Neonatal Nutrition

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Disclosures

The following speaker of this CME activity has no relevant financial relationships with commercial interests to disclose

Objectives

- Describe the effects of prematurity on GI physiology of digestion and absorption
- Describe basic nutritional requirements for premature and high risk term infant and influencing factors
- Discuss parenteral enteral nutrition
- Describe various methods of providing enteral nutrition and management

Nutritional challenges of the premature infant

- High caloric requirement
- Small gastric capacity
- Decreased intestinal enzymes
- Decreased bowel motility
- Poor gag reflex
- Potential for reflux
- Poor sphincter control

In Utero Action

What week gestation?

- Fetus capable of swallowing
- The GI tract fully developed
- GI motor activity present
- Organized peristalsis present

Term fetus swallows how much amniotic fluid daily?

- Plays important role in GI development
- Contains carbohydrates, fat, protein, electrolytes, immunoglobulins, growth factors

Atrophy of gut - within few days of fasting

Suck and swallow coordination begins closer 34-36 weeks

Results of Inadequate Nutrition

- Increased weight loss
- Poor weight gain
- Decreased mechanisms to fight infection
- Inadequate or altered brain development
- Bones not well mineralized→ osteopenia of prematurity, rickets

**** Infants never fed do NOT have normal gut hormones and enzymes to help motility**

Fluid/Caloric Requirements and Weight Gain

Fluid requirements

Term infants – parental 100-120ml/kg/day
enteral 120-150ml/kg/day
Preterm infant- parental 120-150ml/kg/day
enteral 150-200 ml/kg/day

Caloric requirements

Term infants 100-120 kcal/kg/d
Preterm infants 110-130 kcal/kg/day
Infant on TPN 70-90 kcal/kg/day
Parental requirements are 20% less than enteral

Adequate weight gain

Preterm 15-20 grams/kg/day
Term 15-30 grams/day

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Calorie Calculation

Calculation of Fluids

Total volume of intake in 24 hours (mls)
Divide by weight to get ml/kg/day
Example: A 1.8Kg baby had a total intake of 252 mls
How much total fluids did baby receive?

Calculation of Calories

To calculate calories - total volume (mls in 24 hours) and divide by 30 (30ml/ounce)
Then, multiply by calories (20 kcal, 22 kcal, 24 kcal per ounce) = kcal/day
Multiply by kilograms = kcal/kg/d
Example: A 4 kg baby had a total intake of 600mls of term formula. How many kcal/kg/day did the baby receive?

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Expected Growth

OFC 0.5-0.8 cm/week for preterm

 0.33 cm/week for term

Daily weights

Weekly measurements are important (head circumference, length, weight)

Growth charts are plotted weekly (Fenton)

What measurement is the best indicator for growth?

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Etiologies of poor growth

Incorrect calculation actual intake
Feedings not adjusted for weight gain
Delay to achieve full calories
Increased caloric needs
- BPD, SGA

Feeding intolerance – emesis, distention
Weaning from isolette too quickly
- overheating

Presence of acidosis, hyponatremia
Low hematocrit

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TPN: Why do we use it?

Brain grows very rapidly last trimester - first 2 years of life
Inadequate nutrition interrupts brain growth - risk for permanent brain injury

Use TPN - delay in adequate enteral nutrition
Sometimes used to supplement feedings

- Short bowel syndrome, NEC
- BW<1500 gms – starter TPN and MEN
- Insufficient caloric content
- Severe respiratory or cardiac disease
- Congenital anomalies, renal failure

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TPN: What's in it?

Macronutrients

- **Carbohydrates:** Dextrose (1g = 3.4kcal)
  Glucose Infusion Rate (GIR)
  Start 4-6mg/kg/min, advance by 1-2mg/kg/min to goal 10-12mg/kg/min

  Calculation: $\frac{\text{IV rate (ml/hr) x Dextrose concentration (\%) x 0.167}}{\text{Weight (kg)}}$

  Example (3kg baby): $\frac{(10\text{ ml/hr}) \times 10\% \times 0.167}{3\text{ kg}} = \frac{1.67}{3\text{ kg}} = 5.6\text{ mg/kg/min}$
- **Protein:** amino acids, provided as Trophamine (1g = 4 kcal)
  (term 2-3gm/kg/d) (preterm 3-4gm/kg/d)
- **Fats:** always 20%, Intralipids/SMOF/Fish oil (1g = 10 kcal)
  <1kg start 1gm/kg/d, >1 kg 2-3gm/kg/d, maximum 3-3.5gm/kg/d

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TPN: What's in it?

