Retrospective Study

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Clinical and biochemical abnormalities in endurance horses eliminated from competition for medical complications and requiring emergency medical treatment: 30 cases (2005–2006)

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Abstract

Objective – To describe the clinical and clinicopathologic abnormalities in endurance horses eliminated from competition and requiring emergency medical treatment.
Design – Retrospective study over a 2-year period (2005–2006). Ten horses that successfully completed the ride in 2006 were included for comparison.
Setting – Temporary equine emergency field hospital.
Animals – All horses ($n = 30$) that were removed from endurance competition and treated for a metabolic abnormality were studied.
Interventions – Horses were treated with IV fluids and analgesics. Monitoring included lab work (PCV, total protein, and electrolytes) and serial physical examinations. Statistical analysis included descriptive statistics and parametric and nonparametric comparisons (ANOVA, Friedman's test, and Kruskal-Wallis) where appropriate.
Measurements and Main Results – The clinical diagnoses identified included colic, esophageal obstruction, poor cardiovascular recovery, myopathy, and synchronous diaphragmatic flutter. As a group, these sick horses had lower plasma chloride and potassium and higher total plasma protein concentrations as compared with 10 healthy horses that successfully completed the ride ($P < 0.05$, < 0.01, and < 0.05 for chloride, potassium, and total protein, respectively). Horses with colic had a lower PCV as compared with horses with poor recovery and those with synchronous diaphragmatic flutter ($P < 0.05$). All horses, including colics, were treated medically and discharged to owners.
Conclusions – Based on the results of this study, the prognosis for horses requiring emergency veterinary treatment after being removed from endurance competition (for metabolic reasons) appears to be good if horses are withdrawn from competition under the same criteria outlined in this study. Biochemical abnormalities tend to be mild and do not necessarily aid in delineating sick horses from successfully completing horses. None of the horses with gastrointestinal disease required abdominal surgery.

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Introduction

Emergency veterinary treatment is often required for endurance horses that have been removed from competition for metabolic derangements. These horses can often be referred to equine hospitals, but more severe or acute cases may require stabilization on the racecourse itself. There is very little published research to guide the diagnosis and management of these emergency cases.

Endurance horses have been reported to develop a variety of physical and biochemical changes, such as tachycardia and plasma electrolyte changes (such as decreases in sodium, chloride, potassium, and calcium concentrations) during normal competition.[1–5] Competing horses are serially examined throughout the ride by veterinarians, and are removed from competition if they are deemed unfit to continue. Horses are commonly dis-

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qualified under the categories of lameness or metabolic.[6] The metabolic category includes poor cardiopulmonary recovery under the given limits for the specific ride (often a heart rate <60–68/min within 30 min of entering the checkpoint). It may also include horses with synchronous diaphragmatic flutter or exertional myopathy.[2,4]

The available endurance horse research in the peer-reviewed literature primarily focuses on the electrolyte and physical examination parameters related to finishing times or completion rates.[5,7] Decreases in plasma sodium, potassium, chloride, and calcium concentrations have been described at the end of the ride as compared with pre-ride values.[5,7,8] The reported electrolyte alterations in eliminated horses have been mild; however, the majority of studies have not specifically evaluated horses with metabolic conditions requiring emergency veterinary intervention. One study found relatively more severe hypokalemia in horses treated for heat exhaustion during an endurance ride.[2] However, the practice of electrolyte administration by owners has significantly changed since that time and may affect the biochemical derangements currently identified on rides.

There is little published information available on the types of metabolic or medical problems affecting endurance horses. In addition, little is known about the distances where these problems are most likely to occur.[6] Most studies have included only small numbers of horses, and it has therefore been difficult to characterize specific laboratory or physical examination variables for medical conditions affecting endurance horses. A more comprehensive retrospective study describing the conditions and outcome of horses currently treated at endurance rides is needed.

The purpose of this study was to describe the physical examination findings and biochemical profiles of horses disqualified from endurance competition for reasons categorized as metabolic elimination by ride veterinarians. These clinical values were compared with those from 10 healthy horses that successfully completed the same 160 km competition in 2006. The outcome of these eliminated horses is also described.

