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Fluid and Electrolyte Management in Newborns

Standard Operating Procedure (SOP)



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Pediatric (SOP)

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Fluid and Electrolyte Management in Newborns

Term Infants

- Day 1* Give Dextrose 10 % in water at a rate of 60-80 ml/kg/day Neither Na* nor K* supplementation is needed unless unusual body fluid losses are known
- Day 2-7* To modify rate and composition of fluid once tolerance has been established (i.e. urine output of 1-2 ml/kg/hour) (Goals-expected weight loss of 5% body weight, confirmed normal serum electrolyte values, and continued urine output of 2-3 ml/kg/hour)

Specifics of fluid therapy

Infusion fluid volume

- Infusion fluid volume - (Refer Table 1.9 & 1.10)
- Rate of increments-10-20 ml/kg/day
- May increase to 120-160 ml/kg/day by day 7 as tolerated or to meet needs per monitoring

Glucose

- Dextrose 10-12.5 % in water
- To maintain blood glucose level between 2.6 mmol/L to 7 mmol/L

Sodium

- 2-4 m Eq/kg/day
- Usually not required for the first 48 hours of life
- Adjust the sodium intake to keep sodium level normal between 135 and 145 mEq/L
- 0.9 % NS 10 ml = 1.54 mmol or m Eq of Na*
- 1 mmol (m Eq) of Na' = 6.5 ml of normal saline

Potassium

- 1-2 m Eq/kg/day
- Start giving on second or third day of life i.e. only after getting adequate urine output

Nutrition

- Start enteral feedings as soon as possible
- Intravenous fluids are progressively decreased as enteral fluid intake is slowly increased
- Combined fluid intake of-120 ml/kg/day should be maintained

Table 1.9 infusion fluid volume in term infants

Day	Fluid (ml/kg/day)	Glucose (mg/kg/min)
D1	60	4
D2	90	6
D3	120	8
D4	150	10

Preterm Infants

Day 1 During the immediate postnatal period, critically ill premature infants may require volume resuscitation for shock or acidosis.

Day 1-3 Specific fluid therapy

Table 1.10 Infusion fluid volume in preterm infants

Day	<1000 g	1000 - <1500 g	1500 - <2500 g	≥2500 g
1	100	80	60	60
2	120	100	90	90
3	150	130	120	110
4	180	150	150	130
5	180	180	170	150
6	180	180	170	150
7	180	180	170	150

Guide to Fluid Management Chart

Neonatal fluid requirements range widely depending upon environmental conditions body weight and gestation. Use birth weight or the most recent weight whichever is greater.

Glucose

- Dextrose 7.5 to 10 % in water to maintain normal blood glucose level

Sodium - Same as term infants

Potassium - Same as term infants

Day 3-7

- Infusion fluid volume
 - Rate of increments-20-40 ml/kg/day, depending on weight and serum sodium levels

Table 1.11 Insensible water losses

Body Weight	ml/kg/day
>1500g	20 - 25
1250-1500g	40
1000-1250g	55
<1000g	60 - 70

Water losses are affected by many factors: e.g. humidity, phototherapy, type of warmer, respiratory status, skin maturity, renal function, GI losses, etc.

Table 1.12 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, depending on many factors

Note: Calculate Weight as birth weight for first 10days, after which current weight or whichever is greater, is used.

Monitoring of Fluid and Electrolyte Status

Monitoring parameters

A. Body weight

- *Must be recorded daily (Sometimes 2-3 times/ day-i.e. serial weight)*
- *Expected weight loss during the first 3-5 days of life*
 - *10-15% of birth weight (in term)*
 - *15-20% of birth weight (in preterm)*
- *Loss of >20% of birth weight-uncompensated insensible weight loss*
- *Loss of <2% per day in first 4-5 days-Excessive fluid administration*

B. Serum levels

- *Serum hematocrit (Hct), sodium, potassium, blood urea and creatinine*
- *Increase in any of these parameters may indicate inadequate fluid therapy*

C. Accurate fluid intake and output – Essential

- *Methods of urine collections*
Bag collections
 - *Nurse on a dimple plastic sheet and the urine collected with a syringe*
 - *Nurse on cotton wool which is weighed before and after micturition*
- *Urine output <1.0 ml/kg/hour-increase fluid intake*
- *Urine output >3.0 ml/kg/hour-overhydration and need for restriction*

