Pregnancy and Human Development

• Terminology

  – Pregnancy – from time of conception until birth
  – Conceptus – term used for the developing offspring
  – Gestation – time period of development (last menstrual cycle until birth)
  – Preembryonic Development – two weeks following fertilization
  – Embryo – conceptus from 2 – 8 weeks
  – Fetus – week 9 - birth
Pregnancy and Human Development

• From Egg to Embryo
  
  – Fertilization

  • 200 million sperm enter vagina, 1% reach cervix, 200 reach secondary oocyte

  • Typically occurs 12 – 24 hours following ovulation

  • Remain viable for 24 - 72 hrs. (secondary oocyte viable for 24 hours) – 4 day window for fertilization to take place

  • Capacitation – takes about 7 hrs. chemicals from female result in changes in the sperm make it capable of fertilization

  • Acrosomal Reaction and Sperm Penetration

  • Blocks to Polyspermy
Pregnancy and Human Development

• First Week of Development – four events
  – Fertilization
  – Cleavage of zygote
  – Blastocyst formation
  – Implantation
Pregnancy and Human Development

(a) Sperm nucleus
Acrosome
Acrosomal reaction
Granulosa cells of corona radiata
Zona pellucida
Extracellular space
Oocyte plasma membrane
Cortical granule
Oocyte cytoplasm

(b) Sperm nucleus engulfed by oocyte cytoplasm
Pregnancy and Human Development

- Prembryonic Development

  - Completion of Meiosis II and Fertilization
Pregnancy and Human Development

- Cleavage and Blastocyst Formation

1. **Zygote (fertilized egg)**
2. **4-cell stage** (2 days)
3. **Morula** (3 days)
4. **Early blastocyst** (4 days)
5. **Implanting blastocyst** (6 days)

- Fertilization (sperm meets egg)
- Uterine tube
- Oocyte (egg)
- Ovulation
- Uterus
- Endometrium
- Cavity of uterus
- Degenerating zona pellucida
- Blastocyst cavity
- Trophoblast
- Inner cell mass
- Blastocyst cavity
Implantation

(a)

Endometrium
Uterine endometrial epithelium
Inner cell mass
Trophoblast
Blastocyst cavity
Lumen of uterus

(b)

Endometrial stroma with blood vessels and glands
Syncytiotrophoblast
Cytotrophoblast
Inner cell mass (future embryo)
Lumen of uterus

(c)
Placentation

- Placentation
  
  - Extraembryonic mesoderm gives rise to the developing chorion
  
  - Chorion develops chorionic villi, which develop blood vessels that connect with the developing embryo via the umbilical arteries and vein
  
  - Erosion results in large lacunae forming in the stratum functionalis of the endometrium, chorionic villi lie close to these
Placentation

- Layer of endometrium between the chorionic villi and *stratum basalis* becomes the *decidua basalis*; layer surrounding the embryo facing the lumen of the uterus the *decidua capsularis*

- Chorionic villi plus decidua basalis makes up the placenta
Placentation

(f) 13-week fetus

(f) 13-week fetus
Events of Embryonic Development

• Formation and Roles of Embryonic Membranes

  – Amnion

    • Formed from cells of the embryonic disc, epiblast
    • Becomes a fluid filled sac that surrounds the developing embryo

    • Functions

      – Cushioning
      – Temperature regulation
      – Prevents adhering of developing structures
Events of Embryonic Development

- Yolk Sac
  - Formed from cells of the embryonic disc, hypoblast
  - No real nutritive function
  - Forms part of the gut tube
  - Earliest site of erythropoiesis
  - Primordial germ cells

- Allantois
  - Small outpocketing at caudal end of yolk sac
  - Site for waste disposal

- Chorion
  - Helps form the placenta
  - Surrounds the embryo and all of the other membranes
Events of Embryonic Development

- Gastrulation: Germ Layer Formation
  - Occurs at week 3
  - Three germ layers arise
    - Ectoderm
    - Mesoderm
    - Endoderm
Events of Embryonic Development

- Organogenesis: Differentiation of the Germ Layers
  - Specializations of Ectoderm - neuralation
Events of Embryonic Development

(c) 20 days

(d) 22 days

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Events of Embryonic Development

- Specializations of the Endoderm – forms primitive gut
Events of Embryonic Development

- Specialization of Mesoderm
  
  • First seen as the notochord which persists as the pulposus of the intervertebral discs
  
  • Aggregates appear on each side of the notochord, *somites*, each made of three parts
    
    - Sclerotome, gives rise to
      
      » Vertebral column
      
      » Ribs
    
    - Dermatome – gives rise to the skin
    
    - Myotome – develop in skeletal muscles
Development of Fetal Circulation

(a) Placenta

(b) Key:
- Red = High oxygenation
- Purple = Moderate oxygenation
- Pink = Low oxygenation
- Blue = Very low oxygenation

