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Research article

A retrospective analysis of the data of blood lactate concentrations and composite pain scores in Thai native crossbred ponies and full-sized horses underwent colic surgery

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Abstract

Blood lactate (BL) represents the performance of oxygen delivery and tissue perfusion either in a normal condition or gastrointestinal colic. Horses with colic express a different level of pain that relates to the severity of colic, which can be evaluated by composite pain scale scoring system (CPS). BL and CPS are widely studied in colic cases for decades, in attempt to instantly make an accurate diagnosis and optimal treatment plan. This study aimed to assess CPS and BL concentrations in colic horses. Medical records of horses presenting gastrointestinal colic at Kasetsart University Veterinary Teaching Hospital between 2013-2016 were reviewed retrospectively. Forty-four out of 214 colic cases met the inclusion criteria. The samples were divided into Thai native crossbred ponies (n=22) and full-sized horses (n=22). Median value of CPS between the horses (26.0 ± 6.5 scores) and the ponies (25.5 ± 7.3 scores) were not significantly different, neither the treatment outcome or the location and type of lesion. On the contrary, BL concentrations in the ponies (Median ± IQR = 8.5 ± 5.5 mmol/L) was significantly higher than the horses (Median ± IQR = 5.2 ± 3.0 mmol/L). In full-sized horses, BL concentrations showed no significant difference between treatment outcome or the location and type of lesion. Interestingly, BL concentrations in the ponies with the conditions of ischemia, small intestinal lesions and post-treatment death were significantly high. In conclusion, BL concentrations and CPS are useful indicators for treatment selection in Thai native crossbred ponies with colic. Surgical correction must be strongly considered when BL concentration is >8.5 mmol/L and CPS is >26.

Keywords: Blood lactate, Colic, Composite pain scores, Thai native crossbred ponies, Surgery

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INTRODUCTION

Clinical signs as the consequences of intestinal injuries that are caused by obstruction, strangulation, enteritis, and peritonitis originate from several gastrointestinal problems. Diagnosis the cause of abdominal pain based on clinical signs in the horse requires a well-founded understanding of anatomy and pathophysiological events, which take place during the acute abdominal crisis. In the cases of intestinal distension, perfusion alterations, bacterial invasion, third-space fluid accumulation and inflammatory mediator release, all of which create both local and systemic cellular dysfunctions that result in tissue hypoxia which leads to anaerobic glycolysis and increases in lactate concentrations. However, in the event of normal oxygen delivery, level of lactate can be increasing as a secondary effect of reduced clearance due to liver dysfunction or poor tissue oxygen uptake related to cellular dysfunction that caused by sepsis or inflammation (Tennent-Brown, 2011). Lactate measurement has been validated for horses by point-of-care monitor (Tennent-Brown et al., 2007). Monitoring the level of lactate is an uncomplicated procedure and it can be performed with plasma, peritoneal fluid and whole blood. In the past 10 years, utilization of lactate related to outcome of colic has been studied and in particular blood lactate (BL) was the one promising parameter that was more favorable than any others (Tennent-Brown, 2011; Yamout et al., 2011; Peloso and Cohen, 2012; Dunkel et al., 2013; Henderson 2013 and Apichaimongkonkun et al., 2016).

In 2008, Bussieres and coworker developed the composite pain scale (CPS) to evaluate pain in orthopedic cases by establishing scores from 0-3 for 13 parameters based on the horse's physiology, stimuli responses, and behavior expressions when experiencing pain. While score zero means no pain, score 39 means the highest pain. The CPS system was used by Van Loon and his colleague (2010) for evaluation of somatic pain originated from physical problems such as musculoskeletal injury and visceral pain due to the malfunction or inflammation of organs. Moreover, the CPS system has high specificity and accuracy for evaluation of visceral pain after gastrointestinal surgery (Van Loon et al., 2014).

Early and accurate diagnosis that leads to a referral and surgery without delay is critical. This prevents postoperative complications and death, as well as reduces the cost of treatment. Improvement of diagnostic procedures will be continuing to achieve these goals. The aim of this study was to analyze CPS and BL concentration in surgical colic cases retrospectively in Thai native crossbred ponies and horses in order to establish an optimal treatment guideline for colic cases in horses.

