Neonatal Growth and Nutrition Assessment

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Neonatal Grand Rounds
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Disclosures

- None

Objectives

- Distinguish weight classifications at birth and appropriate growth patterns
- Determine optimal macronutrient intake for optimal nutrition
- Determine appropriate vitamin and mineral supplementation
- Evaluate weight gain and evaluate malnutrition status

Nutrition Goals

- Replicate fetal-maternal nutrient accretion
  - Very difficult to achieve but strive to meet accretion as best as possible
- Promote appropriate weight and length gain consistent with intrauterine age
- Achieve appropriate catch up growth when applicable
- Provide adequate protein and other nutrients; replete as needed
- Achieve age appropriate development

Assessing Anthropometrics at Birth

Classification of Birth Weight

- SGA
  - Less than 10%ile
  - Z-score: less than -1.28
- AGA
  - 10-90%ile
  - Z-score: -1.28 to 1.28
- LGA
  - Greater than 90%ile
  - Z-score: greater than 1.28

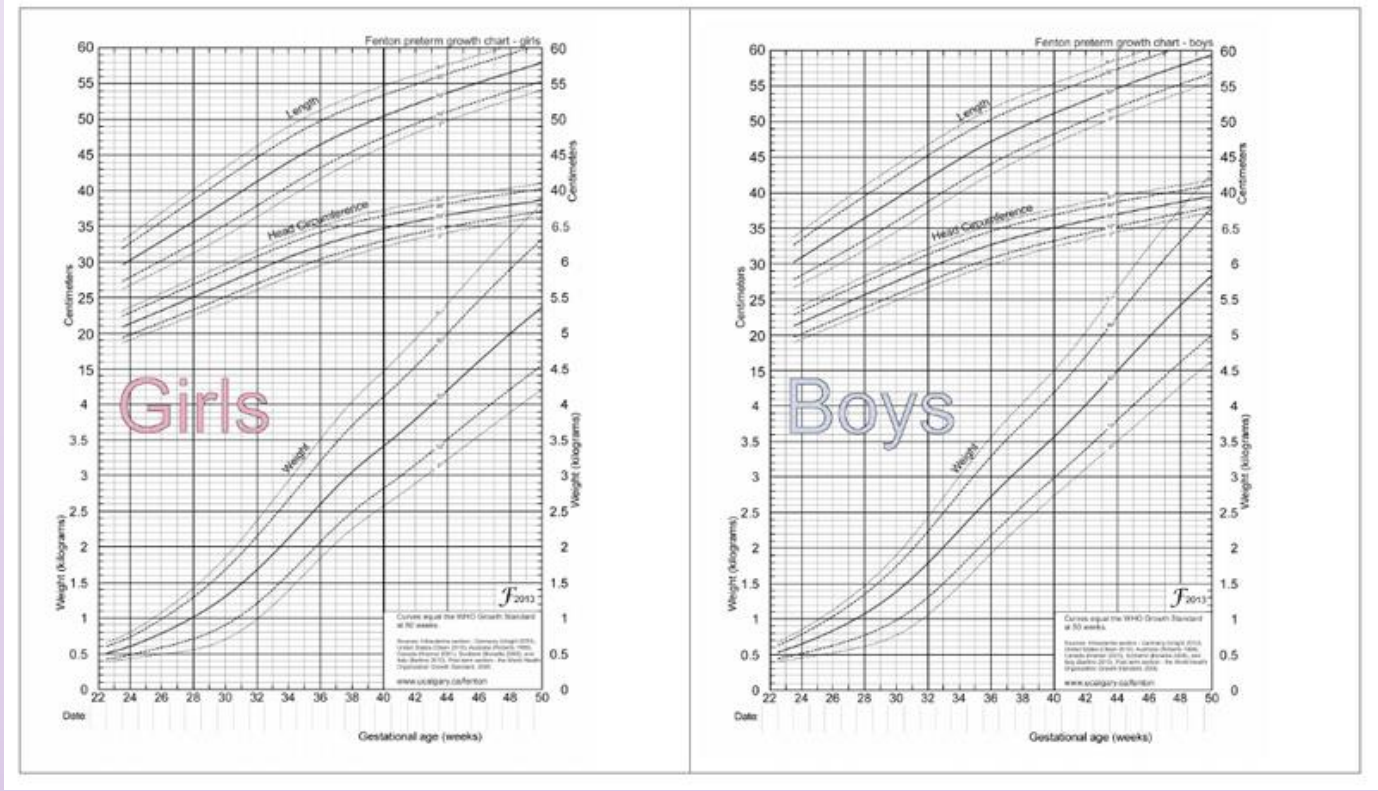
- ELBW
  - <1000gm
- VLBW
  - <1500gm
- LBW
  - <2500gm

Growth Charts

- Preterm/Intrauterine
  - Population: less than 37 weeks
  - Up to 50 weeks CGA
    - Fenton
    - Olson
    - Intergrowth-21

Fenton Growth Chart

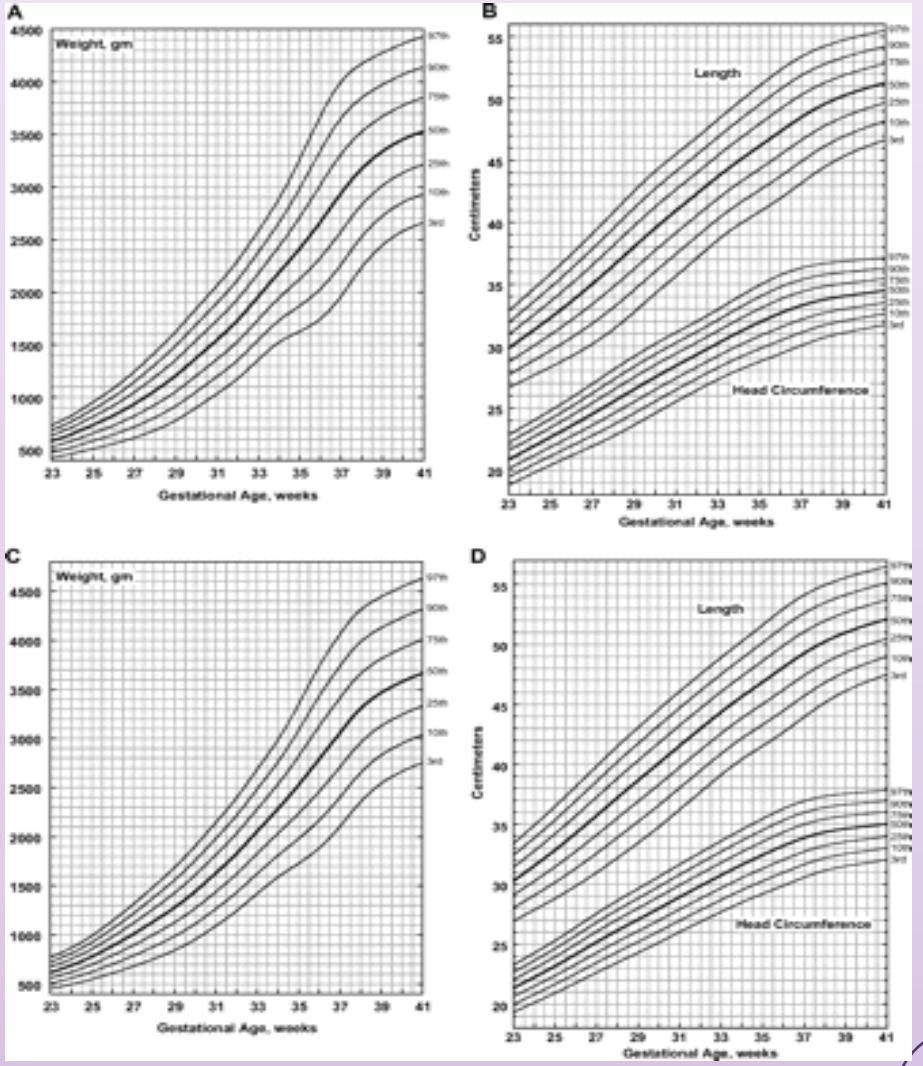
- Preterm growth chart
- Population: over 4 million preterm infants from Germany, Italy, US, Austria, Scotland, Canada
- Gender Specific
- Used in combination with term charts after 40 weeks CGA
- Does not use weight/length or BMI
- Last updated in 2013 in order to accommodate WHO growth standards



Fenton, Tanis R & Kim, Jae H. A systematic review and meta-analysis to revise the Fenton growth chart for preterm infants. BMC Pediatrics.2013, 13:59

Olson Growth Chart

- Intrauterine
- US population only
  - 33 states, 248 hospitals from 1998-2006
  - 391,681 infants enrolled
    - 257,855 used in final sample
      - Exclusions: missing data, unknown gender, factors neg affecting growth, physiologically impossible growth measurements
- Gender specific
- Includes BMI



Olsen, I. Et al. New Intrauterine Growth Curves Based on United States Data. Pediatrics. Feb 2010, 125 (2) e214-e224

Intergrowth-21st Project

- International Fetal and Newborn Consortium for the 21st Century
  - Global: 27 institutions in 18 countries
  - Multidisciplinary
  - Goal: reduce the preventable newborn deaths from preterm birth or poor intrauterine growth
- Growth Charts
  - Multi-center; multi-ethnic
    - 13108 women screened
    - 4321 singleton pregnancies without major complications

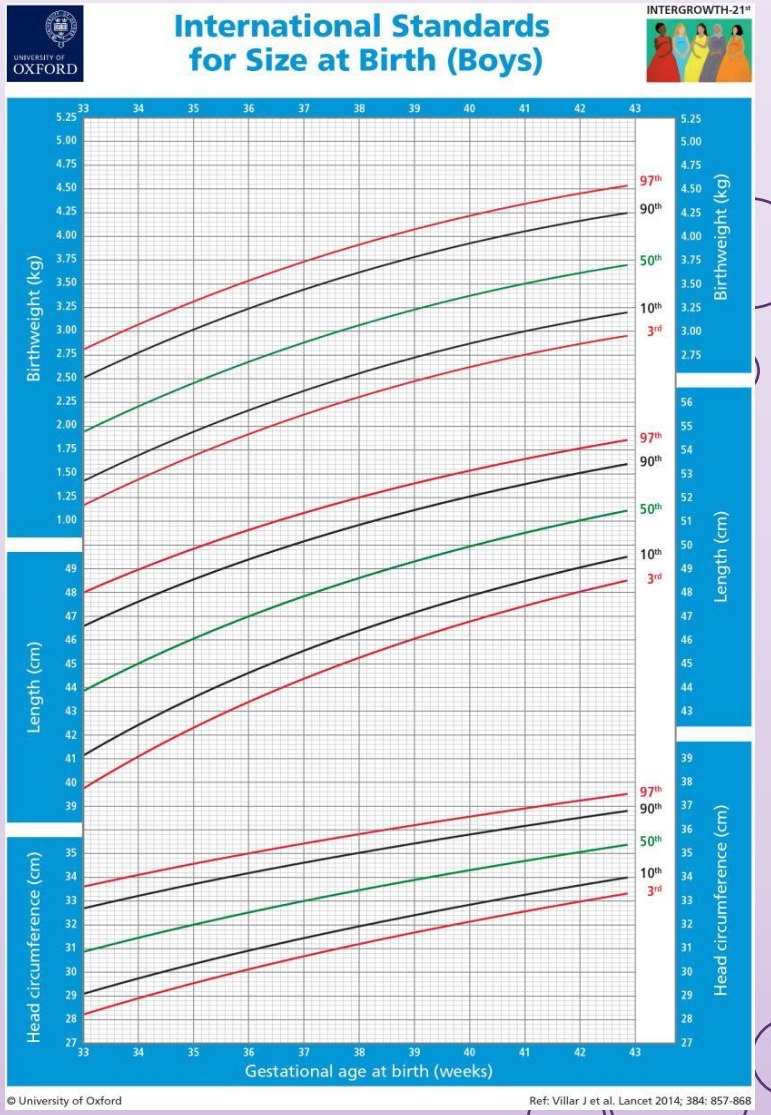
Intergrowth-21 Growth Chart

- 4607 pregnant women enrolled
- 224 singleton pregnancies with preterm births
  - 21 excluded
    - 6 deaths
    - 1 HIV/AIDS
    - 6 positive blood culture/sepsis
    - 7 congenital malformations
    - 1 delivery before 23 weeks
    - 6 BW less than 3%ile – 2 excluded due to fetal growth restriction
  - Final sample: 201
- Wt/length/HC obtained within 12hrs after birth and every 2 weeks after for the first 2 months and every 4 weeks until 8 months

