Physiology of Pregnancy

- Maternal Physiology
- Fetal Physiology
- First Trimester
- Second Trimester
- Third Trimester
- Birth – Labor and Parturition
- Lactation
Maternal Physiology

- Basal metabolic rate increases 15%
- Cardiac output transiently increases 30-40%
- Blood volume increases 30%
- $O_2$ utilization increases 20%
- Ventilation increases 50%
- Renal tubule reabsorption increased 50%
- Glomerulus filtration rate increased 50%
Weight Gain and Pregnancy

- Average – 24 lbs, can be as much as 75 lbs
- Fetus – 7 lbs
- Extraembryonic fluid/tissues – 4 lbs
- Uterus – 2 lbs
- Breasts – 2 lbs
- Body fluid – 6 lbs
- Fat accumulation – 3 lbs
Fetal Physiology - Circulation

Fetal heart rate (FHR) – beating at 5 weeks – 100 beats/min
8 weeks – 160 beats/min
15 weeks – 150 beats/min
Birth – 130 beats/min
Bradycardia – slow pulse rate – very dangerous to fetus
Blood flow – 40% to head/upperbody
30% to placenta
30% to lower body
Fetal Physiology - Lungs

Lung development – limiting for survival of premature births – record 23 weeks

Pulmonary hypoplasia – reduced lung volume
Fetal Physiology - Respiration

Gross breathing movements at 11 weeks
Rapid and irregular – associated with REM (rapid eye movements)
Isolated slow movements – gasps
Apnea – periods of no breathing

Maternal eating → increases breathing rate
Maternal smoking → decreases breathing rate

Function of fetal breathing:
Stimulates growth of the lungs
Conditioning of muscles
Fetal Physiology - Respiration

Pulmonary surfactants – produced 24 weeks – phospholipids, proteins functions to reduce surface tension – prevents lung collapse; induced by glucocorticoids and thyroid hormone

Respiratory Distress Syndrome (RDS)
Common newborn health concern
Associated with low birth weight / Prematurity
Symptoms: rapid and labored breathing at birth
Cause: insufficient pulmonary surfactant
Fetal Behavior

Passive behavior
- Early pregnancy – 7-15 weeks
- All movement types present at 15 weeks
- Diurnal pattern begins 20-23 weeks
  - peaks evening – maternal corticosteroid levels

Stimulated behavior
- Vibro-acoustic stimulus (VAS) – broad band frequencies
- Assay – FHR, fetal movements, breathing rate
- Females – 28 weeks; Males – 30 weeks

Habituation (learning)
- Cessation of response after repeated novel stimulation
- Requires 10-50 stimuli
- Discrimination of vowel sounds or parental voices
<table>
<thead>
<tr>
<th>Movement</th>
<th>Gestation of first appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any movement</td>
<td>7</td>
</tr>
<tr>
<td>Startle</td>
<td>8</td>
</tr>
<tr>
<td>Generalized movements</td>
<td>8</td>
</tr>
<tr>
<td>Hiccups</td>
<td>8</td>
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<tr>
<td>Isolated arm movements</td>
<td>9</td>
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<tr>
<td>Head retroflexion</td>
<td>9</td>
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<tr>
<td>Hand-face contact</td>
<td>10</td>
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<tr>
<td>Breathing</td>
<td>10</td>
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<tr>
<td>Jaw opening</td>
<td>10</td>
</tr>
<tr>
<td>Stretching</td>
<td>10</td>
</tr>
<tr>
<td>Head anteflexion</td>
<td>10</td>
</tr>
<tr>
<td>Yawn</td>
<td>11</td>
</tr>
<tr>
<td>Suck and swallow</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 23.1
The appearance of fetal movements in early pregnancy (adapted from Reference®)
<table>
<thead>
<tr>
<th>Behavioural characteristic</th>
<th>Biological variable and effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate</td>
<td>Advancing gestation produces: fall in baseline, increased correlation of accelerations and movements, faster rate of rise of accelerations, greater height of accelerations, differentiation of baseline variability with state development.</td>
</tr>
<tr>
<td></td>
<td>Ethnic differences exist</td>
</tr>
<tr>
<td>Movement</td>
<td>Diurnal variation in fetal activity from about 20–22 weeks.</td>
</tr>
<tr>
<td></td>
<td>Advancing gestation produces organization into rest/activity cycles and eventually behavioural states.</td>
</tr>
<tr>
<td>Respiratory</td>
<td>Advancing gestation produces: proportion of time spent exhibiting: a) breathing movements are increased and b) hiccups is reduced.</td>
</tr>
<tr>
<td></td>
<td>More breathing movements seen in active states.</td>
</tr>
<tr>
<td></td>
<td>Maternal glucose consumption increases fetal breathing activity.</td>
</tr>
<tr>
<td></td>
<td>Maternal caffeine consumption increases fetal breathing activity.</td>
</tr>
</tbody>
</table>
Table 23.5
The effects of drugs on fetal behaviour

