Fluid therapy in horses – uses, types and administration routes

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ABSTRACT

Fluid therapy is used to restore circulating volume and improve the cardiac output – which will, in turn, increase oxygen delivery to the tissues – and to correct any electrolyte and acid-base disturbances. The fluid deficit should be estimated and replaced using crystalloids, colloids or a combination of both. An ongoing fluid therapy plan should then be generated to account for maintenance requirements and ongoing losses. In addition, any remaining electrolyte and acid base disturbances can be corrected using specific fluids.

Inotropes and vasopressors should be reserved for specific cases that do not respond to fluid therapy alone. The fluids can either be administered via the enteral route or IV. Enteral fluids are contraindicated if ileus, intestinal obstruction or severe mucosal inflammation is present, or if the horse is unable to stand or requires rapid, large volume resuscitation.

Fluid therapy is used, firstly, to restore the circulating volume and improve cardiac output – which will, in turn, increase oxygen delivery to the tissues – and, secondly, to correct any electrolyte and acid-base disturbances.

The fluid deficit should be estimated and replaced using the most appropriate fluid via the most suitable route.

Estimation of fluid deficit
Table 1. Changes associated with dehydration in horses.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Change when dehydrated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>Increased</td>
</tr>
<tr>
<td>Jugular refill time</td>
<td>Increased</td>
</tr>
<tr>
<td>Mucous membranes</td>
<td>Congested</td>
</tr>
<tr>
<td>Capillary refill time</td>
<td>Increased</td>
</tr>
<tr>
<td>Skin turgor</td>
<td>Decreased</td>
</tr>
<tr>
<td>Temperature of extremities</td>
<td>Decreased</td>
</tr>
<tr>
<td>Urine output</td>
<td>Decreased</td>
</tr>
<tr>
<td>PCV</td>
<td>Increased</td>
</tr>
<tr>
<td>Total protein</td>
<td>Increased</td>
</tr>
<tr>
<td>Lactate concentration</td>
<td>Increased</td>
</tr>
<tr>
<td>Creatinine and urea</td>
<td>Increased</td>
</tr>
<tr>
<td>$PvO_2$</td>
<td>Decreased</td>
</tr>
<tr>
<td>Urine specific gravity</td>
<td>Increased</td>
</tr>
<tr>
<td>Central venous pressure</td>
<td>Decreased</td>
</tr>
</tbody>
</table>

The fluid deficit is estimated based on the clinical signs and clinical laboratory data (Table 1). However, it must be remembered these should be interpreted in light of the primary condition. For example, pain will also cause the heart rate to increase, while a protein-losing enteropathy may mask any dehydration-associated increase in total protein.

Mild changes are detectable when the animal is approximately 5% dehydrated, while 12% dehydration is associated with severe signs. Thus, a 500kg horse estimated to be 10% dehydrated will require 50L of fluid. The deficit should be replaced over the following few hours. Commonly, approximately half of the deficit is administered and then the horse reassessed to determine the response to therapy, with the remaining requirement adjusted as necessary. The response to the fluid therapy can be assessed by serially measuring the various clinical signs and laboratory parameters (Table 1).

Types of fluid

The fluids available for replacement and maintenance include crystalloids and colloids. Evidence favouring one over the other is lacking and it is often best to use both concurrently or sequentially as they have different advantages.

Crystalloids
Crystalloids contain water, sodium or glucose, other electrolytes plus a buffer. The fluid may be hypotonic, isotonic or hypertonic relative to plasma. They distribute between the intravascular (25%) and interstitial compartments (75%) within one hour; thus, 1L of crystalloids results in a 250ml increase in plasma volume. Distribution into the interstitial compartment is beneficial if the animal is dehydrated as well as hypovolaemic, but it will also promote tissue oedema formation, which may compromise perfusion.

Distribution in the intravascular compartment will result in a decrease in the total protein concentration (through dilution), which, in turn, will decrease the colloid osmotic pressure (COP), thus favouring further fluid loss into the interstitium, which again may be beneficial or detrimental depending on the individual case. These factors should all be borne in mind when considering the fluid therapy plan.

**Isotonic solutions**

Isotonic polyionic solutions are the most commonly used crystalloid solution in equine veterinary practice. Their electrolyte composition is similar to plasma; however, the potassium concentration is too low for maintenance requirements so 10 milliequivalent (mEq) potassium chloride (KCl)/L to 20mEq KCl/L should be added (see electrolyte supplementation). When choosing a fluid, it should be remembered Hartmann’s solution contains calcium, which will bind anticoagulants in blood products and that these fluids contain a buffer (lactate, acetate or gluconate) metabolised (by the liver, muscle or most cells, respectively) to bicarbonate, which will affect the acid-base balance.

