

## Blood gas analysis, anion gap, and strong ion difference in horses treated with polyethylene glycol balanced solution (PEG 3350) or enteral and parenteral electrolyte solutions

Hemogasometria, anion gap e diferença de íons fortes em equinos tratados com solução balanceada contendo polietilenoglicol (PEG 3350) ou soluções eletrolíticas enteral e parenteral

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### ABSTRACT

Large volumes of different electrolytes solutions are commonly used for ingesta hydration in horses with large colon impaction, but little is known about their consequences to blood acid-base balance. To evaluate the effects of PEG 3350 or enteral and parenteral electrolyte solutions on the blood gas analysis, anion gap and strong ion difference, five adult female horses were used in a 5x5 latin square design. The animals were divided in five groups and distributed to each of the following treatments: NaCl (0.9% sodium chloride solution); EES (enteral electrolyte solution), EES+LR (EES plus lactated Ringer's solution); PEG (balanced solution with PEG 3350) and PEG+LR (PEG plus lactated Ringer's solution). Treatments PEG or PEG + LR did not change or promoted minimal changes, while the EES caused a slight decrease in pH, but its association with lactated Ringer's solution induced increase in AG and SID values, as well as caused hypernatremia. In turn, the treatment NaCl generated metabolic acidosis. PEG 3350 did not alter the acid-base balance. Despite its slight acidifying effect, the enteral electrolyte solution (EES) did not cause clinically relevant changes.

**Key words:** Acid-base balance, cathartic, fluid therapy.

### RESUMO

Grandes volumes de diferentes soluções eletrolíticas são comumente usados na hidratação da ingesta em equinos com compactação, mas pouco se sabe sobre suas consequências sobre o equilíbrio ácido base sanguíneo. Para avaliar os efeitos do PEG 3350 e soluções eletrolíticas enterais e parenterais sobre a hemogasometria, anion gap e diferença de íons fortes, foram utilizadas cinco fêmeas adultas em um quadrado latino 5x5. Os animais foram distribuídos em cinco grupos e submetidos a cada um dos seguintes tratamentos: solução NaCl (cloreto de sódio 0,9%); EES (solução eletrolítica enteral); EES + RL (solução eletrolítica enteral mais Ringer lactato); PEG 3350 (solução

balanceada com PEG 3350) e PEG + RL (PEG 3350 mais Ringer lactato). Os tratamentos PEG ou PEG + RL não alteraram ou promoveram alterações mínimas, enquanto a EES ocasionou discreta diminuição no pH, mas sua associação com Ringer lactato induziu o aumento nos valores do AG e DIF, além de ocasionar hipernatremia. Por sua vez, o tratamento NaCl resultou em acidose metabólica hiperclorêmica. O PEG 3350 não alterou o equilíbrio ácido base. Apesar do seu discreto efeito acidificante, a solução eletrolítica enteral (EES) não promoveu alteração clínica relevante.

**Palavras-chave:** Equilíbrio ácido base, catártico, hidratação.

### INTRODUCTION

Large intestine impaction is one of the most frequent causes of colic in horse (DABAREINER & WHITE, 1995; RIBEIRO FILHO et al., 2012). Traditionally, treatment has been based on the administration of large volume of intravenous electrolyte solution in order to promote hydration of ingesta and faeces. Among the solutions for parenteral use in horses, lactated Ringer's and 0.9% sodium chloride are probably the most common solutions used worldwide. Lactated Ringer's solution (LR) has a polyionic composition similar to plasma, and is therefore commonly administered for general use (ROSE, 1981). LR has a slight alkalinizing effect in blood, which has already been described in horses (RIBEIRO FILHO et al., 2007) and dogs (RIBEIRO FILHO et al., 2008). On the other hand, the 0.9%

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sodium chloride solution can lead to hyperchloremic metabolic acidosis and has been indicated to most animals suffering from dehydration associated with sodium and chloride loss (ROSE, 1981; MATHEWS, 1998).

More recently, enteral electrolyte solution (EES) therapy has gained popularity as a direct and effective way to promote hydration of the ingesta (LOPES et al., 2002; RIBEIRO FILHO et al., 2012). Enteral fluids are also quickly absorbed through intestine and expand blood volume, rehydrate the tissues and correct electrolyte imbalances (RIBEIRO FILHO et al., 2007). Another advantage is the possibility of the enteral solution to be formulated as needed by the patient, as well as its low cost. Despite its advantages, the enteral technique might also cause electrolyte and acid-base imbalances, depending on its composition (RIBEIRO FILHO et al., 2009).

