 (14.0) | 0.009 |
| | Normal | 43 (76.8) | 6 (46.2) | 37 (86.0) | |
| duration of clinical signs (%) | <=12h | 30 (53.6) | 9 (64.3) | 21 (50.0) | 0.536 |
| | >12h | 26 (46.4) | 5 (35.7) | 21 (50.0) | |
| blood lactate | median | 2.50 | 3.85 | 2.40 | 0.032 |
| CRT | median | 2.00 | 3.00 | 2.00 | 0.001 |
| HR | median | 52.00 | 88.00 | 52.00 | <0.001 |
| RR | median | 26.00 | 34.00 | 24.00 | 0.097 |
| rectal temperature | median | 38.00 | 37.40 | 38.00 | 0.238 |
| hematocrit | median | 40.20 | 50.30 | 36.70 | <0.001 |
| total protein | median | 7.10 | 8.00 | 7.00 | 0.147 |

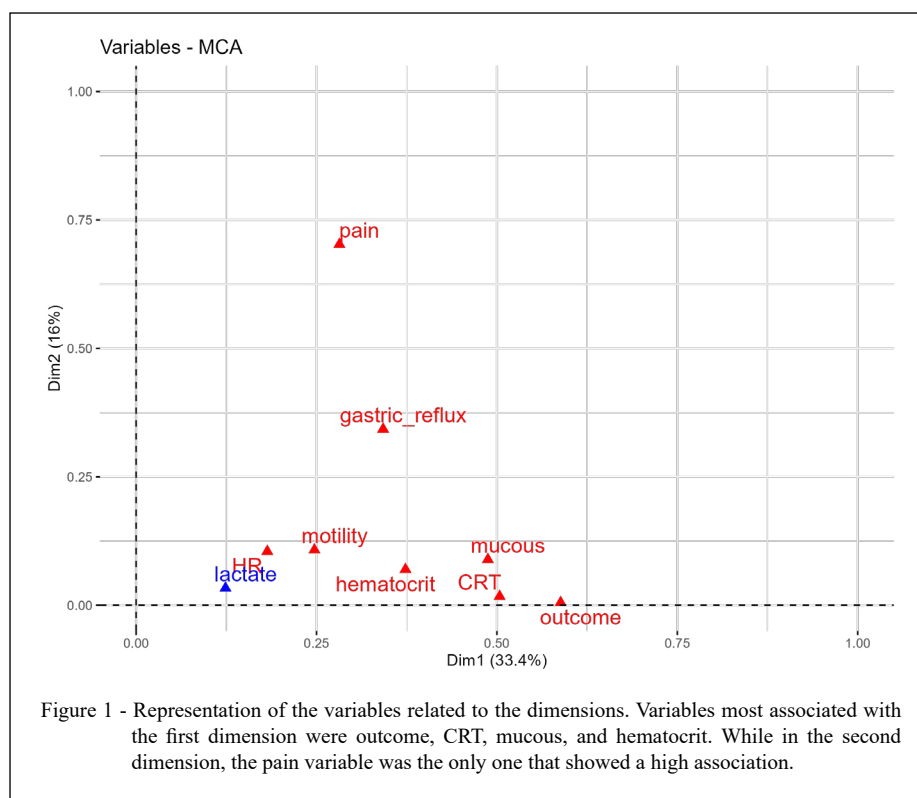
DISCUSSION

Our results indicated that a couple of admission variables can be used to be associated with a poorer prognosis in equine acute abdomen and even predict an outcome. Statistically significant variables to predict the non-survived cases included: hematocrit/PCV (≥ 40), CRT (> 2), altered mucous color, level of pain (severe), gastrointestinal motility (absent), HR (> 48 bpm) and presence of gastric reflux (Figure 2). Several studies have reported different variables in the preoperative, intraoperative and post-operative periods, which can be used as a risk factor for non-survival (FRAIWAN & ABUTARBUSH, 2020; HACKETT et al., 2015; JOHNSTON et al., 2007; KELLEHER et al., 2013; PROUDMAN et al., 2002; VAN DER LINDEN et al., 2003).

The cardiovascular compromise has been reported to be a valuable referral in cases of increased

risk of dead, probably resulting from endotoxaemia (FREEMAN et al., 2000; MORTON & BLIKSLAGER, 2002; PASCOE et al., 1983; PROUDMAN et al., 2002). Some important variables are the mucous color, CRT, heart rate and hematocrit all statistically significant in the present study. Like these findings, packed cell volume (PCV) and increase heart rate (> 48 bpm) at presentation were associated with poor prognosis using multivariable models in surgical colic cases (PROUDMAN et al., 2006). The same results were observed in horses with large colon volvulus, were preoperatively increased heart rate (> 68 bpm) and PCV are associated with not surviving to anesthetic recovery or hospital discharge (KELLEHER et al., 2013).