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Effects of Pregnancy on the Mother

- Anatomical Changes

  - Reproductive organs become large and fill with blood (vagina develops a purplish hue, *Chadwick’s Sign*)
    - Enhances sexual sensations
  - Breasts
    - Fill with blood
    - Glandular tissue develops
    - Areola darkens
  - Pigmentation in face – “mask of pregnancy”
Effects of Pregnancy on the Mother

- Uterus enlarges

  - Relaxin – adjusts center of gravity
Effects of Pregnancy on the Mother

- **Metabolic Changes**

  - Placenta begins to secrete

  - Human placental lactogen (hPL) or human chorionic somatomammotropin (hCS)
    - Works synergistically with estrogen and progesterone to prepare the breasts
    - Promotes growth of the fetus
    - Promotes glucose sparing in mother (can result in gestational diabetes)

  - Human chorionic thyrotropin (hCT) – similar to thyroid stimulating hormone
    - Increases maternal metabolic rate
    - Increased plasma calcium levels
Effects of Pregnancy on the Mother

- Physiological
  - Gastrointestinal
    - Morning sickness
    - Heartburn
    - Constipation – intestinal motility declines
  - Urinary
    - Compressed bladder
    - Increased glomerular filtration
Effects of Pregnancy on the Mother

- Respiratory
  - Tidal Volume > 30 – 40%
  - Expiratory reserve < 40%
  - Functional residual capacity < 25%
  - Minute ventilation rate > 30 – 40%
  - Oxygen consumption > 10 – 20%
  - Dyspnea
Effects of Pregnancy on the Mother

- Cardiovascular
  - Stroke volume > 30%
  - CO > 20 – 30 %
  - Heart Rate > 10 – 15%
  - Blood Volume > 30 – 50%
  - When lying down weight of fetus can compress on aorta and vena cava (leg edema)
  - Compression of renal arteries (renal hypertension)
Parturition (Birth)

• Initiation of Labor
  – Rising levels of fetal cortisol stimulates the uterus to secrete large amounts of estrogen, in response
    • Myometrial cells produce oxytocin receptors
    • Removes inhibiting effects of progesterone on uterine smooth muscle
    • Weak, irregular contractions begin, Braxton Hicks Contractions (false labor)
      – Fetal cells release oxytocin which causes placenta to release prostaglandins – both initiate stronger uterine contractions (positive feedback mechanism begins)
      – Fetal fibronectin becomes a lubricant
Parturition (Birth)

- **Estrogen**
  - from ovaries
  - Induces oxytocin receptors on uterus

- **Oxytocin**
  - from fetus and mother's posterior pituitary
  - Stimulates uterus to contract
  - Stimulates placenta to make Prostaglandins
  - Stimulate more vigorous contractions of uterus

Positive feedback
Parturition (Birth)

- **Stages of Labor**
  - Stage 1: Dilation Stage
    - Time from beginning of labor until cervix reaches 10 cm
    - Contractions 15 – 30 min. apart; last for 10 – 30 sec.
    - Cervix softens, effaces, and dilates
    - Amnion ruptures
    - Can last for 6 – 12 hrs.
    - Baby rotates for birth position
Parturition (Birth)

- Stage 2: Expulsion Stage
  
  - Time from full dilation until birth
  
  - Strong contractions every 2 – 3 min., last about 1 min.
  
  - Can last up to 2 hours, typically less than an hour
  
  - Crowning – when largest portion of baby’s head appears (episiotomy may be done)

- Stage 3: Placental Stage
  
  - Usually about 30 min. after birth
Adjustments of the Infant to Extrauterine Life

- Neonatal Period – first 4 weeks of life

- Apgar Score – performed 1 – 5 minutes after birth, scored from 0 – 2 for each parameter (score of 8 – 10 indicates a healthy baby)
  - Heart rate
  - Respiration
  - Color
  - Muscle tone
  - Reflexes
Adjustments of the Infant to Extraterine Life

- Taking the First Breath
  - Loss of link with placenta result in respiratory acidosis (Effect?)
  - Requires a great deal of effort (Why?)
  - Rate fast for first several weeks, 45/min
Lactation

- Towards end of pregnancy hypothalamus releases prolactin releasing hormone

- Colostrum – first secretion produced by the breasts
  - Yellowish fluid
  - No fat
  - Less lactose than true milk; more
    - Protein
    - Vit. A
    - Minerals
  - Rich in IgA (what type of immunity?)
Lactation

- True Milk Production – in the absence of suckling prolactin production decreases; suckling results in bursts of prolactin being release – same stimulus results in milk let-down reflex
Lactation

• Advantages of Breast Feeding

  – Nutrients more easily absorbed

  – Immune system bolstered, antibodies, complement, lysozyme, etc.

  – Laxative – cleanses bowl

    • Helps remove bilirubin

    • Provides environment for development of natural bacterial flora