Laxatives are substances that increase defecation frequency, fecal bulk, or alter the fecal consistency (CLARK & BECHT, 1987), and can also be used to treat large intestine impactions. Polyethylene glycol (PEG 3350) is an effective osmotic laxative used in humans (CLEVELAND et al., 2001). It has a high molecular weight, does not suffer tissue or bacterial degradation, and acts as a pure osmotic agent, being released quantitatively in the colon (SCHILLER, 1999). In Brazil, was launched recently the Munvilax<sup>R</sup>, a laxative of polyethylene glycol 3350. In commercially available products for laxative use, PEG 3350 is combined with balanced amounts of sodium bicarbonate, sodium chloride and potassium in such way that the exchange of water and electrolytes with the blood is minimal (ATTAR et al., 1999), reducing the risk of dehydration that can occur with other osmotic laxatives. To our knowledge, there are currently no studies evaluating the use of this substance in veterinary medicine, with the exception of an experiment using cats (TAM et al., 2011). The aim of this study was to evaluate the effects of a standard PEG 3350 solution compared with other electrolyte solutions given by intravenous and enteral routes, on the acid-base balance, anion gap and strong ion difference.

## MATERIAL AND METHODS

Five female crossbred horses aged between five and nineteen years (mean = 12.5 years), with good body condition  $392 \pm 18\text{kg}$  (mean  $\pm$  sd) were used. Mares had no history of intestinal disease in the last six months and were considered healthy based on physical examination, blood biochemistry and cell counts, and urinalysis. Ten days prior to the study, horses were dewormed (Ivermectin + Praziquantel<sup>a</sup>,

PO) and received a deltamethrin spray bath (0.025%) for ticks and flies control. During all the research period horses were kept in individual stalls and were fed with commercial concentrated<sup>b</sup> (1% of bwt daily, divided into two meals), Tifton 85 hay (2% of bwt daily, two meals), 50g/day of a minerals mixture<sup>c</sup> and water “*ad libitum*”. During the treatment period horses were fasted (T0h to T12h).

Each mare was submitted to 5 different treatments in a 5x5 Latin square design, considering the effects period, treatment and time with the animal effect being random. The treatments were as follow: NaCl – received 0.9% sodium chloride solution<sup>d</sup> administered intravenously in a dose of  $15\text{mL kg}^{-1} \text{h}^{-1}$  for 12 hours under continuous flux. Osmolarity and pH of the solution:  $309.80\text{mMol L}^{-1}$  and 5.60, respectively. EES – received enteral electrolyte solution containing 6g NaCl; 0.5g KCl; 1g calcium gluconate; 0.3g magnesium pidolate<sup>e</sup>; 5g maltodextrin in 1.000mL of water, via small-caliber nasogastric tube in a dose of  $15\text{mL kg}^{-1} \text{h}^{-1}$  for 12 hours under continuous flux. Osmolarity and pH of the solution:  $321.14\text{mMol L}^{-1}$  and 7.2, respectively. EES+LR – received enteral electrolyte solution (same composition of EES treatment), via small-caliber nasogastric tube in a dose of  $7.5\text{mL kg}^{-1} \text{h}^{-1}$  for 12 hours under continuous flux, plus  $7.5\text{mL kg}^{-1} \text{h}^{-1}$  of lactated Ringer’s solution administered intravenously for 12 hours under continuous flux. PEG – a single dose of PEG 3350<sup>f</sup> ( $1.5\text{g kg}^{-1}$ ) diluted in five liters of water given via nasogastric tube. Osmolarity and pH of the solution:  $252.66\text{mMol L}^{-1}$  and 8.65, respectively. PEG+LR – a single dose of PEG 3350 ( $1.5\text{g kg}^{-1}$ ) diluted in five liters of water, given via nasogastric tube, plus  $15\text{mL kg}^{-1} \text{h}^{-1}$  of lactated Ringer’s solution administered intravenously for 12 hours under continuous flux. Osmolarity and pH of the solution of lactated Ringer’s:  $272.22\text{mMol L}^{-1}$  and 6.75, respectively. The interval between treatment periods was 14 days.

Baseline blood samples for blood gas and biochemical tests were taken immediately before the start of the treatment (T0h) and 6 (T6h), 12 (T12h), 24 (T24h) and 48 (T48h) hours after treatment beginning. For biochemistry analysis, samples were collected aseptically via jugular venipuncture, and stored in vials with sodium fluoride or without anticoagulant<sup>g</sup>. Sodium and potassium serum concentrations were measured using flame photometry<sup>h</sup> while a multi-biochemical analyzer<sup>j</sup> was used to measure serum chloride and plasma L-lactate concentrations.

