The Female Reproductive System
Chapter 28

- Female Reproductive System Anatomy
- Oogenesis and the Sexual Cycle
  - Ovarian Cycle
  - Menstrual Cycle
Female Reproductive System

Functions:

- Produce female sex hormones and gametes
- Provide nutrition for fetal development
- Nourish the infant after birth
The Uterus

- Thick-walled, pear-shaped, muscular chamber opening into vagina.
- Cervix is the rounded opening of the uterus.
- Two uterine tubes (also called Fallopian tubes or oviducts) branch off the uterus and terminate near the ovaries.
Uterine Tubes

- Also called Fallopian Tubes or Oviducts
- Open-ended, muscular tube lined with secretory cells and ciliated cells that sweep secretions and peritoneal fluid towards the uterus.
- Uterine Tube Regions:
  - narrow isthmus near the uterus
  - middle portion is the ampulla
  - flared distally into infundibulum with fimbriae

Fertilization usually occurs in ampulla or isthmus
Epithelium lining the uterine tube consists of ciliated cells, goblet cells and other secretory cells.

Cilia move peritoneal fluid and uterine tube secretions towards the uterus.
Cervix and Vagina normally have a stratified squamous epithelium. Test developed by Dr. G.N. Papanicolaou can detect cervical cancer by identifying transformed squamous cells.

normal PAP smear  abnormal PAP smear
Histology of the Uterus

Perimetrium is the external serosa layer

Myometrium is the middle muscular layer
  – 1 cm thick in nonpregnant uterus
  – composed of smooth muscle
  – produces labor contractions to expel fetus during childbirth

Endometrium
  – simple columnar epithelium with tubular glands
  – **stratum functionalis** is superficial layer that is shed with each menstrual cycle
  – **stratum basalis** is deeper layer that regenerates a new stratum functionalis with each menstrual cycle
Ovary

- Ovaries produce oocytes and female hormones.
- Each oocyte is surrounded by follicular cells.
- Oocytes develop within a follicle.
- As a primordial follicle matures, it swells with fluid and develops into a primary follicle and eventually a mature Graffian follicle.
- Ovulation is the bursting of the Graffian follicle and the release of the oocyte from the ovary.
mature (Graafian) follicles

- Granulosa cells
- Egg nucleus
- Egg
- Zona pellucida
- Cumulus oophorus
- Antrum
- Theca folliculi

Ovary H&E

- follicular cells
- primordial follicle
- oocyte
- primary follicle
- granulosa cells
Oogenesis

- Monthly event that usually produces 1 haploid egg by meiosis
- Right and left ovaries usually alternate every other month
- Embryonic development of ovary:
  - female reproductive cells differentiate into oogonia and multiply by mitosis
  - before birth oogonia differentiate into about 2,000,000 primary oocytes
- Birth to adolescence
  - most primary oocytes degenerate (atresia) during childhood
  - by puberty about 400,000 primary oocytes remain and will be all the eggs that will ever be produced by that person
  - after puberty, each month FSH stimulates maturation of groups of follicles and the primary oocytes complete meiosis I which produces secondary oocytes
- Oocyte will only complete meiosis II if fertilized
  - after fertilization, releases 2nd polar body and becomes a zygote
Egg-making stem cells found in adult ovaries

Discovery could pave the way for new fertility treatments and a longer reproductive life.

Kendall Powell

27 February 2012
Oogenesis and Follicle Development

Development of the egg (oogenesis)

- Mitosis:
  - $2n$ → $2n$
- Multiplication of oogonia:
  - Primary oocyte
- Before birth:
  - Adolescence to menopause
- Meiosis I:
  - $n$ → $n$
  - Secondary oocyte
- First polar body (dies)
- If not fertilized:
  - $n$
  - Dies
- If fertilized:
  - Meiosis II:
    - $n$ → $2n$
    - Zygote
    - Dies
    - Second polar body (dies)

Development of the follicle

- Primordial follicle
- (No change)
- Primary follicle
- Mature follicle
- Ovulation
- Corpus luteum

Granulosa cells
- Antrum
- Oocyte
- Granulosa cells
Ovarian Cycle

• Averages 28 days but may range from 20 to 45 days

• Hormone cycle is under a hierarchy of control:
  – hypothalamus → pituitary → ovaries → uterus

• Follicular phase (2 weeks)
  – menstruation occurs during first 3 to 5 days of cycle
  – uterus replaces lost endometrium and follicles grow

• Postovulatory phase (2 weeks)
  – corpus luteum stimulates endometrial thickening
  – endometrium lost again if pregnancy does not occur
Ovarian Cycle

Gonadotropin secretion:
- FSH (low levels)
- LH (peaks on days 12-13)