D. General appearance and vital signs

- *Mean arterial blood pressure (MAP)*
- *Heart rate, pulse volume and skin perfusion*
- *Normal capillary refill time is typically less than 3 seconds, and is most reliable on pressing the forehead or sternum*
- *Weight, serum sodium concentration and urine output are the best overall clinical guides to assessing the adequacy of therapy*

- Blood pressure and heart rate should be evaluated in conjunction with capillary refill

Monitoring Requirements

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

- Blood taken during the first 12 hours and then at least 12 hourly for U & E's, serum osmolality, pH and BE for the first 48 hours
- Daily blood sampling assuming they are stable
- Urinary specific gravity daily
- Ensure results are obtained early
- Close monitoring of fluid losses, especially urine output
- In addition, measurement of NG losses (especially post GI surgery) and excessive lower GI losses should be considered
- In high-risk infants fluid balance should be re-assessed 6 hourly, to ensure homeostasis is maintained
- Urinary catheterization may be necessary if output is uncertain

Once stable:

- Infants on Iv fluids require daily U & E's
- Continue to monitor urine output, and other losses until no longer clinically indicated
- Twice weekly weight until no longer clinically indicated

Other Infusion Fluid Calculations and Considerations

Conditions in which fluid restriction should be considered

- Birth asphyxia- Restrict fluids to 2/3" of total for first 48 hours if there is a possibility of renal impairment and cerebral edema
- PDA
- Severe RDS
- Oliguric renal failure
- SIADH

Conditions in which fluid requirement should be increased

- Radiant warmer-Increase fluid 50%-100%
- Phototherapy-Fluid increment of 10-20 ml/kg/day
 - 0.5 ml/kg/hr for weight <1.5 kg
 - 1 ml/kg/h for weight >1.5 kg
- Vomiting and /or diarrhoea:

5% dehydration	Extra -50 ml/kg/day
10% dehydration	Extra-100 ml/kg/day
- Pyrexia: increase fluid intake of 10 ml/kg/ 24 hour for each °C above 37°C

Glucose

- Normal glucose requirement – 6-8 mg/kg/min
- How to increase glucose concentration
 - To make up 5 % D/W to 10 % D/W
 - 5% D/W 100 ml = 5g glucose
 - 50% Glucose 10 ml = 5g
 - Every 100 ml of 5 % D/W + 10 ml of 50 % glucose = 10 % D/W
 - To make up 5% D/W to 7.5% D/W
 - 5% D/W 100 ml = 5g glucose
 - 50% Glucose 5ml = 2.5g
 - Every 100 ml of 5% D/W + 5 ml of 50% glucose = 7.5% D/W
 - To make up 10% D/W to 12.5% D/W
 - 10%D/W 100ml = 10g
 - 50%Glucose 5ml = 2.5g
 - Every 100 ml of 10% D/W+50% Glucose 5 ml = 12.5% D/W

Electrolyte Replacement Therapy

First 48 hours - No electrolyte requirements necessary, Plain glucose 10% only is

Adequate

From Day 3-Commence electrolyte supplementation according to table below

Potassium level (mmol/L)	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)
Sodium level (mmol/L)	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)

Hyponatremia (<130 mmol/L)

Immediate questions

- *Is there any seizure activity? (Usually <120 mEq/L)*
- *How much sodium and free water is the patient receiving? Is there weight gain or weight loss?*
- *What is the urine output?*
- *Are salt-wasting medications being given? e.g. Frusemide*

Consider the causes

- *Excessive fluid administration or retention of free water (most frequent)*
- *Inadequate intake of sodium*
- *Increased losses, e.g. preterm, GI losses, NEC, renal tubular losses*
- *Other causes-SIADH, Sepsis, CAH etc.*

Evaluation

- *Check the weight loss or gain*
- *Check fluid intake and output over 24 hours period*
- *Physical examination-signs of volume overload or dehydration*
- *Lab studies-Serum sodium and osmolality, serum electrolyte, creatinine, total protein, urine spot sodium, osmolality and specific gravity*