Villar, J. et al. Postnatal growth standards for preterm infants: the Preterm Postnatal Follow-up Study of the INTERGROWTH-21st Project. Lancet Glob Health 2015;3:e681-91

Intergrowth-21st Growth Charts

- Mean Gestational Age: 35 5/7 weeks
  - Distribution
    - 28 (14%) – 33 weeks or less
    - 68 (34%) – 34-35 weeks
    - 105 (52%) at 36-37 weeks
- Anthropometrics (mean):
  - Weight: 2452gm (SD 519gm)
  - Length: 45.6cm (SD 2.7cm)
  - HC: 31.7cm (SD 1.8cm)



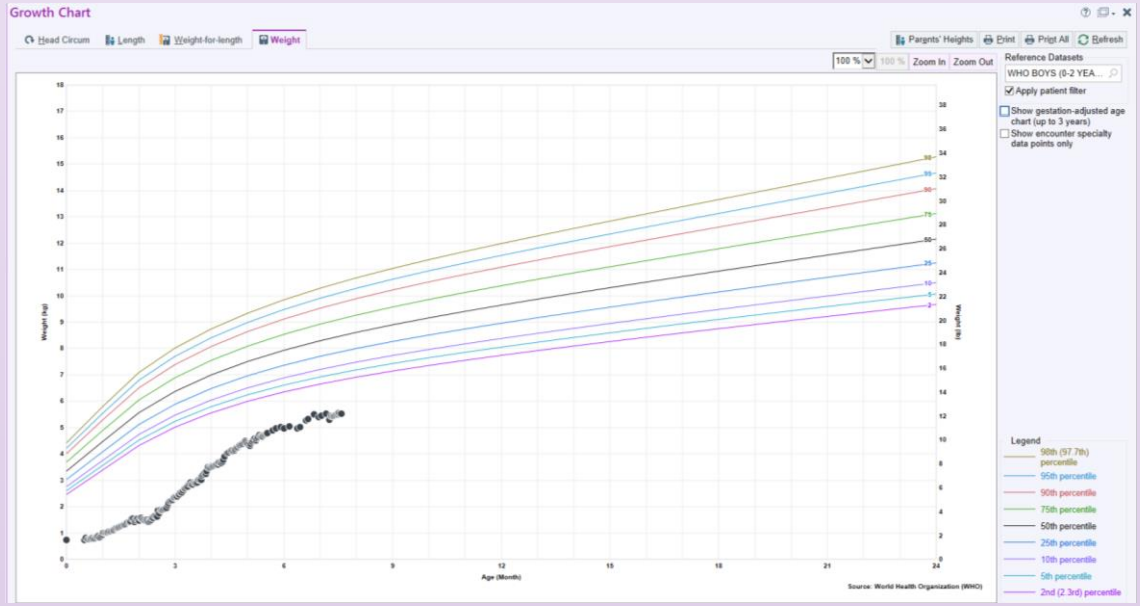
Villar, J. et al. Postnatal growth standards for preterm infants: the Preterm Postnatal Follow-up Study of the INTERGROWTH-21st Project. Lancet Glob Health 2015;3:e681-91

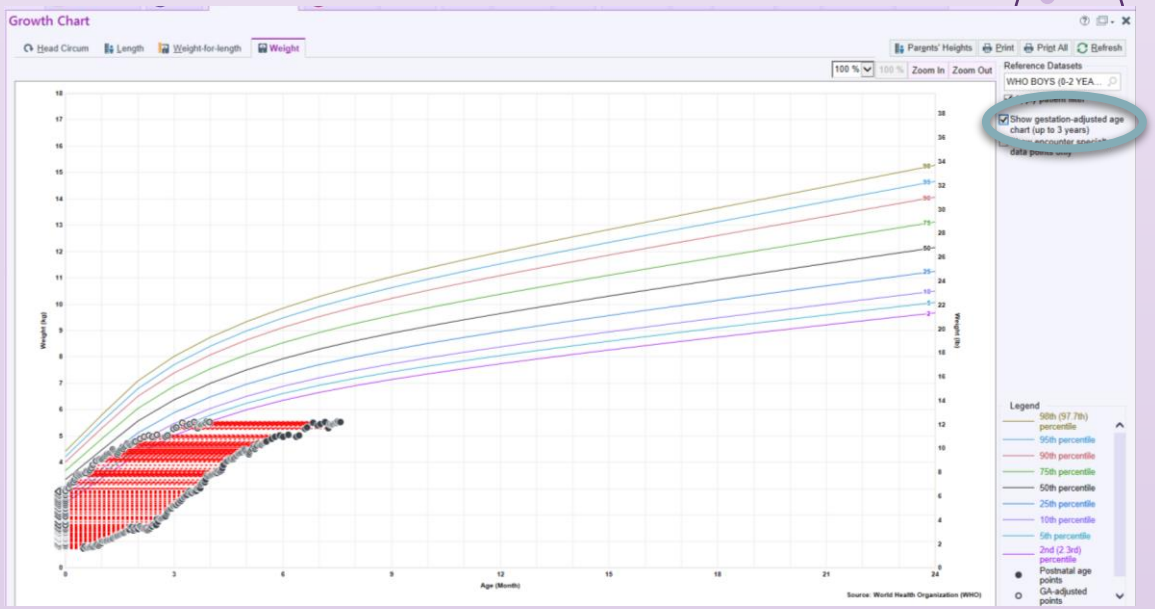
Term & Specialty Growth Charts

- WHO
  - Breastfed infants as norm
  - Describes growth in optimal conditions
  - Gender specific
  - Includes Wt/length
- CDC growth charts available - however CDC recommends using WHO for 0-2yrs old

- Down's Syndrome
- Prader Willi
- Cornelia de Lange Syndrome
- Trisomy 13
- Trisomy 18
- Noonans Syndrome (length only)

WHO Growth Charts





Expected Growth Patterns

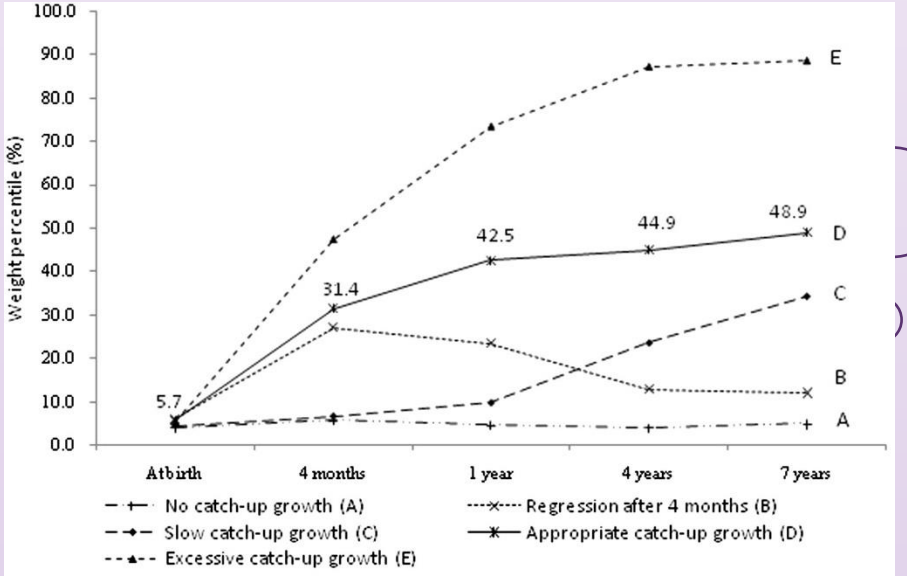
- Anticipated weight loss after birth
  - Typically 4-8%
  - Over 10% may be pathologic
- Expected return to birth weight by DOL 14
  - Typically by DOL 7-10
  - Consider fluid status and medical complications at birth
    - Patients born with hydrops or significant edema will not regain to BW by DOL 14

Optimal Growth

- Weight gain
  - Gestational age dependent
  - Previous thoughts for appropriate weight gain:
    - 10% of weight
    - 15-20gm/kg/d until 2kg
    - However these commonly underestimate the amount of an infant needs to gain in order to maintain current percentiles
  - Peditools.org – reference where when inputted GA/weight/length/HC will provide %iles, z-scores and values for weight gain, length and HC to gain (weekly on preterm growth charts, monthly on term) to maintain current percentiles
- Length
  - Best measured on a length board with 2 person technique
  - Est growth 1-1.5cm per week
  - Indicator of long term growth and lean tissue and nutrient status
- HC
  - Expected growth
    - Preterm infants: 0.9cm/week until close to term gestation
    - Term infants: 0.5cm/week

Catch Up Growth

- Catch up growth
  - Rapid weight gain can increase risk for increased abdominal adiposity, metabolic syndrome, linear growth stunting
  - No standards have been set to determine appropriate catch up growth
- One study in China looked at 5 different methods of catch up growth in a retrospective study using longitudinal data for term SGA babies
  - 1957 study participants
  - Catch up growth separated into the following categories: Extremely Rapid, Rapid, Appropriate, Slow and Almost no catch up growth
  - Findings included
    - Increased Extremely rapid and rapid catch up growth were at increased risk of overweight/obesity.
    - Increased risk of malnutrition in the slow and almost no catch up groups



- Conclusions:
  - Crossing 2 percentile lines in the first several months then maintaining median growth by age 2 would minimize risk of childhood adverse health outcomes
  - Increased risk of obesity and elevated BP at age 7
  - Babies with slow catch up growth or regression after 4 months were assoc with higher risk of lower IQ and growth restriction

Shi, H. et al. Insights into infancy weight gain patterns for term small for gestational age babies. Nutrition Journal. 2018. 17:97

