Pregnancy: A brief overview of physiology & psychology

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Objectives

• Fetal growth & development
• Placental growth & development
• Maternal physiologic adaptations
  — Cardiovascular- hematologic
  — Pulmonary
  — Renal
  — Gastrointestinal
• Maternal psychological adaptations

Fetal Growth & Development

• Synchronized cellular communication & interaction
  — Adjacent tissues induce changes in neighboring cells
• DNA sets up basic body plan that establishes plan of early embryo
• Interaction of genetic & environmental influences creates final product

Pre-embryo Development: 0-14 days

• Zygote- 0-2 days
• Morula: 3-4 days
• Blastocyst- 4-14 days
  — Inner cell mass- embryo
• Trophoblast- placenta & chorionic membranes
• Implantation
  — 6-10 days after ovulation
  — 3-5 days prior to beginning of missed menstrual period

Pre-embryo Development

• Formation of primitive yolk sac by 7-8 days post-fertilization
• Primary days 9-10
  — secretions of the oviduct and uterine endometrial glands
• Secondary until 10 weeks
  — capillary plexus surround early spaces in syncrhitotrophoblast fill with filtrate of maternal serum provides nutrition
  — becomes primitive gut
Embryonic Stage:  
Day 15 through Week 8  
- Cellular processes leading to structural changes  
  - Development of internal & external structures  
  - Organogenesis  
- Driven by  
  - Genetic code  
  - Intrauterine environment  
  - Influence of teratogens

Embryo Development:  
Week 3 (15-21 days)  
- Development of trilaminar embryo  
  - Ectoderm  
  - Mesoderm  
  - Endoderm

Embryo Development:  
Week 4 (22-28 days)  
- CNS development  
  - Neural tube fuses (21-28 days)  
    - Anencephaly: 26 days  
    - Spina bifida: 28 days  
  - Proceeds cranially and caudally  
  - Cranial area enlarges, develops cephalic & cervical flexure

Embryo Development:  
Week 4 (22-28 days)  
- Primitive heart begins beating (22 days)  
- Arm (26 days) and leg (28 days) buds  
- 2-5 mm long  
- Formation of primitive gut  
- Lung primordia appear

Embryo Development:  
Week 6 (36-42 days)  
- Cardiovascular  
  - Heart almost complete  
  - Circulation well established  
  - Liver producing blood cells  
  - Congenital heart defects  
- Short webbed fingers, toe rays visible  
  - Syndactyly

Embryo Development:  
Weeks 7 & 8 (43-56 days)  
- Limbs distinct  
- Fingers longer, toes differentiated  
- Gross spontaneous movements begin  
- Body covered with thin skin  
- 7 cc of amniotic fluid  
- GI and GU systems have separated  
- Kidneys achieved basic structure
Fetal Stage: Week 9 through Birth

- Growth in size
- Structural & biochemical maturation
- Factors affecting development
  - Genetic code
  - Intrauterine environment
  - Teratogens
  - Maternal environment

Fetal Development: Weeks 17-20

- By 20 weeks weighs about 300 g, 25 cm long
- CNS myelinization begins
- Lung development
  - Bronchial development complete
  - Terminal air sacs begin to develop
- Rapid growth
  - 20 gm by end week 16
  - Length of embryo doubles in this month
- Increased muscle & bone development
  - Increased movement
- Brown fat deposition begins

Fetal Development: Weeks 21-29

- Weight begins to increase more rapidly
  - @ 24-25 wks 650-750 gm, 30 cm long
- Skin translucent, no subcutaneous fat
- Fingerprint and foot print ridges form
- Basic structure of eye complete, but functionally immature, lids fused
- Organization of CNS begins
- By 24-25 weeks the lungs are able to support extrauterine life

Fetal Development: 30 Weeks-Term

- Fat and muscle tissue laid down, skin thickness increases
- Bones fully formed, ossification not complete
- Testes descend into scrotum
- Nephrons develop until 36 weeks
- Lung maturation finalizes after 34-35 weeks
- CNS organization prominent
  - Myelinization progresses
  - Sleep-wake cycles established

Critical periods: Sensitivity to averse effects of environment

Susceptibility dependent upon developmental stage at time of exposure

<table>
<thead>
<tr>
<th>Stage</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preconception</td>
<td>Chromosome, mutation, infertility</td>
</tr>
<tr>
<td>Preembryo (0-14 days)</td>
<td>“All or nothing”, syndromes</td>
</tr>
<tr>
<td>Early embryo (15-30 days)</td>
<td>Death, NTD, conjoining</td>
</tr>
<tr>
<td>Late embryo (31-56 days)</td>
<td>Death, malformation</td>
</tr>
<tr>
<td>Early fetus (57-70 days)</td>
<td>Death, malformation, dysfunction</td>
</tr>
<tr>
<td>Late fetus (71 days to term)</td>
<td>Dysfunction, altered growth, stillbirth, preterm birth, malignancy</td>
</tr>
</tbody>
</table>
Teratogenesis