Management

- *General rules-always treat the underlying cause*
- *Specific rules*
 - *Volume overload-fluid restriction*
 - *Inadequate intake-supplement sodium*
- *Inadequate sodium intake*
Commence sodium supplementation according to table above OR

(135 mmol/l - Infant's sodium value) x Weight in kg x 0.6 = Total sodium deficit i.e the amount of sodium needed to correct

Only half of this amount is given over 12-24 hours OR

Use of supplemental sodium chloride if the infant is on enteral feeding

- *Emergency measures*
 - *Hypertonic saline solution (IV 3% sodium chloride) if the infant is having seizures*
 - *Half of the total deficit is to be corrected over 12-24 hours*
- *Caution: When treating hyponatremia do not let serum Na* rise by more than 10 mmol/day*
- *Daily requirement of sodium should be maintained if indicated*

Hypernatraemia (>145 mmol/L)

Table 1.13 Hypernatremic dehydration

Mild hypernatraemia:	146-149 mmol/L
Moderate hypernatraemia	150-169 mmol/L (Usually calculated on 7%-8% dehydration)
Severe hypernatraemia	>170 mmol/L (Calculated on 10% or more dehydration)

During Routine Postnatal Examination:

1. Check adequacy of feeding in all exclusively breastfed infants
2. Weigh between 72 and 96 hours-if weight loss is >8% of birth weight. weigh daily or alternate day until discharge to take appropriate action
3. Refer or take action if weight loss is >10% of birth weight or weight loss <10% of birth weight with any signs and symptoms suggestive of hypernatraemic dehydration
(Weight loss % = Weight loss (g)/Birth weight (g) x 100)
Weight loss = Birth weight minus Current weight

Criteria for diagnosis of hypernatremic dehydration

1. Age (3-21 days)
2. Predominantly breastfeeding with little or no supplementation with infant formula or water
3. Loss of weight 10% or more from birth weight
4. Clinical signs and symptoms of dehydration (see below)
5. Serum sodium >150 mmol/L at presentation

Symptoms and signs of hypernatremic dehydration

- Lethargy
- Irritability: fussy or unsettled during breastfeeding
- Prolonged feeding >45 min
- Delayed change from meconium to transitional stools (infrequent bowel openings)
- Demanding <6 feeds in 24 hour
- Reduced urinary frequency/highly colored urine
- Weight loss/Jaundice/Tremor/increased tone
- Fever/Doughy skin
- Seizures (usually during rehydration)
- Fullness of anterior fontanelle
- Physical examination may be unremarkable

NB. Usual signs (sunken fontanelle, reduced skin turgor) of dehydration may be absent

Causes of hypernatraemia

- *Inadequate breastfeeding or underfeeding*
- *Diarrhoea/vomiting/excessive perspiration*
- *improperly prepared formula*
- *Infection and poor feeding*
- *Renal dysplasia/Obstructive uropathy*
- *Osmotic diuresis/Diabetes insipidus*
- *Sodium bicarbonate or Sodium chloride administration*
- *Diuretic phase following acute kidney injury*
- *Excessive insensible losses in extremely premature babies*
- *Idiopathic causes*

Investigations: as indicated

- *U&E*
- *Calcium*
- *Total bilirubin*
- *Blood glucose*
- *CRP*
- *Blood culture*

Management of Hypernatraemic Dehydration

Fluid Therapy-1

Step 1: Emergency phase

- *Restore vascular volume with bolus of 10-20 mL/kg of 0.9% Normal Saline infused over half an hour in a collapsed newborn infant.*

Step 2: Rehydration phase

- *Aim to correct water deficit and sodium excess within 48 hours.*
- *Fluid should be administered evenly for 48 hours (Fluid deficit calculation-see below)*
- *If the newborn infant appears well, Step 1(Emergency phase) is not necessary and slow rehydration at a rate of 100 ml/kg/day can be carried out using expressed breast milk or proprietary milk or a combination of both*
- *If the child is unwell but not in the state of impending shock/shock rehydration should be carried out intravenously using 0.9 % Saline at 100ml/kg/day together with amount of*

deficit evenly for 48 hours provided the plasma glucose concentration remains greater than 2.5 mmol/L. If it is <2.5mmol/L, use 0.45% saline with 5-10% glucose.