Lei, X. et al. The Optimal Postnatal Growth Trajectory for Term Small for Gestational Age Babies: A Propesctive Cohort Study. J Pediatr 2015; 166:54-8

Intrauterine Growth Restriction

- IUGR
  - Symmetric
    - Typically occurs in the first trimester, toxin, genetic, metabolic or infectious cause
  - Asymmetric
    - Maternal vascular disorders, blood flow
  - Born at smaller growth than anticipated fetal growth
- Can have electrolyte anomalies after birth similar to refeeding syndrome (decreased K, Phos, Mg)
- Growth Goals:
  - If genetically small – growth will follow their own parameters even if less than 3%ile
  - If asymmetric IUGR (esp length and head sparing) – may benefit from catch up growth

Lawrence EJ: Part 1: A matter of size: Evaluating the growth-restricted neonate. Adv Neonatal Care. 6(6):313-22. 2006
Ruth VA. Extrauterine growth restriction: A review of the literature. Neonatal Network 27(3):177-84. 2008


Macronutrients
CARBS
PROTEINS
FATS

Optimal Calorie and Protein Requirements

	Parenteral		Enteral	
Infant age (wk)	Energy goals (kcal/kg)	Protein goals (g/kg)	Energy goals (kcal/kg)	Protein goals (g/kg)
Preterm[101,102] <34 0/7	85-111	3-4	110-130	3.5-4.5
Late preterm[103] 34 0/7-36 6/7	100-110	3-3.5	120-135	3-3.2
Term[101,102] ≥37 0/7	90-108	2.5-3	105-120	2-2.5

- Goldberg DL et al *Journal of the Academy of Nutrition and Dietetics*, 2018

Energy and Macronutrient Needs in Critical Illness - ESPAGHN

Table 2.
Theoretical energy and macronutrient needs during different phases of critical illness in the neonate

	Preterm infants			Term neonates < 28 d		
	Early acute	**Late acute**	**Recovery**	**Early Acute**	**Late acute**	**Recovery**
Energy (kcal/kg/d)						
Enteral	40-55	70-95	110-160	35-50	55-80	90-120
Parenteral[1]	40-55	60-80	90-120	15-40	45-70	75-85
Glucose (g/kg/d)[2]						
Enteral	5-8	7-11	11-15 (18)	4-6	6-10	9-15
Parenteral[1]	5-8 (10)	7-10 (12)	11-14 (17)	4-7 (10)	6-10	8-14
Glucose (~mg/kg/min)						
Enteral	*3.5-5.5*	*5-7.5*	*7.5-10.5 (12.5)*	*3-5*	*4-7*	*6-10.5*
Parenteral[1]	*3.5-5.5 (7.0)*	*5-7 (8.5)*	*7.5-10 (12)*	*3-5 (10)*	*4-7*	*5.5-10*
Protein (g/kg/d)						
Enteral	1.0-2.0	2.0-3.0	3.5-4.5	< 1.5	1.5-2.5	2.0-3.5
Parenteral[1]	1.0-2.0	2.0-3.0	2.5-3.5	0 (-1.0)	1.5-2.5	2.0-3.0
Lipids (g/kg/d)						
Enteral	2.0-3.0	3.0-6.0	5.0-8.0	< 3.0	3.0-4.5	4.0-6.0
Parenteral[1,3]	1.0-2.0	2.0-3.0	3.0-4.0	0 (-1.5)	1.5-2.5	3.0-4.0

[1] When supplementing parenteral nutrition, enteral intakes need to be considered (subtracted from estimated total needs) to optimize nutrient supply and reduce the risk of overfeeding. Note that parenteral energy needs are lower than enteral requirements, and that the maximum ranges of protein (amino acids) and lipids are lower than when given enterally.
[2] The glucose supply should be guided by plasma glucose measurements to avoid hypo- and hyperglycemia
[3] Lipids should be an integral part of PN (30-50% of non-protein calories) and the non-protein energy to protein ratio > 25 kcal/g protein to facilitate protein utilization.

Agostoni, C. et al. Enteral Nutrient Supply for Preterm Infants: Commentary from the European Society of Paediatric Gastroenterology, Hepatology and Nutrition Committee on Nutrition. JPGN. Vol 50 No 1. Jan 2010

ESPAGHN Nutrient Recommendations

Table 5: Nutrient requirements for preterm infants as per ESPGHAN recommendations [45].

For VLBW	Proposed intake recommendation
Energy	110-135 kcal/kg per day
Protein	
Weight up to 1000 g	4.0-4.5 g/kg/day
Weight 1000-1800 g	3.5-4.0 g/kg/day
Carbohydrates	10-5-12.0 g/100 kcal
Lipids	4.8-6.6 g/kg per day; medium-chain triglycerides should be <40% of total intake per 100 kcal
Calcium	109-182 mg per 100 kcal
Phosphorus	55-127 mg per 100 kcal
Magnesium	7.5-13.6 mg per 100 kcal
Vitamin D, IU/day	800-1000
VLBW: Very low birth weight	

Agostoni, C. et al. Enteral Nutrient Supply for Preterm Infants: Commentary from the European Society of Paediatric Gastroenterology, Hepatology and Nutrition Committee on Nutrition. JPGN. Vol 50 No 1. Jan 2010

ASPEN Recommendations

- Recommend to initiate PN after birth as soon as vascular access is obtained
- Protein
  - Initial dose: >3gm/kg
  - Max target dose: 3.5gm/kg
- Lipids:
  - Recommend daily dose of 3gm/kg if using SO-ILE or multi-component ILE
  - No recommendation for specific type of lipid
- Prevention of PNALD
  - Do not recommend routine reduction of AA, dextrose, ILE

Robinson DT, Calkins KL, Chen Y. et al. Guidelines for Parental Nutrition in Preterm Infants: The American Society for Parenteral and Enteral Nutrition. JPEN J Parenter Enteral Nutr. 2023 Sep; 47 (7): 830-858

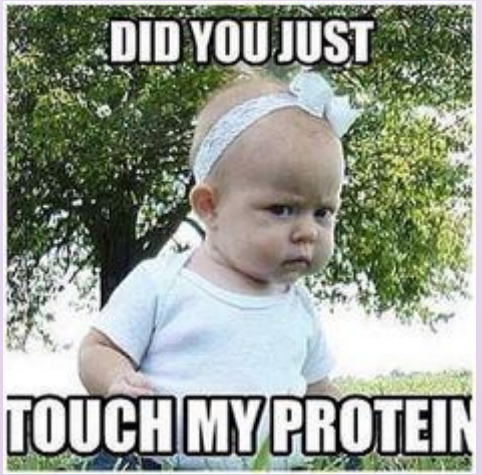
Macronutrient Needs: Carbohydrate

- Preferred source of energy
  - Brain development
  - Protein sparing
- Closely works with fat intake
  - If glucose supply exceeds oxidation rate, glucose is converted to fat and fat oxidation ceases
  - If CHO:fat ratio is reduced – fat utilization increases
- Complications in times of stress: hyperglycemia, stress induced insulin resistance, electrolyte disturbances
- Goal glucoses < 180
- Excessive glucose intake, even with glucose converted to fat – may result in increased CO_2 retention
- Goal approx. 45-50% of calories
- ESPGHAN Guidelines
  - Neonates
    - Estimated glucose production rate (GIR) & glucose oxidation capacity 6mg/kg/min – 8mg/kg/min
  - Term infants:
    - 5mg/kg/min – 12.5mg/kg/min

Moltu, S. et al. Nutritional Management of the Critically ill Neonate: A Position Paper of the ESPGHAN Committee on Nutrition. JPGN 2021 Feb 16

Macronutrient Needs: Protein

- Gluconeogenesis – high energy demand
- Catabolism
  - Conditionally essentially amino acids: glutamine, cysteine, arginine
- Cover turnover and tissue growth – not used for actual growth
- Cannot be stored like glucose and fat
- Goal: 15-20% of calories
- ESPGHAN Guidelines
  - Provides 4kcal/gm
  - Minimum intake 1.3-1.5gm/kg is needed for positive protein balance
    - Higher intakes needed for adequate intake for growth
- ASPEN Guidelines:
  - Initiate 3g/kg w/ max 3.5gm/kg/d



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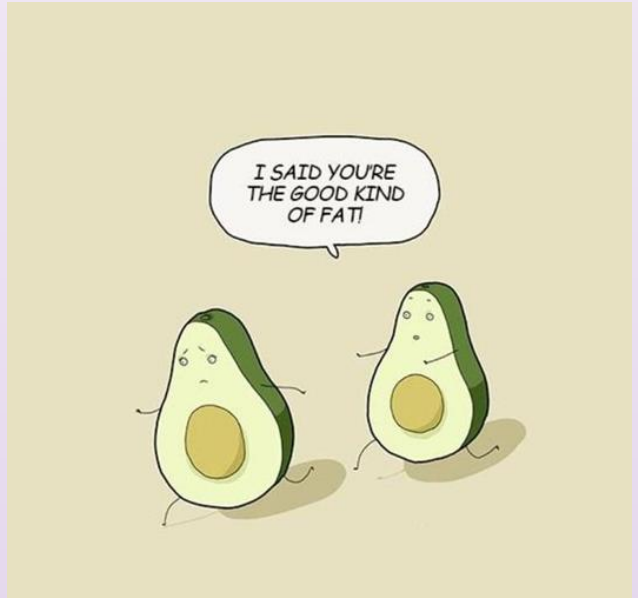
Macronutrient Needs: Protein

- Carnitine
  - Comprised of L-carnitine, acetyl L-carnitine, propionyl-L-carnitine
    - Derived from lysine and methionine
  - Conditionally essential – need exceeds ability to synthesize
    - Groups at high risk for deficiency: preterm infants and end stage renal disease
  - Essential to help transport long chain fatty acids into mitochondria to help in the production of ATP
  - Cochrane review in 2000 by Cairns and Stalker concluded that there was no evidence to support the routine supplementation of parenterally fed neonates however the 6 studies reviewed were small sample sizes, short study lengths and were from 1983-1995.

U.S. Department of Health and Human Services. (2023, April 17). *Office of dietary supplements - carnitine*. NIH Office of Dietary Supplements. https://ods.od.nih.gov/factsheets/Carnitine-HealthProfessional/

Cairns PA, Stalker DJ. Carnitine supplementation of parenterally fed neonates. Cochrane Database Syst Rev. 2000;2000(4):CD000950. doi: 10.1002/14651858.CD000950. PMID: 11034690; PMCID: PMC7061355.