Materials and Methods

Inclusion criteria for this retrospective study included participation in the Western States 100 mile (160 km) Endurance Ride in the years 2005 and 2006 and failure to complete the ride due to metabolic or medical reasons. In addition, horses had to be presented to the treatment veterinarians. Horses eliminated only for orthopedic or traumatic reasons were excluded.

Each horse had an initial physical examination by the treatment veterinarian and subsequent examinations performed by a veterinarian or veterinary assistant under the supervision of a veterinarian. Examinations included recording of heart and respiratory rate, digital rectal temperature (reference interval: 37.2–38.1°C [99.0–100.5°F]), auscultable gastrointestinal sounds (borborygmi scored as absent, decreased, or present), mucous membrane color (scored as pale or pink), and capillary refill time (scored from 1 to 3 s). Horses were evaluated and treated at 3 major checkpoints including the 58-, 111-, and 160-km ride points, which were the sites for the majority of eliminations. Horses could also be removed from the ride at additional checkpoints and transported to 1 of these 3 major treatment locations.

Blood samples were collected from the jugular vein of horses at presentation to the treatment veterinarian, and again after each 10 L isotonic IV fluid bolus. Samples were collected into commercial evacuated tubes containing potassium EDTA and sodium heparin. Lactate was measured on whole blood using a hand-held analyzer.[a] PVC was estimated using the microhematocrit method and total protein (TP) concentration was measured using refractometry. Plasma electrolyte concentrations were measured using a commercial chemistry analyzers[b] on horses evaluated in the year 2006 only. Blood was also collected from 10 control horses successfully completing the ride in 2006 as part of another study (unpublished data) after obtaining client consent. The control horses had been voluntarily included in the study by their owners.

Statistical analysis

Data are presented as mean ± SD. Descriptive statistics were calculated for the sick horses on presentation for all clinical pathology data, physical examination variables, and presenting complaints. Data that were normally distributed as determined by the Kolmogorov-Smirnov method were analyzed with parametric tests; those not normally distributed were compared with nonparametric tests. Admission values for lactate, PCV, TP, and electrolytes (electrolytes were collected during 2006 only) were compared with 10 healthy horses that successfully completed the 2006 ride using the values from the preride, 58-, 111-, and 160-km checkpoints using ANOVA with a post-comparison Tukey's test. Vital signs and clinical pathology data and the distances at which horses were eliminated for the various medical conditions were compared using a nonparametric ANOVA (Kruskal-Wallis test) with Dunn's post-comparison test. A nonparametric ANOVA (Friedman's test) with Dunn's post-comparison test was used to compare lactate, PCV, and TP throughout fluid administration. Level of statistical significance was set at $P < 0.05$.

Results

A total of 30 horses met the inclusion criteria for the study. As a point of reference, in the 2005 ride year, 199

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Table 1: Age, breed, sex, and racing mileage for elimination and control horses in 2006

Horses	Age (y) Mean (range)	Sex	Breed	Previous miles raced (miles) Mean (range)
Eliminated from ride	9.5 (7.3–21.4)	65% Geldings 12% Stallions	77% Arabian 3% Half-Arabian 3% Mustang 17% Not listed	700 (0–3950)
Control	12.9 (6.1–16.6)	80% Geldings	100% Arabian	915 (500–1700)

horses began the ride and 85 completed. In the 2006 ride year, 194 horses began the ride and 87 completed. Table 1 shows the demographic characteristics of the horses included in the study in 2006 as well as the control horses from 2006. Demographic data from the 2005 ride were not available.

The presenting complaints, elimination location within the ride, heart rate, and rectal temperature of horses removed from competition for metabolic or medical problems are shown in Table 2. The most common reason for elimination was colic, followed by poor cardiovascular (heart rate) recovery, and suspected myopathy.

