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Learning Objectives

- Understand aspects of normal fetal growth and causes of abnormal or insufficient growth during fetal gestation.
- Understand nutritional requirements during pregnancy and effects of insufficient nutrition on the fetus and mother.
- Understand methods for measuring fetal and infantile growth and development.
- Understand normal infant growth and developmental patterns and potential threats to each.
- Understand aspects of infant nutrition and effects of insufficient nutrition on the infant.
Fetal Growth and Development

- Patterns of Growth
- Measures of Fetal Growth
- Abnormal Fetal Growth
Patterns of Fetal Growth

- Weeks 1-8
  - Embryonic period
- Weeks 8-20
  - Rapid growth and organogenesis
- Weeks 20-34
  - Differentiation and viability
- Weeks 34-40
  - Fat deposition
Measures of Fetal Growth

**Fundal Height**

- Distance from pubic symphysis to top of fundus
- Very accurate after 16 weeks gestation
Measures of Fetal Growth

**Crown-Rump Length (CRL)**

- Very accurate as early as 6 weeks gestation
- \( \text{CRL} + 6.5 = \text{menstrual age in weeks} \)
Measures of Fetal Growth

**Bi-Parietal Diameter**

- Accurate after 12 weeks gestation
- Very accurate precursor of neonatal head circumference measurement

Measures of Fetal Growth

**Femur Length**

- Accurate after 14 weeks gestation
Measures of Fetal Growth

Abdominal Circumference

- Very sensitive indicator of asymmetric growth retardation

Measures of Fetal Growth

Summary of Normal Fetal Growth Parameters
Newer Modalities

- **Chorionic Villus Sampling**
  - Useful modality to investigate suspected chromosomal anomalies

Illustration of transcervical procedure removed


Newer Modalities

- Fetal Echocardiography
Abnormal Fetal Growth

- AGA-appropriate for gestational age
- SGA-small for gestational age
  - IUGR-intrauterine growth retardation
- LGA-large for gestational age
Small for Gestational Age (SGA)

**Definition**
- Birth weight at < 5th percentile for gestational age

**Cause**
- unknown
Intrauterine Growth Retardation (IUGR)

**Definition**
- SGA with a **known** cause

**Diagnosis**
- Abnormal Biophysical Profile
- Clinical Obstetric Clues
- Neonatal Examination

Source Undetermined
Large for Gestational Age (LGA)

**Definition**
- Birth weight at > 95\(^{th}\) percentile for gestational age

**Causes**
- Infant of a Diabetic Mother
- Maternal Obesity
- Cerebral Gigantism
- Genetic Disorders

Source Undetermined
IUGR Classification

- Symmetric
- Asymmetric
IUGR Etiologies

Asymmetric (80%)
- Maternal Factors
- Uteteroplacental Insufficiency

Symmetric (20%)
- Decreased Growth Potential
- Extreme Fetal Malnutrition
- Genetic Disorder
- Congenital Infection
- Environmental Toxins
- Multiple Gestation
Maternal Malnutrition

- Caloric Requirements
- Vitamin and Mineral Requirements
- Effects of Maternal Age

Prepregnancy weight and weight gain during pregnancy account for 10% of the variance in birth weights
Asymmetric IUGR - Maternal Factors

Maternal Illness

- Hypoxemia
- Hematologic/ immunologic
- Substance abuse/cigarette smoking
- Medications (anticonvulsants, antineoplastic agents)
Asymmetric IUGR—Uteroplacental Insufficiency

- Abnormal vasculature
- Chronic infection
- Ideopathic inflammatory lesions
- Placental mosaicism
Symmetric IUGR- Genetic Disorders

- Trisomy 13,18,21
- Turner Syndrome
- Achondroplasia
- Russell-Silver dwarfism
- Seckel Syndrome
- Cockayne Syndrome

Karyotype abnormalities account for about 20% of IUGR
Symmetric IUGR - Congenital Infections

- Cytomegalovirus
- Rubella
- Toxoplasmosis
- Herpes simplex
- Syphilis
- Parvovirus
- HIV

Account for about 5% of IUGR births
Symmetric IUGR - Environmental Toxins

- Maternal Medications
- Illicit Drug Use
- Alcohol
- Cigarette Smoking

Source Undetermined
Infant Growth and Development

- Measures
- Normal Patterns
- Causes of Abnormal Growth and Development
Infant Growth and Development-Measures