- Hyperglycemia - 1st trimester
  - holoprosencephaly, cardiac defects, sacral agenesis, renal defects, facial clefts
- Folic acid - 24-28 days
  - NTDs: anencephaly, meningomyelocele
- Phenylketonuria (PKU) - entire pregnancy
  - Developmental delay, microcephaly, craniofacial defects
- ETOH - entire pregnancy
  - Developmental delay, altered mid-facies, growth restriction
- Heavy metals - mercury, lead, arsenic - entire pregnancy
  - Developmental delay
- Listeriosis - entire pregnancy
  - SAB, stillbirth, PTB, newborn illness
- Toxoplasmosis - 10-24 weeks
  - CNS defects - developmental delay, microcephaly, blindness

The Placenta

- 10-12 weeks is the period of placentation
- Before implantation
  - Blastocyst divides into embryonic cells and placental cells (trophoblast)
- Implantation and placentation requires communication between blastocyst and endometrium
  - Hormones, cytokines, growth factors, other regulatory substances
- After implantation - trophoblast proliferates and invades endometrial stroma
  - Same molecular mechanisms as tumor growth, but regulated
  - Uterine secretions include growth factors that promote placental growth

Placental Growth & Development

- Rapid early growth prepares way for fetal growth
- Mature form by about 10 weeks
  - Eventually occupies about 1/3 of inner uterine surface
  - Growth continues by increasing size and branching of villi and fetal capillaries
- Larger than fetus until about 15-16 weeks
- By term, fetus 5-6 times heavier than placenta
- Towards term begins to undergo degenerative changes
  - Variable onset of placental degeneration

Placental Circulation - Fetal

- Deoxygenated blood from fetus via umbilical arteries
- Arteries branch radially onto chorionic plate, then down into villi
- Converge back at cord into umbilical vein
- Exchange occurs across fetal basal & maternal apical membranes - syncitiotrophoblast

Maternal Uteroplacental Circulation

- Abdominal aorta → internal iliac / ovarian arteries → uterine arteries → uteroplacental arteries (altered spiral arteries)
- After 10-12 weeks, blood enter IVS via 100-200 uteroplacental arteries
  - Flows toward chorionic plate, then down around villi
  - Exchange between maternal and fetal circulations
  - Leaves IVS via 50-200 uteroplacental veins
- By term 20-25% of maternal cardiac output supplies uterus and intravillous space (IVS)
- Flow 500-600 ml/min by term, low-pressure circuit
- IVS in mature placenta contains about 150 ml blood
  - Replenished every 3-4 minutes

Remodeling of Spiral Arteries

- Phase I
  - Implantation to around 12 weeks
  - Altered structure of endometrial spiral arteries
  - Limited blood enters IVS until 10-12 weeks
- Phase II
  - From 12-14 to 20-24 weeks
  - Final alteration of structure in myometrial arteries
Spiral Arteries: Uteroplacental Circulation

- Adrenergic nerves at base of spiral arteries denervated
- Spiral arteries not responsive to circulatory pressors and autonomic nervous system
- Control is at level of maternal radial arteries

(From Fanaroff & Martin, 1997)

Uteroplacental Circulation

- Mediated primarily by local influences
  - PGI₂ (prostacyclin) is most potent vasodilator produced by placenta
  - Maintains vasodilatation of utero-placental vessels
  - Prevents platelet aggregation
  - Enhances cell disengagement (needed for alterations in elastic and muscular elements)

Normal placental development

- Enhanced capacity of uteroplacental vessels
- Arterial dilation with low resistance circuit
- Increased local control of circulation
- Facilitated maternal-fetal exchange of nutrients, gases, wastes at the intervillous space

Potential consequences of altered uteroplacental development

Clinical implications
- Recurrent pregnancy loss
- IUGR
- Pre-eclampsia

Placental Functions

- Metabolic
- Maintains immunological distance between mother and fetus
- Special endocrine organ: “transient hypothalamo-pituitary-gonadal axis”
- Responsible for exchange of nutrients, gases & metabolic waste products between maternal and fetal circulation

