Nutrition, growth and development 2009

Friday 11.9: Aud 3-13
09.00-10.15: Lecture: Nutrition of the fetus.
10.25-11.00: Lecture: Fetal nutritional insults – does it matter?
11.15-12.00: Lecture: Nutritional physiology of the newborn.

Dietary changes during development?
Why?
- Changes in organ anatomy/physiology (e.g. GIT, liver, pancreas)
- Altered growth of tissues/organ
- Altered function of tissues/organ
- Altered disease sensitivity of tissues/organ

Developmental nutrition research - difficult?
- It takes too long to investigate (PhD programs are 3 years)
- The long-time factor makes experiment uncontrollable
- Cell function changes over the course of an experiment

RESULT: Nutritional advice based on epidemiology and tradition

Topics of ongoing PhD projects (children/piglets):
- Colostrum or mature milk for preterm newborns?
- Optimal lipid and protein in preterm formulas?
- Enteral nutrition of children after gut resection?
- Antibiotics or probiotics to prevent gut disease?
- Can milk bioactives prevent preterm gut disease?
- Enteral versus parenteral nutrition in preterms?
- Stimulation of fetal development before birth?
- Nutrition for children with leukaemia?
- What is the role of amniotic fluid before birth?
- Is lactose good or bad in infant formula?

Nutrition and development of the fetus

Maternal & fetal tissue changes:

Fetal & maternal tissue growth:

Important supplement: Animal model developmental studies

Nutrition-critical life stages:

LONG TERM STUDIES:
- It takes too long to investigate (PhD programs are 3 years)
- The long-time factor makes experiment uncontrollable
- Cell function changes over the course of an experiment

RESULT: Nutritional advice based on epidemiology and tradition
Maternal and fetal tissue changes:

1) What does oxygen consumption illustrate? 2) What are the trends throughout gestation? 3) Do these metabolism trends have any implications for maternal nutrient recommendations?

Anabolic & catabolic pregnancy phases

Despite increasing body weight the physiological state is catabolic.

Maternal and fetal weight gain:

Placental nutrient transfer:

Key Nutrition Concepts - Fetus

- Periods of rapid growth and development of fetal organs and tissues occur during specific times during pregnancy.
- Essential nutrients must be available in required amounts during these times for fetal growth and development to proceed optimally.
- The (human) fetus is not a "parasite".

Birth weight and infant mortality:

Diseases and low birth weight:

"Developmental Origins of Adult Disease" – "Barker Hypothesis"
**Birth weight & cardiovascular disease**

<table>
<thead>
<tr>
<th>Birthweight</th>
<th>Relative Risk OR</th>
<th>Birth Defects</th>
<th>Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5 lb (2268 g)</td>
<td>1.5</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>5.1-7 lb (2269-3200 g)</td>
<td>1.3</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>7.1-7.5 lb (3201-3375 g)</td>
<td>1.1</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>7.6-8 lb (3376-3908 g)</td>
<td>1.0</td>
<td>1.0</td>
<td></td>
</tr>
<tr>
<td>&gt;8 lb (3409-4400 g)</td>
<td>0.9</td>
<td>0.7</td>
<td></td>
</tr>
</tbody>
</table>

*Low birth weight – 50-100% greater risk of heart disease/spread.*

**Fetal undernutrition and adult disease:**

<table>
<thead>
<tr>
<th>Nutrient Supply</th>
<th>Nutrient Demand</th>
<th>Fetal Growth</th>
<th>Fetal Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than demand</td>
<td>Fetal undernutrition</td>
<td>Poor development</td>
<td>Poor growth</td>
</tr>
</tbody>
</table>

**Early malnourishment and later diabetes risk**

<table>
<thead>
<tr>
<th>Gestational Age (wks)</th>
<th>Body Weight (lb)</th>
<th>Length (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>20</td>
<td>0.2</td>
<td>0.4</td>
</tr>
<tr>
<td>30</td>
<td>0.4</td>
<td>0.6</td>
</tr>
<tr>
<td>40</td>
<td>0.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>

**Chemical change during fetal life:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Time (wk)</th>
<th>0</th>
<th>20</th>
<th>30</th>
<th>40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>80%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Protein</td>
<td>10%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat</td>
<td>5%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fe</td>
<td>1%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zn</td>
<td>1%</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