MATERIAL and METHODS

The medical records of colic horses admitted at Kasetsart University Veterinary teaching hospital during 2013 and 2016 were retrospectively reviewed. Data was collected includes sex, breed, age, causes of colic, treatment outcomes, CPS (prior to surgical operation) (Bussieres et al., 2008), BL con-

centrations (the last value prior to surgical operation in case of series measurement), and vital signs as follows: heart rate; respiratory rate; and body temperature. For the causes of colic, the data was categorized by the location and the type of lesion. Locations of lesion were grouped into the large intestine and the small intestine. Types of lesion were divided to be ischemic lesions such as intestinal torsion or small intestine inflammation, and non-ischemic lesions such as intestinal impaction, foreign body obstruction, intestinal displacement, or other non-inflammation lesion. The treatment outcomes were marked as survival or non-survival.

Blood lactate assessments had been performed in colic cases and the values were recorded in the individual medical report. The procedure of BL measurement is described here. Briefly, whole-blood was collected by jugular venipuncture and then subjected to determination of lactate concentration using Roche Accutrend® (Roche Diagnostics Corporation, USA).The report range is 0.8 – 22 mmol/L (Roche Diagnostics Corporation, USA).

Statistical analysis

Data were analyzed by using NCSS statistical program (NCSS version 2007; NCSS statistical software, East Kaysville, Utah, USA). Evaluation of normal distribution of the data was conducted via Mann Whitney U test and Spearman's rank correlation coefficient to perform statistical comparison with skewness. Analyzing the data with 2-sample t-test and simple linear correlation. Statistical outcomes were reported as mean ± standard deviation for data with normal distribution and median ± interquartile range (IQR) for data with skewness. The level of significance was set at 0.05.

RESULTS

Between January 2013 and December 2016, the number of colic horses that were presented at the Kasetsart University Veterinary Teaching Hospital was 214 in total. The major cause of colic was gastric impaction, large intestinal obstruction and small intestinal torsion respectively. Some cases were intra-operative euthanized due to a poor prognosis as a result of extensive non-viable intestine, intestinal perforation, diaphragmatic hernia, and cardiovascular collapsed. The ratio of colic cases that were euthanized in the primary evaluation was 6.1% (13/214), which divided into 2.8% (6/214) for the cause of the owner unable to afford any treatments and 3.3% (7/214) for the cause of grave prognosis. The ratios were calculated from the number of horses that were discharged. The information of the causes of colic, types of treatment and the treatment outcomes of every case were elucidated in Table 1.

Table 1 Causes of colic, treatment and outcome of all horses admitted during 2013 and 2016 at the Kasetsart University Veterinary Teaching Hospital, shown as number of horses (percentage).

Diagnosis	N	None, Non-survivor	Medical		Surgical		Exploratory, Non-survivor
			Medical, Survivor	Medical, Non-survivor	Surgical, Survivor	Surgical, Non-survivor	
Gastric impaction	70 (32.7%)	2 (2.9%)	67 (95.7%)	0	0	0	1 (1.4%)
Small intestinal obstruction	9 (4.2%)	0	1 (11.1%)	0	6 (66.7%)	1 (11.1%)	1 (11.1%)
Small intestinal torsion	15 (7.0%)	1 (6.7%)	0	0	6 (40.0%)	3 (20.0%)	5 (33.3%)
Small intestinal intussusception	1 (0.5%)	0	0	0	0	0	1 (100%)
Small intestinal ileus	4 (1.9%)	0	2 (50%)	0	1 (25%)	1 (25%)	0
Small intestinal perforation	2 (0.9%)	1 (50%)	0	0	0	1 (50%)	0
Endotoxemia	4 (1.9%)	0	2 (50%)	1 (25%)	0	1 (25%)	0
Enteritis and colitis	2 (0.9%)	0	2 (100%)	0	0	0	0
Large intestinal obstruction	62 (28.8%)	1 (1.5%)	36 (58.1%)	0	21 (33.9%)	4 (6.5%)	0
Large intestinal torsion	9 (4.2%)	0	0	1 (11.1%)	3 (33.3%)	1 (11.1%)	4 (44.5%)
Large intestinal displacement	7 (3.3%)	2 (28.6%)	0	0	5 (71.4%)	0	0
Large intestinal perforation	2 (0.9%)	0	0	0	0	2 (100%)	0
Abscess at large intestine	1 (0.5%)	0	0	0	0	0	1 (100%)
Peritonitis	3 (1.4%)	0	0	2 (66.7%)	0	0	1 (33.3%)
Others	19 (9.0%)	2 (10.5%)	13 (68.5%)	0	0	2 (10.5%)	2 (10.5%)
Undiagnosed	4 (0.9%)	4 (100%)	0	0	0	0	0
Total	214 (100%)	13 (6.1%)	123 (57.5%)	4 (1.8%)	42 (19.6%)	16 (7.5%)	16 (7.5%)