Confirming the importance of cardiovascular parameters in determining prognosis, a study have demonstrated the association of CRT to death in horse colic. This research used standardized regression coefficients indicating that



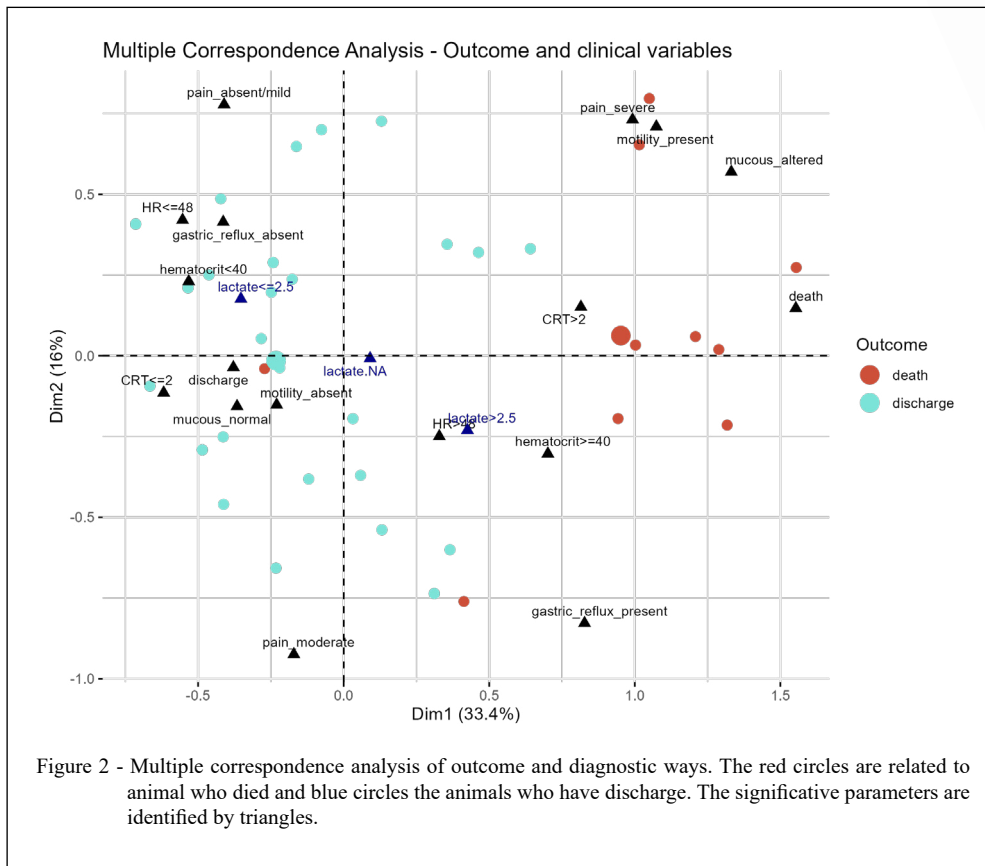
heart rate, PCV and CRT were of approximate equal importance in the model and CRT have the strongest predictor of cardiovascular function (REEVES et al., 1989). Another multivariate model using 357 cases concluded that degree of pain, PCV, CRT and rectal temperature deviation from 38 °C were significantly related to outcome in horse abdominal pain. Besides that, CRT plays a critical role in the multivariate model (THOEFNER et al., 2000), similar to the findings of the present study, with the exception of rectal temperature, which was not significant.

All these studies proved the importance of the findings. A study carried out in Germany showed a significant difference between animals that non-survive and values related to: heart rate, hematocrit and duration of clinical signs (PUOTUNEN-REINERT, 1986), which differs from the present study only in relation to the duration of clinical signs, which did not prove to be significant.

Regarding parameters related to the gastrointestinal tract, it was possible to observe a correlation with the absence of motility and the presence of gastric reflux among the most severe cases of colic in the study population. Only STRATICÒ (2022) showed significant relation between presence of gastric reflux and outcome. Although the amount of gastric reflux

was not investigated, when this was found, it was significantly more represented in non-discharged horses both in the whole population and in those patients that were surgically treated (STRATICÒ et al., 2022). The same has been observed in the present study. Another work doesn't find significant importance in the presence of reflux in colic cases (FARRELL et al., 2021). These results demonstrated the insufficient information about valuable reference parameters who have strong clinical importance in the equine acute abdomen evaluation. Another study elucidated clinical variables (duration of colic signs, heart rate, intestinal sounds, skin tenting, level of pain, and appearance of peritoneal fluid) seemed to predominate as significant predictors of survival, besides diagnostic methods improved (VAN DER LINDEN et al., 2003).