- Neonatal Growth Chart
- Ballard Test of Neonatal Maturity
Infant Growth and Development - Measures

- Infant Growth Chart
Infant Growth and Development - Measures

- Denver Developmental Screening Test II
- Bayley
- Gesell
- Battelle
- MIDI
- Ages and Stages
Infant Growth and Development

Birth Averages

- Weight: 3.2 kg (7 pounds, 7 ounces)  
  normal range: 2.8-3.8 kg

- Length: 50 cm (20 inches)  
  normal range: 46-54 cm

- Head circumference: 35cm (13.8 inches)  
  normal range: 33 to 37 cm
Infant Growth and Development

Weight

- Initial weight gain is 15-30g/day
- 6 months: double birth weight
- 12 months: triple birth weight
- 2 years: quadruple birth weight
- 12 mo old ~ 10 kg; 5 yo ~ 20 kg; 10 yo ~ 30 kg

Head Circumference

- Will be about 80% of adult size by age 2, 90% by age 7
Infant Growth and Development

Length

- 4 years: double birth length
- 13 years: triple birth length

<table>
<thead>
<tr>
<th></th>
<th>Boy</th>
<th>Girl</th>
<th>% Adult Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>27 mo</td>
<td>20 mo</td>
<td>20 mo</td>
<td>50%</td>
</tr>
<tr>
<td>6 yrs</td>
<td>5 yrs</td>
<td>7 yrs</td>
<td>66%</td>
</tr>
<tr>
<td>9 yr</td>
<td>7 yrs</td>
<td>7 yrs</td>
<td>75%</td>
</tr>
</tbody>
</table>

- adult height (adult height (girls) = 1.73 x height at age 3 years boys) = 1.87 x height at age 3 years
Infant Growth and Development

Normal Development

- Development is *stepwise* and progresses at a *non-linear* rate

- Domains:
  - Gross motor
  - Fine motor/Adaptive
  - Personal/Social
  - Language
Infant Growth and Development

Gross Motor Development

- Primitive Reflexes- Asymmetric tonic neck reflex (ATNR), Grasp, Moro
- Should be gone by 4-6 months of age

Mileena, flickr

ThrasherDave, flickr

found_drama, flickr
Infant Growth and Development

**Gross Motor Development**

- Key dates:
  - Neck control: 2 months
  - Sit without support: 7 months
  - Walk independently: 12-14 months
Infant Growth and Development

**Fine Motor Development**

- Key dates:
  - Reaches and grasps objects: 4 months
  - Fine pincher grasp: 12 months
  - Stacks blocks, sorts shapes: 15 months

Source: Undetermined

*Der Bettler,* [flickr](https://www.flickr.com/photos/derbettler/)

*EHPhoto,* [flickr](https://www.flickr.com/photos/ehphoto/)

*Source Undetermined*
Infant Growth and Development

**Personal/Social**

- Key dates:
  - Social smile: 6 weeks
  - Looks for dropped object: 6 months
  - Waves bye-bye: 10 months
  - Interactive games: 12 months
Infant Growth and Development

Language

- Key dates:
  - Coos and fixes/follows: 2 months
  - Babbles in consonants and vowels: 6 months
  - Formed words: 12 months
  - 5-10 words: 15 months
  - 50 words: 2 years
Infant Growth and Development

Abnormalities may be caused by:

- Genetic Factors
- Organic Disease
- Environmental Exposures
- Nutritional Deficiency
- Psychosocial Dwarfism
Infant Nutrition

- Caloric Requirements
- Nutrient Sources for the Newborn
- Vitamin and Mineral Requirements
- Keys to Advancing the Infant’s Diet
Infant Nutrition

Benefits of Human Breastmilk

- **Passive immunity**
  - sIgA, IgG, lactoferrin, immunomodulators
  - decreased incidence of acute gastroenteritis, otitis media, meningitis, bacteremia, UTI.