Forty-four colic horses that had been subjected to the surgical treatment received a complete record of BL measurements and CPS evaluations. In a group of horses included 16 Thoroughbreds, 3 Warmbloods , 2 Quarter Horse , and 1 Gypsy Vanner, the average age was 5.1 ± 3.4 years (ranged from 6 months – 10 years) and the ratios of male and female were 1:2.6. In a group of Thai native crossbred ponies, the average age was 4.9 ± 4.6 years (ranged from 8 months – 20 years) and included 63.6% of male, 27.3% of female and 9.1% of neutered males. Ages were not significantly different between the full-sized horses and the Thai native crossbred ponies ($p = 0.44$). Vital signs, which included heart rate, respiratory rate, and body temperature, were not significantly different between full-sized horses and Thai native crossbred ponies. The causes of colic in all horses that underwent the colic surgery were elaborated in Table 2. The percentage of the cases can be summarized according to the lesion site as follows: 24/44 horses (54.5%) with large intestine location; 19/44 horses (43%) with small intestine location; and 1/44 horse (2.5%) with peritonitis.

Table 2 Causes of colic in full-sized horses and Thai native crossbred underwent colic surgery shown as number of horses (percentage).

Diagnosis	Thai native crossbred ponies (n=22)	Full-sized Horses (n=22)	Total (n=44)
Small intestinal obstruction	1 (4.5%)	5 (22.7%)	6 (13.6%)
Small intestinal torsion	7 (31.9%)	5 (22.7%)	12 (27.3%)
Small intestinal intussusception	0	1 (4.5%)	1 (2.3%)
Large intestinal obstruction	9 (40.9%)	6 (27.3%)	15 (34.1%)
Large intestinal torsion	1 (4.5%)	3 (13.8%)	4 (9.1%)
Large intestinal displacement	2 (9.2%)	0	2 (4.5%)
Large intestinal perforation	1 (4.5%)	1 (4.5%)	2 (4.5%)
Abscess at large intestine	1 (4.5%)	0	1 (2.3%)
Peritonitis	0	1 (4.5%)	1 (2.3%)

BL concentrations and CPS evaluations of Thai native crossbred ponies and full-sized horses that underwent colic surgery were shown in Table 3. From the total surgical cases, Thai native crossbred ponies had BL concentration value with a median (minimum – maximum values) of 8.5 ± 5.5 mmol/L (3.6 – 17.3 mmol/L), which is significantly higher ($p < 0.05$) than that of full-sized horses with a median (minimum – maximum values) of 5.2 ± 3.0 mmol/L (2.6 - 21 mmol/L). In the case of small intestinal lesion and ischemic lesion, BL concentrations of Thai native crossbred ponies were significantly higher than that of full-sized horses ($p < 0.05$), while no differences were found between these two groups when the lesions were non-ischemic or found at large intestine. When compared the locations and the types of lesion within a group of Thai native crossbred ponies, the cases with lesion at the small intestine or having ischemic lesions showed a significantly higher of BL concentration than those with lesions at the large intestine or having non-ischemic lesions. Ponies that survived after the surgical treatment had a significantly lower lactate concentration than the non-survived cases of ponies ($p < 0.01$). On the contrary, BL concentrations in a group of full-sized horses were not significantly different regardless of the locations of lesion, types of lesion, and outcome of surgical treatment.

Table 3 Blood lactate concentration and composite pain scale scoring system in full-sized horses and Thai native crossbred underwent colic surgery.

Diagnosis	Thai ponies		n	Horses		n
	BL (mmol/L)	CPS (scores)		BL (mmol/L)	CPS (scores)	
All admission	8.5 ± 5.5[i]	25.5 ± 7.3	22	5.2 ± 3.0 [ii]	26.0 ± 6.5	22
Location of lesion						
Small intestine	10.1± 4.0 [i,a]	28.5 ± 7.0	8	5.3 ± 4.0 [ii]	24.5 ± 7.8	12
Large intestine	5.2 ± 4.7[b]	24.5 ± 6.0	14	5.2 ± 2.0	26.5 ± 2.8	10
Type of lesion						
Non-ischemia	4.9 ± 3.8[a]	23.5 ± 5.8	12	4.5 ± 2.0	24.0 ± 5.5	11
Ischemia	10.9 ± 3.9 [i,b]	28.5 ± 4.5	10	6.3 ± 4.2 [ii]	28.0 ± 4.5	11
Outcome						
Survivor	5.2 ± 4.7[a]	23.5 ± 7.8	14	4.6 ± 2.9	26.0 ± 5.5	15
Non-survivor	10.9 ± 3.9[b]	27.5 ± 4.3	8	6.5 ± 4.8	30.0 ± 6.0	7

