Fetal Growth & Development

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Learning objectives:

- Explain the relationships between fetal and maternal anatomy and physiology.
- Trace the gestational development of the fetus.
- Explain thermoregulatory problems of neonates.

Fetal Development

Embryonic stage of life

- Fertilization - egg & sperm share genetic material to produce the zygote
- Zygote cells divide and traverse fallopian tube to uterus
- Zygote, now embryo penetrates uterine wall around day five - nourished by mother’s blood

Click to see video on fertilization (.75)
http://www.youtube.com/watch?v=NuD7J3fBV0U

Embryonic Development

- Embryo & placenta develop
- Embryo - Carnegie stages of embryonic development
  - up to 8 or 9 weeks
  - time intervals are not exact - there are no intrauterine calendars

Click to see video on development of embryo & placenta (.75)
http://www.youtube.com/watch?v=jo3NjApFSQE

Embryo to fetus

- Fetus - eight weeks
  - major organs are present, not fully developed
  - hands and feet are present

Click to see video on embryo to fetus (1.0)
http://www.youtube.com/watch?v=HBBNu_dAGhs&NR=1
Embryo to fetus

- **Fetus - 9-12 weeks**
  - Eyelids close until week 28
  - Face is well-formed
  - Fetus can make a fist
  - Tooth buds appear

Embryo to fetus

- **Fetus - 13-16 weeks**
  - Fetal skin is transparent
  - Fine hair (lanugo) develops
  - Meconium formed in GI tract
  - Active movements begin
  - Sucking motions begin

Embryo to fetus

- **Fetus - 17-20 weeks**
  - Fetus can hear
  - Lanugo covers body
  - Mother feels fetal movements
  - Fingernails & toenails appear
  - Fetal heartbeat audible with stethoscope

Embryo to fetus

- **Fetus - 21-24 weeks**
  - Bone marrow starts making blood cells
  - Fat storage begins
  - Eye parts are developed
  - Startle reflex is present
  - **Fetus - 25-28 weeks**
    - Rapid development of CNS
    - Eyelids open and close

Embryo to fetus

- **Fetus - 29-32 weeks**
  - Increase in body fat
  - Rhythmic breathing movements
  - Bones are developed, but soft
  - **Fetus - week 36**
    - Lanugo disappearing
    - Fingernails reach fingertips

Embryo to fetus

- **Fetus - 37-40 weeks**
  - Lanugo nearly gone
  - Breast buds are present
  - Head hair is coarse and thick

Click to see video on fetal development (4.5)
http://www.youtube.com/watch?v=aR-Qa_LD2m4&feature=related
The Placenta

Structure - maternal and fetal contributions

- Chorionic villi - fetal projections into uterus
- Amnion - fetal surface
- Decidua basalis - maternal
- Cotyledons - lobes or segments of discrete areas of attachment

The placenta

Functions

- All gas exchange between fetus & environment
- Transports nutrients, antibodies, and hormones from mom to fetus
- Removes waste from fetus to mom
- Forms placental barrier, which filters out some substances

Fetal-maternal interface

PO2 = 40 mm Hg

The umbilicus

- Lifeline from mom to fetus
- Developed by fifth week gestation
  - Structure
    - Two arteries
    - One vein
    - Surrounded by Wharton's jelly - protects & insulates umbilicus

Click to see cross-section of umbilicus

http://homepages.cae.wisc.edu/~bme300/umbilical_f07/images/IMG_2133.jpg

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The Amnion

Amniotic sac & fluid

Click to see image of fetus within amnion
http://155.37.5.42/eAtlas/GYN/679.htm

Amniotic fluid

- Volume = 1 L at term
- Origins
  - Amniotic membrane
  - Fetal urine
  - Fetal skin
  - Fetal lung

Click to see an amniotic sac with placenta
http://z.about.com/d/pregnancy/1/5/h/c/amnioticsac.jpg

Amniotic fluid abnormalities

- Oligohydramnios - associated with:
  - Potter's syndrome
  - Fetal renal agenesis
  - Fetal urethral obstruction
  - Pulmonary hypoplasia - underdeveloped lung(s)

Click to see images of Potter's syndrome

Amniotic fluid

- Functions
  - Prevents trauma to fetus
  - Permits free movement within uterus
  - Stabilizes temperature
  - Evenly distributes hydrostatic forces during labor to prevent pressure points