<table>
<thead>
<tr>
<th>Drug</th>
<th>Effects</th>
</tr>
</thead>
</table>
| Tranquillizers, narcotics, methadone, atropine, barbiturates, pancuronium, anticonvulsants | General depression  
- reduced FHR variability  
- reduced movements  
- reduced breathing |
| Amphetamines                      | Increased PHR variability and movements      |
| Magnesium sulphate                | Reduced FHR variability, reduced movements and FHR response to VAS |
| Ethanol                           | Reduced FHR variability, movement and breathing |
| Indomethacin, terbutaline         | Increased fetal movements and breathing      |
| Prostaglandin $E_2$               | Reduced fetal movements and breathing        |
Digestive Tract

Development anticipates physiological function
Enzyme secreting cell differentiation begins at 11-12 weeks, but secretion is inhibited until after birth
Meconium – fetal poop – fills the lower digestive tract
Swallowing begins early, 11-12 weeks, and continues throughout development
Suckling response develops late – 32-36 weeks
First Trimester - Maternal

Morning Sickness (1st Trimester)

Sensitive / Sore Breast (1st Trimester), Breast Growth (hormones)

Frequent Urination (Entire pregnancy, enhanced 1st and 3rd trimester)

Constipation (hormones and pressure on the rectum)

Fluctuating Emotions (moodiness)
Nausea and Vomiting during Pregnancy (NVP) (Morning Sickness)

- Peaks during the first Trimester
- Positive correlation with birth weight
- Negative correlation with spontaneous abortions
- Nausea – 50-70% of pregnant women
- Vomiting – 40-50% of pregnant women
- Less than 2% is solely in the morning
Nausea to continuous vomiting
1st trimester to entire pregnancy

Possible causes:
   Elevated hCG
   Elevated estrogen / progesterone
   Bacterial (*Heliocobacter pylori*)
   Serotonin levels

Hyperemesis Gravidarum -- Severe
NVP (0.5-1.0%) - life threatening
   – fetus and mother
   – Dehydration, electrolyte imbalance, nutritional deficiencies

Transcutaneous Acupoint electrical stimulation (ventral wrist where median nerve is close to the skin)
Frequent urination

Insomnia, Indigestion, Muscle cramping

Pains associated with stretching uterus

Leukorrhea – vaginal discharge - increased secretion, vagina and cervix
Third Trimester

Week 29 to 40

Pregnancy Blahs – 10% experience mild to moderate depression

Breathlessness – pressure on diaphragm

Edema – ankles, toes – pressure on vena cava and pelvic vein – restricts blood flow

Preclampsia – edema elsewhere – high blood pressure, protein in urine, incidence 4%, restricted blood flow to placenta

Eclampsia – seizure, 2nd leading cause of maternal death in US
Preclampsia or Toxemia of Pregnancy

- Protein loss → buildup in glomerulus
- Kidney function declines
  - salt and water retention
- Increase blood pressure → Arterial spasms, kidney, brain, liver

Two prevalent theories:
- Hormones
- Immune response to fetus

Symptoms disappear soon after birth
Eclampsia

Extreme degree of preclampsia
Vascular spasms throughout the body
Possible convulsions / coma
Decreased kidney output
Liver malfunction
Extreme hypertension
Lethal without treatment
Treatment: Vasodilators and cesarean section
Ultrasound Assisted – Intrauterine Therapy