Micronutrients
- **Electrolytes** (Na, K, Cl, Ca, Phos, Mg)
- **Trace Elements** (selenium, zinc, copper, manganese, chromium)
  Regulate thyroid function, growth, enzyme reactions, carbohydrate metabolism, glucose/insulin homeostasis)
- **Multivitamins** (A,D,E,K and Vitamin C -ascorbic acid, Vitamin B complex)

Osmolality – Central vs. Peripheral
Maximum dextrose? Ca? Osmolarity?
Why is this important?
Complications – Cholestasis, Sepsis, Osteopenia
- ▸ Staph and Candida

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When to Start Feeds

- Respect immaturity of the gut BUT earlier is better
- Abdominal exam - within normal limits
- Peristalsis activity - bowel sounds, stooling
- Clinical and CV stability (no pressors)
- Absence of retrograde flow - no bilious emesis

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Introducing feedings

Feeding advancement individualized based on clinical condition
- SGA/IUGR
- Prematurity / Gestational age
- Minimal enteral nutrition (<1500 grams)
- Not feeding causes gut atrophy
  - Indocin, Ibuprofen, Pressors
  - Late preterm healthy infant
  - Gastroschisis/bowel compromise
  - Blood transfusion

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Digestion and Elimination

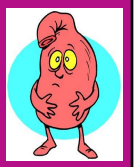
Start small feedings - gradually advance (15-30ml/kg/d)

Small quantity milk in GI tract - promotes ↑ important gut hormones

Gastric emptying slower preterm infants - slowed by high calorie feeding

The more premature the infant, the longer it takes to pass first stool

Monitor for intolerance
- < 1250 grams may need continuous feeds
- 1250-1800 grams - Q 3 hr
- SGA may need continuous feeds - hypoglycemia



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Minimal Enteral Nutrition

Feedings delivered in small volumes (15-30ml/kg/d)
Purpose of gut maturation rather than nutrient delivery

Benefits:
- Improved gut hormones
- Less feeding intolerance
- Earlier progression of full feeds
- Improved weight gain
- Improved Ca/Phos retention
- Fewer days on TPN

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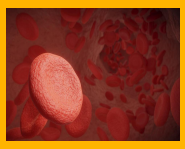
Minimal Enteral Nutrition

What might delay MEN?

Conditions decrease gut blood flow:
- Significant PDA
- Medications - indomethacin
- Severe asphyxia
- Unstable blood pressure - pressors
- Abdominal distention - emesis



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What to Feed?

Human Milk

Human Milk

- Preferred over formula
- Antimicrobial factors - immunoglobulins, lymphocytes (protect against infection)
- Contains hormones/growth factors (enhance development/maturation of intestine)
- Protein and fat - readily digestible - breast milk lipase (lactose easily digested)

Preterm Human Milk

- □ protein, fat ,electrolytes
- Higher caloric density than term human milk
- Preterm infants - need fortified breast milk

Donor Human Milk

- Tested and pasteurized – decrease risk viral transmission
- Pasteurization reduces some antibodies, growth factors, digestive enzymes
- Comes in preterm or term

When would we use it? And why?

Special Needs of Preterm Infant

Preterm infant needs

- More calcium
- More phosphorus
- More sodium
- More protein- growth

Human milk fortification:
adds calories, protein, calcium, phosphorus and sodium

Protein Needs

Weight:	Goal:
0.5 -1.2kg	4.0g/kg/d
1.5 kg	3.6g/kg/d
2.0 kg	3.2g/kg/d
2.5 kg	3.0g/kg/d
2.8 kg	2.8g/kg/d
3.0 kg	2.7g/kg/d
3.5 kg	2.4g/kg/d

FATS

Breastmilk & Formulas provide **~50%** total energy as fat (roughly 5-7 g/kg/day)

We use **20% lipid solution** - Intra Lipids

- Start: 1-2 g/kg/day
- Max: **3.5 g/kg/day**
- Min: 0.5 g/kg/day - avoid fatty acid deficiency
- Cholestasis: 1-2 g/kg/day or use SMOF lipids

- SMOF (soybean, MCT, olive, fish oils)
- Omegaven (Fish oil)

Long Chain Fatty Acids

Breast Milk - *DHA, ARA*

Medium Chain Triglycerides (1 ml = 7.7 kcal) - adds FAT calories

Absorbed directly into portal system. Excellent for…..

