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# *Tutorial Article*

## Administration of enteral fluid therapy: methods, composition of fluids and complications

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### Introduction

The physiological basis for enteral fluid therapy, indications and contraindications for this treatment in horses have been discussed in the companion paper (Lopes 2002a). Despite the potential benefits of enteral fluid therapy, it has barely been mentioned in the current literature. **In this article, the methods of administration, composition of fluids and complications of enteral fluid therapy are discussed.**

### Administration of enteral fluids

#### *Route*

Oral fluid therapy is the most physiological and least invasive way to restore hydration, but most sick horses will not voluntarily drink sufficient fluid volumes. **Forced oral administration of large volumes of fluids is not recommended due to the risk of aspiration.** However, small volumes of **hypertonic electrolyte solutions** or **salt paste administered with a syringe** have been used successfully in endurance horses to replace electrolytes and stimulate thirst (Nyman *et al*. 1996; Sosa Leon *et al*. 1998; Düsterdieck *et al*. 1999).

Fluids can also be given by a nasogastric or naso-oesophageal tube. A tube long enough to reach the caudal cervical oesophagus is indicated (e.g. a nasogastric tube for colicky horses), although **placing the tube in the stomach is advantageous because the presence of net gastric reflux can be ruled out before enteral fluid therapy is started and the stomach can be emptied in case discomfort occurs due to gastric distention produced by fluid therapy**.

Tube manipulation must be gentle to avoid damaging the nasal passage, pharynx, larynx and oesophagus. Alternatively, a tube with a small calibre (external diameter 6 mm) designed for enteral nutrition (Veterinary Enteral Feeding Tube)[1] can be used. This type of tube has the advantage of producing less pressure on the mucosa and less discomfort for the horse (Lopes *et al*. 2001), which is particularly important for prolonged treatments. However, the small-bore tube cannot be used to check for reflux or to drain fluids given in excess.

**Before administering fluids**, the position of the nasogastric tube has to be checked to avoid inadvertent administration of fluids in the trachea. When a large-bore tube is used, it is easy to feel the resistance produced by the collapsed oesophagus while inserting the tube. It is also possible to palpate the tube in the neck dorsolaterally to the trachea. **While passing the small-bore tube**, it is not so easy to feel the difference between the resistance of the oesophagus and the lack of resistance when the tube is in the trachea. The horse usually coughs when the tube is positioned in the trachea. If the horse does not react, a small volume (100 ml) of water can be administered, which will probably produce coughing if the tube has been passed into the trachea. Radiography or ultrasonography of the neck or endoscopy of the pharynx can be used for definitive confirmation of appropriate tube position.

**The best way to administer enteral fluid therapy is by gravity rather than with a pump** (Ecke *et al*. 1997). A large funnel made with a plastic gallon jug (e.g. empty milk jug) can be used (**Fig 1**). Enteral fluid therapy can also be administered continuously to horses kept unrestrained in the stable using a coiled line connected to the nasogastric tube (**Fig 2**). When the small-bore tube is used, it is safe to allow the horse to have free access to feed (Murray and Schusser 1993), while it is more likely that the large-bore nasogastric tube would interfere with deglutition.

When the naso-oesophageal or nasogastric tube cannot be passed (e.g. due to nasopharyngeal or oesophageal obstruction), it may be possible to give fluids through an **oesophagostomy**. A stoma is created surgically in the cervical oesophagus and a large-bore tube passed into the caudal oesophagus. Besides fluid therapy, the oesophagostomy permits the administration of liquid diets composed of a slurry of regular horse feed. As soon as the

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***Fig 1: Administration of fluids via a large-bore nasogastric tube using a funnel.***

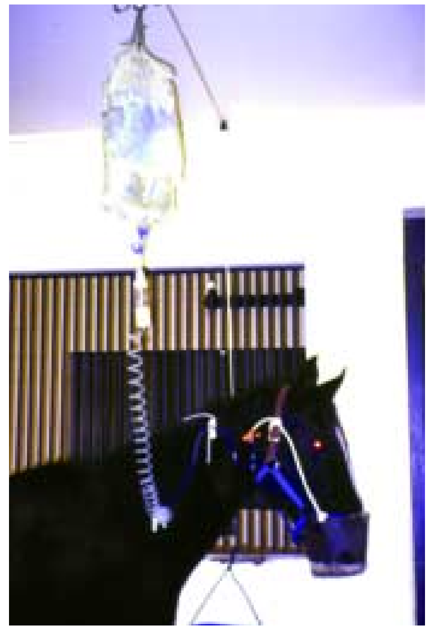

***Fig 2: Administration of fluids via a small-bore nasogastric tube using a coiled line.***

horse regains the ability to eat and drink, the tube can be removed. Complete healing of the fistula occurs in 2 or 3 weeks. Because severe complications, such as laryngeal hemiplegia, perioesophageal infection and mediastinitis, can occur (Stick *et al*. 1981; Lopes 2001), an **oesophagostomy should only be performed as a last resort**.