[i,ii] Showed significant difference between Thai native crossbred ponies and full-sized horses ($p < 0.05$)
[a,b] Showed significant difference between each cause in Thai native crossbred ponies ($p < 0.05$)
BL= blood lactate, CPS=composite pain scale scoring system

For the CPS evaluations, a significant difference between horses and Thai native ponies were not found ($p = 0.55$). When comparing the causes of colic, types of lesion, and treatment outcome, there was also no statistical difference in the CPS values. However, the statistical comparisons of CPS values were made for each type of colic causations within the groups and between the group of horse and ponies.

Pearson correlation coefficient demonstrated a moderate correlation between CPS and BL concentrations of Thai native crossbred ponies with $r = 0.44$ ($p < 0.05$). This indicates that the increasing of BL concentrations can be related to the elevation of pain. Although, the correlation test between CPS and BL concentration showed no significant difference in full-sized horses ($p = 0.31$).

DISCUSSION

Gastrointestinal colic causes the morbidity and mortality in a relatively high ratio in horses. Horses with colic were the majority cases of inner patient department of the Kasetsart University Veterinary Teaching Hospital. From this study, mortality rate of colic patient in medical case was lower than that of the surgical case, this indicates that most of colic cases are successfully treated with medical management. Additionally, the survival rate of surgical treatment (42/58, 72.4%) and medical treatment (123/127, 96.9%) were comparable with the previous studies (Tinker et al., 1997; van der Linden et al., 2003; Latson et al., 2005; Abutarbush et.al.,2005; Delesalle et al., 2007; Yamout et al., 2011; Peloso and Cohen, 2012 and Krueger et. al.,2014.). Even though the overall survival rate of colic case in our hand seems to be satisfied (77.1%), gastrointestinal colic was the number one cause of death. Prompt and accurate decision for treatment of choice is mandatory.

In the present study, impaction of ingesta in stomach and large intestine is the consequence of an improper feeding management such as bulk feeding without portioning, improper type of food, and compromised quality of food. Obstruction in stomach or large intestine with foreign body is likely caused by the neglect of animal husbandry when foreign materials such as ropes, plastic bags, wires, or pebbles are left in a horse's residential area. From the result of this study, the proportion of surgical cases when the lesion was located in large intestine (54.5%) relatively close to the ratio of small intestinal lesion (43%), which disagrees with the report from Krueger et al. (2014) when the lesion has been mainly found at large intestine (77.6%) and only 22.4% of lesion has occured in small intestine. From the total of 44 surgical cases of colic patient, the three major conditions have been found including large intestinal obstruction 34.1% (15/44), small intestinal torsion 27.3% (12/44) and small intestinal obstruction 13.6% (6/44). The conditions found in our surgical cases are different from the study of Abutarbush et al. (2005) when the majority cases of surgical correction has been reported as follows: large colon displacement (24.5%), large colon torsion (14.3%), and strangulating lipoma (13.5%) were the most common sequentially.

This study was conducted to compare BL concentrations between full-sized horses and Thai native crossbred ponies both of which are the major horse populations in Thailand. BL concentrations in Thai native crossbred ponies with surgery case were significantly higher than horses. This correlate with the study of Dunkel et al. (2013) who demonstrated the differences of BL concentrations between breeds in the horses with gastrointestinal colic. Ponies are more sensitive to catecholamine synthesized secondary to stress than horses, which influences the glucose metabolism by increasing glycolysis in peripheral tissue like muscle (Dunkel et al., 2013). There was no significant difference of lactate concentrations when the comparisons were made among the location of lesion, type of lesion, and treatment outcome in the group of full-size horses. On the contrary, Thai native crossbred ponies with particular conditions such as having ischemic lesions, presenting the lesions at small intestine, or died after the surgery had a significantly higher BL concentrations than the ponies that are devoid of those two conditions or survive after the surgery. We speculate that the differences of BL concentrations in a group of Thai native crossbred ponies were found because of the majority of colic condition was small intestinal torsion, and this results in ischemia and tissue hypoxia more severe than that of the large intestine lesions or intestinal obstruction (Freeman, 2002; Tennent-Brown, 2011; Yamout et al., 2011; Dunkel et al., 2013; Henderson, 2013). Thus, BL concentrations is one of the crucial parameter used for diagnosis and evaluation of the severity of colic in order to selects an optimal treatment protocol and prognosticates the outcome in Thai native crossbred ponies with gastrointestinal colic.