Mucous membrane color at presentation was evaluated as pale in 5 of 12 (42%) horses with colic, in 1 of 3 (33%) horses with synchronous diaphragmatic flutter, in 0 of 7 (0%) horses with poor recovery, and 3 of 7 (43%) horses with myopathy. Auscultable gastrointestinal sounds were absent or decreased at presentation in 8 of 12 (75%) horses with colic, 3 of 3 (100%) horses with synchronous diaphragmatic flutter, 3 of 7 (43%) horses with poor recovery, and in 6 of 7 (86%) horses with myopathy. Capillary refill time was ≥ 2 seconds at presentation in 5 of 12 (42%) of horses with colic, 1 of 3 (33%) of horses with synchronous diaphragmatic flutter, 4 of 7 (57%) of horses with poor recovery, and in 3 of 7 (43%) of horses with myopathy.

The laboratory findings of the eliminated horses are shown in Table 3. Horses with a poor heart rate recovery and those with synchronous diaphragmatic flutter had a higher PCV than those presented with signs of colic ($P < 0.05$).

The presenting (admission to the treatment center) electrolyte, lactate, PCV, and TP values of the 2006 eliminated/treated horses ($n = 18$) were compared with those obtained at various time points for 10 healthy horses that completed the ride in the same year (Table 4). Plasma potassium, chloride, and TP concentrations were different between the eliminated horses and the healthy horses at 1 or more time points during the ride (lower potassium and chloride, and higher TP in eliminated animals). There were some additional differences between the healthy horse pre-ride values and the healthy horse values at different time points along the ride (Table 4); namely, sodium, chloride, and bicarbonate concentrations decreased and PCV and TP concentration increased in these control horses during the ride. TP concentration later decreased.

Lactate concentration, PCV, and TP values were monitored after every 10 L of administered isotonic crystalloids (Table 5). The PCV and TP concentrations both exhibited a decrease from prefluid to all subsequent time points as expected ($P < 0.001$). There was no significant difference in blood lactate concentrations between any of these time points.

There were no deaths in the 30 horses evaluated during the 2-year period. None of the horses exhibiting

Table 2: Reason for elimination and elimination location of horses treated for metabolic problems at the 2005 and 2006 Western States Competitive Trail Ride (Tevis Cup)

		Mean ± SD			
Condition	Number of horses (% of cases)	Elimination location (km from the start)	Heart rate (beats/min)	Temperature (°C)	Temperature (°F)
Colic	12 (40)	91.7 ± 30.9	54 ± 11	37.4 ± 0.4	99.4 ± 0.7
Poor recovery	7 (23)	83.4 ± 33.4	60 ± 11	37.8 ± 0.7	100.0 ± 1.3
Myopathy	7 (23)	57.6 ± 0	62 ± 13	37.7 ± 0.5	99.9 ± 0.9
Synchronous diaphragmatic flutter	3 (10)	57.6 ± 0	60 ± 8	37.9 ± 0.2	100.1 ± 0.3
Choke	1 (3)	100	64	37.8	100
All horses	30	79.7 ± 29.0	58 ± 11	37.6 ± 0.5	99.7 ± 0.9

Table 3: Lactate, PCV, and total protein values for horses eliminated from competition for metabolic causes in the 2005 and 2006 competitions

	Mean ± SD			
Condition (number)	**Lactate (mmol/L)**	**PCV (%)**	**TP (g/L)**	**TP (g/dL)**
Colic (12)	2.2 ± 0.5	38.7 ± 3*	70 ± 7**	7.0 ± 0.7**
Poor recovery (7)	2.1 ± 0.7	47 ± 7.4*	84 ± 14**	8.4 ± 1.4**
Synchronous diaphragmatic flutter (3)	2.5 ± 0.4	45 ± 1	79 ± 8	7.9 ± 0.8
Presumed myopathy (7)	2.7 ± 0.6	43.6 ± 4.9	75 ± 12	7.5 ± 1.2
Choke (1)	2.4	49	82	8.2
All sick horses at elimination (30)	2.3 ± 0.6	42.9 ± 5.5	76 ± 11	7.6 ± 1.1

*Significantly different ($P < 0.05$).
**Significantly different ($P < 0.05$).
TP, total protein.

signs of colic required exploratory abdominal surgery. Only 1 of the 30 horses was referred to a local hospital for continued treatment and this was due to its late presentation and closing of the race grounds. Four of the horses with colic had reflux from a nasogastric tube that exceeded 2 L. None of the horses with colic continued refluxing beyond 6–8 hours of starting IV fluid therapy.