Fetal Blood Sampling

Needle

Hepatic Vein
Month Nine

Lightening – Fetus descends to pelvic cavity

Cervix – Dilation, Effacement (softening, thinning)

False Labor – Contractions initiate then diminish

Labor:
- Cervical effacement – dilation to 10 cm
- Bloody Show – mucus plug of the cervix – blood-colored
- Breaking Water Bag – rupturing of the amnion
- Contractions – shorter intervals, longer, stronger
Uterine Contraction

Uterine musculature becomes progressively more excitable

Estrogen/progesterone ratio changes increases excitability
  Progesterone inhibits contraction
  Estrogen increases gap junctional communication between smooth muscle cells → increases contractility

Oxytocin (maternal posterior pituitary gland) increases excitability

Mechanically stretching uterine smooth muscle increases contractility

Cervical stretching elicits uterine contractions

Fetal effects – glucocorticoids → placenta → inhibits progesterone
  Fetal oxytocin is also produced
Labor and Parturition

Parturition: Process by which the baby is born

Labor: Strong uterine contractions, Cervix stretching, Forcing the fetus through the birth canal

Rhythmic strong uterine contractions expel the fetus

Positive-Feedback regulation of labor
  Contractions push baby → stretch cervix
  Stretched cervix → Stronger uterine contraction
  Cycles until parturition is complete
Labor and Parturition

Contractions: 30 minutes → 1-3 minutes
Contractions strongest at top of uterus – forcing baby toward cervix (25 lbs/contraction)
Continuous contractions (tetanus) can stop blood flow and lead to death of the baby
First stage of labor: cervical dilation (8-24 hours)
Second stage of labor: passage through birth canal (few minutes to half hour)
Third stage of labor: expulsion of the placenta
Labor and Parturition

Episiotomy – midline surgical incision just prior to delivery

Forceps aided delivery

Variable Presentations
  95% head is inferior
Stage 3 - After Birth

10-45 minutes after parturition the placenta is delivered

2 Phases – Separation and Expulsion

Separation - Uterine cavity reduces in size → shearing the placenta from the uterine wall

Limited bleeding – controlled by local production of vasoconstrictors (prostaglandins)

Expulsion is by uterine contraction
Breast Development Puberty

Estrogen-dependent growth
Fat deposition

Functional Breast Anatomy:
- Nipple, areola glands (secretory, prevents chafing)
- Lactiferous ducts – connects nipple to mammary gland lobes, distal lactiferous sinus accumulates milk
- Mammary gland - 15-20 lobes, each divided \( \rightarrow \) lobules \( \rightarrow \) terminal alveoli (secretory sac)
- Mammary ligaments to breast skin supports breast
Breast Development

Pregnancy

Hormone-Dependent Growth
- Estrogen
- Growth Hormone
- Prolactin
- Adrenal glucocorticoid
- Insulin

Growth and branching of the ductal system

Fat Deposition

Progesterone: Final stages – synergistic with other hormones – growth of lobules, budding of alveoli, secretory characteristics, but not secretion
Lactation

Estrogen and Progesterone inhibit lactation

Prolactin:
- Promotes milk secretion
- Anterior pituitary
- Hypothalamus (inhibition)
- Steady rise week 5 - birth
- Stimulates colostrum – low volume, no fat

Birth – sudden drop in Estrogen and Progesterone
- 1-7 days prolactin induces high milk production
Lactation (cont.)

Other hormones are required: growth hormone, cortisol, parathyroid hormone

Prolactin production is stimulated by signals from the nipple to hypothalamus (repression of prolactin-inhibiting hormone) → Anterior Pituitary → 10-20x surge of prolactin

Nursing can continue for years

Once nursing stops - milk production declines within a week
Milk secreted into the alveoli of the breast, but must be ejected to the ductal system.

Oxytocin (posterior pituitary) stimulates this reflex

Oxytocin production controlled by hypothalamus (direct innervation of the posterior pituitary gland)

Oxytocin induces contraction of myoepithelial cells around the alveoli

Oxytocin induced by suckling and also crying