North Trent Neonatal Network

North Trent Neonatal Network Clinical Guideline

Title: Fluid and electrolyte management in neonates

Author: Porus Bustani, updated by Dr Catherine Smith

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This clinical guideline has been developed to ensure appropriate evidence based standards of care throughout the North Trent Neonatal Network. The appropriate use and interpretation of this guideline in providing clinical care remains the responsibility of the individual clinician. If there is any doubt discuss with a senior colleague.

Best practice recommendations represent widely used evidence-based practice and high quality standards that all Neonatal Units across the Network should implement. Subsequent suggested recommendations may be put into practice in local units. However, alternative appropriate local guidelines may also exist.

A. Summary page

1. Aims

This guideline aims to provide information on the general management of fluid and electrolyte balance in the newborn infant. The guidance provides a starting point for management on the neonatal unit but clinical status of the infant must also be carefully taken into consideration.

2. Summary of fluid and electrolyte management in neonates

Fluid rates

Age (days)	Birth weight < 1kg	Birth weight 1.0-1.5kg	Birth weight >1.5kg
1	Commence at 80 ml/kg/day See section below for further details	80 ml/kg/day	60 ml/kg/day
2		100 ml/kg/day	80 ml/kg/day
3		120 ml/kg/day	100 ml/kg/day
4		150 ml/kg/day	120 ml/kg/day
5		150 ml/kg/day	150 ml/kg/day

For infants of birth weight < 1000g

- Nurse in 80-85% humidity as directed by NTNN Humidification guideline (in progress).
- Start fluids at 80 ml/kg/day and adjust according to clinical status plus U&Es. Use sodium as a guide to hydration during the first 48 hours after birth.
- These infants should have U+Es on admission and subsequently 8 to 12 hourly together with calculation of the fluid balance for the first 48-72 hours.
- Use birth weight as the infant's working weight for the first 2 weeks of life. Thereafter, allow a maximum increase in working weight of 10% per week whilst the infant is receiving intensive care.

Type of fluid

Intravenous: Glucose 10% is the first choice
Intra-arterial: Heparinised 0.45% sodium chloride at 0.5mL/hr
(NB: 1 unit heparin per mL of fluid)

Monitoring requirements

High-risk infants: 12hrly U&Es, daily weights if feasible, urinary SGs daily.

Stable infants on IV fluids: Daily U&Es, twice weekly weights.

Stable infants on TPN: Check U&Es 2-3 x/week, twice weekly weights.

Stable infants on oral feeds: Weekly U&E's, twice-weekly weights.

Electrolyte replacement therapy

- First 48 hours
  No electrolyte requirements necessary. Plain glucose 10% only is adequate
- Sodium balance
  Normal range 135-145 mmol/L (NB. Acceptable range = 133-145)
- Potassium balance
  Normal range 3.5 - 5.5 mmol/L
- Calcium balance
  Normal range 2.0 - 2.5 mmol/L

B. Full guideline

1. Background

The newborn body consists mainly of water. At 16 weeks gestation water composes approximately 90% of body weight, reducing to 75% at term. Electrolyte imbalance can be a significant problem during the neonatal period.

2. Aim

This guideline aims to provide information on the general management of fluid and electrolyte balance in the newborn infant. The guidance provides a starting point for management on the neonatal unit but clinical status of the infant must also be carefully taken into consideration.

3. Areas outside remit if applicable

- Specialist management of fluid and electrolytes in individual conditions

4. Evidence

4.1 Fluids

4.1.1 Fluid replacement

The following tables give suggested figures for replacement volumes in the first few days of life. They are not absolute and the clinical status of the infant should be carefully considered when evaluating their fluid requirements.

Age (days)	Birth weight < 1kg	Birth weight 1.0-1.5kg	Birth weight >1.5kg
1	Commence at 80 ml/kg/day See section below for further details	80 ml/kg/day	60 ml/kg/day
2		100 ml/kg/day	80 ml/kg/day
3		120 ml/kg/day	100 ml/kg/day
4		150 ml/kg/day	120 ml/kg/day
5		150 ml/kg/day	150 ml/kg/day

4.1.2 Fluid replacement in infants <1kg

- Nurse in 80-85% humidity
- Start at 80 mL/kg/day and adjust according to clinical status and U&E results
- Check U&Es on admission to the NNU
- Monitor U&Es 8-12 hourly, together with calculation of fluid balance for the first 48-72 hours. Adjust fluid requirements accordingly.
- A table of daily fluid requirements is not included as it may be misleading

These infants may very occasionally require 200 mL/kg/day or more within 48 hours of birth. They require much stricter fluid balance management than larger babies. Large volumes may be required early on but once stable, requirements may need to be adjusted to a more appropriate level (e.g. 120 to 175 mL/kg) to avoid fluid overload.