Placental Function: Metabolic

- High metabolic rate
  - Glucose & O₂ consumption similar to brain
- Contributes to quality & quantity of fetal nutrient supply particularly in early pregnancy through active synthesis of glycogen, fatty acids, cholesterol
  - Glycogen synthesis: from maternal glucose & stored
  - Cholesterol synthesis: placental cholesterol is precursor for placental progesterone and estrogens
  - Protein production: rises to 7.5 g per day at term
- Synthesis of hormones
  - Steroids, polypeptides and enzymes that influence embryo/fetal growth and development
  - Hormone precursors
**Placental Function: Immunologic**

- Maternal tolerance of fetus
- Protection of fetus from pathogens
  - Limits passage of some bacteria
  - Allows passage of maternal immunoglobulin antibodies (IgG)

**Placental Endocrinology**

- Placenta hormones essential
  - Maintaining pregnancy
  - Inducing maternal physiologic changes
  - Embryo/fetal growth and development
- Primary hormones synthesized by placenta
  - Polypeptides: human chorionic gonadotropin (hCG), human placental lactogen (hPL), Insulin-like growth factors (IGF)
  - Steroids: estrogens, progesterone
  - Many others!

**Human Chorionic Gonadotropin**

- Glycoprotein produced primarily by syncytiotrophoblast
- Production begins around implantation
- Detected in maternal serum and blood by 7-8 days after ovulation
  - Pregnancy tests most reliable by 3 weeks after conception/5 weeks after LMP
- Peaks at 60-90 days post conception
- Decreases to plateau at low levels
- Disappears by 2 weeks post delivery

**Human Placental Lactogen**

- Polypeptide similar to growth hormone
  - Also called human somatomammotropin
- Produced by syncytiotrophoblast beginning 5 to 10 days after implantation
  - Increases into to 3rd trimester
  - Secretion influenced by maternal glucose
    - Decreased maternal serum glucose = increased hPL
    - Increased hPL = increased maternal lipolysis
- Functions
  - Regulates glucose availability for fetus
  - Alters maternal protein, CHO, and fat metabolism
  - Promotes fetal growth
  - Insulin antagonist
Steroid Formation in the Placenta

Progesterone & Estrogens

**Progesterone**
- Produced by corpus luteum until 8 weeks post fertilization
- Then synthesized primarily by placenta using maternal cholesterol, low-density lipoproteins
  - 90% secreted into maternal circulation
- Inhibits smooth muscle contractility
  - Myometrium
  - GI tract
  - Renal
  - Vascular system
- Altered metabolism
  - Fat storage
- Altered in sodium balance
- Stimulates respiratory center to alter CO₂ sensitivity
- Inhibits action of prolactin on breast
  - Decreases sensitivity of oxytocin

**Estrogens**
- All 3 forms increase in pregnancy
  - Estrone and estradiol increase about 10 fold
  - Estriol increases about 100 fold
- Uterine hyperplasia, hypertrophy, increased blood supply
- Breast development
- Alterations in connective tissue
  - Altered joint mobility
  - Cervical ripening
- Alterations in blood composition (plasma proteins, fibrinogen, serum binding proteins)
  - Skin changes
  - Sodium and water retention
  - Altered HCL and pepsin in gut

The Known and Unknown of Leptin in Pregnancy (Hauguel-de-Mouzon, Am J Obstet Gynecology, 2006)
- "Placental Growth Hormone"
- Maternal plasma leptin levels rise in pregnancy
- Leptin is produced by placenta
- Overproduction of placental leptin is seen with diabetes and htn in pregnancy
- Umbilical leptin levels are biomarker of fetal adiposity
- "Leptin may be sensitive to maternal energy status and coordinate metabolic response accordingly." (King, Ann Rev Nutr, 2006)
**Placental “barrier”**
- Maternal and fetal blood do not mix
- Fetal blood flows through capillary networks within highly branched terminal chorionic villi
- Maternal blood flows through intervillous space
  - Uterine arterioles bring blood in
  - Uterine venules drain blood

**Placental Transfer Mechanisms**
- Simple diffusion
- Facilitated diffusion
- Active transport
- Pinocytosis (endocytosis/exocytosis)
- Bulk flow and solvent drag
- Accidental capillary breaks
- Independent movement

