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%
- O² 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 23.1
The appearance of fetal movements in early pregnancy (adapted from Reference²)

<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>Hiccup</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>
</tr>
<tr>
<td>Hand-face contact</td>
<td>10</td>
</tr>
<tr>
<td>Breathing</td>
<td>10</td>
</tr>
<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>
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

<table>
<thead>
<tr>
<th>Table 23.4</th>
<th>Biological/physiological factors which influence fetal behaviour (From Reference)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral characteristic</td>
<td>Biological variable and effect</td>
</tr>
<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>Movement</td>
<td>Dorsal variation in fetal activity from about 20-22 weeks</td>
</tr>
<tr>
<td>Advancing gestation produces organization into respiration cycles and eventually behavioural states</td>
<td></td>
</tr>
<tr>
<td>Respiratory</td>
<td>Advancing gestation produces proportion of time spent exhibiting: a) breathing movements are increased and b) ‘hiccups’ intensified</td>
</tr>
<tr>
<td>More breathing movements seen in active states</td>
<td></td>
</tr>
<tr>
<td>Maternal glucose consumption increases fetal breathing activity</td>
<td></td>
</tr>
<tr>
<td>Maternal caffeine consumption increases fetal breathing activity</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 23.5</th>
<th>The effects of drugs on fetal behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drug</td>
<td>Effects</td>
</tr>
<tr>
<td>Tranquilizers, narcotics, methadone, barbiturates, paracetrizol, anticonvulsants</td>
<td>General depression</td>
</tr>
<tr>
<td>— reduced P-R variability</td>
<td></td>
</tr>
<tr>
<td>— reduced movement</td>
<td></td>
</tr>
<tr>
<td>Amphetamines</td>
<td>Increased P-R variability and movements</td>
</tr>
<tr>
<td>Magnesium sulphate</td>
<td>Reduced P-R variability, reduced movements and P-R response to VSA</td>
</tr>
<tr>
<td>CIxazol</td>
<td>Reduced P-R variability, movement, and breathing</td>
</tr>
<tr>
<td>Indomethacin, indocinoline</td>
<td>Increased fetal movements and breathing</td>
</tr>
<tr>
<td>Prostaglandin E2</td>
<td>Reduced fetal movements and breathing</td>
</tr>
</tbody>
</table>
Second Trimester

Week 13-29
- 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

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
Birth

Uterine Contraction

Uterine musculature becomes progressively more excitable
- Estrogen/progesterone ratio changes increase 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 → lobules → 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 Letdown

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