Our results demonstrated an association between blood lactate levels above 2.5 mmol/L and non-survive outcome. Hyperlactatemia has been repeatedly associated with a poor prognosis (BISHOP et al., 2022; JOHNSTON et al., 2007; MOORE et al., 1976; TASCHETTO et al., 2023). A study observed that median blood lactate concentration for non-surviving horses at hospitalization time reached 3.8 mmol/L while the survivors reached 2.9 mmol/L (TASCHETTO et al., 2023). Besides that,



horses with $>360^\circ$ volvulus of the ascending colon, presented statistically significant different means between surviving and non-surviving horses, with 2.98 mmol/L (+/- 2.53 mmol/L) and 9.48 mmol/L (+/- 5.22 mmol/L), respectively. Furthermore, no horse with a lactate concentration above 10.6 mmol/L survived (JOHNSTON et al., 2007). The study design and horse population were different in the presented works, so we identify some different values, however, all these reinforce the lactate importance in colic cases.

Equine presenting hematocrit/PCV $>40\%$ non-survived in this study. Selected physical and laboratory findings in 29 horses with acute abdominal crisis were evaluated retrospectively with a logistic regression equation to predict survival or death. Of 17 variables examined, 2 had good predictive correlation. Serum lactate and packed cell volume had a combined predictive value of 94%. Packed cell volume mean values of 43 and 50%, respectively, differentiated survival from death (ORSINI, 1988).

These data can also be used to develop a predictive statistical model for practical application, helping clinicians in the decision and referral of each case, as a work developed in Jordania. Medical records

of 285 horses presented with signs of abdominal discomfort (colic) was used and information collecting regarding the data of age, sex, breed, referral case or not, duration of clinical signs, heart rate, the presence of nasogastric reflux, transrectal examination findings, type of analgesia used, diagnosis, hospitalization days, and the outcome. After these, the data was set in the machine and the programming was standardized to learning algorithms. The machine was able to predict the need for surgery and survivability in the horses with acute abdomen (colic) with 76% and 85% accuracy, respectively (FRAIWAN & ABUTARBUSH, 2020). Besides that, a colic severity score (CSS) for predicting the outcome of equine colic have been already developed in United states, the variables used included pulse rate (beats/min), peritoneal total protein (g/dL), lactate blood concentration (mg/dL), mucous membrane appearance/CRT. Each of the four variables received an assigned value who here added to give the CSS. Survival is predicted if the score is ≤ 7 whereas horses with a score ≥ 8 are predicted to die (FURR et al., 1995).

The differences reported between the studies may be related to the different breeds, breeding systems and climate in the country. The

limitation of the present study is related to the number of cases included, not all horses had a complete data set, resulting in smaller data sets for some variables; collections continue to be carried out for further analysis.

CONCLUSION

The cardiovascular parameters, including heart rate, mucosal color and capillary refill time, were the variables with the greatest contribution to discriminate animals that non-survive from those that were discharged. The pain level was an important factor able to distinguish individuals, being that moderate pain can serve as an alert for the risk of death. Related to complementary exams, lactate levels evidence extremely useful to identify the patient outcome. These results reinforced the importance of a detailed clinical evaluation, and these data can be evaluated to help establish the prognosis and be able to provide a perspective to the horse owner.

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DECLARATION OF CONFLICT OF INTEREST

We have no conflict of interest to declare.

AUTHORS' CONTRIBUTIONS

Gabriela D. Pradella: conceptualization, data curation, formal analysis; funding acquisition; investigation; methodology; project administration; resources; visualization; writing - original draft; and Writing - review & editing. Natália L. B. Dutra: investigation; methodology; project administration. Natalie R. Martins: investigation; methodology; project administration. Adriana Andrade: data curation, formal analysis; investigation; methodology; project administration; visualization; writing - review & editing. Wagner Tassinari: data curation, formal analysis; investigation; methodology; project administration; visualization. Irina Lübeck: conceptualization, data curation, formal analysis; funding acquisition; investigation; methodology; project administration; resources; visualization; writing - review & editing. Claudia A. Duarte: conceptualization, data curation, formal analysis; funding acquisition; investigation; methodology; project administration; resources; visualization; writing - review & editing.

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