**Placental Transfer of Nutrients**

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>Substance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple (passive) diffusion</td>
<td>Water, electrolytes, oxygen, carbon dioxide, urea, simple amines, amino acids, fatty acids, steroids, fat-soluble vitamins, nacronia, antibiotics, barbiturates, and anesthetics</td>
</tr>
<tr>
<td>Facilitated diffusion</td>
<td>Glucose, oxygen</td>
</tr>
<tr>
<td>Active transport</td>
<td>Amino acids, water-soluble vitamins, calcium, inorganic ions, inorganic acids</td>
</tr>
<tr>
<td>Pinocytosis and endocytosis</td>
<td>Glucocorticoids, phospholipids, lipoproteins, antibodies, vitamins</td>
</tr>
<tr>
<td>Bulk flow-related drag</td>
<td>Water, electrolytes</td>
</tr>
<tr>
<td>Independent movement</td>
<td>Intestinal lymphocytes, organisms such as Treponema pallidum</td>
</tr>
</tbody>
</table>

**Factors Affecting Placental Transfer**
- Placental size
  - Surface area
- Diffusion distance
  - Distance decreases as pregnancy progresses, fetal needs increase
- Inflammation
  - Infection, Cytokines, Vascular interruption
  - DM, Obesity
- Maternal-placental blood flow
  - Maternal vascular health
  - Normal placental architecture

**Placental Transfer of Nutrients**

<table>
<thead>
<tr>
<th>Substance</th>
<th>Fetus in Fetus and Placenta</th>
<th>Maternal in Membrane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amino acids</td>
<td>Sodium</td>
<td>Sodium</td>
</tr>
<tr>
<td>Total phosphates</td>
<td>Chloride</td>
<td>Chloride</td>
</tr>
<tr>
<td>Glucose</td>
<td>Urea</td>
<td>Urea</td>
</tr>
<tr>
<td>Sodium</td>
<td>Magnesium</td>
<td>Magnesium</td>
</tr>
<tr>
<td>Calcium</td>
<td>Phosphate/acid</td>
<td>Phosphate/acid</td>
</tr>
<tr>
<td>Potassium</td>
<td>Glucose</td>
<td>Glucose</td>
</tr>
<tr>
<td>Creatinine</td>
<td>Cholesterol</td>
<td>Cholesterol</td>
</tr>
<tr>
<td>Ascorbic acid</td>
<td>Vitamin A</td>
<td>Vitamin A</td>
</tr>
<tr>
<td>Vitamin E</td>
<td></td>
<td>Vitamin E</td>
</tr>
</tbody>
</table>

Factors Affecting Placental Transfer

• Concentration or electrochemical gradient of substance
  – Increased lipid solubility
  – Molecular characteristics
    • Size (smaller <600mc), Ionization (non-ionized)
    – Blood saturation with gases, nutrients
• Maternal-placental metabolism of the substance
• Presence of nutrient transporters
  – Altered by maternal nutrition & disease states
  • DM, HTN, ETOH abuse

Determinants of fetal growth

Embryonic and Placental Development

• http://www.youtube.com/watch?v=UgT5rUQ9EmQ
• http://www.youtube.com/watch?v=jo3NjApFSQE

Maternal Adaptations to Pregnancy: Cardiovascular

• Increased demands on maternal CV system
• Increased circulating maternal blood mass
• Hemodynamic changes directly related to
  – Development of uteroplacental circulation (arteriovenous shunt of maternal vascular compartment)
  – Alterations in SVR- mediated by estrogen, progesterone, prostaglandins
• Mechanical forces due to anatomic alterations

Hemodynamic changes: Increased TBV & PV

• Increased total blood volume
  – 30 to 45% (normal)
  – Begins as early as 6 weeks, increases rapidly to midpregnancy, then increases slowly in last half
• Due to increase in both plasma and RBC volume
  – Peaks by 28 to 34 weeks, may plateau or decrease slightly to term
• Increased plasma volume
  – 40-60% increase (1250-1600 ml)
  – Begins at 6-8 weeks, increases rapidly in 2nd trimester, followed by slower, progressive increase, peaking around 32 weeks
  – Correlates with number of fetuses and fetal weight
• RBC increase lags behind plasma increase in PV
  – 25-33% (250-450 ml)
  – ‘Physiologic anemia of pregnancy’ result of hemodilution

TBV & PV changes
Mean hemoglobin concentrations (5th and 95th percentiles) for healthy pregnant women taking iron supplements

Basis for changes in TBV and PV
- Progesterone inhibits the action of aldosterone on the renal tubular cells, thus contributing to sodium retention and an increase in total body water
- NO mediated vasodilatation induces RAA and stimulates Na and H₂O retention
- Mechanical factors
  - increasing uteroplacental circuit capacity, low-resistance
  - increased distensibility of maternal vascular system

