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Intravenous fluid therapy in the horse

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ABSTRACT: Intravenous fluid therapy is an important part of critical patient care. Therefore, it is important to understand the specific challenges of providing intravenous fluids to horses and their special electrolyte requirements. This article reviews the essentials of equine intravenous fluid therapy, including the fluid electrolyte compositions for treating horses and foals with specific conditions. Also provided are dose rates and formulations for tailoring intravenous fluids to specific purposes.

The principles of intravenous fluid therapy are similar for all species. The general aims are to restore the plasma volume, replace the fluid deficit, counteract the ongoing losses and maintain the fluid and electrolyte balance. However, there are specific differences in the approach to horses, because of the massive volume of fluids that may be required, and the particular need of horses for the electrolytes potassium and calcium.

Optimising the electrolyte content of intravenous fluids more rapidly re-establishes and maintains electrolyte and acid-base balances in critically ill patients. When we are considering whether a patient would benefit from intravenous fluids, we must also consider what electrolyte content would be optimal.

Gaining intravenous access

Catheter types

There are many catheter types available for use in the horse, but the most commonly employed catheters in equine medicine are either Teflon (Angiocath) or polyurethane (Mila). The choice of catheter material depends on the length of time the catheter will be in place.

Teflon catheters should be changed every three days, however, polyurethane catheters can be maintained for up to two weeks. Severely dehydrated, endotoxic or septicaemic horses are more likely to develop catheter site infections and vascular thrombosis, and so polyurethane would be the material of choice in these cases.

In adult horses, a 14- or 12-gauge catheter is appropriate, while in foals narrower 16- or 14-gauge 'over-the-wire' catheters are the most suitable. 'Over-the-wire' catheters (Figure 1) may not commonly be used in the jugular vein of adult horses, but can be a better choice than 'through-the-needle' catheters when attempting to catheterise the lateral thoracic vein.

Catheter sites

Common sites for catheter placement in horses are the jugular, lateral thoracic, and, occasionally, cephalic veins. Catheter sites must be clipped and aseptically prepared prior to insertion. Once in place the catheter site must be managed aseptically and inspected daily for signs of infection or thrombophlebitis.

It is not necessary to cover the catheter site in adult horses; but in foals, especially recumbent ones, bandaging helps to protect it and prevent intervention by the mare.

Figure 1: 'Over-the-wire' catheter placed in the jugular vein for colloid and crystalloid fluid administration

Catheters should be flushed, generally with 10 iu/ml heparinised saline, at least every six hours when not being used for intravenous fluid administration. When injecting drugs through the catheter, the injection cap should be swabbed with alcohol prior to needle insertion.

Administration sets

Long, flexible fluid lines are necessary in ambulatory adult horses moving about the stable. Coiled sets are especially good for this, although rolling or continual box walking can twist, occlude or disconnect the administration set.

Mares can get tangled in – or interfere with – foal administration sets, and so alternatives to gravity feed administration sets include pressurised back packs that can be fitted to a foal holding a 1 litre fluid bag, providing a continuous flow of up to 250ml per hour.

Alternatively, fluids can be pulsed to foals at 1 litre over 15 minutes at intervals of two to four hours. This method is not as desirable as continuous rate fluid administration, but is safe and convenient in most ambulatory foals.

Rate of administration

'Shock' dose fluid rates are rarely achievable or warranted in adult horses. A gravity-fed fluid system and a 14- or 12-gauge catheter generally produce maximum flow of approximately 10 litres per hour. The use of a peristaltic pump can increase this to 20 litres per hour. However, the horse must be monitored carefully, as a peristaltic pump will continue to force air into the vein if the bag empties.

The rate of fluid administration should be based on the estimation of the requirements for the next 24 hours. This will include an estimation of the current fluid deficit (% dehydration), an estimate of the ongoing losses (such as diarrhoea or reflux) and a calculation of the maintenance fluid requirement.

The maintenance fluid rate for adults is 50ml/kg/day, whereas it is 80-100ml/kg/day in foals, because their extracellular fluid (ECF) compartment is proportionally almost twice that of an adult horse. Estimating the fluid deficit is sometimes difficult and no one measurement is wholly accurate. Blood lactate measurement will accurately indicate hypovolaemia, with a value of >2.5mmol/l, suggesting inadequate circulating plasma volume. It does not, however, indicate the severity of the hypovolaemia.

TABLE 1 Estimation of dehydration based on clinical parameters

Dehydration	Skin tent (seconds)	Capillary refill (seconds)	Heart rate (beats/minute)	Pulse strength (beats/minute)	PCV/TP (%/g/l)
5%	1-3	<2	40-50	Normal	40/70
8%	3-5	2-3	51-70	Weak	45/75
10%	>5	>4	71-100	Very Weak	50/80
12%	>5	>4	>100	Not Palpable	>50/>80

Other clinical parameters that can be used to estimate dehydration are listed in Table 1. Taken as a group, they can give a semi-quantitative estimate of the fluid deficit.

Ongoing fluid losses can sometimes be measured in the case of nasogastric reflux, but it must be estimated. Monitoring of blood lactate and the parameters in Table1 can be used to determine if the administered fluid volume is counteracting the ongoing losses.

Such monitoring and re-evaluation should be done at least twice a day when patients are on intravenous fluids, and more frequently (every six hours) when there is severe cardiovascular compromise.