Isotonic saline (0.9% salt; NaCl) is hypernatraemic and hyperchloraemic relative to plasma and lacks other electrolytes. It is only available as 1L bags, so is primarily used in cases of hyponatraemia and hypochloraemia, rather than for resuscitation or maintenance.

**Hypertonic solutions**

Hypertonic saline (7% to 7.5% NaCl) is hypertonic relative to plasma and so initiates movement of water into the intravascular space from the interstitium, resulting in rapid expansion of the circulating volume. The plasma volume expansion achieved is two to four times that of the infused volume (2ml/kg to 4ml/kg). However, this will result in intracellular dehydration, so it should be followed up with 10L of isotonic fluids for every 1L of hypertonic saline administered in two-and-a-half hours.

**Hypotonic solutions**

A 5% dextrose is a hypotonic solution that will replace water without electrolytes. Thus, it is only used in animals that are hypernatraemic and hyperchloraemic. It should be used with caution as it can cause hyperglycaemia with rapid administration, which will subsequently result in osmotic diuresis, and so further fluid loss.
**Colloids**

Colloids contain large sugar or protein molecules and are a mix of large and small molecules. The advantages of colloids over crystalloids are the large molecules improve oncotic pressure and provide rapid intravascular volume replacement by expanding the plasma volume by 100% to 200% of the volume infused, thus improving microvascular perfusion with less tissue oedema formation. The disadvantages are they are affected by alterations in capillary permeability, do not correct dehydration (interstitial losses) and can have side effects in some animals.

Colloids available in the UK include plasma, whole blood and the synthetic colloid gelofusine. Unfortunately, alternative colloids previously used in horses – including pentastarch and hetastarch – are no longer available in the UK due to their withdrawal from the human market.

**Plasma**

Albumin is the primary component of plasma contributing 65% to 75% of plasma COP. It can be collected from a suitable donor (see whole blood; Figure 1) or is commercially available in the form of hyperimmune plasma. Commercially available plasma only comes in 1L bags and is rarely used in rehydration due to the high cost and large volume required. Instead, it is normally used for its additional components including immunoglobulins (in failure of passive transfer), clotting factors, anticoagulants and platelets.

Horses receiving plasma should be closely monitored for signs of hypersensitivity including tachycardia, pyrexia and urticaria. If signs occur, the infusion should be stopped and corticosteroid therapy IV may be necessary.

**Whole blood**

Whole blood is only indicated in cases of acute severe haemorrhage or haemolysis. No universal donor exists, but, ideally, the donor should be Aa and Qa antibody and antigen negative, although this requires a donor to have been blood typed in advance. Suitable alternatives include a young, healthy gelding that has never received a blood product, or a mare that has never had a foal.

Usually, cross matching is not performed the first time a blood or plasma transfusion is given, but should be performed for all subsequent transfusions, regardless of the donor.

**Gelofusine**

The synthetic colloid gelofusine contains succinylated gelatin and sodium chloride. In other species, it has been shown to expand the blood volume by 68% one hour after infusion and by 30% after six hours.
Side effects reported in other species include proteinuria (not clinically significant), hyperchloraemia (which may cause metabolic acidosis) and anaphylaxis. In a published study, 10ml/kg and 20ml/kg gelofusine resulted in haemodilution and an increase in COP in healthy ponies, and were not associated with clinically significant adverse effects on haemostasis or renal parameters (Gratwick et al, 2017).

**Electrolyte supplementation**

Electrolyte concentrations should be measured after the initial correction of the fluid deficit. Any imbalances can then be corrected through the initiation of supplementation and the response to therapy should be monitored.

Hypokalaemia is common due to fasting and because the potassium composition of fluids used is too low for maintenance requirements. Supplementation in the form of potassium chloride can be given at a rate of less than 0.5mEq/kg/hr, which equates to 40mEq/L for fluid rates up to 10ml/kg/hr.

Hypocalcaemia is common due to fluid therapy. It can be corrected using 23% calcium gluconate – 100ml to 300ml should be added to the IV fluids and the circulating concentrations rechecked after four to eight hours.

Magnesium is necessary for renal potassium reabsorption, thus hypokalaemia may not resolve in the face of hypomagnesaemia. Supplementation of the IV fluid can be provided in the form of magnesium sulphate (4mg/kg to 16mg/kg).

**Acid-base disturbances**

The most-common acid base disturbance in the adult horse is metabolic acidosis due to poor perfusion, resulting in anaerobic respiration and lactate production. This occurs most frequently in conjunction with hypovolaemia and endotoxaemia, and should be treated with fluid resuscitation using polyionic fluids. Metabolic acidosis can also occur secondary to hyponatraemia – for example, in association with colitis, peritonitis or GI torsion – and should be treated with normal or hypertonic saline.