For blood gas analysis, samples were collected anaerobically via jugular venipuncture

using previously heparinized<sup>k</sup> 3mL disposable plastic syringes and 30x7 needles. A blood gas analyzer<sup>d</sup> was used to obtain the following variables: pH<sub>(v)</sub>, oxygen partial pressure - pO<sub>2(v)</sub>, carbon dioxide partial pressure - pCO<sub>2(v)</sub>, carbon dioxide total concentration - tCO<sub>2(v)</sub>, plasma bicarbonate concentration - cHCO<sub>3(v)</sub> and base excess - BE<sub>(v)</sub>. The strong ion difference (SID) and anion gap (AG) were calculated using the respective formulas: SID (mMol) = (Na<sup>+</sup> + K<sup>+</sup>) - (Cl<sup>-</sup> + lactate<sup>-</sup>); AG (mMol) = (Na<sup>+</sup> + K<sup>+</sup>) - (Cl<sup>-</sup> + HCO<sub>3</sub><sup>-</sup>) (CONSTABLE, 1999).

Data was analyzed using specific statistical software (SAEG UFV-01.09.2007). ANOVA was used to compare the effect of treatments within each time and the effect of times within each treatment. Post-hoc comparisons were made using the Tukey test. The nonparametric Kruskal–Wallis test was used when data did not meet the assumptions of normality or equality of variance. The null hypothesis was rejected when P<0.05.

## RESULTS AND DISCUSSION

Our results showed that therapeutic protocols commonly used for ingesta hydration using intravenous or enteral routes can produce significant changes in the blood acid-base and electrolyte balances in normal horses. On the other hand, the proposed protocol using PEG 3350 solution alone administered in a single dose did not alter any of the studied variables.

An important change in the physiologic balance occurred in NaCl group, where hyperchloremia (Table 1) with a concomitant decrease in blood pH were detected at the end of electrolyte solution administration (T12h). Normal saline (0.9% NaCl solution) has higher levels of chloride compared to plasma (MATHEUS, 1998) and administration of large volumes can cause changes in acid-base balance, i.e. hyperchloremic metabolic acidosis (CONSTABLE, 1999; PROUGH & BIDANI, 1999). Metabolic acidosis is traditionally divided into hyperchloremic (normal anion gap) and normochloremic (high anion gap) based on the anion gap and chloride (DeMORAIS & BIONDO, 2012). Chloride is the most prevalent strong anion in the ECF. At a constant [Na<sup>+</sup>], an increase in [Cl<sup>-</sup>] decreases SID causing hyperchloremic acidosis. The effects of increasing [Cl<sup>-</sup>] without changing [Na<sup>+</sup>] can be understood when considering a fluid with an SID = 0 (e.g., 0.9% NaCl where [Na<sup>+</sup>] = [Cl<sup>-</sup>] and thus SID = [Na<sup>+</sup>] - [Cl<sup>-</sup>] = 0) (CONSTABLE, 2003), producing the occurrence of the acidifying effect of 0.9% NaCl, which can be seen in tables 1 and 2.

The traditional approaches for assessing blood gas analysis also demonstrated by the presence of metabolic acidosis in the animals of NaCl group, ie a decrease in pH, tCO<sub>2</sub>, HCO<sub>3</sub> and base excess values compared with baseline was seen in animals of that group at T12h (Table 1 and 2), which was also coincident with a similar increase in the chloride levels (Table 3). The decrease in the concentration of HCO<sub>3</sub>, and thus in the base excess, occurred due to the compensation mechanism, when there is an increase of the chloride anion, the body increases the excretion of bicarbonate anion. Increases in serum chloride concentrations in horses after the enteral administration of electrolyte solutions were recorded by others (ECKE et al., 1998; ALVES et al., 2005). For other treatments of this research, despite the decrease in pH values, tCO<sub>2</sub>, HCO<sub>3</sub> and base excess did not detect the presence of metabolic acidosis as can be seen in tables 1 and 2.

In T12h, pCO<sub>2</sub> values declined (P<0.05) in treatments EES, compared to T6h, and NaCl, compared to T0h, with the lowest average for animals treated with NaCl (Table 2). According to CARLSON & BRUSS (2008), pCO<sub>2</sub> decreases as a compensatory response of the respiratory component to metabolic acidosis. Therefore, in the same way that EES treatment caused a decrease in pH, tCO<sub>2</sub>, HCO<sub>3</sub> and base excess, it also reduced pCO<sub>2</sub>, which recovered quickly after treatment completion. Emphasizing that despite the decrease, all variables remained within the reference, even in animals of NaCl treatment. In turn, there was no difference between treatments either in treatments over time nor in the values of pO<sub>2</sub>.

When using enteral electrolyte solutions containing carbohydrates as an energy source, there is the possibility of these substances to predispose to the onset of acidosis. This is because sugars and starches undergo bacterial metabolism in the gastrointestinal tract, generating organic acids (ZHANG et al., 2003). Among these acids are the isomers L-lactate and D-lactate (FALL & SZERLIP, 2005). Once absorbed in the digestive tract, the D-lactate metabolism is carried out at a very slow rate (FALL & SZERLIP, 2005), because mammals have little specific mechanisms for metabolizing D-lactate and the accumulation in the blood can cause metabolic acidosis (EWASCHUK et al., 2005). But the results of this experimental study show that the maltodextrin (10g L<sup>-1</sup>) present in treatments ESS and ESS+LR did not cause the appearance of this adverse effect.