Increased cardiac output
- ↑ CO driven by increased maternal O₂ consumption maternal heart and respiratory muscle demands
  - concomitant ↓ in SVR and redistribution of blood flow
- ½ of total increase occurs by 8 weeks, the increases slowly to the 3rd trimester
  - 3rd tri CO may ↓ due to fall in systemic vascular resistance (SVR)
- CO peaks at 30-50% above non-pregnant at 28-32 weeks
  - possibly 20-26 wks
- Result of changes in both stoke volume (early pregnancy) and HR (late pregnancy)
  - ↑ SV secondary to increased ventricular muscle mass and increased end diastolic volume
- No associated increase in BP because of the marked decrease in SVR

Increased HR & SV
- ↑ Heart rate by 10-20% (10-20 beats per minute)
- Begins as early as 5 weeks, gradually increases during pregnancy
- Peaks by 32 weeks
  - Plateaus to term
- Stroke volume increases 25-30%
  - Peaking at 16 to 24 weeks then declining to term
- Leads to elevated myocardial oxygen requirement

Decreased systemic vascular resistance
- 20% decrease - may be the stimulus for HR, SV, CO changes
- Begins as early as 5 weeks, reaching lowest point at 16-34 weeks, gradually increases (slightly) toward term
- Result of vascular smooth muscle relaxation
  - Softening of cartilage and hypertrophy of vascular smooth muscle
  - Remodeling of the maternal spiral arteries
  - Addition of the low resistance UP circulation
  - Progesterone and vasoactive prostaglandins
  - Endothelial derived relaxant factors such as NO

Decreased systemic vascular resistance
- Allows changes in CO without increase in arterial pressure
- Slight decrease in mean blood pressure
  - Diastolic falls toward mid pregnancy (by ~ 10 to 15 mm with nadir at 24-32 weeks, then increases to term)
  - Systolic pressure decreases less, also reaching a nadir by mid pregnancy
  - Values significantly influenced by maternal position
Altered regional blood flow

- Uterus receives 10-20% of cardiac output by term
  - 10-fold increase → average of 500-600 L/min flow by term
  - Decreased uterine vascular resistance due to remodeling of spiral arteries
- ↑ cardia output above needs of UP unit diverted to other organ systems, acts as reservoir
  - Renal blood flow ↑ 50-80% by end of 1st trimester
  - ↑ Mammary blood flow
  - ↑ Skin, mucosa perfusion
  - ↑ Pulmonary vascular bed

Clinical Implications

- Nutrient concentration declines due to increased plasma volume, but total amount of vitamins and minerals in circulation actually increases
- During most pregnancies increased cardiovascular demands are met without compromising the mother
  - Superimposed upon existing disease state with compromised hemodynamics ↑ risk to mother
  - If maternal hemodynamics do not change
- Compromised uteroplacental circulation ↑ risk of fetal compromise
- Effects of abnormal placentation on maternal & fetal well-being reflected in pregnancy-related vascular disease

Maternal Adaptations: Respiratory

- Changes in maternal respiratory function
  - 30% ↑ production of CO₂ due to O₂ consumption
  - fetus & placenta; ↑ maternal cardiac, ventilatory, renal func; ↑ maternal tissues; ↑ CHO & lipid metabolism
- 50% ↑ volume and air gas exchange
  - Increase availability of O₂ and removal of CO₂
- Related to mechanical & biochemical factors
  - Increased thoracic dimensions, elevated diaphragm → gradual overall increase in lung volume
  - Progesterone- respiratory stimulant, smooth muscle effects
    - Decreased airway resistance
- Increased tidal volumes & sl ↑ in rate → ↑ minute ventilation

Ventilatory Function in Pregnant Women

<table>
<thead>
<tr>
<th>Factor</th>
<th>10 Weeks</th>
<th>24 Weeks</th>
<th>36 Weeks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory rate (L/min)</td>
<td>15-16</td>
<td>16</td>
<td>16-17</td>
</tr>
<tr>
<td>Tidal volume (mL)</td>
<td>600–650</td>
<td>650</td>
<td>700</td>
</tr>
<tr>
<td>Minute ventilation (L)</td>
<td>—</td>
<td>—</td>
<td>10.5</td>
</tr>
<tr>
<td>Vital capacity (L)</td>
<td>3.8</td>
<td>3.9</td>
<td>4.1</td>
</tr>
<tr>
<td>Inspiratory capacity (L)</td>
<td>2.6</td>
<td>2.7</td>
<td>2.9</td>
</tr>
<tr>
<td>Expiratory reserve volume (L)</td>
<td>1.2</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>Residual volume (L)</td>
<td>1.2</td>
<td>1.1</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Clinical Implications