Metabolic alkalosis occurs in association with hypochloraemia – secondary to high volume gastric reflux, which should be treated with normal saline, and hypoalbuminaemia, which should be treated with colloids.

Respiratory acidosis occurs in conjunction with pneumonia and hypoventilation, while respiratory alkalosis occurs in conjunction with hyperventilation due to pain. In these situations, the underlying respiratory problem should be addressed.
Inotropes and vasopressors

Critically ill horses often have disturbances of the cardiovascular system, which can result in inadequate oxygen delivery to the tissues. This is due to:

- Loss of large volumes of fluids into the gastrointestinal (GI) tract.
- Endotoxin and ischaemia-reperfusion injury-induced capillary damage, allowing fluid and albumin to leak out, causing hypovolaemia and, consequently, reduced intravascular COP and increased interstitial COP drawing out more fluid.
- Sepsis and endotoxaemia-associated vasodilation, which leads to relative hypovolaemia.
- Endotoxin and sepsis-associated production of cytokines, which cause myocardial depression.
The critical aim of fluid therapy is to ensure adequate oxygen delivery to the tissues. The first approach to this is using fluid therapy. However, if the mean arterial pressure (MAP) is less than 70mmHg and the horse does not respond to a fluid bolus (10ml/kg crystalloids or 3ml/kg colloids), then it may require vasoactive drugs.

The main agents used fall into two categories: inotropes and vasopressors. Inotropes raise the cardiac output by increasing the stroke volume, while vasopressors raise the blood pressure through arteriolar vasoconstriction, thereby increasing the pressure gradient across a capillary bed,
improving perfusion.

These drugs should be used with caution as inotropes may cause tachycardia in patients not sufficiently fluid resuscitated, resulting in increased myocardial oxygen demand and reduced coronary perfusion. Inappropriately large doses of vasopressors may also increase the cardiac afterload. The combination of hypovolaemia and increased afterload results in decreased cardiac output and so reduced tissue perfusion.

It is safest to start with an inotrope, and evidence suggests dobutamine is the best option, beginning at a dose of 2mg/kg/min. A MAP response should occur within 10 minutes. The dose can be increased up to 10mg/kg/min. If a vasopressor is required, evidence suggests noradrenaline is the best first choice. The drug should be started at a dose of 0.1mg/kg/min and a MAP response should occur within 15 minutes. The dose can be increased up to 5mg/kg/min and can be used in combination with dobutamine.

**Ongoing fluid therapy plan**

An ongoing fluid therapy plan should be formulated once the deficit has been replaced to take into account maintenance requirements (40ml/kg/day to 60ml/kg/day) and ongoing losses, such as diarrhoea.

**Administration routes**

Two main administration routes should be considered: enteral and IV (Figure 2). Enteral fluids are contraindicated if ileus, intestinal obstruction or severe mucosal inflammation is present, or if the horse is unable to stand or requires rapid, large volume resuscitation. In these cases, only IV fluid therapy should be considered.

For all other cases, it should be remembered the two routes can be used alone or in combination.

**Enteral fluids**

The main advantages of enteral fluids are the lower cost and the fact GI mucosa acts as a natural selective barrier – making iatrogenic imbalances less likely. Absorption from the GI tract is increased in hypovolaemia, so enteral fluids have a haemodynamic effect in about 30 minutes, which is quick enough in many cases.

The indications for enteral fluids include:

- restoration of electrolyte balance and hydration status
- to prevent dehydration occurring in horses with ongoing losses that are not drinking
- to increase hydration of the GI contents – for example, if a large intestinal impaction is
Enteral fluids can be administered via a nasogastric or naso-oesophageal tube, and as a bolus or continuously by gravity. Most commonly, a bolus is administered via a nasogastric tube. Up to 10L every 30 minutes (40ml/kg/hr) can be given and maintenance rates are 2.5ml/kg/hr. Ideally, the fluid should be isotonic. This can be achieved by adding 4.9g NaCl and 4.9g lo-salt (KCl) to each litre of water. Including glucose has no apparent beneficial effect on the rate of absorption in the horse.

Complications that should be monitored for include aspiration, nasogastric tube complications, abdominal discomfort, GI rupture and electrolyte imbalances.

**IV fluid therapy**

IV fluid therapy requires vascular access. Most commonly, the jugular vein is used as it is the only site suitable for high volume resuscitation (Figure 3). However, it must be remembered thrombophlebitis at this site can cause significant morbidity. If the horse is severely dehydrated, fluids can be administered via both jugular veins simultaneously using a large gauge catheter combined with a wide bore delivery system, allowing a maximum administration rate of 35L/hr.

Other sites suitable for catheterisation include the lateral thoracic vein, the cephalic vein and the saphenous vein.

**References**