

Physiology of Pregnancy

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

Maternal Physiology

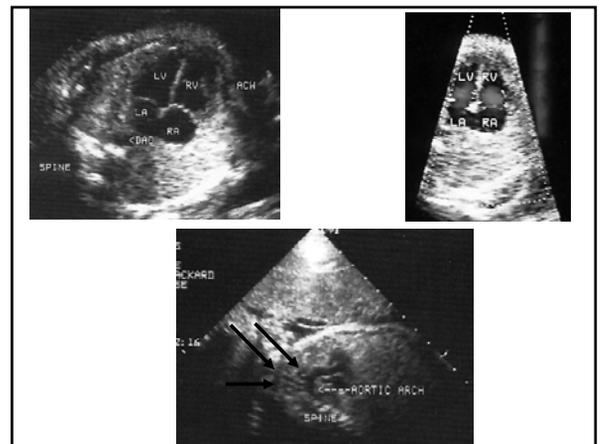
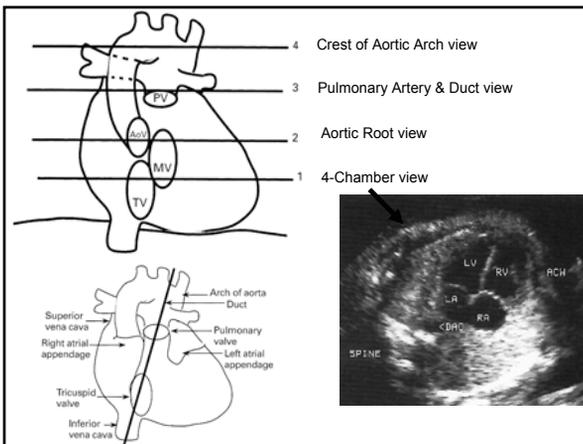
- Basal metabolic rate increases 15%
- Cardiac output transiently increases 30-40%
- Blood volume increases 30%
- O₂ utilization increases 20%
- Ventilation increases 50%
- Renal tubule reabsorption increased 50%
- Glomerulus filtration rate increased 50%

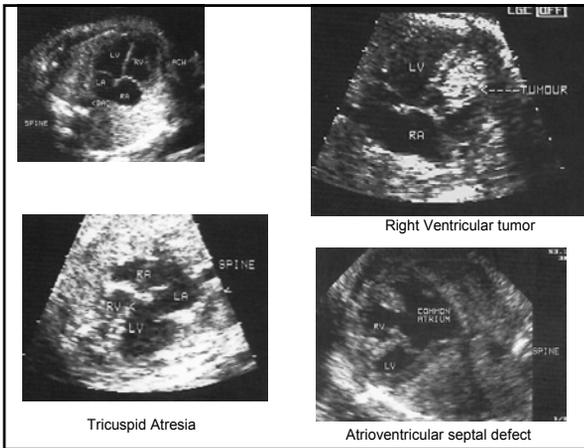
Weight Gain and Pregnancy

- Average – 24 lbs, can be as much as 75lbs
- 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 Reference⁹)

Movement	Gestation of first appearance
Any movement	7
Startle	8
Generalized movements	8
Hiccups	8
Isolated arm movements	9
Head retroflexion	9
Hand-face contact	10
Breathing	10
Jaw opening	10
Stretching	10
Head antelexion	10
Yawn	11
Suck and swallow	12

Table 23.4 Biological/physiological factors which influence fetal behaviour (from Reference ¹⁰)	
Behavioural characteristic	Biological variable and effect
Heart rate	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 Ethnic differences exist
Movement	Diurnal variation in fetal activity from about 20-22 weeks Advancing gestation produces organization into rest/activity cycles and eventually behavioural states
Respiratory	Advancing gestation produces: proportion of time spent exhibiting: a) breathing movements are increased and b) hiccups is reduced More breathing movements seen in active states Maternal glucose consumption increases fetal breathing activity Maternal caffeine consumption increases fetal breathing activity

Table 23.5 The effects of drugs on fetal behaviour	
Drug	Effects
Tranquillizers, narcotics, methadone, atropine, barbiturates, pancuronium, anticonvulsants	General depression — reduced FHR variability — reduced movements — reduced breathing
Amphetamines	Increased FHR 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 ₁	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

