Electrolytes and neonatal parenteral nutrition

Neonates have complex fluid and electrolyte requirements and close attention to fluid and electrolyte balance is essential. This article demonstrates the calculations behind adjusting electrolyte levels in parenteral nutrition solutions, the impact of adjusting infusion rates of such amended infusions and the effect other fluids can have on electrolyte loads.

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Key points

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1. Premature infants can have unstable electrolyte requirements leading to a need to manipulate TPN solutions.
2. TPN solutions are not the only source of electrolytes and other fluids can contribute significantly to the electrolyte load.
3. Changes to drug fluid volumes need to take into account the potential effect on electrolyte load to the infant.

Neonates in special care and intensive care often have a fluid requirement consisting of intravenous (IV) fluids, predominantly parenteral nutrition (PN). However it is not uncommon for many babies to be on complex IV drug regimes which, in addition to the volume potentially compromising nutrition, can impact on the electrolyte load the neonate receives.

These babies often have immature renal function and one manifestation of this is excess secretion of sodium. This can be compensated for by manipulating the PN when it is ordered from the pharmacy Central Intravenous Additive (CIVA) service, but can often require further adjustment outside pharmacy working hours.

Adding extra electrolytes to neonatal PN

Most neonatal intensive care units in the UK have a clinical pharmacy service which includes an input to PN. Regular monitoring enables each patient to have daily PN supplied which is individually tailored to their needs, reducing the need for manipulations to PN bags at ward level. However, situations may still arise where patients require additions to the PN infusion, for example overnight or at weekends, when there may not be a pharmacy CIVA service available and when using ready prepared 'standard' bags or running separate infusions instead of adding to tailored bags may compromise nutrition.

The calculations required to determine what volumes of electrolytes to add to PN can be an area of neonatal practice that prescribers find challenging and errors in calculations have the potential to lead to serious consequences. It is therefore good practice for prescribers to familiarise themselves with these calculations to ensure that they feel competent, particularly as this sort of situation is most likely to arise outside normal working hours, when reduced support is available.

FIGURE 1 Typical neonatal TPN setup with multiple drug infusions.

Example 1 on the next page describes a neonate receiving a set rate of PN providing 3mmol/kg/day of potassium and explains the correct calculation required to work out how much potassium chloride 15% (ie 2mmol/mL) to add to a specific volume of this PN to give 5mmol/kg/day.

Increasing PN rates and the effects on electrolytes

Another issue surrounding neonatal PN, which requires some consideration, occurs

Example 1

Baby weighs 700g (0.7kg)

- Baby currently receives PN at a rate of 5.4mL/hr providing 3mmol/kg/day potassium
- Baby requires 5mmol/kg potassium at the same rate
- How much potassium chloride 15% should be added to a 50mL volume of TPN?

The correct calculation is as follows:

1) *How much potassium does the baby currently receive over 24 hours?*

3mmol/kg of potassium = 3 x 0.7kg = 2.1mmol of potassium per day

2.1mmol is in the total daily volume of PN

Total daily volume (rate mL/hr x 24) = (5.4 x 24) = 130mL

You have 2.1mmol of potassium in 130mL of PN

* 50mL of PN contains (50/130) x 2.1mmol = 0.8mmol of potassium

Therefore you have 0.8mmol of potassium in 50ml of PN fluid.

2) *How much potassium do we want to give?*

Using the same calculations as before:

New daily requirement is 5mmol/kg = 5 x 0.7 = 3.5mmol of potassium per day

Infusion rate remains the same so we require 3.5mmol in 130mL

In 50mL: (50/130) x 3.5 = 1.35mmol potassium

We therefore need to have 1.3mmol* potassium in 50mL PN fluid

Subtraction of the amount of potassium already in the 50mL volume gives us the required addition quantity

1.3mmol – 0.8mmol = 0.5mmol

Need to add 0.5mmol of potassium to 50mL of PN = 0.25mL of KCl 15%

* *It is good practice to round calculations so that the result is a volume of drug that can be accurately measured. For these calculations round down, rather than up.*

This calculation can be repeated for the addition of other electrolytes to PN fluid, eg sodium.

Example 2

Baby weighing 670g (0.67kg) receiving:

- TPN 2.4mL/hr providing 12mmol/kg/day sodium
- Lipid 0.2mL/hr
- Milk 1.5mL/hr
- Insulin 0.2mL/hr
- Heparin 1 unit/mL 0.5mL/hr

Total fluid volume = 4.8mL/hr equivalent to 170mL/kg/day

Following assessment of the baby a provisional diagnosis of possible necrotising enterocolitis (NEC) was made. The decision was taken to stop enteral feeds. Heparin was also stopped at the same time. The PN rate increased to 4.4mL/hr to compensate.

Example 3

PN formed a very small part of the baby's overall fluid total (0.9mL/hr out of a total of 3mL/hr) and contained approximately 0.65mmol/kg/day of sodium.