Another significant source of BL producing is striated muscle in the event of musculoskeletal problem. For this retrospective investigation, the information of the degree of musculoskeletal stress in each patient is lacking, in which, muscle pain can be involved or non-involved with the colic-concerned trauma. In a routine treatment protocol for colic, horse is periodically forced to walk or do a light cantering to stimulate gut movement. This type of exercise

can be defined as a low speed exercise. In a previous study of anaerobic metabolism in Thai native crossbred ponies that performed a high-speed exercise, blood lactate clearance required approximately 71 minutes to lower the BL concentration from maximum level after exercise (8 mmol/L) to a normal base line (1.8 mmol/L) (Thawornpattanapong et al., 2016). Therefore, the effect of muscle-producing BL would be lessening within an hour, moreover, low speed exercise during colic treatment would unlikely induce muscular damage and increase BL concentration. Giving credence to the notion that data of blood lactate concentration in this study is mostly originated from the gastrointestinal-related source.

As consequences of gastrointestinal colic, increasing of BL concentrations and muscle enzyme activity can be detected due to tissue hypoxia and inflammation. Krueger et al.(2014) found that increasing of pre-operative plasma CK and AST activity was significantly associated with the presence of intestinal ischemia and also positively correlated with mortality rate. Nevertheless, the specific types of CK isoenzyme including MM, MB, BB that can be used to indicate the source of CK producing were not identified separately in their study (Krueger et al., 2014). In our study, absent of a history of recent musculoskeletal injuries and no obvious self-inflicted trauma during the gastrointestinal pain episode relatively determined that increasing of muscle enzyme activity have likely been contributed by the injuries of gastrointestinal system. BL concentrations can be used to evaluate the severity of colic even though the increasing in pre-operative plasma CK and AST activity, low amount of visible trauma associated with acute gastrointestinal pain and no previous history of muscular lameness are found.

Evaluation of clinical parameters in horse presenting with colic is an important tool to conduct the diagnosis, set up a treatment plan, and give the most precise prognosis. Clinical variables such as level of pain, heart rate, gastrointestinal borborygmi and indicators of hypovolemia are considered as essential indicators of the initial assessment at the primary veterinary examination, and could be marked as a triage when confront the horses presenting with colic (Curtis et. al., 2015). Moreover, duration of colic signs, intestinal motility, skin tenting, and gross appearance of peritoneal fluid have been shown to be significantly associated with survival rate in colic cases (Van der Linden et al., 2003). In the present study, pre-operative parameters such as heart rate and respiratory rate were remarkably high, however, body temperature was within normal range. Thus, clinical variables appeared to be a good predictor for the outcome of gastrointestinal colic.

Gastrointestinal pain in colic horses is categorized as visceral pain, large intestine and small intestine were referred as the organs that cause the highest pain in colic (Roberson and Sanchez, 2010). Horse responses to colic pain by express the behavior of kicking or biting belly assuming to relieve the pain, however, this behavior is neither specific to the area causing the pain nor the level of pain. The Composite Pain Scales (CPS) scoring system is an accurate tool that is suitable for differentiating the visceral pain from somatic pain due to its high specificity (Van Loon et al., 2014).

Bussieres et al.(2008) developed a CPS scoring system that was applied to the present study. Utilization of this CPS scoring system is broadly applica-

ble despite the differences between breeds, location of lesion, type of lesion, and treatment outcome. Additionally, a previous research has demonstrated the irrelevant between pain scores and the location of lesion or breed of horse (Van Loon et al., 2014). In this study, the median value of CPS of Thai native crossbred ponies (25.5±7.3) and full-sized horses (26.0±6.5) that have been subjected to colic surgery is concordant with the finding from Apichaimongkonkun et al.(2016).

The simple linear correlation test showed a positive correlation between CPS and BL concentrations. Therefore, elevating of CPS gives us an anticipation that the BL concentration is raising. In conclusion, BL concentrations can be used to assess the condition of colic in Thai native crossbred ponies along with the CPS, in order to decide the treatment options and evaluate the treatment outcomes. We recommend to consider the surgical treatment as a strong choice in case of Thai native crossbred ponies that the BL concentrations is higher than 8.5 mmol/L and CPS is higher than 26 scores.

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