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Original Research

Peritoneal Fluid Lactate Evaluation in Horses With Nonstrangulating Versus Strangulating Small Intestinal Disease

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ABSTRACT

The purpose of this retrospective study was to report the peritoneal fluid lactate (PFL) levels in horses diagnosed with nonstrangulating small intestinal (NSSI) lesions and to compare those values to horses diagnosed with strangulating small intestinal (SSI) lesions. Medical records between 2005 and 2016 were reviewed. Subject details, presenting clinical findings, and disease category (strangulating/NSSI lesion) were obtained. Comparison of SSI lesions to NSSI lesions revealed no significant difference in PFL values. However, horses with SSI lesions had significantly higher peritoneal fluid lactate:blood lactate ratios and were more likely to have serosanguinous peritoneal fluid color than those with NSSI lesions.

1. Introduction

Duodenitis-proximal jejunitis (DPJ) (also referred to as anterior enteritis or proximal enteritis) is characterized by abdominal pain, nasogastric reflux, small intestinal ileus, and inflammation of the duodenum and jejunum [1,2]. Clinical findings of this disease and other nonstrangulating small intestinal (NSSI) lesions (ileal impactions, ileal hypertrophy, intramural masses) can be indistinguishable from those of horses presenting with strangulating small intestinal (SSI) lesions.

Peritoneal fluid lactate (PFL) values have been used as biomarkers of ischemic bowel injury in horses with colic [3] and can be useful in determining strangulating versus nonstrangulating lesions [3–5]. Peritoneal fluid lactate in normal horses is typically <2.0 mmol/L [3–6]. Horses with strangulating obstructions (of the small or large intestine) are reported to have higher PFL values (8.45 mmol/L) compared to those with nonstrangulating obstructions (2.09 mmol/L) [3]. Horses with NSSI lesions such as DPJ may have peritoneal fluid that has an elevated total protein without a concurrent increase in nucleated cell count and is yellow or cloudy in color but rarely serosanguinous [2,7,8]. To the author's knowledge, PFL levels in horses with DPJ or other NSSI lesions have not been specifically reported in the literature.

The aim of this study is to report the PFL and BL levels in horses diagnosed with NSSI lesions and to compare those values to horses diagnosed with SSI lesions. It has been our clinical impression that horses with NSSI can have PFL values that are as high or higher than horses with SSI. We hypothesize there would be no difference in PFL levels

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between horses with NSSI lesions and horses with SSI lesions and that PFL alone is not predictive of strangulation.

2. Materials and Methods

2.1. Inclusion Criteria and Case Selection

Medical records of horses admitted to Michigan State University College of Veterinary Medicine between 2005 and 2016 were reviewed. Two groups of cases were obtained. Group 1 included horses with NSSI lesions that had an abdominocentesis performed on admission. Non-strangulating small intestinal cases were searched with keywords including: DPJ, anterior enteritis, proximal enteritis, enteritis, enterocolitis, duodenitis, or jejunitis. Horses were considered to have a NSSI lesion if DPJ (anterior enteritis, proximal enteritis, or similar terminology) was the single diagnosis from exploratory surgery or necropsy or if the following criteria were met: (1) multiple loops of dilated small intestine were noted on rectal palpation or on transabdominal ultrasound; (2) >4L net reflux was obtained upon nasogastric intubation at admission, and nasogastric reflux was persistent for >24 hours, or no net reflux was obtained at admission, but nasogastric reflux was persistent for >24 hours; and (3) the horse responded to medical management. Horses from group 1 were excluded if they had primary clinical signs of diarrhea or if PFL was not recorded.

Group 2 included horses with SSI disease that had an abdominocentesis performed on admission and had a SSI lesion diagnosed during exploratory celiotomy. Group 2 included horses with strangulating small intestine that required a resection and horses with strangulating small intestine that did not require a resection. Strangulating small intestinal cases were searched with keywords including: strangulating lipoma, gastrosplenic entrapment, epiploic foramen entrapment, small intestinal volvulus, or intussusception. Cases were excluded from group 2 if PFL was not recorded.