Other medication comprised:

- Heparin 1 unit/mL infusion 0.5mL/hr
- Dopamine 0.9mL/hr (22.5µg/kg/min)
- Morphine 0.2mL/hr (10 µg/kg/hr)
- Insulin 0.5mL/hr (0.05 units/kg/hr)
- Vancomycin 7mg BD

when the PN rate is increased, to compensate for other IV or enteral fluids being discontinued, in order to maintain a target total fluid volume. When a change in rate is small or the patient is receiving a standard formulation PN bag, the clinical effects on the patient will be minimal. However, if the rate of a bag containing extra electrolytes is significantly increased, this can lead to inadvertent administration of considerably higher amounts of electrolytes, often sodium and/or potassium.

This is of particular concern at weekends when there is often no pharmacy CIVA service and weekend bags commonly require to be prepared based on Friday's prescription. A neonate could, therefore, continue to receive higher amounts of sodium and potassium for 2-3 days before review by a pharmacist and a new bag is ordered. It is therefore important that all healthcare professionals who have an input to neonatal nutrition are aware of this issue, consider the electrolyte content of a PN bag before increasing the rate for any reason and ensure regular U&E levels are checked after any prescription rate change.

In **Example 2**, the changes made to the fluids would result in the amount of sodium being administered to the baby from the PN increasing from 12mmol/kg/day to 22mmol/kg/day due to the increased PN volume, almost double the baby's current requirement. It is worth bearing in mind that if a similar situation occurred in a baby receiving extra potassium, this could have far more serious consequences for the patient.

How much sodium do we actually give to neonates?

For neonates who are receiving PN, adjustment of electrolyte levels is made through adjustment of the PN regimen. **Example 2** shows how an increase in the rate of PN can result in the administration of more sodium than was intended. However, when considering how much sodium a baby is receiving, all their parenteral intake needs to be considered, including drugs and flushes, to give an accurate picture.

Example 3 considers a 24-week gestation, 680g neonate who was on 105mL/kg of fluid daily (3mL/hr) and whose sodium level was 161mmol/L, and was on an upward trend.

TABLE 1 shows the amount of sodium that the baby was actually receiving daily and how a plan was made to reduce this by making fluids up in alternative diluents – 0.225% sodium chloride (NaCl) or 5% glucose.

The volume of fluid for saline flushes is something that is often not considered. We estimated that 0.5mL was being used for each flush, but nursing staff believed that the volume used was closer to 2mL per flush – if correct this would have added a further 3mmol/kg to the sodium total. The pharmacy supplied sufficient flushes to last 24 hours via the CIVA service, each consisting of 0.5mL of 0.18% sodium chloride, ensuring that the volume of sodium administered during these procedures was minimised.

Although the baby was receiving insulin to treat hyperglycaemia the decision was taken to prepare some of the infusions in glucose 5% to reduce sodium load, and adjust blood sugars using the insulin infusion. As a result, the sodium load the baby was receiving was able to be reduced by just over 70%, from 8.8mmoL/kg to 2.4mmoL/kg. With careful management the hypernatraemia resolved. Some other common drugs used in neonatology can also contribute significantly to the sodium load of an infant.

Sodium bicarbonate

The above infant subsequently required a sodium bicarbonate infusion for correction of a metabolic acidosis. This required 3mmol over a 24 hour period – a total of just under 4.5mmol bicarbonate over 24 hours. However, for every mmol of bicarbonate given, a further 1mmol of sodium is also given. In this case it would have been an additional 50% of sodium for the baby, based on the original fluids.

Fluconazole

This is an anti-fungal medicine which is routinely used in neonatal units for prophylaxis of patients on multiple antibiotic regimes. Dosage regimes vary across units but are commonly 6-12mg/kg. This equates to 3-6mL of fluid/kg. The product is presented in a solution of 0.9% sodium chloride. This would have resulted in a sodium load of 0.5-1mmol/kg depending on dosage.

	Sodium (mmol)	Sodium (mmol/kg)	Planned sodium (mmol/kg)
TPN 0.9mL/hr	0.43	0.63	0
Hepsal 0.5mL/hr (0.45% NaCl)	1	1.47	0.75 (0.225% NaCl)
Dopamine 0.9mL/hr (0.45% NaCl)	1.8	2.65	0 (5% Glucose)
Morphine 0.2mL/hr (0.45% NaCl)	0.4	0.59	0 (5% Glucose)
Insulin 0.5mL/hr (0.45% NaCl)	1	1.47	0.75 (0.225% NaCl)
Total	**4.63**	**6.8**	**1.5**
Vancomycin	0.42	0.6	0.6
Flushes for gases 8 x 0.5mL	0.6	0.9	0.18 (0.18% NaCl)
Other antibiotics 2mL 0.9%	0.3	0.45	0.11 (0.225% NaCl)
Total sodium	**6**	**8.8**	**2.4**

TABLE 1 Current and adjusted sodium intake.

Summary

Premature neonates often have unstable electrolyte requirements. This can be addressed by manipulation of intravenous fluids administered to the baby. However, when such changes to IV fluids are made, the potential consequences of rate changes to the quantities of electrolytes being administered need to be taken into account. Other fluids, medicines and flushes the baby is receiving also need to be considered where there are problems maintaining stable electrolyte levels.