Prematurity	Proximal ostomy	Short Bowel
Dysmotility	Malabsorption	Intestinal Failure
Chylothorax	Cholestasis	Liver Dysfunction

Carbohydrates

Breastmilk & infant formulas provide ~45% total energy as carbohydrates (roughly 3-4 mg/kg/day)

Glucose Infusion Rate (GIR) - dextrose in IVFs/TPN solution
- < 1500g - begin with 4-6 mg/kg/min
- > 1500g - begin with 6-8 mg/kg/min

Infant of Diabetic Mother, SGA
- May need 8-10 mg/kg/min soon after birth

Weight Gain requires
- 8-10 mg/kg/min <1000g
- 10-12 mg/kg/min > 1000g
- </= 14 mg/kg/min severe hypoglycemia

IRON

Preterm infants - deplete iron stores by 2 months
- Need 2-4 mg/kg/day supplemental iron
- Start at 2 weeks of age

Most infant formulas/fortifiers provide ~2 mg/kg/day at 120 kcal/kg/day

Ferrous Sulfate ($FeSO_4$)
Oral supplement
Start with 2-4 mg/kg/day
Discontinue when taking enough Fe rich foods - 6-12 months

Vitamin D

Maternal vitamin D concentrations - play role in bone mineral content of newborn

70% infants with alkaline phosphatase > 1000 u/L have vitamin D deficiency

Supplementation - may protect against Type I Diabetes

AAP recommends 400 IU / day for all infants, breastfed or formula fed

Oral **Vitamin D supplement**
200 IU in 0.5 mL / 400 IU in 1 mL
Discontinue when transition vitamin D milk - 12 months

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Breast milk Comparison

Fortified Breast Milk(1000mls)/(24 cal/oz)
Protein 25 grams
Calcium 1147 grams
Phosphorus 627 mg
Vitamin A 13,377 IU
Na 407 mg
Fe 15.6 mg

Plain Breast Milk (1000mls)/(20 cal/oz)
Protein 14 grams
Calcium 248 mg
Phosphorus 128 mg
Vitamin A 3,899 IU
Na 248 mg
Fe 1.21 mg

Human Milk Fortification - liquid vs. powder
Contains MCT, whey protein, minerals

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Formula

Carbohydrate – usually mostly lactose, corn syrup solids

Protein – whey, casein, soy protein
Whey is better tolerated
Breast milk is predominantly whey

Fats – MCT, corn, soy, safflower & coconut oils
More MCT in preterm formulas -

Hydrolyzed protein – already partially broken down proteins

Elemental – the most easily digested and absorbed

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Preterm Formulas

- Premature formulas - whey predominant (similar breastmilk)
- Contain easy to digest carbohydrates - less lactose than term formulas
  50% lactose
  50% glucose polymers - starch/cellulose (give energy/assist absorption Ca)
- Fats - MCT (vs LCT)- easier digestion/better absorption by liver
- More protein, calcium, & phosphorus

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Formula Comparison

20 cal/oz term formula	24 cal/oz preterm formula
Protein 14 grams	Protein 24 grams
Ca 528 mg	Ca 1461 mg
Phosphorus 284mg	Phosphorus 812 mg
Iron 12 mg	Iron 14.6 mg
Na 162 mg	Na 349 mg
Vitamin A 2029 IU	Vitamin A 10,144 IU
Vitamin D 406 IU	Vitamin D 1217 IU
Vitamin E 10.1 IU	Vitamin E 32.5 IU

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SOY FORMULAS

- Allergy to cow's milk or significant family history of allergy
- Contains corn syrup solids and sucrose (rather than lactose)
- Use for primary lactase deficiency
- Temporary lactase deficiency (gastroenteritis)

Lactose intolerance - uncommon preterm infants

**** Soy formulas *NOT recommended* for preterm (<1800 grams)- less calcium and phosphorus = osteopenia, rickets**

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ELEMENTAL FORMULA

Hypoallergenic
Protein - casein hydrolysate
Fat as MCT - easily absorbed by liver
Carbohydrate as corn syrup solids
Some indications for use:

- **Sensitivity to cow's milk protein**
- **Malabsorption disorder**
- **Short gut**
- **GI immaturity**
- **Not good for long term use in preemie**

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Probiotics

Probiotics - not regulated by FDA
Current evidence - probiotic supplementation significantly reduces mortality and NEC without significant adverse effects in preterm neonates
Bifidobacteria and lactobacilli - species commonly used
Bifidobacteria - dominant strains in infancy
Combination of lactobacilli and bifidobacteria - promotes growth of normal flora
Start supplementation - when ready for enteral feeds
Discontinue at corrected gestational age 36 to 37 weeks