2.2. Subject Details

Details obtained from the medical records included: age, gender, transabdominal ultrasound findings, rectal examination findings, net nasogastric reflux on admission, first 24 hours net nasogastric reflux, blood lactate (BL), PFL, peritoneal fluid total protein, and gross description of the color of the peritoneal fluid. The peritoneal fluid color was categorized as either serosanguinous (including the description orange) or normal (including descriptions such as clear or yellow). An automated analyzer (Stat Profile Critical Care Ultra, Nova Biomedical Corp, Waltham, MA) or hand-held portable analyzer (Lactate Pro, Arkray, KDK, Japan) was used to measure BL on whole blood samples and PFL values on noncentrifuged peritoneal fluid samples.

2.3. Statistical Analysis

Data retrieved was entered into Excel (Microsoft Corp, Redmond, WA). Data management and statistical analyses were conducted using Stata 14.2 (Stata Corp, College Station, TX). The association between the dichotomous outcome and individual variables of interest was analyzed using logistic regression analysis. The magnitude of these associations was expressed as the odds ratio (OR), and the *P*-value for testing the null hypothesis that OR was equal to 1 (equal odds of SSI as compared to NSSI for a given variable) was reported. Approximate normal distribution of a continuous variable was assessed by visual inspection of a histogram and tested using the Shapiro–Wilks test. If a continuous variable was not normally distributed, various transformations to obtain normality were explored. An important assumption for logistic regression is that the model is linear in the logit for continuous variables [9]. To assess this assumption for continuous variables, the variable was divided into four categories with similar number of observations per category, and the linearity of a graph with the logit plotted as a function of the midpoint of the four categories of the continuous variable was evaluated [9]. If a continuous variable did not meet this assumption, the difference in the distribution of a variable between SSI and NSSI was determined using the nonparametric Wilcoxon Rank-sum test. Some continuous variables were dichotomized based on findings of exploratory data analysis.

3. Results

Of the cases admitted between 2005 and 2016, 39 horses met our inclusion criteria for NSSI lesions. Eighteen horses with NSSI lesions were diagnosed definitively: 15 at surgery and 3 at necropsy. Twenty-one horses were diagnosed presumptively with a NSSI lesion based on clinical signs and response to medical management; 35/39 horses with NSSI lesions had small intestinal distension on transabdominal ultrasound, 16/39 also had small intestinal distension on rectal palpation, and 4 horses had neither of those findings, but diagnosis of DPJ was made at surgery or necropsy. Of the medically managed NSSI cases, 18/21 horses had >4L of nasogastric reflux on admission and continued to have persistent reflux for >24 hours, and 3/21 horses did not have net reflux on admission but produced net reflux persistently for >24 hours. Sixty-one horses met our inclusion criteria for SSI lesions, 11 did not require a resection, and 50 required a resection. The specific SSI lesions included: 36 strangulating lipoma, 7 epiploic foramen entrapment, 8 gastrosplenic entrapment, 5 omental strangulation, 1 mesenteric rent, 2 volvulus, and 2 intussusception.

The association between continuous variables (Table 1) and dichotomous variables (Table 2) were evaluated. No continuous variables fulfilled the assumption for inclusion in logistic regression models, and hence, they were dichotomized for this purpose. Peritoneal fluid lactate at admission was not associated with SSI lesions, whether considered a continuous variable ($P = .100$, Table 1) or as a dichotomous variable (<4.0 or ≥4.0 mmol/L; $P = .397$, Table 2). Blood lactate at admission was not associated with SSI lesions, whether considered a continuous variable ($P = .220$, Table 1) or as a dichotomous variable (<2.4 or ≥2.4 mmol/L; $P = .153$, Table 2). A PFL:BL ratio ≥2.0 was associated with being in the SSI group, whether considered a continuous variable ($P < .001$, Table 1) or as a dichotomous