Macronutrient Needs: Fat



- Used for brain development
- ESPGHAN Guidelines
  - Utilization is dependent on glucose supply
  - Reducing glucose: fat ratio can promote fat utilization and reduce lipid peroxidation
    - Optimal ratio has not been defined
  - Serum triglycerides can be monitored to assess lipid clearance
    - Generally acceptable less than 265
  - During severe sepsis, disseminated intravascular coagulation, thrombocytopenia, impaired liver function, increased TG, metabolic acidosis – may decrease lipid supply
  - High GIR and overfeeding may also impair lipid utilization thus first line would be to decrease glucose load before reducing lipid intake
- Goal: 20-30% of calories in PN; 45-55% calories in enteral nutrition
- Minimum needs to prevent essential fatty acid deficiency
  - Parenteral needs: 0.5-1gm/kg (soy based lipid); 2.2gm/kg SMOF
  - Enteral: 3.5-4gm/kg

Moltu, S. et al. Nutritional Management of the Critically ill Neonate: A Position Paper of the ESPGHAN Committee on Nutrition. JPGN 2021 Feb 16

IV Lipids

	Intralipid	SMOF	Omegaven
Source	Soybean	Soy/MCT/Olive/Fish Oil	Fish Oil
FDA Approval	1972	Adults 7/13/2016 Pediatrics: 3/24/22	Pediatrics: 7/27/2018 Rescue only
Omega 3 (a-linolenic acid)	4-11%	1.5-3.5%	1.1%
Omega 6 (linoleic acid)	44-62%	14-25%	1.5%
Omega 9 (oleic acid)	19-30%	25-35%	4-11%
Recommended max dose	3gm/kg	3gm/kg	1gm/kg
Min dose to prevent EFAD	1gm/kg	2.2gm/kg	Must provide supplemental lipids to meet EFAD
Caloric Content	2kcal/ml	2kcal/ml	1.12kcal/ml

Nutrients in EBM w/ HMF & Prolacta and SSC 24kcal/oz & Neosure 22kcal/oz

Nutrient	Koletzko	ESPGHAN	RDA/AI	Nutrient	HMF 24kcal/oz		Prolact + 8		SSC 24kcal/oz		Neosure 22kcal/oz	
Fluid	135-200ml/kg	135-200ml/kg	0.7L/d	Fluid	130ml/kg	150ml/kg	130ml/kg	150ml/kg	130ml/kg	150ml/kg	130ml/kg	150ml/kg
Energy	110-130kkd	110-135kkd	555kcal/d	Energy; kkd	104	120	121	140	104	120.0	95	110
CHO	11-13gm/kg	11.6-13.2gm/kg	60g/d	CHO, mg/kg	10.5	12.2	10.3	11.9	10.7	12.4	9.6	11.1
Protein	3.5-4.5gm/kg	(<1kg) 4-4.5gm/kg	9.1g/d	Protein, gm/kg	3.7	4.3	3.5	4.1	3.1	3.6	2.7	3.1
		(-1.8kg) 3.5-4gm/kg										
Fat	4.55-8.1gm/kg	4.8-6.6 gm/kg (<40% MCT)	31gm/d	Fat; gm/kg	5.2	5.97	7.1	8.3	5.6	6.5	5.2	6.1

Hodges B, Johnson M, Merlino Barr S, eds: Pocket Guide to Neonatal Nutrition, 3rd Edition. Chicago: Academy of Nutrition and Dietetics, 2023


VITAMINS
MINERALS
Mn
Ca
B2
B5
Zn
H
Co
Se
Fe
A
F
Mg
D3
F
PP
K
Na
B12
E
C
B6
Cu
Cl
Cr

Vitamins

Fat Soluble Vitamins

Nutrient	Major Physiological Function	Deficiency Signs	Excess Signs	Important Food Sources	Potential Causes of Deficiency	Status Assessment
Vitamin A	Formation/maintenance of skin and mucous membranes; Necessary for formation of rhodopsin of the rods governing vision in dim light; necessary for growth and normal immune function	Night blindness; degeneration of the retina, xerophthalmia, follicular hyperkertosis, poor growth, ketatomalcia, bitot's spots	Fatigue, malase, lethargy, abd pain, hepatomegaly, alpoecia, headache with increased ICP	Carrots, liver, green veg, sweet potatoes, butter, margarine, apricots, melons, peaches, broccoli, cod, liver oil, breastmilk, formula	liver disease, CF, short gut, protein deficiency (alters transportation)	Plasma retinol (HPCL), plasma retinol binding protein, relative dose response, dark adaption test, liver biopsy concentration
Vitamin D	Promotes intestinal absorption of calcium and phos; Renal conservation of calcium and phos	Rickets, osteopenia, costochondral beading, epiphyseal enlargement, Cranial bossing, bowed legs, persistently open anterior fontanel	Hypercalcemia, vomiting, anorexia, diarrhea, convulsions	Cod liver oil, fish, eggs, fortified milk, sunlight (activation of 7-dehydrocholesterol); Infant formula	Liver disease, CF, short gut, renal disease, Anti-epileptic meds, anti-retroviral meds, obesity, malabsorption, non-ambulatory status, BF infants	Plasma 25-OH ViT D, serum alk phos, calcium, phos, radiography, bone densitometry
Vitamin E	Antioxidant and free radical scavenger to prevent perioxidation of polyunsaturated fatty acids in the body, Neuromuscular function	Hemolytic anemia (preterm, newborn) enhanced fragility of red blood cells; Increased perioxidation hemolysis	In anemia - surpasses normal hematological response to iron	Oils high in polyunsaturated fatty acids, milk, eggs, Breastmilk, infant formula	CF, short gut, liver disease	Plasma tocopherol - corrected for total or LDL cholesterol, hydrogen peroxide hemolysis
Vitamin K	Necessary for prothrombin and 3 blood clotting factors VII, IX, X, Half of Vit K is of intestinal origin, synthesized by gut flora Necessary for bone mineralization	Hemorrhagic manifestations (esp in newborns), prolonged clotting	Hemolytic anemia, nerve palsy	Green leafy vegetables, fruits, cereals, dairy, Soybeans, breastmilk, infant formula	Liver diseas, antibiotic therapy	Prolonged prothrombin time, clotting factor levels, protein induced, By vit K absence or antagonists II (PIVKAII)

Water Soluble Vitamins

Nutrient	Major Physiological Function	Deficiency Signs	Excess Signs	Important Food Sources	Potential Causes of Deficiency	Status Assessment
Ascorbic Acid (Vit C)	Forms collagen cross linkage of proline hydroxlase, thus strengthening tissue and improving wound healing and resistance, aids in absorption of iron	Join tenderness, scurvy, (capillary hemorrhaging), impaired would healing, Acute periodontal gingivitis, petechiae, purport, anemia	Documentation of a high intake may result in Rebound deficiency symptoms	Heat-labile, broccoli, papaya, orange, mango, grapefruit, strawberries, tomatoes, potatoes, leafy veg, breastmilk, infant formula	Stress	Plasma level (enzyme assay/HPLC), leukocyte concentration (long term) whole blood concentration, urine concentration
Biotin	Component of several carboxylating enzymes; Plays role in metabolism of fat and CHO	Anorexia, nausea, vomiting, glossitis, Depression, dry, scaly dermatitis, thin hair, loss of eyebrows		Liver, kidney, egg yolk, breastmilk, infant formula	Certain inborn errors of metabolism	Plasma (microbiologic plasma lactate assay), urine organic acids, lymphocyte carboxylase
Cobalamine (B12)	Cobalamin-containing coenzymes function in the degradation of certain odd-chain fatty acids, Recycling of tetrahydrofolate	Megablastic anemia, neurologic deterioration		Liver, leafy vegetables, fruit, yeast, breastmilk, formula	Liver disease, alcoholism, celiac disease, IBD, High dose folate can mask B12 def	Plasma level (RIA or microbiologic), schilling test, plasma homocysteine,
Folacin	Utilized in carbon transfer and Nucleotide synthesis	Megaloblastic anemia, stomatitis, glossitis, neural tube defects in pregnancy		Liver, leafy veg, fruit, yeast, Breastmilk, infant formula	Liver disease, alcoholism, celiac disease, IBD	Plasma level (RIA or microbiologic), red cell level
Niacin	Aids in energy utilization as part of a coenzyme (NAD+ and NADP+) in fat synthesis; Tissue respiration and CHO utilization; Aids in digestion and fosters a normal appetite, Synthesized from tryptophan	Pellagra (dermatitis, diarrhea, dementia, death), Cheilosis, angular somatic inflammation of mucous, Membranes, weakness	Dilation of capillaries, vasomotor instability, flushing (utilization of muscle glycogen, serum lipids, mobilization of fatty acts during exercise)	Liver, meat, fish, poultry, peanuts, fortified cereal products, yeast, Breastmilk, infant formula	B6 deficiency (impairs conversion of tryptophan to niacin)	Urine ratio of metabolites (N-methylnicotinamide/2-pyridone), Tryptophan load, red cell NAD or NAD:NADP ratio

Water Soluble Vitamins

Nutrient	Major Physiological Function	Deficiency Signs	Excess Signs	Important Food Sources	Potential Causes of Deficiency	Status Assessment
Pantothenic Acid	Component of co-enzyme A, Plays role in release of energy from CHO and in synthesis and Degradation of fatty acids	Infertility, abortion, slow growth, depression, Vomiting, malaise, abd stress	Diarrhea, water retention	Meat, fish, whole grains, legumes, breastmilk, infant formula	Severe malnutrition	Urine excretion, whole blood level (RIA/microbiologic)
Pyridoxine (B6)	Coenzyme component for many enzymes of amino acid metabolism, All compounds implicated as neurotransmitters are synthesized and/or metabolized in B6 dependent reactions	Convulsions, weight loss, and distress, vomiting, Hyper irritability, depression, confusion, hypo chromic and macrocytic anemia	Neuropathy	Fish, poultry, meat, wheat, breastmilk and formula	Elderly, high protein intake	Red cell aminotransferase activity, pyridoxal phosphate (HPLC) Tryptophan load test, urine 4-pyridoxic acid
Riboflavin (B2)	Functions primarily as reactive portion of flavoproteins, Concerned with biologic oxidations (cellular metabolism)	Cheilosis, glossitis, photophobia, angular Stomatitis, corneal, vasculation, scrotal skin changes, seborrhea, magenta tongue		Dairy products, liver, almonds, lamb, pork, Breastmilk, infant formula	Alcoholism, starvation, chronic diarrhea, malabsorption	Erythrocyte glutathione reductase activity (EGR), Red cell flavin adenine diculeotide, urine riboflavin:creatinine ratio
Thiamine (B1)	Aids in energy utilization as part of coenzyme component to promote utilization of CHO, Promotes normal functioning of the nervous system, Coenzyme for oxidative carboxylation of 2-keto acids	Beriberi, neuritis, cardiac failure, anorexia, restlessness, confusion, Loss of vibration sense and deep tendon reflexes, Calf tenderness, edema		Lean pork, nuts, whole grain and fortified cereal products, Breastmilk and infant formula	Alcoholism, refeeding syndrome, prolonged dialysis	Red cell transketolase activity, Whole blood (HPLC), Urine Thiamine:creatininie ratio