- Increased maternal CO₂ sensitivity
  - Progesterone related increase in maternal minute ventilation
  - Begins early in pregnancy, 60% of total ↑ by 20 wks
- Results in state of mild compensated maternal respiratory alkalosis
  - Slight ↓ in maternal alveolar and plasma CO₂ & ↑ maternal O₂
  - Facilitates transfer of CO₂ from fetus to mother by increasing maternal arterial CO₂ pressure gradient

Maternal Adaptations: Renal

- Fluid & electrolyte homeostasis during pregnancy
- Structural alterations
  - Dilation & loss of tone- renal pelvis, ureters, bladder
  - Primarily progesterone driven
  - Pressure from enlarging uterus
- Functional alterations in hemodynamics
  - Significant cardiovascular alterations
  - ↓ vascular resistance ↑ renal blood flow
  - Altered glomerular filtration & tubule reabsorption of certain substances
Renal function changes

- Increased renal blood flow
  - Increases 50-80% by end of 1st trimester
  - Decreases gradually to term
- Glomerular filtration rate (GFR)
  - Increases 40-50% 110-180 (avg 120-150) ml/min
  - Begins at 5 weeks, peaks at 9-16 weeks, elevated to 36 weeks
  - May decrease 15-20% from 36 weeks to term

Clinical Implications

- Proteinuria
  - Protein excretion rises from <150 mg/24 hrs to up to 250 to 300 mg/24 hrs
- Glycosuria
  - Urinary glucose values may be 10 to 100 fold greater at normal plasma levels
  - From normal 20 mg/24 hrs to 100 mg/24 hrs
  - About 70% excrete >100 mg/24 hrs; 50% excrete >150
- Renal acid-base balance altered to compensate for mild respiratory alkalosis
  - Increased excretion of sodium bicarbonate, retention of H⁺
  - Serum bicarbonate levels fall to 18-22 mEq/L

Maternal Adaptations: GI

- Alterations include:
  • increased intestinal absorption, reduced excretion
- Alterations are driven by:
  • hormonal changes, fetal demands, maternal nutrient supply
- There may be more than one adjustment for each nutrient.
- Maternal behavioral changes augment physiologic adjustments
- When adjustment limits are exceeded, fetal growth and development are impaired
- The first half of pregnancy is a time of preparation for the demands of rapid fetal growth in the second half
- Alterations in maternal physiology facilitate transfer of nutrients to the fetus
Maternal Adaptations to Pregnancy: GI

- Anatomic changes
  - Effects of growing uterus
- Hormonal changes
  - Progesterone
    - relaxation of gastrointestinal smooth muscle
  - Estrogen
    - increased tissue vascularity, hypertrophy
    - influence carbohydrate, lipid, and bone metabolism
  - Appetite driven by insulin, glucagon, progesterone, estrogen, leptin
- Functional changes

Meeting nutrient needs during pregnancy

- Energy costs of pregnancy
  - Kcal intake does not parallel changes in BMR or fetal growth
  - Energy needs of term fetus met by CHO 80% (glucose), amino acids 20% (alternate energy source, substrate for lipid formation)
- Increased maternal BMR
  - Altered to spare energy for fetal growth
- Tissue anabolism
  - Maternal tissues, uteroplacental tissues, fetal growth
- 2nd tri 300-340 kcal/day → 3rd tri 450 cal/day
  - Total average 80,000 kcal up to 120,000 kcal
  - Altered by increasing intake, decreasing activity, limiting maternal fat storage

Late gestation is characterized by

- Anti-insulinogenic, lipolytic effects of hp lactogen, prolactin, cortisol, glucagon
- Glucose intolerance, insulin resistance, decreased hepatic glycogen, mobilization of adipose tissue

Energy intake & weight gain

Infant birth weight & maternal weight gain
Meeting nutrient needs during pregnancy

- Protein requirements
  - 60 gm or sl more
  - provide adequate nitrogen for tissue synthesis
  - All essential amino acids and essential fatty acids (linoleic)

Lipid requirements

<table>
<thead>
<tr>
<th></th>
<th>Non pregnant</th>
<th>Early Pregnancy</th>
<th>Late Pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total triglycerides</td>
<td>60</td>
<td>75 to 100</td>
<td>210</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>170</td>
<td>175 to 200</td>
<td>250</td>
</tr>
<tr>
<td>VLDL cholesterol</td>
<td>10</td>
<td>10</td>
<td>25</td>
</tr>
<tr>
<td>LDL cholesterol</td>
<td>105</td>
<td>100 to 125</td>
<td>150</td>
</tr>
<tr>
<td>HDL cholesterol</td>
<td>55</td>
<td>55 to 75</td>
<td>65</td>
</tr>
</tbody>
</table>

Nitrogen Balance (g/day)

