Fluid & Electrolyte Balances in Term & Preterm Infants

JAMAICAN PAEDIATRIC NEPHROLOGY WORKSHOP 2018

Carolyn Abitbol, M.D.
University of Miami/
Holtz Children's Hospital

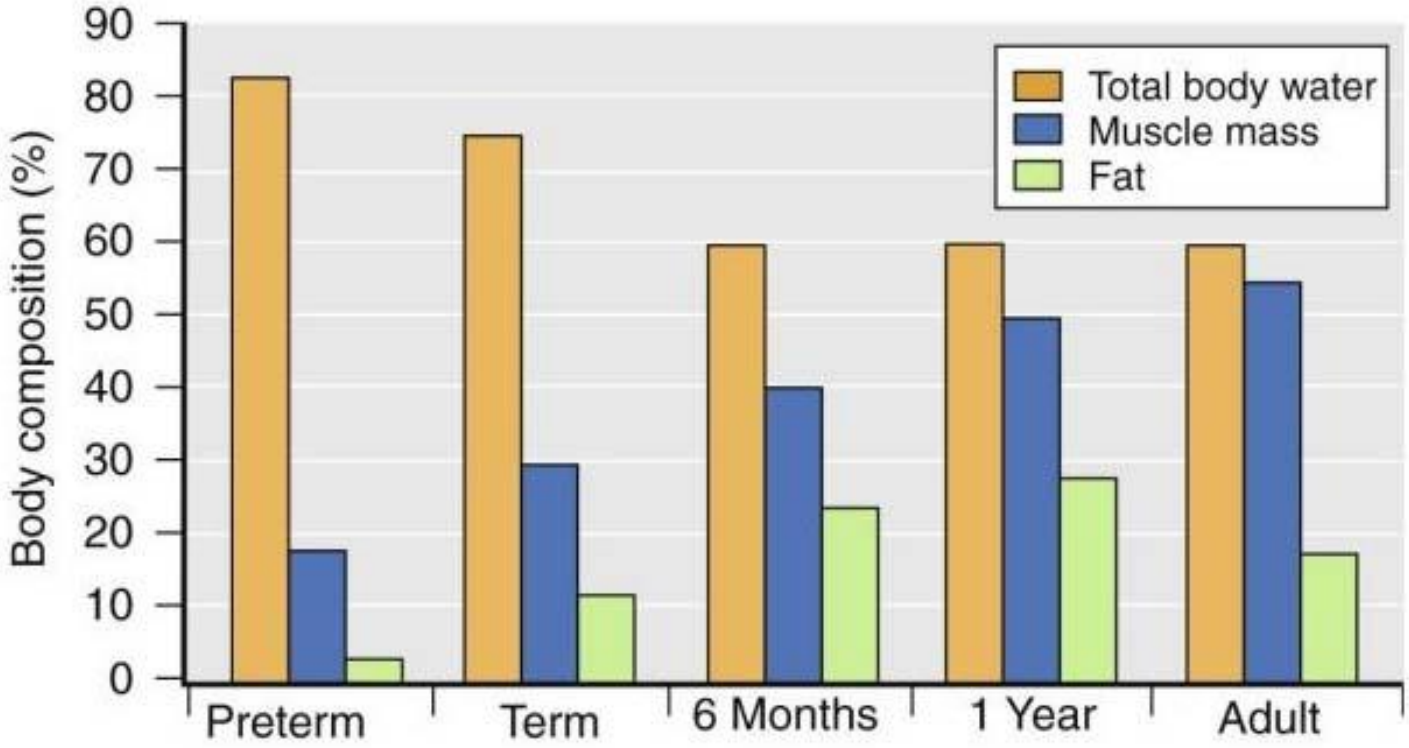
Objectives

- Review maintenance fluid & electrolyte requirements in neonates
- Discuss global guidelines in fluid and oral & parenteral nutritional therapies
- Treatment protocols for common electrolyte deviations
  - Hyponatremia
  - Hypernatremia
  - Bone, mineral, renal dynamic
- Summarize progressive fluid & nutritional therapies

NEONATAL PHYSIOLOGY HOW IT IS DIFFERENT???