Vitamins – Recommendations and Current Dosing in TPN

Nutrient	Preterm	Term		Amount per 5ml vial	0.5kg (1ml)	1kg (2ml)	1.5kg (3ml)	2kg (4ml)	> 2.5kg (5ml)
Vitamin A, IU/kg (mcg/kg)	700-1500 (227-455)	500-1000 (150-300)		2300 IU (697mcg)	460IU	920IU	1380IU	1840 IU	2300 IU
Vitamin D, IU (mcg)	200-1000 (5-25)	400 (10)		400 IU (10mcg)	2mcg	4mcg	6mcg	8mcg	10mcg
Vitamin E, IU/kg or mg/kg	2.8-3.5	2.8-3.5		7 IU (7mg)	1.4 IU	2.8IU	4.2 IU	5.6 IU	7IU
Vitamin K, mcg/kg	10	10		200mcg	40 mcg	80mcg	120mcg	160 mcg	200mcg
Thiamin, mcg/kg	350-500	350-500		1200mcg	240 mcg	480mcg	720mcg	960 mcg	1200mcg
Riboflavin, mcg/kg	150-200	150-200		1400mcg	280 mcg	560mcg	840 mcg	1120 mcg	1400mcg
Niacin, mg/kg	4-6.8	4-6.8		17 mg	3.4 mg	6.8mg	10.2 mg	13.6 mg	17 mg
Vitamin B6, mcg/kg	150-200	150-200		1000 mcg	200 mcg	400mcg	600mcg	800 mcg	1000 mcg
Folic Acid, mcg/kg	56	56		140mcg	28 mcg	56mcg	84mcg	112 mcg	140mcg
Vitamin B12, mcg/kg	0.3	0.3		1mcg	0.2 mcg	0.4mcg	0.6mcg	0.8mcg	1mcg
Pantothenic acid, mg/kg	2.5	2.5		5mg	1 mg	2mg	3mcg	4 mcg	5mg
Biotin mcg/kg	5-8	5-8		20mcg	4 mcg	8mcg	12mcg	16 mcg	20mcg
Vitamin C, mg/kg	15-25	15-25		80mg	16 mg	32mg	48 mg	64 mg	80mg
				UF Health Dosing: 2ml/kg up to 5ml max					

Dose recommendations by weight:	0.5-1kg	1.5ml
	1-2.5kg	3.25ml
	>2.5kg	5ml
Dose recommendations ml/kg:	≤ 2.5kg	2ml/kg
	>2.5kg	5ml

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Nutrients in EBM w/ HMF & Prolacta and SSC 24kcal/oz & Neosure 22kcal/oz

Nutrient	Koletzko	ESPGHAN	RDA/AI	Nutrient	HMF 24kcal/oz		Prolact + 8		SSC 24kcal/oz		Neosure 22kcal/oz	
					130ml/kg	150ml/kg	130ml/kg	150ml/kg	130ml/kg	150ml/kg	130ml/kg	150ml/kg
Vit A	400-1000mcg/kg	400-1100mcg/kg	400mcg/d	Vit A, mcg/kg	357.0	446.0	59.4	68.8	390.0	450.0	99.8	115.5
Vit D	400-1000IU/d (10-25mcg/d)	800-1000IU/d (20-25mcg/d)	10mcg/d	Vit D, mcg/kg	3.6	4.4	5.7	6.6	3.9	4.5	3.6	4.2
Vit E	2.2-11mg/kg	2.2-11mg/kg	4mg/d	Vit E, mg/kg	5.1	6.4	0.2	0.2	2.8	3.2	2.3	2.6
Vit K1	4.4-28mcg/kg	4.4-28mcg/kg	2mcg/d	Vit K1, mcg/kg	9.9	12.4	0.2	0.3	260.0	300.0	10.5	12.1
l-Ascorbic Acid	16.5-41mg/kg	11-46mg/kg	40mg/d	l-Ascorbic Acid, mg/kg	42.0	52.4	7.4	8.5	38.5	44.4	14.3	16.5
Thiamine	132-275mcg/kg	140-300mcg/kg	0.2mg/d	Thiamine, mcg/kg	23.1	28.8	17.8	20.6	260.0	300.0	166.3	192.5
Riboflavin	200-430mcg/kg	200-400mcg/kg	0.3mg/d	Riboflavin, mcg/kg	348.1	434.4	47.6	55.0	644.8	744.0	142.5	165.0
Niacin	1.1-5.5mg/kg	0.38-5.5mg/kg	2mg/d	Niacin, mg/kg	4.1	5.1	0.3	0.4	5.2	6.0	1.9	2.1
Pyridoxine (B6)	66-275mcg/kg	45-300mcg/kg	0.1mg/d	Pyridoxine, mcg/kg	217.3	271.2	4.6	5.3	260	300	95	110
Cobalamin	0.12-0.6mcg/kg	0.1-0.77mcg/kg	0.4mcg/d	Cobalamin, mcg/kg	0.6	0.7	0.1	0.1	0.6	0.7	0.4	0.4
Folic Acid	22-100mcg/kg	35-100mcg/kg	65mcg/d	Folic Acid, mcg/kg	31.6	39.5	14.5	16.8	38.5	44.4	23.8	27.5
Pantothenic Acid	0.6-2.1mg/kg	0.33-2.1mg/kg	1.7mg/d	Pantothenic Acid, mg/kg	1.4	1.8	0.3	0.3	2.0	2.3	0.8	0.9
Biotin	3.3-15mcg/kg	1.7-16.5mcg/kg	5mcg/d	Biotin, mcg/kg	23.8	29.8	0.5	0.6	38.5	44.4	8.6	9.9
Choline	≥ 33mg/kg	8-55mg/kg	125mg/d	Choline, mg/kg	13.2	16.4	0.0	0.0	10.4	12.0	15.2	17.6

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Minerals

Minerals

Nutrient	Major Physiological Function	Deficiency Signs	Excess Signs	Important Food Sources	Potential Causes of Deficiency	Suggested Supplementation	Status Assessment
Calcium	Essential for calcification of bone (matrix formation), Assists in blood clotting; functions in normal muscle contraction and relaxation, Normal nerve transmission	Osteomalacia, osteoporosis	Hypercalcemia, vomiting, anorexia, lethargy	Dairy products, sardines, oysters, salmon, herring, Greens, breast milk, formula	Renal disease, liver disease		Plasma total Ca, plasma free Ca in altered binding protein (Hypoalbuminemia), acidosis, radiographs, computer tomography, photon densitometry
Magnesium	Essential in many enzyme systems, important for maintaining electrical Potential in nerves and muscle membranes, and energy turn over	Tremor, convulsions, hyper excitability (hypocalcemic tetany)	Diarrhea, transient hypocalcemia	Widely distributed esp in food of vegetable origin, Breastmilk, infant formula	Protein calorie malnutrition, refeeding syndrome		Plasma total or free Magnesium, magnesium loading test
Phosphorus	Important intracellular anion, involved in many chemical reactions within the body, Necessary for energy turnover (ATP)	Weakness, anorexia, malaise, bone pain, growth arrest	Hypocalcemia (when parathyroid gland is not functioning)	Dairy products, fish, legumes, pork, Breastmilk, infant formula	Renal disease, liver disease, refeeding syndrome		Plasma concentration Alk Phos, radiography, densitometry, Renal tubular excretion threshold

Minerals – Recommendations in TPN

Nutrient	Gestation	Initial Dose (range)	Target (range)
Sodium, mEq/kg or mmol/kg	Preterm	0-2	2-5
	Term	0-2	2-3
Potassium, mEq/kg or mmol/kg	Preterm	0-3	2-5
	Term	0-3	1.5-3
Chloride, mEq/kg or mmol/kg	Preterm	0-3	3-5
	Term	0-3	2-3
Chloride/acetate ratio, %	Preterm	0/100-25/75	50/50
	Term	50/50	50/50
Calcium, mEq/kg (mmol/kg)	Preterm	>2 (>1)	2.5-4 (1.3-2)
	Term		1.6-3 (0.5-1.5)
Phosphorus, mmol/kg	Preterm	1-2	1-3
	Term	0.7-1.3	0.5-
Calcium/Phosphorus Ratio, mmol:mmol	Preterm	0.8-1:1	1.3-1.5:1
	Term	0-0.6	1-1.3
Magnesium, mEq/kg (mmol/kg)	Preterm	0.2-0.4 (0.1-0.2)	0.4-0.6 (0.2-0.3)
	Term	0.2-0.4 (0.1-0.2)	0.2-0.4 (0.1-0.2)

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Nutrients in EBM w/ HMF & Prolacta and SSC 24kcal/oz & Neosure 22kcal/oz

Nutrient	Koletzko	ESPGHAN	RDA/AI	Nutrient	HMF 24kcal/oz		Prolact + 8		SSC 24kcal/oz		Neosure 22kcal/oz	
Calcium	120-200mg/kg	120-140m/kg	200mg/d	Calcium, mg/kg	146.2	182.4	152.7	176.7	187.2	216.0	99.8	115.5
Phos	70-120mg/kg	60-90mg/kg	100mg/d	Phos, mg/kg	81.7	102.0	80.1	92.7	104.0	120.0	58.9	68.2
Magnesium	8-15mg/kg	8-15mg/kg	30mg/d	Magnesium, mg/kg	11.6	14.5	10.5	12.2	12.5	14.4	8.6	9.9
Sodium	3-5 Meq/kg (69-115mg/kg)	3-5mEq/kg (69-115mg/kg)	120mg/d	Sodium, mEq/kg	1.9	2.4	2.9	3.4	2.0	2.3	1.3	1.5
Potassium	2-5mEq/kg (78-195mg/kg)	1.7-3.4mEq/kg (66-132mg/kg)	400mg/d	Potassium, mEq/kg	3.5	4.3	2.9	3.3	3.4	4.0	3.4	4.0
Chloride	3-5mEq/kg (108-177mg/kg)	3-5mEq/kg (150-177mg/kg)	180mg/kg	Chloride, mEq/kg	3.2	4.0	2.2	2.5	2.4	2.8	2.0	2.3

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Trace Elements

Trace Elements

Nutrient	Major Physiological Function	Deficiency Signs	Excess Signs	Important Food Sources	Potential Causes of Deficiency	Suggested Supplementation	Status Assessment
Chromium	Maintenance of normal glucose metabolism, cofactor for insulin	Disturbed glucose metabolism (lower glucose tolerance caused by insulin resistance)		Brewers yeast, meat products, cheeses	Protein calorie malnutrition, elderly	Preterm infants (<3kg) 0.05-0.2 mcg/kg; 3-40kg: 0.2mcg/kg; Adolescent 5-15mcg	Plasma chromium, glucose tolerance
Copper	Constituent of protein and enzymes, some of which are essential for proper utilization Of iron; immunity; skeletal development	Anemia (hemolytic), neutropenia, bone disease	Excess accumulation in the liver, brain, kidney, cornea, Anemia, diarrhea	Oysters, nuts, liver, kidney, corn oil, margarine, dried legumes	Menses kinky hair syndrome ---- Excess: Wilson's disease	0-40kg: 20mcg/kg; Adolescent >40kg 200-500mcg; Adult 300-500mcg	Plasma copper, plasma ceruloplasmi (ferrocealatase), Liver biopsy concentration, Superoxide dismutase activity
Fluoride	Main target organs of fluoride in man are the enamel of teeth and bones; incorporated into crystalline structure of hydroxyapatite and produces increased caries resistance	Poor dentition, caries, osteoporosis	Mottling, brown staining of teeth (in excess of 4ppm), fluorosis occurs after prolonged (10-20yr) ingestion of 20-80mg/d	Fluoridated water; depends on geochemical environment, Amount varies widely in food	Unfluoridated water, bottled water		
Iodine	Component of thyroid hormones triiodothyronine and thyroxine, Important in regulation of cellular oxidation and growth	Goiter - depressed thyroid function, Cretinism	Thyroid suppression (thyrotoxicosis)	Iodized table salt, salt water, fish, shellfish (content varies), Breastmilk, infant formula	Endemic goiter in low iodine areas		Thyroid hormones, TSH, urinary iodide:creatinine ratio