Discussion

In this study there were only minor differences in the laboratory values between horses that were eliminated and those that successfully completed the competition. Given the small magnitude of these differences, the clinical significance is questionable. As in our study, potassium concentration has been reported previously to be lower in endurance horses with metabolic conditions; however, it is unclear whether hypokalemia plays a role in the metabolic failure, or whether it is a sequellae.[2] The slightly decreased chloride concentration in sick horses may reflect increase sweating and losses from the extracellular fluid compartment. The increase in TP concentration in sick horses is likely due to dehydration and hypovolemia, but it is difficult to determine whether this abnormality existed before the development of clinical signs or as a result of the metabolic derangement. For example, a horse with myopathy may be less likely to drink water due to discomfort and may have body fluid compartment shifts. In addition, successfully completing horses also had a similar magnitude of increase in TP concentration from pre-ride to the 58-km checkpoint, further supporting dehydration as the cause of the increase.

Metabolic alkalosis has been described previously in other studies.[2] This was not observed in the horses of our study, in fact the plasma bicarbonate concentration decreased in the successfully completing horses over time ($P = 0.003$). This discrepancy may be due to changes in oral electrolyte supplementation by owners over the period of time elapsed between previous studies and this one. This difference in acid-base status between studies warrants further investigation, especially in light of the importance of electrolyte, fluid and acid-base derangements in the pathophysiology of the metabolic conditions observed.

Previous studies have reported only mild increases in lactate concentrations in healthy horses during endurance exercise, but much higher values have been

Table 4: Comparison of electrolytes, lactate, PCV, and total protein between sick horses at presentation to the veterinary treatment station in 2006 and healthy, finishing horses in the 2006 ride (data presented as mean ± SD)

Group	Na^+ (mmol/L)	K^+ (mmol/L)	Cl^- (mmol/L)	HCO_3^- (mmol/L)	Lactate (mmol/L)	PCV (%)	TP (g/L)	TP (g/dL)
2006 sick horses ($n = 18$)	144.8 ± 4.2	3.1 ± 0.5^{c}	101.4 ± 3.5^{d}	26.8 ± 3.2	2.2 ± 0.5	41.2 ± 4.4	72 ± 7^{j,m}	7.2 ± 0.7^{j,m}
2006 healthy horses pre-ride ($n = 10$)	148.1 ± 1.8^{a}	3.6 ± 0.3	106 ± 1.5^{d,n}	29.1 ± 1.1^{e,f}	2.0 ± 0.6	36.4 ± 3.8^{g,h,i}	65 ± 4^{m,o}	6.5 ± 0.4^{m,o}
2006 healthy horses at 58 km ($n = 10$)	147.7 ± 1.8^{b}	3.4 ± 0.5	105.2 ± 2.1	24.1 ± 2.7^{e}	2.2 ± 0.6	45.2 ± 5.3^{g}	72 ± 6^{k,o}	7.2 ± 0.6^{k,o}
2006 healthy horses at 111 km ($n = 10$)	144.2 ± 3.3	3.7 ± 0.5^{c}	102.1 ± 3.8	25.7 ± 3.0	2.2 ± 0.8	43.6 ± 3.9^{h}	66 ± 6	6.6 ± 0.6
2006 healthy horses at 160 km ($n = 10$)	143.4 ± 3.3^{a,b}	3.5 ± 0.3	101.4 ± 5.2^{n}	25.2 ± 3.0^{f}	2.5 ± 0.7	43.2 ± 4.1^{i}	64 ± 3^{j,k}	6.4 ± 0.3^{j,k}

Same letter superscript within columns denotes a significant difference (g, $P < 0.001$; c, e, $P < 0.01$; a, b, d, f, h, i, j, m, n, o, $P < 0.05$).
TP, total protein.