Intravenous fluid types

There are two distinct fluid requirements: the need for immediate plasma volume and electrolyte replacement (resuscitation fluid therapy); and the need to maintain the whole body hydration and electrolyte composition over time (maintenance fluid therapy).

Resuscitation fluid therapy involves the rapid administration of solutions that have a similar composition to plasma, whereas maintenance fluid therapy involves slower infusions of solutions that maintain both intracellular and extracellular fluid space electrolyte concentrations.

Resuscitation fluids

These may take the form of isotonic crystalloids, hypertonic crystalloids or colloids. The choice of which one to use depends on the need for plasma expansion versus rehydration, the need for rapid plasma expansion and whether or not there has been a loss of plasma protein from the body.

Isotonic crystalloids such as 0.9 per cent saline and Hartmann's solution, immediately reconstitute the circulating volume, but are redistributed throughout the entire extracellular compartment within a matter of minutes. Since the ECF volume is three times that of blood, three times as much must be administered in order to gain the desired plasma volume expansion.

Hypertonic crystalloids (7.2 per cent saline) draw fluid by osmosis from the interstitial space into the circulating plasma. This effect is rapid, making this a suitable plasma expander for pre-operative colics or acute colitis cases (Figure 2). However, the plasma expansion gained in this fashion

Figure 2: Rapid administration of hypertonic saline to a horse to expand plasma volume prior to induction for colic surgery

relatively short lived, lasting only hours. If isotonic fluids are administered following hypertonic saline, then the plasma expansion can be maintained.

A standard protocol would be to administer 4ml/kg of 7.2 per cent hypertonic saline as rapidly as possible, followed by at least 30ml/kg of isotonic fluids over the following three to six hours.

Plasma is used in cases of hypoproteinaemia to maintain oncotic pressure and retain fluid in the vascular space. High rates of crystalloid fluid administration will lead to interstitial oedema in horses that are hypoalbuminaemic (<20g/l).

Whenever the PCV per cent is numerically higher than the total plasma protein concentration in g/l, then we must consider using plasma or a synthetic colloid to expand plasma volume. If you decide to give a plasma transfusion then give 8-10ml/kg as a single infusion – 4 litres in a 500kg horse. There is little merit in giving a 500kg horse one litre of plasma each day.

Colloids are synthetic fluids that contain a molecule which can exert oncotic pressure. Their disadvantages compared to plasma are that they do redistribute – although much slower than crystalloids; and that they lack other proteins, such as fibrinogen, which may be beneficial if clotting is impaired.

The advantage of colloids is that they are easy to store and are considerably less expensive than plasma. One of the commonly used synthetic colloids is Hetastarch 6 per cent, which is administered at 10ml/kg.

Maintenance fluids

The difference between resuscitation and maintenance electrolyte requirements lies largely in the different compositions of the extracellular fluid and intracellular fluid (ICF) (Table 2).

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Potassium is present at a 30 times higher concentration in the ICF than the ECF, and the ICF is twice the volume of the ECF. Therefore, many anorexic horses on low potassium intravenous fluids become hypokalaemic within three days, especially when there is concurrent diarrhoea or gastrointestinal reflux.

Hypocalcaemia may also develop during acute anorexia, and deficits in calcium may have profound effects on muscle function, cardiac output and intestinal motility. Since both low plasma potassium and calcium concentrations have a negative effect on intestinal motility, the need to maintain normal body potassium and calcium ion concentrations may be beneficial in the medical support of postoperative colics.

Tailoring fluids

Hartmann's solution may be administered rapidly in cases where restoration of plasma volume is essential, or it can be supplemented with electrolytes to render a suitable maintenance fluid.

The addition of potassium at 20mmol/l to Hartmann's provides enough potassium for a horse's requirements, while still being safe to administer at 5-10 times maintenance fluid rates in cases with normal renal function. The maximum safe infusion rate for potassium is 0.5mmol/kg/h.

Since anorexic horses on maintenance fluid rates of Hartmann's solution frequently become hypocalcaemic, calcium may be added to Hartmann's at 0.3g/l (7.5 mmol/l). However, blood calcium levels should be monitored to ensure that patients do not become hypercalcaemic when on high maintenance fluid rates.

TABLE 2 Concentrations of common electrolytes in ECF and ICF spaces

Electrolyte	ECF (mmol/l)	ICF (mmol/l)
Na^+	142	10
K^+	4	140
CL^-	103	4
HCO_3^-	228	10
Ca^{2+}	2.4	0.0001
Mg^{2+}	1.2	58

Specific fluids for specific disorders

In certain acute cases, sodium-rich rather than potassium-rich intravenous fluids are warranted. For example, in foals with a ruptured bladder, administration of 0.9 per cent – or even 1.8 per cent saline – is beneficial to lower the plasma potassium levels and risk of cardiac arrhythmia prior to anaesthesia.

Likewise, in cases of hyperkalaemic periodic paralysis, the administration of even low concentration potassium fluids can have a negative effect on treatment. Also in an exhausted horse, the administration of 0.9 per cent saline can help counteract the metabolic alkalosis that often accompanies this syndrome.

Conclusion

A key factor in intravenous fluid therapy is assessing and reassessing the patient to determine their fluid and electrolyte requirements. We can then to produce an appropriate formulation and administration rate, tailored to the individual needs of the patient, rather than relying on commercial preparations designed for the average patient.

When we change from resuscitation to maintenance fluid rates, we should also think about changing the electrolyte composition of the fluids.

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