Chapter 10: Fluids, Electrolytes and Parenteral Nutrition (PN)

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General Information

The overall goal for infant nutrition is to mimic in-utero growth rate

- Fetal Growth
  - 24-28 weeks 18 gm/kg/d
  - ≥ 28 weeks 16 gm/kg/d
- From 24 weeks to term; as total body percentage
  - –water decreases from 87 to 71%
  - –protein increases from 8.8 to 12%
  - –fat increases from 1 to 13.1%
- Growth goal for preemie: 15-20 gm/kg/day

Calculation of Fluid Requirements

- Three principals
  1. Maintenance
  2. Replacement of deficit
  3. Replacement of ongoing water loss
- Ongoing water loss
  - –Insensible water loss (IWL)
  - –Urinary loss
  - –Stool loss
  - –Gastric losses
  - –Chest tube/ wound loss
- Insensible Water Loss
  - –Mostly from skin and respiratory tract.
  - –Gestational age is inversely proportional to insensible water loss.
  - –Elevated body temperature, radiant warmer
  - –Gastroschisis, omphalocele, myelomeningocele and phototherapy may increase IWL

Total caloric requirement:

- Enteral feeds ~110-130 kcal/kg/day
- Parenteral nutrition ~90-100 kcal/kg/day
- Combined parenteral and enteral nutrition ~100-120 kcal/kg/day
- Need a minimum of 60 kcal/kg/day + 2.5-3.5 gm/kg/d of protein for positive nitrogen balance

arenteral Fluids and Nutrition

1. Fluid volume:

- Fluid requirement on first day of life
  - Goal is to prevent dehydration, fluid overload and hypoglycemia

Components	Term (ml/kg/d)	Preterm (ml/kg/d)
Maintenance	20	±25
IWL	15	±30
Urine	20	±20
Stool	10	±20
Total	**65**	**±80**

  - Suggested total fluid intake on Day 1 of life

Weight (gm)	< 750	750-1000	1000-2500	>2500
Fluid (ml/kg/d)	80-100	80	60-80	60

- Determining the amount of fluid to be administered as TPN
  - Decide the total daily fluid needed (ml/kg/day)
  - Subtract other drips and IV fluids
  - Subtract enteral feeding volume (if applicable)
  - Example: 1.2kg infant

Total daily fluid = 120 ml/kg/day	rate = 6 ml/hr
UAC present	rate = 1 ml/hr (subtract)
Dopamine drip	rate = 0.5 ml/hr (subtract)
Remaining amount for TPN+fat	rate = 4.5 ml/hr (90 ml/kg/day)

ey points for infants born < 2000 gm:

- For IV fluids
  - Initiate starter PN (D10W + 3% amino acids + heparin) ASAP after birth
  - Starting at 80-100 ml/kg/day will give 2.4-3 gm/kg/day of protein
  - Add fat emulsion within the first 36 hours of life (consult with pharmacist)
  - Transition to custom PN when clinically appropriate (consult with pharmacist)

- Total fluids after first day
  - If normal homeostasis, increase total fluid intake by 20 ml/kg/day until goal of 130-150 ml/kg/d is reached
  - Decrease total fluids if: Signs of CHF, poor urine output, hyponatremia
  - Increase total intake if: Increased urine output, high IWL, hypernatremia
  - Monitor hydration status: body weight, urine output (I/O's), HR, BP, Labs: Electrolytes, urine specific gravity

2. Macronutrients

A. Protein

- Supplied as crystalline amino acids
- Contains 40-50% of essential amino acids (cysteine, taurine, tyrosine, methionine)
  - Goal intake equals:
    - 4 gm/kg/day – infants less than 35 weeks' gestation
    - 3.5 gm/kg/day – infants 35-37 weeks' gestation
    - 3 gm/kg/day – infants greater than 37 weeks' gestation
- Calories = 4 kcal/gm
- Management of metabolic acidosis coincident with TPN
  - Do not exceed 3.5-4 g/kg/day amino acids
  - May need to add acetate 2-3 mEq/kg/day to TPN

B. Fat

- 20% lipid emulsion is used to supply calories from fat
  - Intralipid® consists of soybean oil (with glycerin and egg lecithin)
  - SMOFlipid® consists of soy, MCT, olive and fish oils and is used for infants at increased risk for developing cholestasis
- Calories = 9 kcal/gm (or 2 kcal/ml with 20% fat emulsion)
- Usual maximum is 3 g/kg/day

- Maintain lipid calories ≤ 50%-60% of total calories
- Very small premature infants develop evidence of essential fatty acid deficiency (EFAD) in less than a week
- It is safe to administer in a peripheral IV line
- Areas of concern with the infusion of fat emulsions include:
  - Hyperlipidemia
  - Consider checking TG levels with advancement, particularly in VLBW
  - Cholestasis (increasing direct bili with minimal PO intake): change infant to SMOFlipid product if not already on it.