Trace Elements

Nutrient	Major Physiological Function	Deficiency Signs	Excess Signs	Important Food Sources	Potential Causes of Deficiency	Suggested Supplementation	Status Assessment
Iron	Part of hemoglobin molecule, Prevents nutritional anemia and fatigue; increases resistance to infection, Functions as part of enzymes involved in tissue respiration	Anemia, malabsorption, irritability, anorexia, Pallor, lethargy	Hemosiderosis, hemachromatosis	Red meat, liver, dried beans and pasta, Enriched farina, breastmilk, infant formula, infant cereal	PLE, malabsorption, acute on chronic blood loss---- Excess: hemochromatosis		Plasma iron and ferritin, TIBC, H/H, Red cell indices, RBC zinc protoporphyrin:heme ratio; bone marrow, aspirate stain
Magnanese	Essential part of several enzyme systems involved in protein and energy metabolism formation of mucopolysaccaride	Impaired growth, skeletal abnormalities, lowered reproductive function, neonatal ataxia	Extremely high exposure of contamination: severe psychiatric and neurological disorders	Nuts, whole grains, dried fruits, fruits, leafy vegetables			Plasma level, whole blood level, mitrocholdrial superoxide dismutase
Molybdenem	Essential for function of flavin-dependent enzymes involved in production of uric acid and in the oxidation of aldehydes and sulfites		Acts as an antagonist to copper; Gout like syndrome w/ assoc Elevated blood levels of molybdenum, uric acid, and xanthin oxidase	Varies coniderably depending on growing environment: Main contributions comes from meats, grains, legumes			
Selenium	Functions as part of the enzyme glutathione peroxidase which protects cellular component from oxidative damage	Cardiomyopathy, prob 2/2 oxidative damage	In animals: blindness; abd pain	Seafoods, kidney, liver, meat, grains (depending on grow environment)	CF		Plasma concentration, glutathione peroxidase activity, nail/hair selenium
Zinc	Constituent of enzymes involved in most major metabolic pathways, Specifically nucleic acid synthesis for growth and repair	Growth failure, skin changes delayed wound healing, hypogeusia, Sexual immaturity, hair loss, diarrhea	Acute GI upset, vomiting, sweating, sissiness, copper deficiency	Whole grains, legumes, beef, lamb, pork, poultry, nuts, seeds, shellfish, eggs, Some cheese, breastmilk, formula	Malabsorption, chronic diarrhea, liver disease, sickle-cell disease	Preterm Infant (<3kg) 400mcg/kg; Term (3-10kg) 250mcg/kg); Children (10-40kg) 50mcg/kg; Adolescent >40kg 2000-5000mcg	Plasma concentration Alk Phos, urinary exertion, leukocyte concentration

Trace Element Recommendations and Current Dosing in TPN

	Zinc (mcg/kg)	Copper (mcg/kg)	Manganese (mcg/kg)	Chromium (mcg/kg)	Selenium (mcg/kg)
Preterm infant (birth to term)	400-500 (0.4-0.5mg)	20-40	1	0.1	3 to 7
Term (birth to 3 months)	250 (0.25mg)	20	1	0.1	2
Cholestasis (D bili >2)		varies	0		
GI losses	Increase up to twice standard dosign	Increase by 10-15			
Renal Insufficiency (Cr >1mg/dL, undialyzed)	600 if high output renal failure				

Multrys	Per 1ml	0.5kg (0.2ml)	1kg (0.4ml)	1.5kg (0.6ml)	2kg (0.8ml)	2.5kg (1ml)
Zinc	1mg	0.2mg	0.4mg	0.6mg	0.8mg	1mg
Copper	60mcg	12mcg	24mcg	36mcg	48mcg	60mcg
Manganese	3mcg	0.6mcg	1.2mcg	1.8mcg	2.4mcg	3mcg
Chromium	0	0	0	0	0	0
Selenium	6mcg	1.2mcg	2.4mcg	3.6mcg	4.8mcg	6mcg
UF Health dosing: 0.4ml/kg up to 1ml						

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Nutrients in EBM with HMF and Prolacta and SSC 24kcal/oz and Neosure 22kcal/oz

Nutrient	Koletzko	ESPGHAN	RDA/AI	Nutrient	HMF 24kcal/oz		Prolact + 8		SSC 24kcal/oz		Neosure 22kcal/oz	
Zinc	2-3mg/kg	1.1-2mg/kg	2mg/d	Zinc, mg/kg	1.6	2.0	1.1	1.3	1.6	1.8	1.1	1.3
Copper	120-230mcg/d	100-132mcg/kg	200mcg/d	Copper, mcg/kg	126.0	157.2	112.5	130.2	260.0	300.0	114.0	132.0
Iron	1-3mg/kg	2-3mg/kg	0.27mg/d	Iron, mg/kg	0.6	0.7	0.1	0.1	1.9	2.2	1.7	2.0
Iodine	10-55mcg/kg	11-55mcg/kg	110mcg/d	Iodine, mcg/kg	12.5	15.6	23.4	27.0	6.2	7.2	14.3	16.5
Fluoride	n/a	1.5-60mcg/kg	0.01mg/d	Fluoride	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Selenium	7-10mcg/kg	5-10mcg/kg	15mcg/d	Selenium, mcg/kg	1.9	2.4	6.1	7.0	2.1	2.4	2.2	2.5

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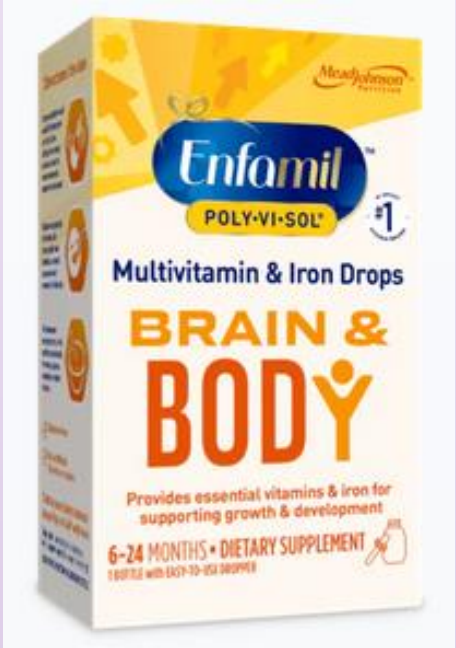
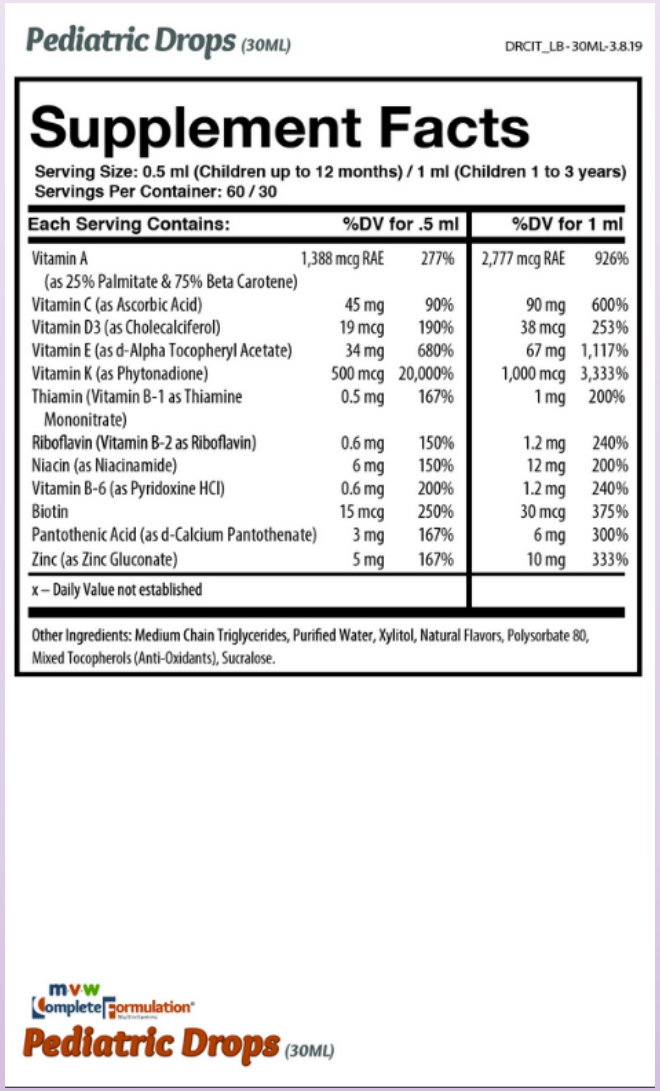
Poly-vi-sol

- Not a complete multivitamin
- In 1ml of poly-vi-sol
  - 250mcg/d Vit A
  - 50mg Vit C
  - 400IU (10mcg) Vit D as cholecalciferol
  - 5mg Vit E
  - 0.3mg Thiamine
  - 0.4mg Riboflavin
  - 4mg NE Niacin
  - 0.3mg Vit B6
  - 11mg Iron



MVW Complete

- UF Health Formulary version of children's ADEK
- Designed for pts needing additional supplementation or who have difficulty absorbing fat soluble vitamins such as cystic fibrosis
- We have used for wound healing, increased GI losses, & liver dysfunction



Pediatric Drops *(30ML)* DRCIT_LB-30ML-3.8.19

Supplement Facts

Serving Size: 0.5 ml (Children up to 12 months) / 1 ml (Children 1 to 3 years)
Servings Per Container: 60 / 30

Each Serving Contains:		%DV for .5 ml		%DV for 1 ml
Vitamin A (as 25% Palmitate & 75% Beta Carotene)	1,388 mcg RAE	277%	2,777 mcg RAE	926%
Vitamin C (as Ascorbic Acid)	45 mg	90%	90 mg	600%
Vitamin D3 (as Cholecalciferol)	19 mcg	190%	38 mcg	253%
Vitamin E (as d-Alpha Tocopheryl Acetate)	34 mg	680%	67 mg	1,117%
Vitamin K (as Phytonadione)	500 mcg	20,000%	1,000 mcg	3,333%
Thiamin (Vitamin B-1 as Thiamine Mononitrate)	0.5 mg	167%	1 mg	200%
Riboflavin (Vitamin B-2 as Riboflavin)	0.6 mg	150%	1.2 mg	240%
Niacin (as Niacinamide)	6 mg	150%	12 mg	200%
Vitamin B-6 (as Pyridoxine HCl)	0.6 mg	200%	1.2 mg	240%
Biotin	15 mcg	250%	30 mcg	375%
Pantothenic Acid (as d-Calcium Pantothenate)	3 mg	167%	6 mg	300%
Zinc (as Zinc Gluconate)	5 mg	167%	10 mg	333%

x – Daily Value not established

Other Ingredients: Medium Chain Triglycerides, Purified Water, Xylitol, Natural Flavors, Polysorbate 80, Mixed Tocopherols (Anti-Oxidants), Sucralose.