**Intracaecal administration** of fluids through a percutaneous catheter has been used to maintain hydration in ponies, but 3 of the 6 ponies developed **septic peritonitis** (Mealey *et al*. 1995). **The high risk of complications precludes using this route of administration.**

Rectal administration of large volumes of fluids (44 l) has been reported to increase the water content in the small colon and large dorsal colon of dehydrated horses, but did not change central venous pressure, PCV or total plasmatic protein (Hjortkjaer 1979). Current use of enemas is limited to cases of impactions of the small colon and rectum, such as meconium impaction (Hanson 1999), with the objective of softening the impacted mass. **Enemas can cause tenesmus and rupture of the rectum and should be administered cautiously.**

### *Volume and rate of infusion*

Since stomach capacity is about 18 l in the average horse (Pfeiffer and MacPherson 1990) and fluids rapidly leave the stomach after nasogastric administration (Sosa Leon *et al*. 1997), relatively fast rates of infusion can be achieved with enteral fluid therapy. Normal horses and those with large colon impaction may tolerate as much as 10 l every 30 min (**40 ml/kg bwt/h for a 500 kg horse**) (Rose *et al*. 1986; Sosa Leon *et al*. 1997; Lopes *et al*. 1999). Slower rates of infusion have been proposed by other authors, although no data have been presented to support these recommendations (Morris 1987; Schlipf and Baxter 1992; Holbrook and Eades 1995). Fluids can be administered as either continuous infusion or large boluses. Continuous infusion may reduce the risk of excessive gastric distention but may minimise the gastrocolic response. These hypotheses were not proven when 80 l were administered to normal horses over 8 h as 10 l boluses or continuous infusion (167 ml/min) (Lopes *et al*. 2001), but further investigation is necessary. To prevent excessive gastric distention and abdominal discomfort, it is advisable to start with smaller doses or slower rates of infusion and gradually increase the dose over a few hours.

### *Temperature*

Because of concerns regarding adverse effects of fluid temperature, warm fluids have been used (Lopes *et al*. 1999). However, in normal horses, fluids at 5°C did not affect gastric emptying or fluid absorption (Sosa Leon *et al*. 1995). Since cold fluids may increase energy consumption (Carlson 1971), **it is preferable to use warm fluids** (38°C) whenever large volumes are going to be administered, particularly when the environment is cold and in horses with malnutrition or hypothermia. On the other hand, the administration of cold fluids may help to combat hyperthermia in horses with **post exercise dehydration**.

## Composition of fluids for enteral use

Horses that are being fed and have normal kidney function may tolerate large amounts of fluids that do not have the ideal composition. In this instance, the diet will be a source of electrolytes and the kidneys will help to prevent severe electrolyte imbalances. For horses with anorexia or kidney disease and for prolonged treatments (more than 24 h), **the composition of the fluid is more critical**.

### Water

Water is a hypotonic solution (10–20 mOsm/l) with very low concentrations of electrolytes (Gisolfi and Duchman 1992). Since water is absorbed passively following the absorption of sodium, maximum absorption should not be expected with the administration of plain water, although a major part will be absorbed rapidly (Sosa Leon *et al*. 1995; Marlin *et al*. 1998; Monreal *et al*. 1999). The administration of small volumes of water (e.g. **30 l/day for a 500 kg horse**) may be safe in horses that are eating and are going to be supplied with some electrolytes from their diet. However, hyponatraemia (Sosa Leon *et al*. 1995; Marlin *et al*. 1998; Lopes 1999; Monreal *et al*. 1999), synchronous **diaphragmatic flutter** (Monreal *et al*. 1999) and **seizures** (Lopes 1999) have been reported after the administration of water by nasogastric tube. **Large volumes of water should never be administered without closely monitoring plasma electrolytes.**

### Electrolyte solutions

A 0.9% NaCl solution (**9 g table salt/l water**) is **isotonic** and contains sodium, which is important for water absorption. However, a 0.9% NaCl solution can produce hypernatraemia, hyperchloraemia and acidosis, because its sodium and chloride concentration is higher (154 mol/l) than in plasma (Lopes *et al*. 2001). **Since it does not contain potassium**, 0.9% NaCl administration can contribute to hypokalaemia, which may already be present in a horse that has not been eating. When large volumes are going to be administered, other electrolyte solutions, containing different concentrations of sodium and chloride and including a source of potassium, such as KCl, should be used. To adjust the Na:Cl ratio closer to that which is normal in plasma, **a chloride-free salt such as sodium bicarbonate** ($NaHCO^3$) can be added. As an example, a solution made up of 5.9 g NaCl, 0.3 g KCl and 3.4 g $NaHCO^3$/l water has sodium, potassium and chloride concentrations close to those normally found in plasma (141, 4 and 105 mmol/l, respectively). The administration of 60 l of this solution at the rate of 10 l/h to normal horses did not produce any abnormality in plasma sodium, potassium or chloride (Lopes *et al*. 2002b).