- **Species-specificity**
  - protein: lower content, higher whey:casein ratio, amino acids ideal (incl. taurine)
  - fat: long-chain polyunsaturated
  - carbohydrate: lactose
Infant Nutrition

Benefits of Human Breastmilk

- **Cost**-estimated savings $400/yr, decreased work absence due to illness
- **Bonding**-high prolactin levels may effect bonding
- **Long-term effects?**-Possible effect on incidence of atopy, SIDS, IDDM, Crohn’s dz, cognitive development
- 12% of American babies are breastfed through 6 months of age
Infant Nutrition

- **Formulas** differ in carbohydrate, protein, and fat sources
- **Cow’s milk vs. Soy vs. Hydrolyzed Proteins vs. others**

### Table 4-1: Comparison of breast milk and infant formulas (nutrients per 100 calories)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Breast Milk</th>
<th>Similac</th>
<th>Enfamil</th>
<th>Isomil</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protein (g)</strong></td>
<td>1.54</td>
<td>2.14</td>
<td>2.10</td>
<td>2.45</td>
</tr>
<tr>
<td>% of calories</td>
<td>6</td>
<td>9</td>
<td>8</td>
<td>11</td>
</tr>
<tr>
<td>Source</td>
<td>milk</td>
<td>cow's milk</td>
<td>reduced mineral whey/nonfat milk</td>
<td>soy protein isolate</td>
</tr>
<tr>
<td><strong>Fat (g)</strong></td>
<td>5.74</td>
<td>5.40</td>
<td>5.3</td>
<td>5.46</td>
</tr>
<tr>
<td>% of calories</td>
<td>52</td>
<td>48</td>
<td>47</td>
<td>49</td>
</tr>
<tr>
<td>Source</td>
<td>mature term human milk</td>
<td>soy and coconut oils</td>
<td>palm oil/soy coconut/sunflower</td>
<td>soy and coconut oils</td>
</tr>
<tr>
<td><strong>Cholesterol (mg)</strong></td>
<td>22</td>
<td>1.6</td>
<td>&lt; 1</td>
<td>0</td>
</tr>
<tr>
<td><strong>Carbohydrate (g)</strong></td>
<td>10.6</td>
<td>10.9</td>
<td>10.9</td>
<td>10.3</td>
</tr>
<tr>
<td>% of calories</td>
<td>42</td>
<td>43</td>
<td>43</td>
<td>41</td>
</tr>
<tr>
<td>Source</td>
<td>lactose</td>
<td>lactose</td>
<td>lactose</td>
<td>Corn syrup</td>
</tr>
<tr>
<td><strong>Vitamins</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vitamin D (IU)</td>
<td>3.0</td>
<td>60</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Vitamin K (mcg)</td>
<td>0.3</td>
<td>8.0</td>
<td>8.0</td>
<td>15</td>
</tr>
<tr>
<td><strong>Minerals</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>41</td>
<td>73</td>
<td>78</td>
<td>105</td>
</tr>
<tr>
<td>Phos. (mg)</td>
<td>21</td>
<td>56</td>
<td>53</td>
<td>75</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>0.04</td>
<td>1.8</td>
<td>1.8</td>
<td>1.8</td>
</tr>
<tr>
<td>Renal Solute Load (millies/molar)</td>
<td>11.1</td>
<td>14.3</td>
<td>14.2</td>
<td>16.3</td>
</tr>
</tbody>
</table>

Source: Department of Clinical Nutrition, Children's Hospital of Philadelphia.
Infant Nutrition—milk protein intolerance

- **Colitis/proctitis**
  - appears in the first few months of life
  - blood streaked stools in an otherwise healthy appearing infant
  - may have mild anemia, poor weight gain
  - usually resolve by 1 year with protein avoidance

- **Enterocolitis**
  - appears in the first year of life
  - bloody diarrhea and vomiting, infant may be “septic” appearing
  - 90% resolve by 3 years

- Many infants cross react to soy protein
Infant Nutrition

Vitamin D

- Normally synthesized through sunlight exposure
- Important for calcium metabolism
- Not in breast milk at substantial levels
- Cases of rickets in breastfed babies have led to 2008 AAP recommendation for supplementation with 400IU VitD/day
Infant Nutrition

Fluoride

- Fluoride strengthens the tooth enamel and decreases the risk of dental caries by 20-65%
- Most municipal water sources are fluorinated
- Some controversy does exist about supplementation—excess fluoride can cause fluorosis (discoloration of teeth)
Infant Nutrition

Advancing the Infant Diet

- Water
- Starting Solids
  - 6 months
  - Cereals before Fruits/Vegetables before Meats
- Adding Finger Foods
  - 8-9 months
- Detecting Food Allergy
Health Supervision of Infants (well baby visits)

- Growth Parameters
- Developmental Assessment
- Social and Family History
- Physical Examination
- Immunization
- Disease Surveillance
- Anticipatory Guidance

all in 20-25 min!!
THE END

See you in Pediatric clinic!
Additional Source Information

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