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CARDIOVASCULAR SUPPORT

Like pre-operative care, there is a growing body of evidence from human medicine that optimising cardiovascular support after surgery leads to better outcomes.¹ There is no controlled clinical data on post-operative cardiovascular support available for the horse.²

Fluid therapy

Crystalloid therapy is one of the mainstays of post-operative care of the colic patient. For vets, one of our main approaches to these patients is one of convenience. We choose fluid formulations that are available in five litre bags (rather than only in one litre bags), namely polyionic resuscitation formulas such as lactated Ringer’s solution or Normosol-R. Although this therapy is suitable for a number of patients, it certainly could not be ideal for every patient. In our practice, we attempt to individualise therapy by starting with standard polyionic resuscitation fluids and adding different electrolyte solutions as necessary. It is rare for us to use or make up solutions not based on lactated Ringer’s solution in horses other than neonatal foals after colic surgery. Rarely we will use sodium chloride as the base solution, and this would be more common in weanlings than adult horses. Our rationale to individualise crystalloid therapy is that changes in plasma electrolyte concentrations are very common in horses following surgery for colic. However, it is worth noting that it is rarely possible to associate these electrolyte disturbances with specific clinical signs.

Colloids have a role in post-operative fluid therapy, particularly when there is peripheral oedema or a low plasma total solids concentration.² Low plasma protein concentrations are particularly prevalent in horses after correction of strangulating lesions of the large intestine.² It is important to remember that hydroxyethyl starches interfere with coagulation, particularly at higher doses.³ The total daily dose of hetastarch should be limited to 10 ml/kg to avoid this complication. For pentastarch and tetrastarch, the maximum dose depends on the exact formulation, but is around 15 ml/kg/day.

Generally, I have reduced the length of time that I maintain horses on intravenous fluid therapy after surgery, especially for simple displacements. In the practice I joined in 2006, the reduction in fluid use meant that bills for surgical colic patients decreased, despite more intensive monitoring and blood sampling (and this did not include the cost and labour of constantly replacing urine-soaked shavings in the stalls!). In many horses, we use intermittent nasogastric fluids to maintain good hydration of the gastrointestinal contents, after we have stopped fluid therapy.

Inotropes and pressors

Standard practice for animals which are severely hypotensive on the table involves administration of fluids and dobutamine with or without a vasopressor (usually phenylephrine or norepinephrine).⁴ This support is then discontinued as the horse moves off the table into the recovery room. This support is given for two reasons: one is to offset the negative car-
diovascular effects of endotoxaemia/SIRS and the other is to offset the negative cardiovascu-
lar effects of inhalation anaesthesia. Neither
of these negative effects ends as the horse is
moved to the recovery room, which also coin-
cides with removal of most of our intensive
monitoring.
There are many practical reasons why this
is standard practice. As the animal begins to
move, it is very hard to maintain a drip and
monitoring. We have maintained fluids, in-
otropes and pressors during the initial stages
of recovery, at the infusion rates that we have
been giving at the end of surgery. However,
when the animal begins to make attempts to
stand, we have not found a safe way to main-
tain the infusion.
Following recovery, we have used low dose
dobutamine (0.5–2 mcg/kg/min) in an at-
tempt to improve splanchnic perfusion. At
the higher end of this infusion rate, we have
seen significant hypertension in a proportion
of patients.
Fenoldopam is a specific vasodilator of the
splanchnic, renal, coronary and cerebral vas-
culatures.5 It is possible that this drug might
protect the splanchnic circulation after colic
surgery, and it would be interesting to investi-
gate. Unfortunately, its current cost precludes
its use in adult horses.

**PARENTERAL NUTRITION**

Parenteral nutrition has been proposed for post-
operative colic patients, to prevent the negative
energy balance associated with feed with-hold-
ing in the initial post-operative period.6,8
In adult horses with gastric reflux, ileus, oe-
sophageal obstruction and anorexia, parenteral
nutrition should be considered if the interrup-
tion to enteral feeding is predicted to last at
least three days.9 The use of parenteral nutrition
may be especially indicated in acute protein
losing enteropathy, where its use may prolong
the oncotic effects of exogenously adminis-
tered plasma, possibly by preventing plasma al-
bumin from being metabolised for energy.
Total parenteral nutrition solutions commonly
consist of dextrose, amino acids, lipids and a
vitamin/mineral mix. The estimated energy re-
quirement of a normal adult horse standing in a
stall is calculated by the equation:10

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\text{Energy requirement (Mcal/day)} = 0.975 + [0.021 \times \text{bodyweight (in kg)}].
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Often partial parenteral nutrition is given to
post-operative patients, rather than attempting
to meet their complete nutritional require-
ments. Supplying 10–15 kcal/kg/day (42–63
kJ/kg/day) in the form of glucose and amino
acids is sufficient to reverse hyperlipaemia.11
This rate is therefore often used in the post-
operative period, to provide energy but not in-
cur excessive costs. The inclusion of lipids in
the nutrition formulation may be unnecessary,
and adds to the expense.
In adult horses, our most common formulation
is 2 L of 50% glucose solution (1) and 1 L of
15% amino acids (2) which we combine in a
fluid bag specifically made for parenteral nutri-
tion (3). Given at 170 ml/hr, this provides 12
kcal/kg/ day (50 kJ/kg/day). This provides 167
non-protein calories per gram of nitrogen. In
our clinic, the cost of this is 219 Euros (=195
UK pounds; =322 US dollars) per day.
Parenteral nutrition should be started at 50% of
the target rate. After four hours, the blood glu-
cose concentration should be measured and the
rate of administration increased to 75% of the
target rate if the blood glucose concentration is
less than 9.5 mmol/l (171 mg/dl). After a fur-
ther four hours and a further blood glucose
concentration determination, the rate of ad-
mministration may be increased to the final tar-
get rate. There are two options if the blood glu-
cose concentration increases above 9.5 mmol/l
(171 mg/dl). First, the rate of infusion can be
reduced and then increased more slowly to al-
low more time for the horse to adapt to the
high glucose load. Second, if the first strategy
is unsuccessful, an insulin infusion may be
started (titrated to the blood glucose concen-
tration from an initial rate of 0.01 to 0.05

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(1) 50% Glucose Intravenous Infusion - Baxter Health-
care, Thetford, Norfolk, UK.
(2) Intrafusin 22 - Fresenius-Kabi AG, Bad Homburg,
Germany.
(3) Freka® Mix + 6 - Fresenius-Kabi AG, Bad Homburg,
Germany.
units/kg/h). If an insulin infusion is used, the blood glucose concentration should be monitored closely and maintained between 4.4 mmol/l (80 mg/dl) and 9.2 mmol/l (165 mg/dl) by adjusting the insulin infusion rate. During TPN infusion (i.e. with lipids), the serum should also be monitored for lipaemia. If there is gross lipaemia, the parenteral nutrition can be formulated with a lower lipid concentration or without lipids. Lipaemia may also respond to an insulin infusion. It is also important to serially monitor plasma electrolytes as hypokalaemia and hypomagnesaemia are common complications. It is my practice to start supplementing potassium (as potassium chloride) at 0.1-0.3 mmol/kg/hr, when parenteral nutrition is started.

When discontinuing parenteral nutrition, it is advisable to decrease the rate of administration over several hours. TPN does not affect appetite in human children and clinical experience suggests that this is also the case in horses. Therefore, it is possible to start feeding whilst decreasing the parenteral nutrition.

REFERENCES