- Thereafter oral rehydration with breast milk or artificial milk with cautious increases in volume rates as the plasma sodium concentration decreases to normal levels in the subsequent days.

Fluid deficit calculation (Example)

Birth weight or previous weight 2.98 kg, Weight at presentation 2.30 kg

Weight loss = 680g

Percent weight loss = $680/2980 = 0.228 = 23\%$ (see formula)

Free wafer deficit = weight loss = 680 ml

Fluid Therapy

Step 1: Emergency phase

The baby was given 15 ml/'kg or 40 ml of normal saline as a bolus for 20 to 30 mins.

Step 2: Rehydration phase

Fluid should be administered evenly for 48 hours (5% dextrose/0.45% saline)

Maintenance fluid for 2 days: $100 \text{ ml/kg/d} \times 2.98 \text{ kg} \times 2 \text{ days} = 580 \text{ ml}$

Maintenance + deficit = $580 \text{ ml} + 680 \text{ ml} = 1260 \text{ ml}$ and take initial hydration fluid (Step 1) out of this

$1260 - 40 \text{ ml} = 1220 \text{ ml}$

$1220 \text{ ml}/48 \text{ hour} = 25.4 \text{ ml/hr}$ of 5% dextrose/0.45% normal

Fluid Therapy-2

If birth weight or the previous weight is not known, fluid deficit may be calculated on percentage of dehydration at presentation together with daily maintenance requirement for 2 or 3 days.

(Daily requirement x 2 days) + % of dehydration

5% = 50 ml /kg/day

10% = 100 ml kg/day

15% = 150 ml/kg/day

Fluid deficit (ml) = Percentage of dehydration x Body weight x 10

e.g. Fluid deficit for 10% dehydration in 3 kg newbron

$10 \times 3 \times 10 = 300$

e.g. Day 7 with 10% dehydration at presentation: current weight 3 kg

Fluid deficit calculation

Daily requirement 100 ml/kg/day for 2 days = $100 \times 3 \times 2 = 600 \text{ ml}$

10% dehydration = $100 \text{ m/kg/day} = 100 \times 3 = 300 \text{ ml}$

Total fluid = 900 ml

i.e. to be given evenly for 48 hours (19 ml/hr)

Management of Hypernatremic Dehydration Algorithm-1

Symptoms/signs of Dehydration or Clinical suspicion of Hypernatraemia

Indications for serum sodium measurement :

- Wt loss >10%
- Wt loss 8-10% with either S/S dehydration or "not looking well"

Send blood for U&E if available

Mild hypernatraemia
(146-149 mmol/L)

Manage in postnatal ward

- Put baby to the breast and encourage mother to express breast milk (EBM)
- Top up baby with EBM/formula milk 100 mL/kg/day by cup or spoon or syringe
- Check U&E after 12 hr
- Check blood glucose and calcium
- Aim- to establish breastfeeding and reduce top-up once BM alone is sufficient
- If Na⁺ returns to normal before sufficient BM, liberalise feeds calculated according to local guideline