mvw Complete Formulation
Pediatric Drops (30ML)

Poly-vi-sol vs MVW Complete

	Koletzko	ESPGHAN	Poly-vi-sol w/ Iron	MVW Complete	MVW Complete
Dose			1ml	0.5ml	0.25ml
Vit A	400-1000 mcg/kg	400-1100mcg/kg	250 mcg	1388 mcg	694 mcg
Vit C	16.5-41 mg/kg	11-46 mg/kg	50 mg	45 mg	22.5 mg
Vit D3	10-25 mcg/d	20-25mcg/d	10 mcg	19 mcg	9.5 mcg
Vit E	2.2-11 mg/kg	2.2-11 mg/kg	5 mg	34 mg	17 mg
Vit K	4.4-28 mcg/kg	4.4-28 mcg/kg		500 mcg	250 mcg
Thiamine (B1)	0.13-0.275 mg/kg	0.14-0.3mg/kg	0.3 mg	0.5 mg	0.25 mg
Riboflavin (B2)	0.15-0.2 mg/kg	0.15-0.2 mg/kg	0.4 mg	0.6 mg	0.3 mg
Niacin	4-6.8 mg/kg	4-6.8 mg/kg	4 mg	6 mg	3 mg
Vit B6	0.15-0.2 mg/kg	0.15-0.2 mg/kg	0.3 mg	0.6 mg	0.3 mg
Biotin	5-8 mcg/kg	5-8 mcg/kg		15 mcg	7.5 mcg
Pantothenic acid	2.5 mg/kg	2.5 mg/kg		3 mg	1.5 mg
Zinc	2-3 mg/kg	1.1-2mg/kg		5 mg	2.5 mg
Iron	1-3 mg/kg	2-3mg/kg	11 mg		

Growth & Malnutrition Assessment

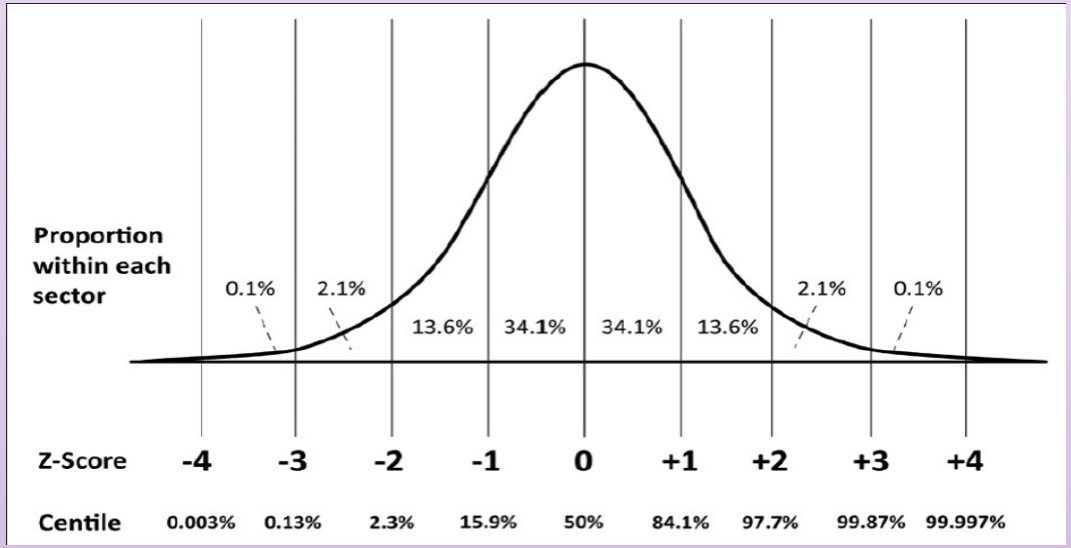
Growth Assessment

- Peak growth for preterm infants occurs at 28 days to 2 months of life corrected age
- Growth goals should be individualized
- Clinical judgement will be important to determine weight gain goals depending on medical condition, growth, and nutrient intake
  - I.e. An infant who loses weight with initiation of diuretic therapy may not be malnourished
- Weight gain goals can be established using the online preterm growth calculator such as www.peditools.org which provides the amount of weight gain weekly needed to maintain current growth parameters

Goldberg, D. et al. Identifying Malnutrition in Preterm and Neonatal Populations: Recommended Indicators. *Journal of the Academy of Nutrition and Dietetics*. 2018.

Use of Z-scores for Growth Assessment

- A z-score is the standard deviation away from the 50th percentile on the growth chart
- This is a more sensitive measure of changes to detect growth failure
- Available on the Fenton, Olsen and WHO growth charts



Goldberg, D. et al. Identifying Malnutrition in Preterm and Neonatal Populations: Recommended Indicators. *Journal of the Academy of Nutrition and Dietetics*. 2018.

Extrauterine Growth Restriction & Postnatal Growth Failure

- Defined as infants weighing less than 10%ile at time of discharge
- Definition is changing as a pt born below the 10%ile may not have growth restriction at time of discharge however remain below 10%ile
- Does not account for linear growth
- Not predictive of adverse outcomes
- Do not include normal postnatal weight losses
- More focus is needed on overall weight patterns and trends vs one point in time

Fenton, TR et al. "Extrauterine growth restriction" and "postnatal growth failure" are misnomers for preterm infants. J of Perinataology. 2020. 40:704-714

Preterm and Neonatal Malnutrition Criteria

- American Society of Enteral and Parental Nutrition and Academy of Nutrition and Dietetics created a consensus statement describing malnutrition criteria in 2018
- Intended population:
  - Preterm infants until 44 weeks CGA
  - Term infants until 1 month of age

Goldberg, D. et al. Identifying Malnutrition in Preterm and Neonatal Populations: Recommended Indicators. *Journal of the Academy of Nutrition and Dietetics*. 2018.

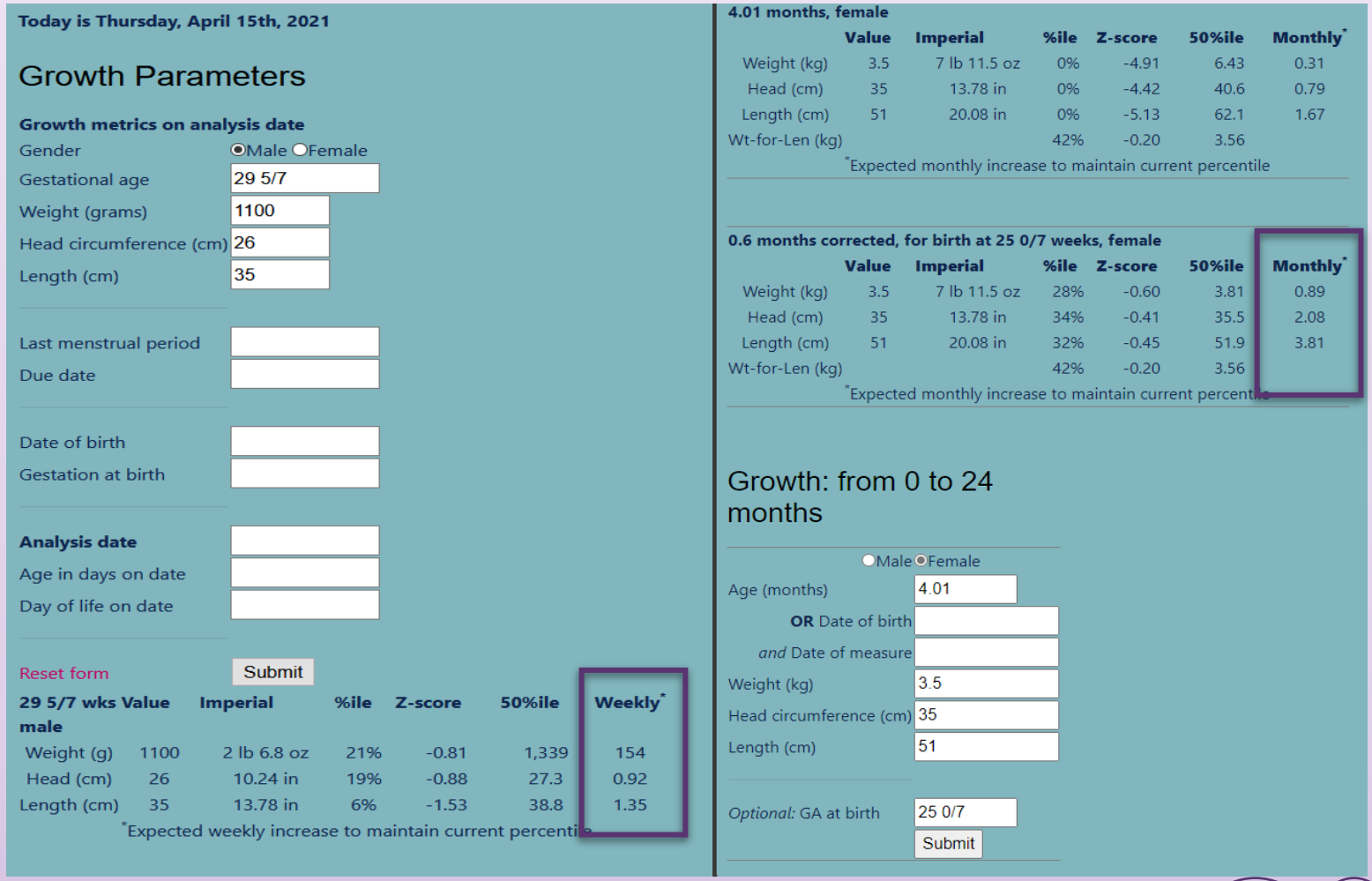
Preterm/Neonatal Indicators of Malnutrition

- Days to regain to birth weight
  - Expected to lose 7-20% within the first 3-5 days of life
  - Should be used in conjunction with nutrient intake to diagnose malnutrition
- Growth Velocity
  - Preterm Infants
    - Previous defined weight gain goals of 15-16gm/kg or 25-35gm/d may underestimate the actual weight gain goals needed to maintain percentiles
      - 15-20gm/kg/d is shown to be insufficient to prevent postnatal growth retardation
      - 20-30gm/kg/d is assoc with improved neurodevelopmental outcomes, reduction of extrauterine growth restriction, maintenance/improvement in a preterm infants birth z-score
    - It is recommended gm/d weight gain be used to identify malnutrition

Goldberg, D. et al. Identifying Malnutrition in Preterm and Neonatal Populations: Recommended Indicators. *Journal of the Academy of Nutrition and Dietetics*. 2018.