As expressed in table 3, the values of lactate remained within the reference (KANEKO et al., 2008) in animals of all treatments, despite the difference detected between treatments at

T6h and T12h and in treatments throughout the experimental phase, making them without clinical significance. The D-lactate was not measured in this study, however its level can be estimate through the anion gap (AG). The AG reference values for horses range from 5 to 16.2 mMol L<sup>-1</sup> (CARLSON & BRUSS, 2008). It is used primarily to identify metabolic acidosis, confirm the mixed disturbances and prognosis (GOSSETT et al., 1987). Higher rates to the reference range indicate metabolic acidosis due to an increase in unmeasured anions, especially the D-lactate, as occurs in lactic acidosis, determining the bicarbonate decrease (DeMORAIS & DiBARTOLA, 1993). As significant changes in the AG values were not detected in the EES group, corroborates the assertion that the maltodextrin

administered at a dose of 10g L<sup>-1</sup> does not cause the onset of metabolic acidosis (Table 1).

The animals receiving EES+RL treatment showed an important increase in sodium concentration at T12h (P<0.05). Hyponatremia is characterized by a value of serum sodium exceeding 147 mEq L<sup>-1</sup> (STEWART, 1998). Although water loss through dehydration is considered the main cause of hyponatremia, it can also be caused by excessive sodium intake through hydration with the electrolyte solutions, such as sodium bicarbonate administered intravenously and also with 0.9% NaCl solution given enterally (BARBOSA & SZTAJNBOK, 1999). The increase of sodium concentration in the EES+LR at T12h (P<0.05) can be attributed to the fact that animals received sodium from three sources:

Table 1 - Means and standard deviations values of  $\text{HCO}_3^-$  (mMol L<sup>-1</sup>), BE (mMol L<sup>-1</sup>), Anion Gap (mMol L<sup>-1</sup>) and SID (mMol L<sup>-1</sup>), in venous blood (v) of five horses treated with PEG, PEG+LR, EES, EES+LR, and NaCl in pretreatment (T0h), treatment (T6h and T12h) and post-treatment (T24h and T48h) periods.