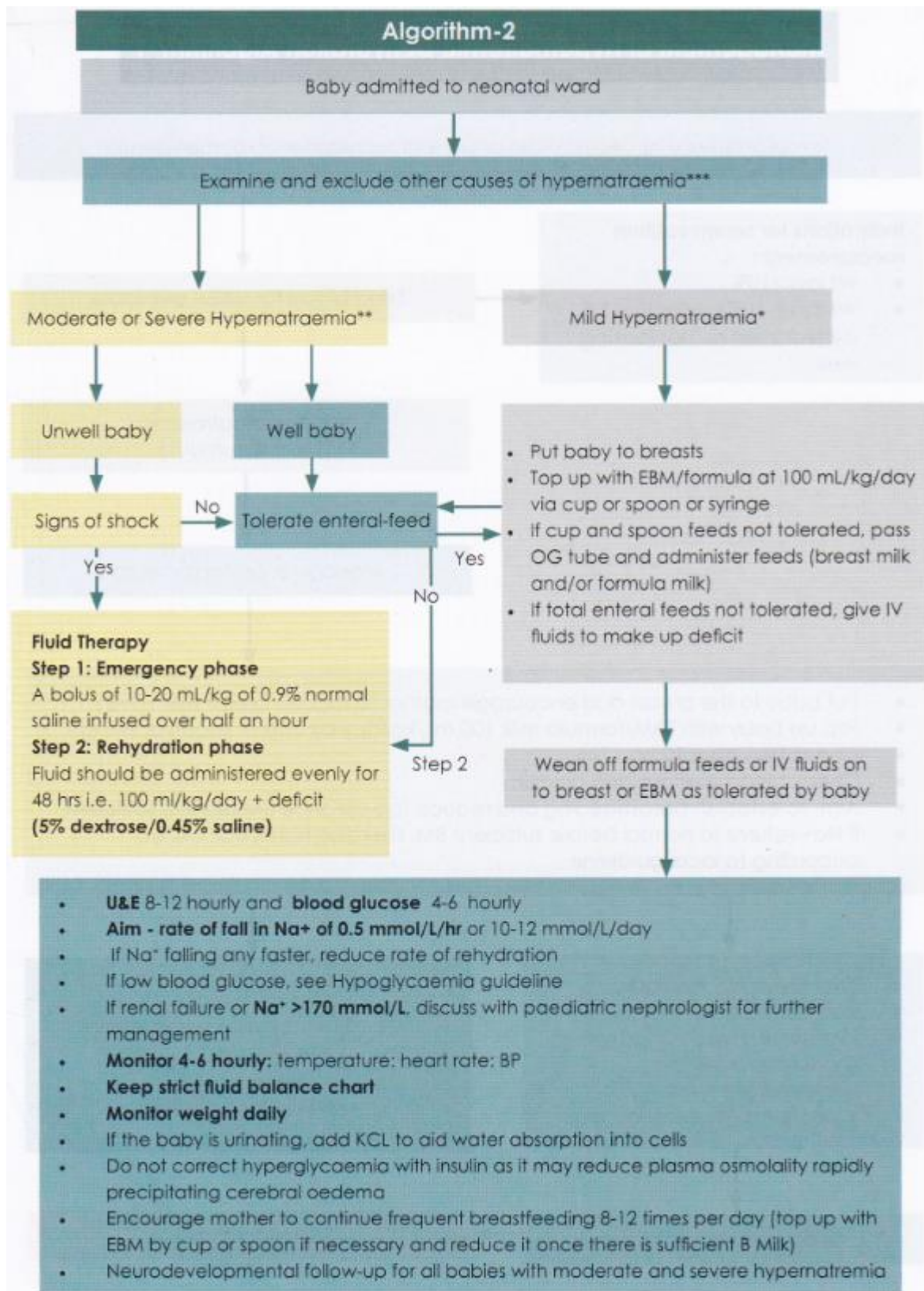
- Oral feeds not tolerated
- Baby unwell
- Worsening hypernatraemia or moderate or severe hypernatraemia
- Associated hypocalcaemia