- All babies are born with an excess of TBW, mainly ECF-
  - Adults have 60% water (20% ECF, 40% ICF)
  - Term neonates have 75% water (40% ECF, 35% ICF)
  - Preterm neonates have more water
    - (23 wks: 90% : 60% ECF, 30% ICF)
- Renal function is only 25 % of an adult
- Urine concentration is low (50 – 800 mOsm/L

DISTRIBUTION OF BODY WATER



Factors affecting insensible water losses in the neonate

- Level of maturity
- Elevated body temperature increases loss by 10%
- Radiant warmer - increased by 50% compared to thermo-neutral with high humidity
- Phototherapy increases losses by 50%
- High ambient or inspired humidity - reduced by 30%
- Double walled isolette or plastic shield reduces losses by 10-30%

GUIDELINES FOR INITIATION AND ADVANCEMENT OF PARENTERAL NUTRITION IN THE NICU

- Early aggressive nutrition in premature infants has been shown to improve growth outcomes, neurodevelopment and resistance to infection.
- Timely intervention with TPN begins with the provision of glucose **as soon as possible after birth**, amino acids within 12 hours and intravenous lipids within 24 hours.
- Newborn infants who do not receive protein have negative nitrogen balance and lose up to 1% of their protein stores daily. Catabolism is a particular problem of the very low birth weight infant who may have minimal nutritional reserves.
- Additionally, recent studies have indicated that when there is a shortage of amino acids, insulin levels fall, resulting in hyperglycemia and hyperkalemia.

Goals for Early Nutritional Therapy

- To minimize the interruption of nutrient delivery and prevent catabolism, especially in premature infants.
- Aggressive use of amino acids to prevent “metabolic shock” that would trigger endogenous glucose production and catabolism. Amino acids stimulate insulin secretion to improve glucose tolerance.
- To attempt to achieve intrauterine growth and nutrient accretion rates in preterm infants.
- To optimize nutritional status to help both term and preterm infants resist the effects of trauma and disease and improve overall morbidity rates and responses to medical and surgical therapy.

Initial Fluid & Electrolyte Requirements

Rationale: **Target Patient:**

- Newly admitted patients <1500 grams
- Newly admitted patients 1500-1800 grams who are NPO for 24 hours
- Term infants NPO >1-2 days or complex surgical patients.

Recipe:

Central & Peripheral Lines: D10W (Dextrose 10g/100mL) + 8.25 g/100mL Neonatal amino acids + 1.5 mEq/100mL Calcium Gluconate

Procedure:

Run @ 1.5 mL/kg/hour

- For example: Birth weight of 500 grams = run at 0.75 ml/hr

- This volume provides 36 ml/kg/day of fluid, a GIR of 2.5 mg/kg/min, 3 g/kg/day of protein and 0.54 mEq/kg/day calcium

- Standard pre-op and post-op IVF for infants with normal hydration and electrolyte balance: **D10W ¼ NS @ ~100-120 ml/kg/day.**

Fluid requirements in the first month of life

Birth Weight	Water Requirements		
DOL	Day 0-2	Day 3-7	Day 8-30
<750	100-200	150-200	120-180
750-1000	80-150	100-150	120-180
1000-1500	60-100	80-150	120-180
>1500	60-80	100-150	120-180

Electrolyte requirements

- Day 1-2
  - Sodium or chloride are not provided in IVF due to high content of these electrolytes in body fluids (unless serum Na <135 mEq/l)
  - Potassium is not added until urinary flow has been established
- Day 3-7
  - Na, K, Cl requirements are about 2-3mEq/kg/day for term infants and 3-5 mEq/kg per day for preterm infants
- After the first week
  - 2-3mEq/kg/day of sodium and chloride are needed

Essentials of Macronutrients

Macronutrients (Protein, Dextrose and Lipids)

- Dextrose: Maximum concentration peripherally = 12%; Central 25%
- Maintain glucose infusion rate (GIR) $\leq$ 12 mg/kg/min for optimal glucose utilization

GIR (mg/kg/min) = (% dextrose X rate in mL/hr ÷ 6 ÷ (wt in kg))