Treatment	Period				
	T0h	T6h	T12h	T24h	T48h
-----HCO <sub>3</sub> <sup>-</sup> -----					
PEG	28.96±1.86 <sup>Aa</sup>	27.28±1.65 <sup>Aa</sup>	26.70±1.21 <sup>Aa</sup>	29.14±1.23 <sup>Aa</sup>	28.36±1.23 <sup>Aa</sup>
PEG+LR	27.66±1.53 <sup>Aab</sup>	26.62±0.33 <sup>Aab</sup>	25.98±1.27 <sup>ABb</sup>	29.30±1.25 <sup>Aa</sup>	27.96±1.87 <sup>Aab</sup>
EES	28.60±0.82 <sup>Aa</sup>	26.06±2.35 <sup>ABab</sup>	24.88±0.95 <sup>ABb</sup>	26.54±1.33 <sup>Bab</sup>	27.32±1.23 <sup>Aab</sup>
EES+LR	29.26±1.11 <sup>Aa</sup>	25.34±1.76 <sup>ABb</sup>	25.60±1.16 <sup>ABb</sup>	28.24±1.54 <sup>ABab</sup>	28.24±1.89 <sup>Aab</sup>
NaCl	28.52±0.78 <sup>Aab</sup>	22.42±0.80 <sup>Bbc</sup>	21.02±1.66 <sup>Bc</sup>	27.94±0.87 <sup>ABabc</sup>	28.82±1.19 <sup>Aa</sup>
-----BE-----					
PEG	4.10±1.59 <sup>Aa</sup>	2.50±1.45 <sup>Aa</sup>	1.84±0.98 <sup>Aa</sup>	3.92±0.83 <sup>Aa</sup>	2.98±1.24 <sup>Aa</sup>
PEG+LR	3.32±1.34 <sup>Aab</sup>	1.68±0.39 <sup>Ab</sup>	0.82±0.92 <sup>ABb</sup>	4.28±1.04 <sup>Aa</sup>	3.50±1.60 <sup>Aab</sup>
EES	4.10±0.74 <sup>Aa</sup>	-0.14±1.29 <sup>ABb</sup>	-0.52±0.80 <sup>ABb</sup>	1.52±1.13 <sup>Bab</sup>	2.30±1.33 <sup>Aab</sup>
EES+LR	4.52±1.34 <sup>Aa</sup>	0.24±1.72 <sup>ABb</sup>	0.72±2.04 <sup>ABb</sup>	3.46±1.25 <sup>ABab</sup>	3.04±1.04 <sup>Aab</sup>
NaCl	3.46±0.60 <sup>Aab</sup>	-2.64±1.07 <sup>Bbc</sup>	-4.18±2.00 <sup>Bc</sup>	2.90±0.78 <sup>ABabc</sup>	3.72±1.00 <sup>Aa</sup>
-----Anion Gap-----					
PEG	6.64±13.37 <sup>Aa</sup>	17.38±6.95 <sup>Aa</sup>	7.16±14.02 <sup>ABa</sup>	7.94±9.32 <sup>Ba</sup>	10.50±7.26 <sup>ABa</sup>
PEG+LR	5.24±5.19 <sup>Aa</sup>	3.24±24.41 <sup>Aa</sup>	2.08±8.44 <sup>Ba</sup>	-1.58±6.93 <sup>Ba</sup>	4.54±12.34 <sup>Ba</sup>
EES	12.60±5.65 <sup>Aa</sup>	1.38±8.52 <sup>Aa</sup>	5.42±14.49 <sup>Ba</sup>	2.00±7.37 <sup>Ba</sup>	-1.30±7.31 <sup>Ba</sup>
EES+LR	11.18±7.10 <sup>Ab</sup>	16.44±8.48 <sup>Aab</sup>	30.16±14.70 <sup>Aa</sup>	24.76±5.72 <sup>ABab</sup>	22.50±7.83 <sup>Aab</sup>
NaCl	8.94±5.58 <sup>Aa</sup>	8.66±3.28 <sup>Aa</sup>	6.92±8.64 <sup>Ba</sup>	8.56±10.01 <sup>Ba</sup>	12.08±5.02 <sup>ABa</sup>
-----SID-----					
PEG	35.06±12.56 <sup>Aa</sup>	44.09±6.58 <sup>Aa</sup>	35.30±10.62 <sup>Ba</sup>	36.53±9.97 <sup>ABa</sup>	38.29±6.91 <sup>ABa</sup>
PEG+LR	32.34±8.11 <sup>Aa</sup>	29.34±24.33 <sup>Ba</sup>	29.45±5.92 <sup>Ba</sup>	27.15±6.39 <sup>Ba</sup>	31.94±12.33 <sup>Ba</sup>
EES	40.63±5.58 <sup>Aa</sup>	26.80±6.84 <sup>Ba</sup>	29.68±14.31 <sup>Ba</sup>	26.01±6.43 <sup>Ba</sup>	25.44±6.86 <sup>Ba</sup>
EES+LR	39.85±7.97 <sup>Aa</sup>	41.19±8.51 <sup>Aa</sup>	55.15±15.43 <sup>Aa</sup>	52.40±5.33 <sup>Aa</sup>	50.14±8.50 <sup>Aa</sup>
NaCl	36.91±5.19 <sup>Aab</sup>	30.50±3.83 <sup>Bab</sup>	27.33±3.67 <sup>Bb</sup>	35.90±9.64 <sup>ABab</sup>	40.25±5.33 <sup>ABa</sup>

Means in the same column followed by equal capital letters and in the same row followed by equal lowercases letters do not differ at 5% level of probability by Tukey test.

PEG (Polyethylene glycol)

PEG+LR (PEG plus lactated Ringer's solution)

EES (enteral electrolyte solution)

EES+LR (EES plus lactated Ringer's solution)

NaCl (0.9% sodium chloride solution)

the EES with 6g L<sup>-1</sup> of sodium chloride, lactated Ringer's solution containing 6g of sodium chloride and 3g of sodium lactate. The sum of them yielded in sodium concentration of 232.2 mMol L<sup>-1</sup>, which is higher than plasma's (139±3.5 mMol L<sup>-1</sup>), resulting hypernatremia after their administration. As horses had access to water and food after the hydration phase (T24h and T48h), there was a gradual decrease in serum sodium during this time in animals of this group. Other study using isotonic enteral solution also reported hypernatremia due to the use of more than one sodium source (ALVES et al., 2005).

The hypernatremia observed in animals in the EES+RL at T12h was concomitant with the increase in the values of AG and SID (P<0.05) at time 12 hours (Table 1). This increase was caused

by the presence of high serum sodium concentration due to the composition of electrolyte solutions used in such treatment. As the AG and SID were calculated by the equations: AG = (Na<sup>+</sup> + K<sup>+</sup>) - (Cl<sup>-</sup> + HCO<sub>3</sub><sup>-</sup>) and SID = (Na<sup>+</sup> + K<sup>+</sup>) - (Cl<sup>-</sup> + lactate), the increase in the concentration of serum sodium, explained above, determined the elevation of both values. Since the change in AG value was not commensurate with bicarbonate's (Table 1) in the same period (T12h), one should suspect the presence of mixed disorders as quoted CARLSON & BRUSS (2012).

The treatments had no effect on serum potassium values that have remained unchanged throughout the experimental phase and within the reference range (KANEKO et al., 2008).