Glucose is known to improve absorption of rehydration solutions in man and animals, because of the cotransport mechanism of sodium and glucose. Amino acids have the same effect but, **due to problems of stability and toxicity, they are not commonly included in rehydration solutions** (Schedl *et al*. 1994). Despite the good results obtained with glucose solutions, it is thought that fluids containing carbohydrate polymers (e.g. maltodextrin) have the advantages that: 1) more solute (including electrolytes) can be added while keeping osmolality low, which may contribute to increase water absorption, since the small intestine is highly permeable to water and acts as an equilibration chamber; and 2) hydrolysis of polymers by brush border enzymes results in a higher concentration of glucose on the mucosal surface, increasing the efficiency of glucose absorption by membrane transporters (Thillainayagam *et al*. 1998).

Despite the known benefits for man (Gisolfi and Duchman 1992; Anon 1996), glucose failed to improve absorption of oral rehydration solutions in horses experimentally dehydrated by frusemide administration (Sosa Leon *et al*. 1995; Monreal *et al*. 1999). The extremely fast transit of fluids through the small intestine in the horse compared to man may limit the efficiency of glucose-electrolyte solutions. Additionally, horse sweat is hypertonic and equine athletes may need to replace more electrolytes than human athletes, but there is a limit imposed by the osmolality of the rehydration solution. Although it has not been tested in horses, **replacing glucose with a carbohydrate polymer** would make it possible to increase the electrolyte concentration in the rehydration solution, which may improve water absorption and electrolyte replacement.

When an increase in hydration of ingesta is a major goal of fluid therapy (e.g. to treat impactions), it is tempting to add a poorly absorbed solute to hold water in the gastrointestinal lumen. Magnesium sulphate has been used for decades as an osmotic laxative because its absorption is thought to be limited and slow. Oral administration of magnesium sulphate (1 g/kg bwt) is considered to be safe and effective (Freeman *et al*. 1992). However, this dose is more than 6 times the dose needed by i.v. route to cause neuromuscular blockage and recumbency in horses (Bowen *et al*. 1970) and **magnesium toxicosis** has been reported in dehydrated horses treated with magnesium sulphate (Henninger and Horst 1997). **Sodium sulphate** (0.8 g/kg bwt) has also been shown to produce cathartic effects in horses (Meyer *et al*. 1986) and may be associated with a lower risk of toxicosis. Traditionally, saline cathartics have been administered with a small volume of fluids possibly followed by i.v. fluid therapy, but the effectiveness and safety of the administration of saline cathartics with repeated administration of fluids by nasogastric tube have not been evaluated.

### Solutions containing glycerol

Solutions containing glycerol are thought to increase blood osmolality favouring an increase in plasma volume, but their use is controversial. Theoretically, glycerol ingestion before exercise would benefit athletes trying to avoid the deleterious effects of dehydration caused by prolonged physical activity. However, many studies in man failed to demonstrate improvement in hydration status or performance. The effects of glycerol ingestion on gastric emptying and the potential for toxicity have not been investigated fully; however, bloating, nausea and vomiting have been reported (Wagner 1999). Oral administration of 2.4 ml/kg bwt glycerol in conjunction with electrolytes immediately before and during endurance exercise has been evaluated in horses, but the effects were similar to electrolytes alone (Düsterdieck *et al*. 1999; Schott *et al*. 1999).

## Planning and monitoring enteral fluid therapy

The same criteria recommended for i.v. fluid therapy can be followed for enteral fluid therapy. Clinical and laboratory findings are the basis for selection of the appropriate fluid composition, volume and rate of administration (Rose 1981; Barton and Moore 1999; Corley 2001). However, the margins for error may be significantly wider than for i.v. fluid therapy and close attention to fluid volume and composition is not so critical.

Based on studies evaluating water intake (Tasker *et al*. 1967; Fonnesbeck 1968), the **maintenance rate of fluid administration for normal horses** has been estimated to be about 2.5 ml/kg bwt/h (Corley 2001). However, ongoing fluid losses may be significantly higher, e.g. in cases of horses with diarrhoea (Rose 1981). To calculate the initial rate of infusion, water and electrolyte deficits should also be considered. **The response to fluid therapy should be monitored frequently** and adjustments in fluid composition and infusion rate made as needed.

**If hydration status cannot be restored or maintained** with enteral fluid therapy, such as in cases of severe colitis, **i.v. fluid therapy must be administered**. Intolerance to enteral fluid therapy may be manifested by gastric dilation and abdominal discomfort, which can be managed by slowing the rate of infusion. However, in some cases, enteral fluid therapy may have to be discontinued.