- Protein: Begin with 3 g/kg/day and advance to goal of 3.5-4 g/kg/day. Never begin with < 3g/kg/day since this is the amount delivered in Starter TPN
- Lipids: 0.5-1 g/kg/day is needed to prevent essential fatty acid deficiency (can develop within 72 hours after birth)
  - Advance lipids by 0.5-1 g/kg/day to maximum of 3-3.5 g/kg/day

TPN Macronutrients: Initiation and Advancement Guidelines

		Initiation	Advancement	Goal
Premature Infant < 32 weeks, < 1000 grams	Dextrose (GIR)	4 – 6 mg/kg/min	1 – 2 mg/kg/min	≤ 12 mg/kg/min [c]
	Amino Acids	3 – 3.5 g/kg/d [e]	0.5 - 1g/kg/d	4 g/kg/d
	Lipids	1 g/kg/d	0.5 - 1g/kg/d	3-3.5 g/kg/d [d]
	[a] Non-Protein Calories	40 -50 kcals/kg/d [b]	60 – 70 kcals/kg/d	85 - 95 kcals/kg/d
	Total Calories	50 – 60 kcals/kg/d	70 – 80 kcals/kg/d	90-100 kcals/kg/d
Premature Infant < 32 – 36 weeks, > 1000 grams DOL: 0	Dextrose	4 – 6 mg/kg/min	1 – 2 mg/kg/min	≤ 12 mg/kg/min [c]
	Amino Acids	3 – 3.5 g/kg/d [e]		3.5 g/kg/d
	Lipids	1 g/kg/d	0.5 - 1g/kg/d	3 g/kg/d [d]
	[a] Non-Protein Calories	40 -50 kcals/kg/d [b]	60 – 70 kcals/kg/d	85 - 95 kcals/kg/d
	Total Calories	50 – 60 kcals/kg/d	70 – 80 kcals/kg/d	90-100 kcals/kg/d
Term Infant, > 37 weeks	Dextrose	6 – 8 mg/kg/min	2 – 3 mg/kg/min	≤ 12 mg/kg/min [c]
	Amino Acids	2 – 3 g/kg/d [e]	0.5 - 1g/kg/d	2.5 - 3 g/kg/d
	Lipids	2 g/kg/d	0.5 - 1g/kg/d	2.5 - 3 g/kg/d [d]
	[a] Non-Protein Calories	40 – 50 kcals/kg/d [b]	50 – 60 kcals/kg/d	70 - 80 kcals/kg/d
	Total Calories	50 - 60 kcals/kg/d	60 - 70 kcals/kg/d	80 - 90 kcals/kg/d

LAB MONITORING GUIDELINES FOR PARENTERAL NUTRITION IN THE NICU

	< 1 week of TPN	>1 week of TPN and clinically stable
Electrolytes**	Daily	2x/week
Ca, Mg, Phos	2x/week	1x/week
Glucose	Daily	Every other day
BUN/Cr	Daily-2x/week	1-2x/week
Bilirubin (T/D)	2x/week	1x/week
Triglycerides	As lipids advance	1x/week
Prealbumin	----	Every other week if unable to maximize protein in TPN
Alk Phos	----	Every other week if inadequate calcium/phos in TPN
AST/ALT	----	1x/month

Rationale for monitoring patient groups on parenteral nutrition:

- Electrolyte abnormalities are the most common metabolic complication in infants on IV fluids.
- Premature infants are at risk for hyper and hyponatremia when establishing baseline fluid and electrolyte needs.
- Indirect bilirubin is used to determine need for phototherapy and/or exchange transfusions.
- Hyperkalemia is frequent in VLBW infants.
- BUN and creatinine help to evaluate renal function, hydration and protein status.
- Micropreemies (birth weights <700 grams) and IUGR infants are at increased risk for altered electrolytes.
- Infants receiving parenteral nutrition for >2 weeks are at risk for cholestatic jaundice.
- Infants receiving parenteral nutrition for >2 weeks are at risk for developing metabolic bone disease.