Amniotic fluid abnormalities

- Polyhydramnios
  - Causes
    - Fetal GI obstruction - i.e., esophageal atresia
    - Severe brain malfunction - impaired swallowing
  - Effects - hydrops fetalis - accumulation of fluid (edema)
    - ascites
    - pleural, pericardial effusions

Click to see an amniotic sac with placenta
http://z.about.com/d/pregnancy/1/5/h/c/amnioticsac.jpg

Click to see image of fetus within amnion
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Fetal Lung Development

Fetal lung development stages

- Embryonic (4-6 wks)
  - Lung bud differentiates
  - Diaphragm develops
- Pseudoglandular (6-16 wks)
  - Formation of airways
  - Mucous glands appear
  - Ciliated cells appear
  - Breathing movements at 12 wks

- Canalicular (16-26 wks)
  - Distal airways develop
  - Type II cells begin to differentiate
- Alveolar (27-40 wks)
  - Appearance of macrophage
  - Type I cells thin - permits diffusion
  - Type II cells proliferate - surfactant increases
  - Chemoreceptors develop

Click for pictures of fetal lung development

Pulmonary changes at partum

- Lung initially filled with fluid
- Pulmonary vascular resistance is high - pulmonary blood flow is minimal
- Uterine contractions assist expulsion of fetal lung fluid

Pulmonary Changes at Partum

- First breath
  - triggered by:
    - touch
    - temperature
    - chemical changes
  - requires -40 to -100 cm H2O
  - establishes FRC
Fetal Circulatory Development

Development of the heart
- Originates as two parallel tubes
- Tubes convolute to form chambers
- Septa and valves form from endocardial cushion

Fetal Circulation Characteristics
- Normal shunts:
  - Foramen ovale - between atria
  - Ductus arteriosus - aorta to pulmonary artery
  - Ductus venosus - bypasses liver

Click for information and pictures of fetal heart development
http://user.gru.net/clawrence/vccl/chpt1/fetal.HTM

Circulatory Changes at Partum
- Removal of placenta ==> increased systemic vascular resistance
- Aeration of lungs ==> decreased pulmonary vascular resistance
- Functional closure of foramen ovale
- Ductus remains open for about first fifteen hours (transitional circulation)

Click for video of fetal circulation (5.75)
http://www.youtube.com/watch?v=OV8wtPYGE-I&feature=related
Failure in circulatory development
- endocardial cushion
  - atrial septal defect
  - ventricular septal defect
  - incompetent atrioventricular valves
- aorticopulmonary septum
  - persistent truncus arteriosus
  - ventricular septal defect
  - functionally - single ventricle

Failure in circulatory transition
- persistent fetal circulation
  - patent foramen ovale
  - patent ductus arteriosus
  - pulmonary hypertension
  - right-to-left shunt - severe hypoxemia

Neonatal Thermoregulation

Thermoregulation
- Balance between heat production and heat retention
- Mechanisms for heat retention:
  - peripheral vasoconstriction - decreased circulation to skin
  - insulation with subcutaneous fat

Thermoregulation
- Mechanisms for heat production
  - shivering thermogenesis - most efficient
  - non-shivering thermogenesis

Thermoregulation
- Non-shivering thermogenesis initiated at 35-36 C
  - Skeletal muscle activity
  - Brown adipose tissue metabolism
    - neck, thorax
    - norepinephrine release mediates metabolism to produce heat
    - recently found active in adults

FYI - click to download article on brown adipose tissue in adults
http://ajpedit.physiology.org/cgi/reprint/293/2/E444
Infant thermoregulation problems:
- no shivering
- large body surface area: weight - increases heat loss to environment
- decreased subcutaneous fat (insulation)

Special problems with prematurity
- very large BSA: BW
- poor muscle tone - spread eagle posture
- no brown adipose tissue
- missing or thin epidermis ==> increased evaporation

Thermal stress increases caloric demand ==>
- hypoxemia
- acidemia
- hypoglycemia

Mechanisms for heat exchange
- conduction - direct contact with surface
- convection - current of fluid (air)
- evaporation - calorie uptake with H2O evaporation
- radiation - radiant heat waves to, or from warmer, colder body

Implications for Practice
- Keep infants dry & covered
- Close incubator doors
- Insulate contact surfaces
- Warm & humidify all medical gases

Embryonic and fetal development
- Gestational structures, functions
  - placenta
  - umbilical cord
  - amnion & amniotic fluid
- Fetal lung development
- Fetal circulatory development
- Fetal thermoregulation
References