Although the protocol using PEG 3350 balanced solution (PEG) alone did not alter any of the

Table 2 - Means and standard deviations values of pH, pO<sub>2</sub> (mmHg), pCO<sub>2</sub> (mmHg) and tCO<sub>2</sub> (mMol L<sup>-1</sup>) in venous blood (v) of five horses treated with PEG, PEG+LR, EES, EES+LR, and NaCl in pretreatment (T0h), treatment (T6h and T12h) and post-treatment (24h and T48h) periods.

Treatment	Period				
	T0h	T6h	T12h	T24h	T48h
	pH				
PEG	7.41±0.01 <sup>Aa</sup>	7.42±0.01 <sup>Aa</sup>	7.41±0.01 <sup>Aa</sup>	7.41±0.02 <sup>Aa</sup>	7.40±0.03 <sup>Aa</sup>
PEG+LR	7.42±0.02 <sup>Aa</sup>	7.41±0.02 <sup>ABa</sup>	7.40±0.01 <sup>ABa</sup>	7.41±0.01 <sup>Aa</sup>	7.40±0.02 <sup>Aa</sup>
EES	7.43±0.02 <sup>Aa</sup>	7.37±0.02 <sup>CBb</sup>	7.38±0.01 <sup>ABb</sup>	7.40±0.02 <sup>Aab</sup>	7.41±0.01 <sup>Aab</sup>
EES+LR	7.42±0.02 <sup>Aa</sup>	7.39±0.02 <sup>ACa</sup>	7.40±0.02 <sup>Aa</sup>	7.42±0.02 <sup>Aa</sup>	7.40±0.02 <sup>Aa</sup>
NaCl	7.41±0.01 <sup>Aab</sup>	7.35±0.03 <sup>Ch</sup>	7.35±0.04 <sup>Bb</sup>	7.42±0.02 <sup>Aab</sup>	7.42±0.07 <sup>Aa</sup>
	pO <sub>2</sub>				
PEG	31,52±1,80 <sup>Ba</sup>	35,50±5,35 <sup>Aa</sup>	34,04±2,01 <sup>Aa</sup>	33,04±2,93 <sup>Aa</sup>	35,08±4,69 <sup>Aa</sup>
PEG+LR	36,10±2,64 <sup>ABa</sup>	36,38±5,30 <sup>Aa</sup>	32,12±3,29 <sup>Aa</sup>	32,80±3,37 <sup>Aa</sup>	34,32±4,21 <sup>Aa</sup>
EES	36,50±2,93 <sup>Aa</sup>	39,64±4,85 <sup>Aa</sup>	36,66±4,16 <sup>Aa</sup>	36,40±3,90 <sup>Aa</sup>	36,34±4,51 <sup>Aa</sup>
EES+LR	36,74±1,26 <sup>Aa</sup>	34,78±4,51 <sup>Aa</sup>	36,12±3,90 <sup>Aa</sup>	33,22±5,78 <sup>Aa</sup>	33,84±3,03 <sup>Aa</sup>
NaCl	35,62±3,19 <sup>ABa</sup>	37,50±1,84 <sup>Aa</sup>	35,80±4,91 <sup>Aa</sup>	30,88±5,68 <sup>Aa</sup>	34,26±3,67 <sup>Aa</sup>
	pCO <sub>2</sub>				
PEG	47.98±4.43 <sup>Aa</sup>	43.24±2.46 <sup>Aa</sup>	43.14±2.90 <sup>Aa</sup>	47.14±3.60 <sup>Aa</sup>	47.10±4.15 <sup>Aa</sup>
PEG+LR	44.68±1.91 <sup>Aa</sup>	43.30±1.70 <sup>Aa</sup>	43.20±2.50 <sup>Aa</sup>	45.88±2.43 <sup>Aa</sup>	44.48±1.82 <sup>Aa</sup>
EES	44.04±1.27 <sup>Aab</sup>	46.70±1.66 <sup>Aa</sup>	42.90±0.68 <sup>Ab</sup>	44.04±3.04 <sup>Aab</sup>	44.16±1.03 <sup>Aab</sup>
EES+LR	45.76±0.75 <sup>Aab</sup>	42.82±2.95 <sup>Aab</sup>	42.06±3.18 <sup>Ab</sup>	44.96±2.27 <sup>Aab</sup>	46.68±1.90 <sup>Aa</sup>
NaCl	45.52±1.62 <sup>Aa</sup>	42.60±3.10 <sup>Aab</sup>	39.02±2.16 <sup>Ab</sup>	44.64±3.20 <sup>Aa</sup>	45.48±1.40 <sup>Aa</sup>
	tCO <sub>2</sub>				
PEG	30,92±1,99 <sup>Aa</sup>	28,62±1,69 <sup>Aa</sup>	28,04±1,32 <sup>Aa</sup>	30,58±1,32 <sup>Aa</sup>	29,80±1,27 <sup>Aa</sup>
PEG+LR	29,38±1,54 <sup>ABa</sup>	27,92±0,37 <sup>ABa</sup>	27,30±1,34 <sup>ABb</sup>	30,70±1,29 <sup>Aa</sup>	29,32±1,87 <sup>ABa</sup>
EES	30,18±0,79 <sup>Aa</sup>	26,86±1,68 <sup>ABb</sup>	25,98±0,68 <sup>ABb</sup>	27,94±1,32 <sup>Bab</sup>	28,66±1,27 <sup>ABa</sup>
EES+LR	30,84±1,02 <sup>Aa</sup>	26,72±1,88 <sup>ABb</sup>	28,88±5,21 <sup>ABa</sup>	29,68±1,67 <sup>ABab</sup>	29,70±1,19 <sup>ABa</sup>
NaCl	29,92±0,80 <sup>Aa</sup>	24,48±1,81 <sup>Bab</sup>	22,26±1,59 <sup>Bb</sup>	29,32±0,94 <sup>ABab</sup>	30,22±1,19 <sup>Aa</sup>