As weight loss occurs during the first week, use the birth weight for the first two weeks of life. Failure to lose this weight and conversely to gain weight in the early days of life is considered pathological and evidence suggests there is an increased rate of PDA, NEC and CLD in these fluid overloaded infants

After two weeks of age, only allow the working weight to increase by 10% per week if the infant is receiving intensive care. An exception to this (at consultant discretion) is the mature IUGR infant who may accrue true weight more quickly. It is only by 10 days that infants may return to birth weight and thereafter surpass this weight. Thereafter, infants gaining solid weight will probably gain no more than 15g/kg/day equivalent to 10% of their weight.

Once full feeds are established, babies <1.5kg should be increased to 180mL/kg/day of milk (volume does not apply to water/glucose/other).

4.1.3 Type of fluid

Glucose 10% is the first choice.

If Blood glucose >11 and glycosuria++:

- calculate glucose rate; if >10mg/kg/min then decrease to 5% dextrose
- If <10mg/kg/min and hyperglycaemia maintained, then commence insulin and look for cause
- For infants on insulin infusions, monitor potassium and phosphate levels as both can fall

If Blood glucose <2.5mmol/l

- Give 2 ml/kg glucose 10% as IV bolus and increase fluids by 30%
- If no response after 1 incremental increase, change to glucose 12.5% solution
- If still problematic increase to 15% (NB: This MUST be given via central line)
- Refer to Hypoglycaemia guideline

Electrolytes are not routinely given in the first 48 hours, and may be associated with worse long-term outcomes. Avoid unless specific clinical problems- see Electrolytes section

Intra-arterial

- Give heparinised sodium chloride 0.45% (NB: 1 unit heparin per mL of fluid)
- Arterial fluids should be infused at 0.5 mL/hour. This may need to be increased to 1mL/hour for peripheral arterial lines to prevent occlusion.

4.1.4 Assessment of fluid balance

Although the tables above may give an indication to fluid volumes necessary, it is important the clinician tailors requirements to the individual infants needs

When assessing fluid needs remember: -

- When calculating fluid volumes take into account all infusions (i.e., IA, long lines, UVC, UAC, TPN, drug infusions, etc.)
- All infants on intravenous fluids need regular clinical and biochemical assessment

4.1.5 Monitoring requirements

High-risk infants (e.g. ELBW, severe HIE, major surgical pathology, renal failure) require: -

- Blood taken during the first 12hours and then at least 12 hourly for U & Es, phosphate, serum osmolarity, pH and B.E. for the first 48 hours. Subsequently, daily blood sampling assuming they are stable.
- Urinary specific gravity daily
- Close monitoring of fluid losses, especially urine output. Measurement of NG losses (especially post GI surgery) and excessive lower GI losses should also be considered.
- Be aware of insensible losses and other environmental factors (e.g. phototherapy, radiant warmers, humidity)
- In high-risk infants fluid balance should be re-assessed 6 hourly
- Ideally weight should be checked daily in order to help monitor fluid balance
- Urinary catheterisation may be necessary if output is uncertain

Once stable:

- Infants on iv fluids require daily U&Es
- Infants on a stable TPN prescription require U&Es to be monitored 2-3 times/week
- Continue to monitor urine output and other losses until no longer clinically indicated
- Twice weekly weights until discharge

4.1.6 Acceptable/normal fluid losses

Urine output	1-2 mL/kg/hour
Stool losses	5-10 mL/kg/day depending on gestation
NG losses	1 mL/kg/hour
Skin losses	Very variable, dependent on many factors