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Special Nutritional Needs

Inborn errors of metabolism

PKU (phenylketonuria) – restriction amino acid phenylalanine, supplement tyrosine
Maple syrup urine disease – restrict branch chain amino acids, supplement valine/isoleucine
Galactosemia – restrict galactose/lactose, supplement calcium
Glycogen storage disease (G6PD)- restrict galactose/fructose, modified fat/moderate protein, frequent feedings
Urea cycle disorder - low protein diet with nonessential amino acid restriction, supplement carnitine, biotin, folate, pyridoxine
BPD/Cardiac Defects – increased metabolic demand, respiratory workload/oxygen consumption, energy needs increase 20-40%, fluid restriction to decrease pulmonary edema or cardiac workload = increase calories
Short Bowel Syndrome – reduction intestinal absorption, poor motility, full enteral feeds can be achieved with 25cm small bowel + ileocecal valve or 40cm without valve, may need prolonged TPN and slow enteral feed progression

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Methods of Feeding - Bolus

Benefits

Low risk and cost - tube placement
Minimal loss of nutrients - tubing
Hunger/Satiation development
May increase gastric emptying

Risks

Vagal response
Perforation esophagus/stomach - tube insertion
Adverse effect on ventilation - stomach filled
Vomiting - possible aspiration
Slow emptying - immature physiology

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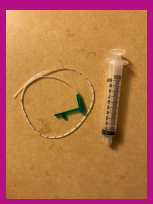
Nursing Interventions with Bolus Feedings

Provide every 2-3 hours - similar breast/bottle feeding
NG/OG - tube size, length
NG preferred - oral feedings
Check tube position
Infant position
Controlling rate of milk flow
Non-nutritive sucking - offer pacifier
Close observation during feeding
May leave tube open - no more than 30 minutes



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Continuous Feedings

Benefits

Avoids full stomach
May lessen compromise to ventilation
May reduce risk of aspiration
May work best infant's < 1000 grams

Risks

Nutrients lost in tubing
Aspiration - malposition of tube
Costs - supplies and pumps
Bacterial contamination
Abdominal distention
Gastric perforation - bleeding
Vomiting
Mortality - aspiration, dislodge

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Breastfeeding

- Establish breastfeeding prior to bottle feeds
- Assess interventions to increase supply
- Assess obstacles - breast too full, difficult latch, flat or inverted nipples
- Skin to skin holding
- Try modified demand - breastfeed when vigorous
- Lactation consultation - support for mother
- Find feeding pattern that works for mother & baby
- Try to establish some degree of success prior to discharge

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Infant Driven Feedings (Cue Based)

- Proven to shorten time to full oral feedings
  5 days (+or - 4.2 days) for experimental group vs. 10 days (+or - 3.1 days) for control group
- Heavier infants took longer time to achieve full oral feeds as did multiples
- Formula fed infants gained more weight (5 grams/day)
- Infants who attained full oral feedings and were ready for discharge 5 days sooner, saving $15,685 per infant
- Can use in conjunction with Speech Therapy

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When to Introduce Oral Feedings Infants

Intact suck and gag reflexes

At least 33-34 weeks gestation

May start non-nutritive breastfeeding first

Able to maintain oxygenation in room air or minimal oxygen requirement <= 30%

Tolerating bolus feeds

Self regulated feedings (all feedings based on cues)

Uses non-nutritive sucking to promote awake behaviors

Shows readiness to feed

Successful Feeder

Actively sucks liquid from bottle
Actively swallows in coordination with sucking
Loses no or minimal amount of liquid during feeding
Coordinates sucking, swallowing & breathing
Remains hemodynamically stable - comfortable breathing, stable saturations

What's not helpful?
Twisting or turning bottle
Moving nipple up/down or in/out of infant's mouth
Moving infant's jaw up/down
Liquid passively entering infant's mouth increases risk of aspiration

References

Blackburn, S.T. *Maternal, Fetal and Neonatal Physiology: A clinical perspective* (4th ed). St. Louis, 2014, Elsevier Saunders.

Verklan, M. PhD, CCNS, RNC, FAAN, Marlene Walden, PhD, RN, NNP-BC, CCNS. *Neonatal Intensive Care Nursing* (5th ed). Galveston, Tx, 2015, Elsevier Health Sciences.