## Complications of enteral fluid therapy

### *Inadvertent administration of fluids into the respiratory tract*

Horses with dysphagia (e.g. caused by tetanus or other neurological diseases) or oesophageal obstruction should not be allowed to drink because of the risk of fluid aspiration. Forced administration of oral fluids is also a risky procedure even in normal horses and should not be used. The administration of fluids through a nasogastric tube can also result in fluid administration into the respiratory tract if the tube is accidentally passed into the trachea. Usually the horse reacts vigorously when the tube is in the trachea, but depression due to disease or sedative administration can prevent the horse from reacting (Scaratt *et al*. 1998). Besides the absence of this characteristic reaction, other signs of correct intubation must be verified to prevent inadvertent administration of fluids into the trachea.

### *Other accidents due to nasogastric intubation*

Nasal bleeding can occur even with the most gentle manoeuvres to pass the nasogastric tube. In almost all cases, bleeding is not severe enough to cause any problem and will stop without treatment. A tube with an appropriate gauge and a smooth tip lubricated with water-soluble jelly should be used in order to prevent bleeding. Proper restraint of the horse and careful handling of the tube, which should be advanced slowly through the ventral meatus, is also recommended (Adams 1970). Trauma to the pharynx, larynx and oesophagus may also occur, which can lead to nasal discharge of feed and saliva, dysphagia and anorexia. Severe lesions can occur when a tube with sharp edges is used or when the tube is passed with rough manoeuvres. The risk is increased when large diameter tubes are used, when the tube is kept in place for several days and when the horse resists intubation (Hardy *et al*. 1992).

### *Abdominal discomfort*

**If pain is observed immediately after fluid administration**, excessive gastric distention should be suspected and the nasogastric tube should be used to empty the stomach. Large doses of fluids (more than 5 l for a 200 kg horse, or more than 10 l for a 500 kg horse) should be avoided to prevent excessive gastric distention. When even small volumes of fluids (e.g. 5 l for a 500 kg horse) cause pain, pathological conditions of the stomach such as gastric ulcers or impaction should be considered. In horses with intestinal obstruction or displacement, the increase in motility produced by the gastrocolic response may cause pain, which can be explained by an intestinal contraction moving over an impaction, or stretching of the intestine and mesentery (Steinebach and Cole 1995; Lopes *et al*. 1999). Pain produced by increased motility can be managed with drugs to relieve spasm (e.g. scopolamine, xylazine) or analgesics (e.g. flunixin).

### *Rupture of stomach or intestine*

The administration of an excessive amount of fluids into the stomach may cause gastric rupture. However, no report of gastric rupture produced by enteral fluid therapy has been published. If the horse is not heavily sedated or severely depressed, excessive gastric distention should produce signs of pain and rupture may be prevented by prompt drainage of fluids through the nasogastric tube.

In horses with severe impaction, the increase in intestinal motility produced by enteral fluid therapy may result in rupture of the impacted region, as reported in a horse with caecal impaction (Lopes 1999). However, the risk of caecal rupture in horses with caecal impaction is high even when enteral fluids are not used (Collatos and Romano 1993). Large or small colon rupture due to enteral fluid therapy has not been reported.

### *Electrolyte imbalance*

Electrolytes and water are absorbed readily through the gastrointestinal mucosa and enteral fluid therapy can change electrolyte concentration in plasma. **Close monitoring of plasma electrolytes should guide enteral fluid therapy.** This is particularly important in horses that are not eating or when kidney function is abnormal.

### *Pulmonary oedema*

Horses appear to be quite tolerant to high volumes of fluids given by the i.v. route, and pulmonary oedema is rare (Barton and Moore 1999). Although fluid therapy has not been studied extensively in horses, it is reasonable to believe that the risk of pulmonary oedema may be even lower when fluids are given enterally. In an 'overhydrated' horse, in addition to the activation of diuresis, water absorption by the gastrointestinal mucosa is likely to be reduced by several mechanisms as reviewed in the companion article (Lopes 2002a). Therefore, the rate of delivery of fluids into the circulation is slowed down when enteral fluid therapy is used, while these natural mechanisms are bypassed when i.v. fluid therapy is used.

## Conclusions

**Enteral fluid therapy is an efficient, practical and inexpensive treatment for horses with many clinical conditions. Horses with normal gastrointestinal transit may tolerate large volumes administered in a short period of time, while some horses may require slower rates of administration. Rational judgement of clinical condition based on clinical and laboratory findings should be used to adjust fluid composition and rate of administration according to the horse's needs. More studies are needed to better define the guidelines for enteral fluid therapy in horses**.

## Manufacturer's address

[1]Mila International, Inc., Florence, Kentucky, USA.

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