C. Carbohydrate

- The balance of non-protein calories is provided as IV dextrose
- Calories = 3.4 kcal/gm
- Hepatic glycogen mobilization has been estimated at 4-8 mg/kg/min
- Most neonates requiring PN will tolerate an initial glucose infusion rate (GIR)* of 6-8 mg/kg/min (Dextrose 8.6-11.5 g/kg/d)
- ELBW infants may need lower infusion rates (2-6 mg/kg/min) due to hyperglycemia
- Monitor for hyperglycemia and glucosuria
- Increase dextrose infusion in 1-3 gm/kg/day increments to a goal of 15-18 gm/kg/day (if needing full parenteral nutrition)
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- GIR* (mg/kg/min) = $\frac{\text{Dextrose concentration x rate (ml/hr)}}{\text{6 x weight (kg)}}$
  - D10W has 10gm/100ml
  - Conversion: mg/kg/min x 1.44 = gm/kg/day

3. Electrolytes and Minerals

A. Sodium
- Normal serum level 135-145 mEq/L
- Maintenance sodium requirement = 2-4 mEq/kg/day
- Hypernatremia (Na > 145)
  - Increase total fluid intake by 10-30 ml/kg/d
  - Remove or decrease Na in IVFs
- Hyponatremia (Na < 130)
  - Decrease total fluid intake
  - Increase Na supplement
- Growing preemie may need 5-8 mEq/kg/d Na supplements

B. Chloride
- Normal level 96-110 mEq/L
- Supplement 2-3 mEq/kg/d (balanced with other anions- P and acetate)

C. Potassium
- Normal serum level: 3.5-5.5 mEq/L (higher with hemolyzed specimen)
- Begin supplementing when good urine output and the serum potassium is within normal limits
- Maintenance potassium requirements = 1-2 mEq/kg/day
- Hyperkalemia
  - Tall, peaked T waves, prolonged PR interval, wide QRS
  - Acute treatment-calcium gluconate, + hyperventilation, sodium bicarbonate (1 mEq/kg)
  - Chronic treatment-albuterol, furosemide, insulin + glucose

D. Calcium
- Normal serum level: 6-11 mg/dl
- Ionized Ca: - 0.9-1.5 mmol/L in preemie (3.7-6 mg/dl)
  - 1.15-1.4 mmol/L in term infant (4.5- 5.5 mg/dl)
- Ca accretion in fetus 25 wk-term is 90-120 mg/kg/d
- It is presently impossible to safely provide sufficient calcium in PN solutions to approximate in-utero accretion

- Parenteral supplementation is 2-3 mEq/kg/d
- Limit calcium in peripheral lines (Extravasations can cause tissue necrosis)
- High concentrations of calcium and phosphate in PN may lead to precipitation
- For acute, symptomatic hypocalcemia:

  – 10% calcium gluconate 50-100 mg/kg –

E. Phosphorus
- Normal serum level: 4.5-9 mg/dl
- Parenteral supplement 1- 2 mmol/kg/day
- SGA infants may be severely hypophosphatemic and may need additional supplement

F. Magnesium
- Normal serum level: 1.6-2.2 mg/dl
- A maintenance magnesium requirement is not known but is reported to be 0.2-0.5 mEq/kg/d
- Delay adding if mom was on $MgSO_4$ – assure normal infant Mg level before adding
- May need to remove if infant is anuric.

G. Acetate
- Acetate is rapidly metabolized to bicarbonate and is added to PN solutions when the infant has evidence of metabolic acidosis
- Requirement varies between 0-3 mEq/kg/day
- The amount that can be added to the PN solution is dependent on the amounts of Na+, K+, and phosphorus

4. Vitamins
- Exact intravenous vitamin requirement is not known for premature infants.
- Give 2 ml/kg for babies < 2.5 kg and 5 ml/day for infants ≥ 2.5kg

5. Trace Elements

- Trace elements are provided in the PN solution based on infant need and discretion of the pharmacist ordering the solution
- For short term PN patients, zinc is the only essential agent dosed at 400 mcg/kg/day
- Infants who remain on TPN for > 2 weeks with little enteral intake should have selenium 2 mcg/kg/day added to the TPN solution.

Other Considerations:

A. Peripheral Vein PN
   - Limit calcium
   - Glucose concentrations should not exceed 12.5%
   - Osmolarity should be < 900-1000 mOsm/L

B. Cessation of PN
   - PN infusion is gradually replaced by enteral feedings by decreasing the rate of PN infusion as feedings increase and modifying the composition based on enteral intake
   - Fat emulsion is discontinued when infant is tolerating 80-100 ml/kg/day of enteral feeds and complete cessation of PN when tolerating 100-120 ml/kg/day of enteral feeds. – Refer to feeding guidelines

C. The NICU pharmacist will enter the PN order and a progress note into EPIC daily after consultation with the medical team.

D. Monitoring Parameters
   - Baseline assessments should include serum electrolytes and blood glucose
   - Serum triglyceride should be monitored more closely in extremely low birth weight infant.
   - Infants who are expected to remain on parenteral nutrition ≥ 1 week, or who are severely SGA should have a baseline nutritional panel checked (T/D bilirubin, LFT's (AST, ALT, GGT), Ca+, P, Mg, alkaline phosphatase, triglyceride, albumin, BUN, and creatinine) and repeated at 1-2 week

intervals while continuing to receive parenteral nutrition.

References:

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4. Corkins MR, ed The A.S.P.E.N. Pediatric Nutrition Support Core Curriculum, 2nd Ed, Silver Spring, MD: ASPEN; 2015.