4.1.7 When to give extra fluids

- Pathophysiological influences, e.g. prematurity, respiratory status, surgical babies (inc. NEC, stomas, obstructed bowel, diarrhoea), excessive urinary losses (inc. renal failure, caffeine, diuretics)
- Iatrogenic influences, e.g. phototherapy, open cot vs. incubator, incubator humidification, heat shields, ventilation with humidified air
- Specific clinical situations:
    - Phototherapy - do not routinely increase fluids, but careful monitoring of fluid balance status as they may require additional fluids e.g. 30mls/kg/day
    - Post-gastrointestinal surgery
        - Infants with gastro-intestinal pathology can undergo severe fluid losses/shifts due to inflammation, stasis, gut resection, etc
        - Close monitoring is essential
        - Replace NG losses with sodium chloride 0.9%
        - Consider potassium replacement if needed
        - Infants may need additional volume replacement

4.1.8 When to restrict fluid input

- Birth asphyxia-consider possible renal impairment and cerebral oedema. Restrict total fluids to 40mL/kg/day for first 48 hours. Liberalisation will then depend upon clinical progress.
- Oliguric renal failure - exclude pre-renal failure as the cause. Assuming cause is intrinsic (e.g. ATN) - Restrict input to insensible losses plus previous 6 hours urine output, to be replaced over following 6 hours. Fluid balance must be re-calculated every 6 hours.

  For example, in the term infant restrict to 40ml/kg/day maintenance fluids (including infusions) and replace preceding 6 hours urine output over the subsequent 6-hour period. More immature infants, particularly those less than 14 days old, have greater insensible losses and therefore will need higher maintenance fluid volumes.

  Example:
    - For 3kg baby with 9ml urine output over the last 6 hours
      40ml/kg/day = 5ml/hr maintenance fluids (including infusions)
      9ml/6 (hours) = 1.5ml/hr replacement of urinary losses
      Total infusion rate for subsequent 6 hours = 6.5ml/hr

- Paralysed infants - third spacing can complicate fluid management

Electrolyte balance

4.2. Sodium balance

Normal range: 135-145 mmol/L (NB. Acceptable range 133-145 mmol/L)
Supplementation should be given to maintain this range

Replacement therapy
First 48 hours - No electrolyte requirements necessary. Plain glucose 10% only is adequate
After 48 hours- Commence electrolyte supplementation as below

Sodium level	*Amount of sodium to add to fluids*
>150	No sodium supplement (look for cause, repeat sample)
145 – 150	0-1 mmol/kg/day (look for cause)
135 – 145	2 mmol/kg/day
130 – 135	3 mmol/kg/day
125 – 130	4-6 mmol/kg/day (look for cause)
<125	Increase as necessary (look for cause, repeat sample)

- If serum values are not returning to normal using the above table, then increase/decrease supplements appropriately
- Remember to exclude inappropriate ADH / fluid overload as the management is different
- Sodium supplements are required even when sodium is in normal range due to maintenance needs. Do not confuse maintenance electrolyte needs for replacement needs.

Notes:
- When estimating sodium requirements work out amount needed as total per day in mmol
- Check amount already being given in other fluids (e.g. sodium chloride in I.A. lines)
- Work out volume of fluid sodium is to be added to, and then calculate equivalent dose that should be added to a 500 mL bag of fluid (i.e. normally add supplements to 500 mL bags of fluid)
- Check concentration of sodium to be added and calculate volume in mL equivalent to required number of mmols
- Ensure infusion with required amount of electrolyte additive is clearly written, and easy to understand
- If Na level >155 or <125 aim to adjust serum levels by less than 10 mmol/day to prevent major fluid shifts

4.2.1 Hypernatraemia

Definition: Na > 145 mmol/L

Causes:
- Dehydration, due to insufficient fluid replacement is most likely
- Other causes include: diabetes insipidus, iatrogenic, high output renal failure, diuretics, and GI losses with abdominal pathology.
- Excessive sodium intake

Management:
- Assess fluid status, based on clinical and laboratory criteria
- Treat any underlying cause
- Cut back sodium supplements as appropriate
- Collect urine for analysis – dipstick for specific gravity and send for urinary electrolyes

CAUTION: When treating hypernatraemia, do not let serum sodium drop by more than 10 mmol/day

4.2.2 Hyponatraemia

Definition: Na<130 mmol/L

Causes:

- Fluid overload e.g. excessive fluid input
- Inappropriate ADH
- Insufficient supplementation
- Sepsis
- Hormonal reasons e.g. congenital adrenal hyperplasia
- Excessive losses e.g. renal tubular losses, GI losses, diuretics
- Hyponatraemia of prematurity probably due to immature renal system

Management:

- Assess infant clinically including a weight
- Urinary electrolytes
- Treat underlying cause
- Give additional supplements as required
- For infants with ongoing stoma losses, check weekly urine sodium

CAUTION: When treating hyponatraemia do not let serum sodium rise by more than 10 mmol/day

4.3 Potassium balance

Normal range: 3.5 – 5.5 mmol/L

Replacement therapy

- Nil required in first 48 hours of life
- From day 3 commence replacement according to table below

Potassium level	*Amount of potassium to add to fluids*
> 5.5	No potassium supplements (look for cause)
4.5 – 5.5	1 mmol/kg/day
3.5 – 4.5	2 mmol/kg/day
2.5 – 3.5	3+ mmol/kg/day
< 2.5	4+ mmol/kg/day (look for cause)

Similar calculations as for sodium supplements should be made when calculating potassium requirements.

4.3.1 Hyperkalaemia

Definition: K > 5.5 mmol/L **Note**: Treatment level >7.5 mmol/L (see NTNN hyperkalaemia guideline in progress)

Causes:

- Haemolysed sample
- Potassium-containing medications
- Excessive administration
- Oliguric renal failure
- Immature distal tubular function

Signs:

- Clinical signs of underlying pathology
- ECG changes include large T waves, increased PR interval

Management (Please refer to hyperkalaemia protocol)

- Check/repeat sample

- Treat underlying cause
- Stop all potassium supplements
- Specific therapy options include:
    - Alkalinisation of serum with sodium bicarbonate 2mmol/kg over 30 minutes – one hour
    - Give calcium chloride 0.5 mmols/kg over at least 10mins under ECG monitoring
    - Calcium resonium 0.3-1mL/kg PR (not for use in preterm infants)
    - Salbutamol infusion 0.1 micrograms/kg/min
    - Glucose and insulin infusion (consultant decision only)
    - Exchange transfusion
    - Peritoneal dialysis

4.3.2 Hypokalaemia

Definition: K < 3.0 mmol/L

Causes:

- Insulin administration
- Fluid overload
- Deficient intake
- Excessive losses

Management:

- Treat underlying pathology
- Give additional supplements

4.4 Calcium balance

Normal range: 2.0 - 2.5 mmol/L
(NB: This is a serum total level, not the range for ionised calcium)

Replacement therapy

- Nil in first 48 hours of life
- Subsequently, calcium is routinely replaced in TPN, but not in peripheral fluids unless there is a clinical reason to do so

Calcium level	*Amount of calcium*
> 2.5	Reduce-discuss with pharmacy
1.5 – 2.5	1.5 mmol/kg/day
< 1.5	Look for cause; discuss with pharmacy

4.4.1 Hypercalcaemia

This is unusual in neonates, and is usually iatrogenic. Discussion with consultant and biochemists may be needed. It rarely causes any clinical problems.

4.4.2 Hypocalcaemia

Definition: Total value of <1.6 mmol/L or ionised value of less than 0.8.

This must, however, be interpreted with care, as it is very dependent on the serum albumin levels. NB. Serum calcium falls by 0.1mmol/L for every 4 g fall in serum albumin. Ionised calcium levels are more reliable than total calcium.

Causes:

- Severely ill infants in the first 24 - 48 hours
- Infants of diabetic mothers

- Exchange transfusion
- Hypovitaminosis D (maternal and fetal)
- High phosphate milks
- Renal failure
- Primary hypoparathyroidism
- Di George syndrome

Signs:
- Jittery, fits, arrhythmias, tetany, heart failure, apnoea

Management:
- Look for and treat underlying pathology
- Ensure adequate supplementation
- Give calcium chloride 0.5mmols/kg over few minutes with ECG control if symptomatic – ideally this should be given by a central route

5. Audit criteria
- Fluid administration on admission

6. References

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C. Appendices

1. Evidence grading

Appendix 1. Grades of recommendation

Grade	
A	Requires at least one meta analysis, systematic review or RCT rated as 1++, and directly applicable to the target population, and demonstrating overall consistency of results
B	Requires a body of evidence including studies rated as 2++, directly applicable to the target population, and demonstrating overall consistency of results; or Extrapolated evidence from studies rated as 1++ or 1+
C	Requires a body of evidence including studies rated as 2+, directly applicable to the target population and demonstrating overall consistency of results; or extrapolated evidence from studies rated as 2++
D	Evidence level 3 or 4; or Extrapolated evidence from studies rated as 2+