Means in the same column followed by equal capital letters and in the same row followed by equal lowercases letters do not differ at 5% level of probability by Tukey test.

PEG (Polyethylene glycol)

PEG+LR (PEG plus lactated Ringer's solution)

EES (enteral electrolyte solution)

EES+LR (EES plus lactated Ringer's solution)

NaCl (0.9% sodium chloride solution)

Table 3.- Means and standard deviations values of sodium (mMol L<sup>-1</sup>), chloride (mMol L<sup>-1</sup>), potassium (mMol L<sup>-1</sup>) and L-lactate (mMol L<sup>-1</sup>) serum of five horses treated with PEG, PEG+LR, EES, EES+LR and NaCl in pretreatment (T0h), treatment (T6h and T12h) and post-treatment (24h and T48h) periods.

Treatment	Period				
	T0h	T6h	T12h	T24h	T48h
-----Sodium-----					
PEG	141,20±15,65 <sup>Aa</sup>	149,20±6,68 <sup>Aa</sup>	140,80±11,03 <sup>ABa</sup>	142,80±9,18 <sup>ABa</sup>	142,20±8,55 <sup>ABa</sup>
PEG+LR	137,40±8,88 <sup>Aa</sup>	137,60±21,35 <sup>Aa</sup>	138,40±5,13 <sup>ABa</sup>	133,60±5,18 <sup>Ba</sup>	137,60±11,33 <sup>ABa</sup>
EES	142,40±4,66 <sup>Aa</sup>	132,60±7,83 <sup>Aa</sup>	137,40±13,50 <sup>Ba</sup>	130,40±6,23 <sup>Ba</sup>	128,00±6,63 <sup>Ba</sup>
EES+LR	143,20±7,60 <sup>Ab</sup>	148,20±6,30 <sup>Ab</sup>	162,80±3,77 <sup>Aa</sup>	157,20±7,05 <sup>Ab</sup>	152,80±8,78 <sup>Ab</sup>
NaCl	139,80±5,07 <sup>Aa</sup>	139,40±3,58 <sup>Aa</sup>	138,80±4,15 <sup>ABa</sup>	141,60±8,68 <sup>ABa</sup>	142,00±4,53 <sup>ABa</sup>
-----Chloride-----					
PEG	108,90±4,33 <sup>Aa</sup>	108,56±2,24 <sup>Aa</sup>	108,56±2,22 <sup>Ba</sup>	109,52±2,03 <sup>Aa</sup>	107,28±4,10 <sup>Aa</sup>
PEG+LR	109,94±5,87 <sup>Aa</sup>	111,04±3,38 <sup>Aa</sup>	111,78±1,31 <sup>ABa</sup>	109,60±1,40 <sup>Aa</sup>	108,80±1,61 <sup>Aa</sup>
EES	104,58±1,03 <sup>Ad</sup>	108,46±1,29 <sup>Ab</sup>	110,84±1,60 <sup>ABa</sup>	107,48±1,13 <sup>Abc</sup>	105,80±1,15 <sup>Accd</sup>
EES+LR	106,58±1,68 <sup>Aa</sup>	109,84±2,78 <sup>Aa</sup>	110,68±2,42 <sup>ABa</sup>	107,94±2,69 <sup>Aa</sup>	106,22±3,41 <sup>Aa</sup>
NaCl	105,84±1,44 <sup>Ac</sup>	111,74±1,41 <sup>Ab</sup>	114,02±1,90 <sup>Aa</sup>	108,96±2,07 <sup>Abc</sup>	105,24±3,03 <sup>Ac</sup>
-----Potassium-----					
PEG	3,30±0,38 <sup>Aa</sup>	4,02±0,77 <sup>Aa</sup>	3,60±0,38 <sup>Aa</sup>	3,80±0,52 <sup>Aa</sup>	3,94±0,56 <sup>Aa</sup>
PEG+LR	3,44±0,57 <sup>Aa</sup>	3,30±0,60 <sup>Aa</sup>	3,42±0,37 <sup>Aa</sup>	3,72±0,67 <sup>Aa</sup>	3,70±0,54 <sup>Aa</sup>
EES	3,38±0,22 <sup>Aa</sup>	3,30±0,63 <sup>Aa</sup>	3,74±0,26 <sup>Aa</sup>	3,64±0,43 <sup>Aa</sup>	3,82±0,25 <sup>Aa</sup>
EES+LR	3,82±0,42 <sup>Aa</sup>	3,42±0,53 <sup>Aa</sup>	3,64±0,65 <sup>Aa</sup>	3,74±0,35 <sup>Aa</sup>	4,16±0,37 <sup>Aa</sup>
NaCl	3,50±0,20 <sup>Aa</sup>	3,42±0,37 <sup>Aa</sup>	3,16±0,36 <sup>Aa</sup>	3,86±0,35 <sup>Aa</sup>	3,74±0,85 <sup>Aa</sup>
-----L-lactate-----					
PEG	0,60±0,46 <sup>Aa</sup>	0,79±0,12 <sup>ABa</sup>	0,71±0,10 <sup>ABa</sup>	0,71±0,24 <sup>Aa</sup>	0,82±0,19 <sup>Aa</sup>
PEG+LR	1,04±0,71 <sup>Aa</sup>	1,37±0,55 <sup>Aa</sup>	1,42±0,35 <sup>Aa</sup>	0,99±0,27 <sup>Aa</sup>	0,95±0,42 <sup>Aa</sup>
EES	0,74±0,14 <sup>Ab</sup>	0,63±0,26 <sup>Bab</sup>	0,49±0,06 <sup>Bb</sup>	0,82±0,17 <sup>Ab</sup>	1,09±0,43 <sup>Aa</sup>
EES+LR	0,71±0,17 <sup>Aa</sup>	1,08±0,66 <sup>ABa</sup>	0,96±0,49 <sup>ABa</sup>	1,12±0,48 <sup>Aa</sup>	1,10±0,33 <sup>Aa</sup>
NaCl	0,62±0,09 <sup>Aa</sup>	1,08±0,71 <sup>ABa</sup>	1,04±0,72 <sup>ABa</sup>	0,90±0,28 <sup>Aa</sup>	1,07±0,14 <sup>Aa</sup>