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Table 5: PCV, total protein, and blood lactate concentrations during isotonic crystalloid fluid administration

Parameter	Admission	10 L	20 L	30 L
PCV (%)	$42.7 \pm 5.5^{a,b,c}$	36.1 ± 4.8^{a}	32.6 ± 3.9^{b}	30.7 ± 4.0^{c}
TP (g/L)	$75 \pm 10^{d,e,f}$	63 ± 8^{d}	57 ± 4^{e}	53 ± 7^{f}
Total protein (g/dL)	$7.5 \pm 1.0^{d,e,f}$	6.3 ± 0.8^{d}	5.7 ± 0.4^{e}	5.3 ± 0.7^{f}
Lactate (mmol/L)	2.3 ± 0.6	2.0 ± 0.6	2.2 ± 0.7	2.3 ± 0.4

Superscript letters: admission values are different from all other time points ($P < 0.05$).
TP, total protein.

measured during higher intensity exercise.[7,9] This is an expected response, as endurance competition is largely aerobic exercise. To the authors' knowledge, lactate values have not been described in endurance horses eliminated from competition for metabolic causes. The lactate concentrations in the sick horses of this study were mildly increased above reference intervals (<2 mmol/L) and were lower than those observed in horses with colic in other reports.[10] Furthermore, the lactate concentrations were not different between eliminated horses and those successfully completing the race. In fact, no horse had a lactate value >4.0 mmol/L. This value of 4.0 mmol/L is a common cut-off point used to identify critically ill human patients with severe hemodynamic compromise.[11] Based on this finding, further research is needed to determine what role hypovolemia or hypotension plays in the disease processes observed in these horses. The lack of significant hyperlactatemia in the sick horses suggests that the cause for elimination may have been due to reasons other than marked hypoperfusion. Severe hypovolemia may have been prevented by the elimination criteria of the ride.

Serial changes in lactate concentrations in response to fluid therapy have been used to aid in prognosis and evaluation of response to treatment in human patients.[12] There was very little change in lactate values in the horses treated in this study. In fact, most of the clinical signs resolved while lactate values remained mildly increased as compared with preride values. There are other potential causes of increased blood lactate concentrations that have been described, including an increase in oxygen demand (exercise), systemic inflammation, catecholamines, thiamine deficiency, and liver disease.[13] It is possible that hypovolemia may not be the cause for these mild increases in blood lactate in eliminated endurance horses with metabolic conditions.

A number of the horses in this study were presented with severe signs of colic that were often difficult to control with xylazine, butorphanol, and flunixin meglumine. Despite the severity of signs, none of the horses required surgical intervention. Only 1 horse had an abdominal ultrasonographic examination performed that identified distended and nonmotile small intestine with a normal wall thickness. These changes are consistent with exercise-induced ileus.

A limitation of this study was that we were unable to obtain information about electrolyte administration during the ride. It is not possible to determine whether the mild electrolyte derangements seen in these horses were related to administration of supplements by riders or due to the underlying disease process. However, veterinarians must often make treatment decisions for endurance horses without knowing this information. Another disadvantage of the study is the small numbers of horses in some of the groups, making the ability to detect real differences very difficult.

Subjective physical examination parameters reported in this study, including gastrointestinal motility and mucous membrane color, must be interpreted with caution as the exams were performed by several different veterinarians. The exams were not blinded and therefore examiners may have been biased by the presenting complaint. For example, a horse that was presented with signs of colic may have been more likely to be identified with decreased gut sounds. The small group sizes make comparison between groups difficult.

In conclusion, this study provides an evaluation of endurance horses with a variety of disorders that are classified as *metabolic* or *medical* during endurance completion. Colic, suspected myopathies, poor heart rate recovery, and synchronous diaphragmatic flutter are the common conditions affecting these animals. Based on the data available from this study performed at this ride, the hematologic and biochemical changes are often mild with most of these disorders; finding more severe changes in a case would therefore warrant careful attention for additional or more severe problems. Prospective studies would be helpful to determine efficacy of specific treatments, such as fluid therapy, for the various conditions affecting these horses.

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Footnotes

[a] Accutrend Lactate Analyzer, Roche Diagnostics, Indianapolis, IN.
[b] IDEXX VetStat, IDEXX Laboratories Inc, Westbrook, ME.

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