Monitoring fluid and electrolytes

- During the first few days of life
  - Urine output should be about 1-3ml/kg/hour
  - SG of urine 1.008-1.012
  - Wt loss of 5-8% in term and 15% in VLBW infants
  - Monitor serum electrolytes at 8-24 hour intervals
  - Obtain urine electrolytes and creatinine to calculate Fractional excretions
- After the first week
  - weight gain of 20-30gm/day
  - Monitor electrolytes at intervals based on use of TPN

Hyponatremia

- Serum sodium < 130mmol/L
- Early onset in the first week is due to excess free water or increased vasopressin release
  - perinatal asphyxia, respiratory distress, bilateral pneumothoraces, IVH
- Increased free water or suboptimal sodium in formula or IV fluids

Correction of hyponatremia

- Based on sodium deficit X volume of distribution of sodium
- mEq Na needed = (Goal Na-Serum Na) X TBW (60%) X body weight in kg
  - Prevents rapid correction (no more than 0.5 mEq/L/h)
- mEq Na = (140-serum Na) X 0.6 X body weight
- **Avoid hypertonic saline!!**
  - May cause cerebral hemorrhage
- Use the enteral route if at all possible.

Hypernatremia

- Serum sodium > 150mEq/L
- Most often in ELBW infants
  - High rates of insensible water losses and reduced ECF volume
- Treat by reducing sodium administration and increasing free water
- Rapid correction of more than 0.5 mEq/L/h should be avoided. No more than 5 mEq/day!!!
  - causes cerebral edema, seizures, and death
- Calculate free water deficit

CH2O=(Serum Na – Desired serum Na) X4 ml x kg weight

Rapid correction causes cerebral edema, brain hemorrhage, herniation!!!!!

Hyperkalemia

- Serum potassium > 6mEq/L
- Causes
  - renal failure, CAH, IVH, cephalohematoma, hemolysis, excess administration
- EKG- Peaked T waves, flat P waves, increased PR interval, widening of QRS
- Bradycardia, SVT, VT may occur

Treatment of Hyperkalemia

- D/C potassium in IVF
- Reverse the effect of hyperkalemia on the cell membranes
  - infuse 10% Calcium gluconate (100mg/kg/dose)
- Promote movement of K from the ECF into the cells
  - $NaHCO_3$ 1-2 mEq/kg IV over 5-10 min
  - Insulin-0.05 units/kg with 2ml/kg/hr of D10
  - Nebulized Albuterol (β-adrenergic stimulation of K-uptake)
- Furosemide 1mg/kg/dose if there is adequate renal function to increase renal excretion
- Theophylline 3-5 mg/kg iv to promote diuresis
- Kayexalate enema 1-2 gram/kg as ionic resin

ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Calcium, phosphorus and magnesium

W. Mihatsch [a, *], M. Fewtrell [b], O. Goulet [c], C. Molgaard [d], J.-C. Picaud [e], T. Senterre [f], the ESPGHAN/ESPEN/ESPR/CSPEN working group on pediatric parenteral nutrition[1]

Please cite this article in press as: Mihatsch W, et al., ESPGHAN/ESPEN/ESPR/CSPEN guidelines on pediatric parenteral nutrition: Calcium, phosphorus and magnesium, Clinical Nutrition (2018), https://doi.org/10.1016/j.clnu.2018.06.950

Recommendations for calcium, phosphorus, and magnesium intake in newborns and children on parenteral nutrition.

Age	Suggested parenteral intake in mmol (mg)/kg/d		
	Ca	P	Mg
Preterm infants during the first days of life	0.8–2.0 (32–80)	1.0–2.0 (31–62)	0.1–0.2 (2.5–5.0)
Growing premature infants	1.6–3.5 (100–140)	1.6–3.5 (77–108)	0.2–0.3 (5.0–7.5)
0–6 m[a]	0.8–1.5 (30–60)	0.7–1.3 (20–40)	0.1–0.2 (2.4–5)
7–12 m	0.5 (20)	0.5 (15)	0.15 (4)
1–18 y	0.25–0.4 (10–16)	0.2–0.7 (6–22)	0.1 (2.4)

[a] Includes term newborns.

Summary of Fluid & Electrolytes Parenteral Nutrition in the Newborn

- Complex formulas derive from complex physiology and early adaptive mechanism during the newborn period.
- Close monitoring of serum electrolytes, renal function and growth will allow for successful prescribing of parenteral and enteral fluids.
- Careful and prudent correction of electrolyte abnormalities is important for maintaining brain integrity.

IPNA

GREAT CARE FOR LITTLE KIDNEYS, EVERYWHERE