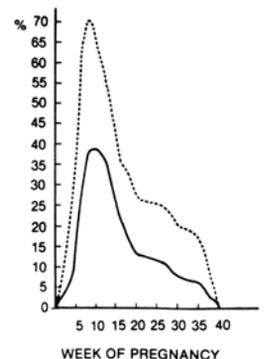
1st trimester to entire pregnancy

Possible causes:

- Elevated hCG
- Elevated estrogen / progesterone
- Bacterial (*Helicobacter 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)



Second Trimester

Week 13-29

Four Months

Five Months

Six Months

Frequent urination
 Insomnia, Indigestion,
 Muscle cramping
 Pains associated with stretching uterus
 Leukorrhoea – vaginal discharge - increased secretion, vagina and cervix

Third Trimester

Week 29 to 40

Seven Months

Eight Months

Nine Months

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

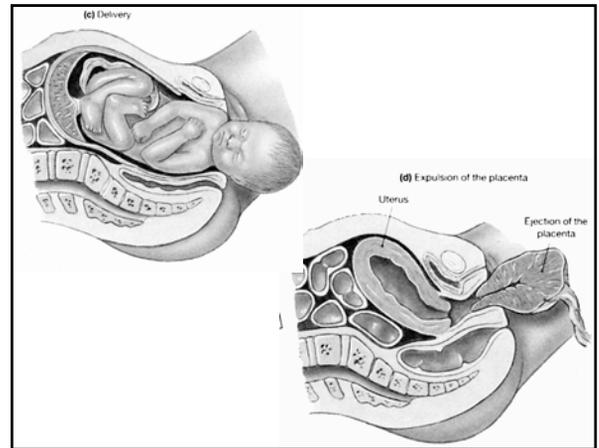
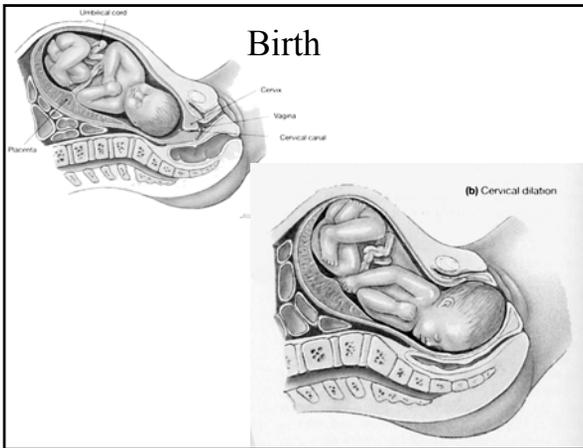
Fetal Blood Sampling

Needle
 Hepatic Vein

Month Nine

Nine Months

Lightening – Fetus descends to pelvic cavity
 Cervix – Dilatation, 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

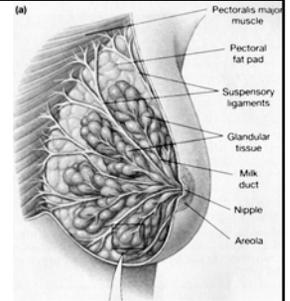
2 Phases – Separation and Expulsion

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)

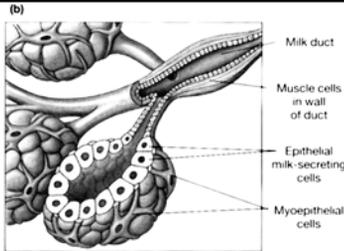
Lactiferous ducts – connects nipple to mammary gland lobes, distal lactiferous sinus accumulates milk

Mammary gland - 15-20 lobes, each divided → 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

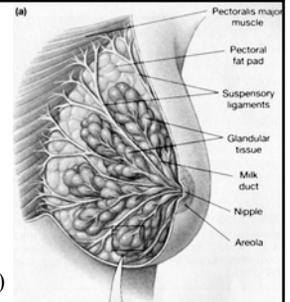
Hypothalamus (inhibition)

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



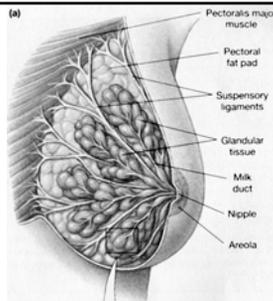
Lactation (cont.)

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