<table>
<thead>
<tr>
<th>Source</th>
<th>Early pregnant</th>
<th>Late pregnant</th>
<th>Non-pregnant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intake</td>
<td>12.03</td>
<td>12.19</td>
<td>11.88</td>
</tr>
<tr>
<td>Fecal</td>
<td>0.82</td>
<td>0.92</td>
<td>0.64</td>
</tr>
<tr>
<td>Urinary</td>
<td>10.52</td>
<td>9.02</td>
<td>10.56</td>
</tr>
<tr>
<td>Integumental</td>
<td>0.14</td>
<td>0.18</td>
<td>0.21</td>
</tr>
<tr>
<td>Retention</td>
<td>0.56</td>
<td>2.10</td>
<td>0.46</td>
</tr>
</tbody>
</table>

Vitamins & Minerals

- Dietary references ↑ by 20-100% of water soluble
  - Vit C, thiamin, niacin, Vit B6 & B12
- Lipid soluble vitamins cross placenta more easily
- Trace minerals usually sufficient
- IOM recommendations balanced diet do not require routine vitamin & mineral supplementation
Adjustments in Nutrient Metabolism

- Goals
  - support changes in anatomy and physiology of mother
  - support fetal growth and development
  - maintain maternal homeostasis
  - prepare for lactation
- Adjustments are complex and evolve throughout pregnancy

Psychosocial Adaptations

- Understanding maternal role attainment behavior
- Process which occurs over time and is a prerequisite for development of parenting identity & behavior
- Pregnancy
- Birth
- Postnatal attachment to newborn

Variables affecting attachment

- Psycho-social
  - Culture, education, SES, social support
  - Life experiences
    - Personal experience of being parented
    - Previous pregnancies or parenting
- Physical health
  - Maternal, pregnancy, fetal, newborn
- Mental health, personality characteristics
  - Maternal
  - Newborn

Health implications of parent-infant attachment

- Medical focus on the physical well-being of mother and fetus
  - *partially* successful in meeting health outcome goals
- Countries incorporate social, as well as medical, models of care have demonstrated *greater* success in reaching health outcomes

Health implications of parent-infant attachment

- Ameliorating effects of psychosocial intervention during pregnancy and early postpartum
  - Improved parent-infant attachment
    - improved child care, decreased child neglect/abuse
    - improved maternal physical well-being
    - improved pregnancy & neonatal outcomes
  - Improved parenting
    - Decreased risk of child abuse, maltreatment in this generation & next
    - Improved parental well-being (generational effect)
Disrupted attachment

- Energy required to cope with stressors detracts from opportunity, ability to do developmental work required
- Risk factors vary
  - intensity, length of exposure, potential consequences
- And, have varying modifiability
  - Parental control of risk, motivation & resources
  - Healthcare provider’s ability to offer effective prevention/intervention

Benedick: pregnancy as a transition

- Normal transitional period
  - pregnancy to parenthood a developmental phase for mother (both parents)
- Opportunity to work through past issues
  - reorganize ideas about herself as a woman, how she was mothered, how she will mother
  - Transform idea of baby to be
- Two central goals of this work
  - Acceptance, embodiment of role of mother
  - Awareness of and bonding with fetus

Bibring: Pregnancy as crisis

- Developmental phenomenon - point of no return
  - Passage from one phase of life to another
  - Old ways no longer relevant
- Induce acute disequilibria
  - Opportunity for the individual to move to higher level of self-awareness and behavioral maturation
  - Mastery of new knowledge & skills
- Far-reaching effects on mother-child relationship

Rubin: Attainment of maternal role

- Mother’s *experience* of pregnancy, childbirth and early postpartum that leads to the development of her maternal role identity
- Progressive transition from a ‘woman without’ to a ‘woman with’
- Maternal ‘role-taking’ seen as inseparable, irreversible incorporation into her whole personality
- Grief with loss of incompatible roles, diffusion of her identity,

Maternal role attainment:

Developmental tasks of pregnancy

- *Ensuring safe passage for self and baby*
- Care and knowledge seeking behaviors
- Manifested as characteristic worrying
  - 1st: Focus on her own well-being
  - 2nd: Shifts focus to fetus/baby
  - 3rd: Finally, surviving labor and birth
- Goal: personal survival and safe birth of healthy baby

Developmental tasks of pregnancy

- *Seeking acceptance of and support for self and baby*
- Re-defining relationships with spouse/partner, family, friends
  - Re-examine relationship with family of origin, friends
  - Development of new social support networks
  - Healthcare provider/system included
- Goal: to ensure a place in the world for herself, as a woman with a child, and her baby
Developmental tasks of pregnancy