PediTools

- www.peditools.org
- Growth charts available:
  - Fenton
  - Olsen
  - WHO
  - Trisomy 21



Today is Thursday, April 15th, 2021

Growth Parameters

Growth metrics on analysis date

Gender ◉Male ○Female
Gestational age 29 5/7
Weight (grams) 1100
Head circumference (cm) 26
Length (cm) 35

Last menstrual period
Due date

Date of birth
Gestation at birth

Analysis date
Age in days on date
Day of life on date

Reset form Submit

29 5/7 wks male	Value	Imperial	%ile	Z-score	50%ile	Weekly*
Weight (g)	1100	2 lb 6.8 oz	21%	-0.81	1,339	154
Head (cm)	26	10.24 in	19%	-0.88	27.3	0.92
Length (cm)	35	13.78 in	6%	-1.53	38.8	1.35

*Expected weekly increase to maintain current percentile

4.01 months, female

	Value	Imperial	%ile	Z-score	50%ile	Monthly*
Weight (kg)	3.5	7 lb 11.5 oz	0%	-4.91	6.43	0.31
Head (cm)	35	13.78 in	0%	-4.42	40.6	0.79
Length (cm)	51	20.08 in	0%	-5.13	62.1	1.67
Wt-for-Len (kg)			42%	-0.20	3.56	

*Expected monthly increase to maintain current percentile

0.6 months corrected, for birth at 25 0/7 weeks, female

	Value	Imperial	%ile	Z-score	50%ile	Monthly*
Weight (kg)	3.5	7 lb 11.5 oz	28%	-0.60	3.81	0.89
Head (cm)	35	13.78 in	34%	-0.41	35.5	2.08
Length (cm)	51	20.08 in	32%	-0.45	51.9	3.81
Wt-for-Len (kg)			42%	-0.20	3.56	

*Expected monthly increase to maintain current percentile

Growth: from 0 to 24 months

○Male ◉Female
Age (months) 4.01
OR Date of birth
and Date of measure
Weight (kg) 3.5
Head circumference (cm) 35
Length (cm) 51

Optional: GA at birth 25 0/7
Submit

Preterm/Neonatal Indicators of Malnutrition

- Change in weight-for-age z-score
  - Primary indicator
  - One study indicated a decline from birth weight during diuresis that exceeds 0.6 SD or 10%ile points is unphysiologic
  - Another study showed preterm infants transitioned to a growth trajectory parallel to the Fenton 2013 0.8SD below their birth z-score
  - Cutoffs for mild, moderate, severe malnutrition reflect the rapid expected weight gain for preterm infants and neonates
- Length
  - Nutritional factors influence the degree of pre and post d/c linear growth which is negatively assoc with cognitive development
  - Used in conjunction with nutrient intake to diagnose malnutrition

Goldberg, D. et al. Identifying Malnutrition in Preterm and Neonatal Populations: Recommended Indicators. *Journal of the Academy of Nutrition and Dietetics*. 2018.

Preterm/Neonatal Indicators of Malnutrition

Indicator	Mild Malnutrition	Moderate Malnutrition	Severe Malnutrition	Use of Indicator
Primary indicator requiring 1 indicator				
Decline in weight-for-age z-score	Decline of 0.8-1.2 SD	Decline of >1.2-2 SD	Decline of >2 SD	Not appropriate for first 2 weeks of life
Weight gain velocity	<75% expected rate of weight gain to maintain growth	< 50% expected rate of weight gain to maintain growth	<25% expected rate of weight gain to maintain growth	Not appropriate for first 2 weeks of life
Nutrient intake	≥ 3-5 consecutive days of protein/energy intake < 75% est needs	≥ 5-7 consecutive days of protein/energy intake < 75% est needs	≥ 7 consecutive days of protein/energy intake < 75% est needs	Preferred indicator during the first 2 weeks of life
Primary indicators requiring 2 or more indicators				
Days to regain to BW	15-18 days	19-21 days	> 21 days	Use in conjunction with nutrient intake
Linear growth velocity	<75% expected rate of linear growth to maintain growth	< 50% expected rate of linear growth to maintain growth	<25% expected rate of linear growth to maintain growth	Not appropriate in the first 2 weeks of life, may be deferred in critically ill unstable infants; Use in conjuction with another indicator when accurate length measurement available
Decline in length-for-age z-score	Decline of 0.8-1.2 SD	Decline of >1.2-2 SD	Decline of >2 SD	Not appropriate in the first 2 weeks of life, may be deferred in critically ill unstable infants; Use in conjunction with another indicator when accurate length measurement available

Goldberg, D. et al. Identifying Malnutrition in Preterm and Neonatal Populations: Recommended Indicators. *Journal of the Academy of Nutrition and Dietetics*. 2018.

Malnutrition Criteria - Considerations

- Consensus statement
- Not validated
- Does not take the place of clinical judgement
  - Different units are using it differently
- Will change over time as it is studied and optimized

Infant/Toddler Malnutrition Criteria

- 2013 ASPEN published Pediatric Malnutrition Criteria which was endorsed by the AAP
- 2014 Academy of Nutrition and Dietetics published a consensus statement for the pediatric malnutrition criteria
- UF Health has adopted and has been utilizing the following criteria to assess pediatric patients growth since late 2014
- Patient population:
  - Term infants > 30 days
  - Preterm infants > 44 weeks CGA

Infant/Toddler Malnutrition Criteria

	Primary Indicator	Mild Malnutrition	Moderate Malnutrition	Severe Malnutrition
No historical Information available	Weight/length z-score	-1 to -1.9	-2 to -2.9	Greater than -3
	Length/age z-score	No data	No data	Greater than -3
	MUAC z-score	-1 to -1.9	-2 to -2.9	Greater than -3
	MUAC (cm)	No Data	11.5 to 12.4	Less than 11.5
If historical Information available	Weight Gain Velocity (0-2 yrs)	<75% expected weight gain	<50% expected weight gain	<25% expected weight gain
	Deceleration in Wt/Ln z-score	Decline of 1	Decline of 2	Decline of 3
	Nutrient Intake	51-75% of estimated needs	26-50% of estimated needs	Less than 25% of estimated needs

Nutrition Recommendations

What do I do if the baby still isn't growing on standard fortification?

Nutrition Recommendations

- No standard approach to further increasing fortification outside of standard fortification
- Recommendations are based on an individual approach
  - What is their BMI (Olson growth chart) or weight/length
  - What is their BUN?
  - Are they receiving DBM and close to transitioning to formula?
- Consider checking urine sodium
  - If a preterm baby has a low urine sodium (<30) or very low (<10) due to immature kidneys it is unlikely they will be able to achieve appropriate growth (weight and length)
  - This is also the case in babies with short bowel syndrome due to increased sodium losses due to dumping/malabsorption
  - Not an accurate assessment if a patient is on chronic diuretics (unless the level is low despite the diuretics)

Fortification Options

- HMF to 26kcal/oz
  - Off label use, increases mOsm of FBM
  - Increases protein and all e'lytes, vitamins/minerals in HMF
  - Reserved for patients with significant volume restriction or *persistently* high Alk Phos despite standard fortification
- Liquid protein
  - Alimentum protein (extensively hydrolyzed)
  - Dose 1ml/25ml – when feeds are at 150ml/kg will provide an additional 1gm/kg protein
  - Minimal caloric intake (need to provide 6ml of liquid protein for an additional 4kcal)
- MCT oil
  - Dosing:
    - 0.25ml/oz provides 2kcal/oz
    - 0.5ml/oz provides 4kcal/oz
  - Can contribute to worsening reflux
  - Only provides calories from fat
- Formula products
  - Similac/Enfamil – appropriate for term babies
  - Neosure/Enfacare – appropriate for discharge however if pts have significant metabolic bone disease, it is better to give straight bottles of formula over FBM for optimal Ca/Phos supplementation
  - SSC 30kcal/oz

Fortification Options

- Please be cautious when fortifying w/ HMF beyond 24kcal/oz AND adding liquid protein

	22kcal/oz	24kcal/oz	26kcal/oz
TFV	150ml/kg/d	150ml/kg/d	150ml/kg/d
Calorie intake	110kkd	120kkd	130kkd
Protein intake	3.3gm/kg	4.3gm/kg	5.7gm/kg
Additional 1ml/25ml liquid protein	4.3gm/kg	5.3gm/kg	6.7gm/kg

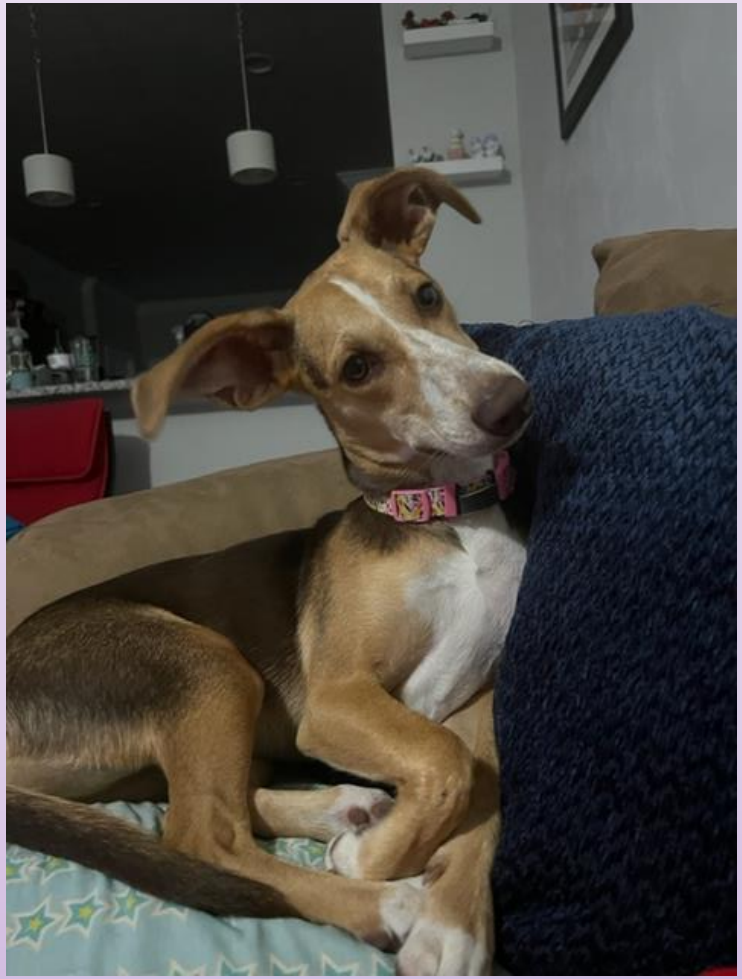
Fortification Options

	Human Milk	FBM 22 w/ HMF	FBM 24 w/ HMF	FBM 22 w/ Neo	FBM 24 w/ Neo	Neosure	SSC
kcal	100	100	100	100	100	100	100
gm pro	1.54	2.97	3.58	1.67	1.77	2.8	3
Ca, mg	41	105	152	47.7	53.7	105	180
Phos, mg	21	58	85	25.7	29.3	62	100

Conclusions

- Nutrition is both science and an art
- Growth should be monitored closely with adjustments as needed
- Nutrition needs should be individualized for each patient

Questions?



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