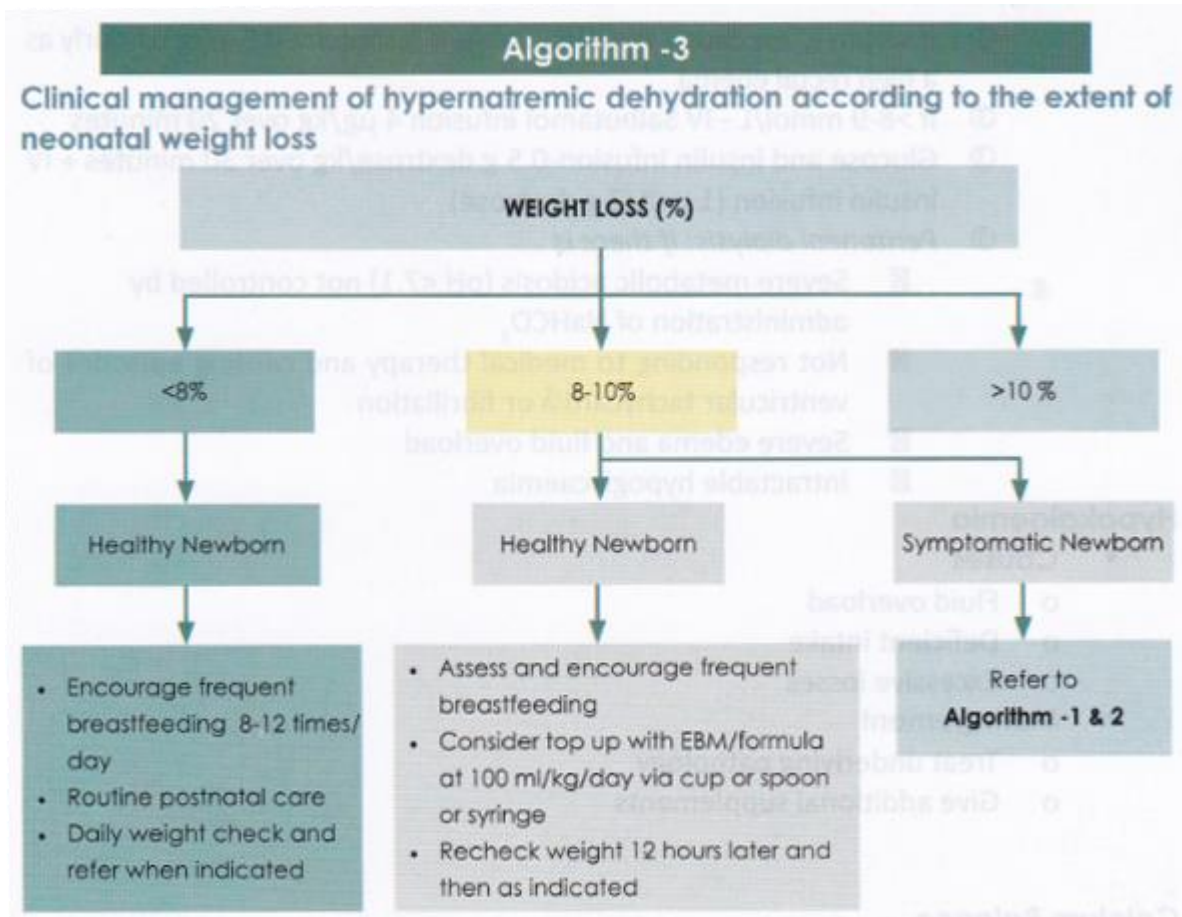
Baby improving

- Continue routine postnatal care
- Encourage frequent BF
- Daily wt check
- Repeat U & E as indicated

Admit to neonatal ward

See Algorithm-2





Hyperkalaemia (>5.5 mmol/L)

- Treatment level >7.5 mmol/l
- 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
 - Check/repeat sample
 - Treat underlying cause
 - Stop all Potassium supplements
 - Specific therapeutic options include
 - ③ Alkalinization of serum with 4.2% sodium bicarbonate 2 mmol/kg over 5-10 minutes with ECG monitoring

- ③ Give 10% calcium gluconate 2 ml/kg IV over at least 10 minutes
- ③ If serum K⁺ exceeds 7 mmol/L, Calcium resonium-0.5 g/kg 6 hourly as a high rectal enema
- ③ If >8-9 mmol/L-IV Salbutamol infusion 4 ug/kg over 20 minutes
- ③ Glucose and insulin infusion-0.5 g dextrose/kg over 30 minutes + IV insulin infusion (1 unit/3 g dextrose)
- ③ Peritoneal dialysis: if there is
 - ❖ Severe metabolic acidosis (pH <7.1) not controlled by administration of NaHCO₂
 - ❖ Not responding to medical therapy and causing episodes of ventricular tachycardia or fibrillation
 - ❖ Severe edema and fluid overload
 - ❖ Intractable hypoglycaemia

Hypokalaemia

- Causes
 - Fluid overload
 - Deficient intake
 - Excessive losses
- Management
 - Treat underlying pathology
 - Give additional supplements

Calcium Balance

- Normal range 2.0-2.5 mmol/L (NB: This is a serum total level, not the range for ionized 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 clinical reason to do so

Calcium level (mmol/L)	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

Hypercalcaemia

- This is unusual in neonates, and usually iatrogenic
- It rarely causes any clinical problems

Hypocalcaemia

- 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 Ca^{++} falls by 0.1 mmol/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 transfusions
 - Hypovitaminosis D (maternal and fetal)
 - 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 0.5 mmol/kg over few minutes with ECG control if symptomatic