- "Binding-in" to unborn child
  - Attachment to fetus → infant
- Begins in childhood
  - Intensifies in pregnancy with fantasizing about unborn infant, assigning attributes to fetus
  - Well-developed relationship with 'baby' by 3rd tri
  - At birth, mother lets go of being pregnant and adjusts to being a mother, lets go of fantasy baby and begins to integrate real baby
- Considered by Rubin to be corner stone of maternal identity development

Role attainment: theoretical strategies

- Mimicry - seeking information, mimicking observations
- Role-play - seeking role models, seeking information
- Fantasy - fantasizing about herself as a mother, imagining the idealized fetus/unborn baby
- Introjection-projection-rejection (de-differentiation)introjects observed behaviors, projects how those behaviors would be for her, and rejects behaviors that don't 'fit': process of sorting, processing & selecting
- Identity - end-point to maternal role-taking, incorporation of image of herself as a mother, starts with ideal, stabilizes as she 'gets to know' her baby

Rubin: Maternal role attainment

- Maternal identity - inseparable incorporation in to the whole personality
- Constructs an internal concept of herself as a mother during pregnancy as preparation for motherhood
- Chooses the behaviors which give her a sense of becoming a 'good mother', of being successful and in control
- When reality does not reflect what she imagined/prepared for → cognitive dissonance

Mercer: Becoming a mother

- Progressive process in which a mother achieves competence in her role, integrates mothering behaviors into her established role set, and becomes comfortable with this new identity
- Stages progress through postpartum period
- Progress in becoming a mother marked by self-appraisal/maternal perception
  - Competence as parent, satisfaction with parenting, relationship with infant, stressors

Stages of becoming a mother

- Anticipatory stage
  - Pregnancy
  - Psychosocial preparation for role of mother
  - Commitment, attachment to the unborn baby, and preparation for delivery and motherhood
- Formal stage
  - Birth - the first 2 to 6 weeks following birth
  - acquaintance/attachment to the infant, identifies her infant's uniqueness
  - Begins care-taking tasks by copying experts' behaviors, following advice
  - physical restoration
Stages of becoming a mother

- Informal stage
  - 2 weeks to 4 months postpartum
  - Moving toward a new normal
  - Progresses from rigidly following directions of others to using her judgment about the best care for her infant
- Personal (maternal) identity stage
  - Postpartum- by around 4 months
  - Achievement of a maternal identity through redefining self to incorporate motherhood
  - Characterized by sense of harmony, confidence, satisfaction in the maternal role, attachment to infant, congruence of self and motherhood as others accept her performance

Becoming a mother (BAM)

- Variables affect successful achievement of becoming a mother
- Maternal variables
  - age, SES, perception of the birth experience, her parenting in early infancy, social stress/support, personality traits (temperament, empathy, rigidity), self-concept, child-rearing attitudes, perception of the infant, role strain, health status, perception of her mothering competence
- Infant variables
  - temperament, appearance, responsiveness, health status

Mercer: Becoming a mother

- Majority achieved maternal identity by 4 months
- 4% had not achieved it at one year
- Self-reported and observed maternal behaviors and feelings of attachment and competence vary over time
  - Peak at 4 months
  - Appear and feel significantly less competent around 8-12 months

BAM: Dynamic Transformation

- Transformation and growth of self
  - Intensive commitment
  - Active involvement
- Begins before or during pregnancy
- Expansion of maternal identity after birth of baby
  - With growth of child, new challenges, subsequent pregnancies, aging
- Congruent with psychosocial developmental and transition theories

Psychology: ‘Prenatal attachment’

- Relates attachment theory to pregnancy drawn form Bowlby’s theories about attachment
- Maternal emotional affiliation with fetus
  - Women form concrete inner representational models of their unborn child, related to a woman’s own attachment history
  - Feelings of attachment begin early in pregnancy, increase rapidly beginning at approximately 16 weeks, peak levels reported in the second trimester

Psychology of successful prenatal attachment

- Predictive of postnatal maternal behavior and attitudes, postnatal maternal attachment to the infant, and mother–infant interaction and attachment patterns after the child is born
- Correlate with pregnancy-related health practices, such as receiving prenatal care and adhering to prenatal care regimens and reducing alcohol consumption during pregnancy
Putting it all together

• Understanding the physiologic processes and adaptational changes occurring in pregnancy is critical to understanding the role maternal nutrition plays in outcomes.
• Understanding the particular psychosocial developmental changes that occur during pregnancy helps our understanding of motivational factors involved in behavior changes.

Reference