Means in the same column followed by equal capital letters and in the same row followed by equal lower cases letters do not differ at 5% level of probability by Tukey test.

PEG (Polyethylene glycol)

PEG+LR (PEG plus lactated Ringer's solution)

EES (enteral electrolyte solution)

EES+LR (EES plus lactated Ringer's solution)

NaCl (0.9% sodium chloride solution)

studied variables, the combination with lactate Ringer's solution (PEG+RL) induced minor changes like decreases of  $\text{CHCO}_3^-$  in T12h, compared to T24h, and of BE in T6h and T12h, compared to T24h. Emphasizing that despite the decrease had been significant, the values remained within the reference range (KANeko et al., 2008), making them of no clinical significance. Moreover, the values promptly returned to baseline levels in T24h (Table 1).

## CONCLUSION

The PEG 3350 electrolyte solution did not interfere with the acid-base balance, and should be considered as therapeutic option for horses that need laxatives. Despite the slight acidifying effect, the proposed enteral electrolyte solution showed to be clinically safe to be used in normal horses. The association of intravenous

Ringer lactate with the used enteral electrolyte solutions or the infusion of intravenous 0.9% NaCl solution using doses and infusions rates presented in this study can cause important electrolytes and acid-base imbalances and should be used with caution in clinical cases.

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## SOURCES AND MANUFACTURES

<sup>a</sup> Padock NFgel® - Lab Vetbrands

<sup>b</sup> Equisul Special Ration 15 - Total Foods, Três Corações, MG

<sup>c</sup> Hiposal 80% - Total Foods, Três Corações, MG

<sup>d</sup> Sodium chloride 0.9% - Texon

<sup>e</sup> Pidotmag® - Baldacci Laboratory, Brazil

<sup>f</sup> Muvinalax - Libbs

- <sup>a</sup> Frasco Vacuum II – Bacton & Dickinson Ind. Cirúrgica Ltda., Brasil  
<sup>b</sup> Single Channel Flame Photometer - FC 180 Model: Celm  
<sup>i</sup> Automatic device Alizé - Clinine 150  
<sup>k</sup> Parinex – Hipolabor Laboratory  
<sup>l</sup> Venous blood gas i-STAT - i-STAT Corporation, USA

## BIOETHICS AND COMMITTEE APPROVAL

The experimental design was submitted to Ethics Committee of the institution of origin, and was approved by the protocol number 050/2007.

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