**Growth trajectories in fetal life?**

<table>
<thead>
<tr>
<th>Fetal Age</th>
<th>Fetal Weight</th>
<th>Fetal Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>3.0</td>
<td>56</td>
</tr>
<tr>
<td>1 month</td>
<td>5.5</td>
<td>68</td>
</tr>
<tr>
<td>2 months</td>
<td>8.0</td>
<td>75</td>
</tr>
<tr>
<td>1 year</td>
<td>14.0</td>
<td>90</td>
</tr>
</tbody>
</table>

**Chemical change during fetal life:**

- Skeletal development – muscle development – fat development
Different tissue priorities at different life stages (Sir Hammonds “growth waves”)

Tissue growth rate during development

Early Nutrition – Later disease:

- Early delivery – postnatal catch-up
- In utero intra-amniotic feeding?
- Prenatal growth hormones?
- Maternal enriched milk formulas
- Prenatal growth hormones?

Under-weight or immature fetuses – how to help?

- Delivery delay – nutrition?
- Ex utero feeding of “fetal” diets?
- Parenteral or elemental diets
- Postnatal maturation hormones?

Nutritional transition at birth:

- Parenteral nutrition in utero
- Enteral nutrition ex utero

Growth & maturation – not the same:

Nutritional transition at birth:

Birth and its complications

CASE study: Immature gut & nutrition

Following birth, preterm babies at Rigshospitalet have severe digestive problems. Use research to solve the problems. You have unlimited resources to work with pigs as a model animal. Suggest 3 experiments to understand and/or solve the problem? Indicate specific questions/methods/expected results.

Nutrition of an immature gut?

How to understand and/or solve the problem?

Q: Mode of birth?
Exp: Caesarean section versus vaginal birth
Anat: Hormonal levels, gut microbiology?

The nutritional transition at birth:
Energy stores in newborn infants and animals (Fletcher, 1992)

<table>
<thead>
<tr>
<th>Species</th>
<th>Weight (kg)</th>
<th>Fat stores (g/kg)</th>
<th>Muscle glycogen (g/kg)</th>
<th>Liver glycogen (g/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humans</td>
<td>3.5</td>
<td>160</td>
<td>7.5</td>
<td>3.8</td>
</tr>
<tr>
<td>Guinea P.</td>
<td>0.1</td>
<td>110</td>
<td>4.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Rabbit</td>
<td>0.05</td>
<td>58</td>
<td>2.3</td>
<td>2.7</td>
</tr>
<tr>
<td>Sheep</td>
<td>4.5</td>
<td>30</td>
<td>8.8</td>
<td>2.2</td>
</tr>
<tr>
<td>Pig</td>
<td>1.3</td>
<td>11</td>
<td>20.9</td>
<td>2.1</td>
</tr>
<tr>
<td>Rat</td>
<td>0.005</td>
<td>11</td>
<td>1.8</td>
<td>5.8</td>
</tr>
</tbody>
</table>

Time and terms, pre- and postnatally

Infant mortality:

Weight, age at birth and mortality

Infants at Risk

- Low birthweight infants
- Preterm infants born before 34 weeks of gestation
- Infants born with consequences of abnormal development
- Infants at risk for chronic health problems
- Families of infants with special health care needs

Perinatal problems in famous people

Key Nutrition Concepts

- Early nutrition services and other interventions can improve long-term health and growth among infants born with a variety of conditions.
- The number of infants requiring specialized nutrition and health care is increasing due to the improved survival rates of small and sick newborns.
- Infants who are born preterm or who are sick early in life often require nutritional assessment and interventions that ensure they are meeting their nutritional needs for growth and development.
Key Nutrition Concepts

- Nutrient requirements of term newborns have to be modified for preterm infants.
- Knowing the needs of sick and small newborns results in greater understanding of the complex nutritional needs of all newborns and infants.
- Changing feeding practices, such as the care of infants outside the home and the early introduction of foods, markedly affect nutritional status of infants.

Haemodynamics & jaundice

Villous growth, enteral food and GLP-2

Catheterization of fetal pigs in utero