Ovarian events:
- Developing follicle
- Mature follicle
- Corpus luteum
- Involution
- Corpus albicans
- New follicles
- Follicular phase
- Preovulatory phase
- Ovulation
- Luteal phase
- Premenstrual phase
**Ovarian Cycle**

**Follicular Phase**
Initially high levels of FSH matures about 20-25 oocytes in primordial follicles into primary follicles. Granulosa cells of the maturing follicles secrete estrogen. Estrogen negatively feeds back on the hypothalamus (maintaining low levels of GnRH) and the pituitary maintaining a low level of LH and a reduction in FSH. Drop in FSH causes atresia (degeneration) of most of the 20-25 follicles. Granulosa cells of the surviving follicles produce more and more estrogen until it peaks at mid-cycle. The prolonged high concentration of estrogen stimulates the mid-cycle surge in FSH and LH due to increased sensitivity of the pituitary gonadotropes to GnRH (negative feedback from the high levels of estrogen leads to an up-regulation of GnRH receptors on the gonadotropes).

**Ovulation**
Spike of LH and FSH triggers ovulation: oocyte bursts out of mature follicle and is released from the ovary and is guided into a uterine (Fallopian) tube by the fimbriae.

**Postovulatory Phase**
Granulosa cells of the ruptured follicle develop into the corpus luteum as they become responsive to LH. The maturing corpus luteum secretes increasing amounts of progesterone and estrogen through the luteal phase. Progesterone inhibits pituitary gonadotropes and LH and FSH levels drop. Without high levels of FSH and LH, new follicles will not develop. Without developing follicles, estrogen levels drop.

**Fertilization and Pregnancy**
If the oocyte is fertilized it will implant into the endometrium of the uterus. The chorion membrane of the developing embryo develops into the placenta and produces human chorionic gonadotropin (HCG). HCG keeps the corpus luteum alive and secreting progesterone and estrogen. Progesterone and estrogen maintain the endometrium of the uterus and develop the mammary glands. Progesterone and estrogen inhibit FSH and LH which prevents development of follicles during pregnancy.

**No Fertilization**
Without HCG, the corpus luteum undergoes involution (dies) and turns into the corpus albicans. Progesterone and estrogen levels drop causing endometrial arteries to constrict. Without sufficient blood flow, the surface endometrium tissue dies and is shed. Low levels of progesterone and estrogen allow an increase in pituitary FSH and LH that leads to maturation of a new group of follicles.
Corpus Luteum secretes Progesterone.
Ovulation of a Human Follicle

Uterine tube

Fimbriae

Corona radiata

Oocyte

Stigma

Ovary
Menstrual Cycle

Ovarian hormone secretion
Estrogen

Progesterone

Thickness of endometrium

Menstrual fluid

Menstruation

Proliferative phase

Secretory phase

Premenstrual phase
**Menstrual Cycle**

**Menstruation**
Menstruation is the loss of the uterine endometrium over 4-5 days.

**Proliferative Phase**
Increasing estrogen levels from developing follicles increases the thickness of the remaining endometrium by increasing the amount of connective tissue under the epithelium.

**Secretory Phase**
Increasing progesterone levels from the corpus luteum develop spiral arteries and uterine glands throughout the endometrium. Glands produce a mucus that helps a fertilized zygote to attach to the endometrium.

**Permenstrual Phase**
Without implantation of a zygote, the corpus luteum dies and progesterone and estrogen levels drop. Lymphocytes invade the endometrium, spiral arteries constrict and the superficial tissue dies and is shed resulting in menstruation.
Hormone Levels during Pregnancy

- Human chorionic gonadotropin
- Estradiol
- Progesterone

Weeks after beginning of last menstrual period

Ovulation
Parturition
Hormones of Pregnancy

- **HCG (human chorionic gonadotropin)**
  - secreted by the chorionic membrane of the embryo within 9 days of fertilization
  - keeps corpus luteum alive and secreting progesterone and estrogen

- **Estrogen**
  - increases to levels 30 times higher than before pregnancy
  - corpus luteum is source for first 12 weeks until placenta takes over
  - causes growth and enlargement of the uterus and mammary tissues
Hormones of Pregnancy (continued)

• Progesterone secreted by placenta and corpus luteum
  • suppresses secretion of FSH & LH preventing follicular development
  • prevents menstruation and thickens endometrium
  • stimulates development of breast tissue
• HCS (human chorionic somatomammotropin)
  • called human placental lactogen
  • secreted from placenta in direct proportion to its size
  • ↓ mother’s glucose usage and ↑ release of fatty acids
• Other hormones related to pregnancy:
  • thyroid gland increases 50% in size and increases the basal metabolic rate (BMR) of the mother
  • parathyroid glands enlarge and stimulate osteoclasts to release additional calcium from the mother’s bones
  • aldosterone secretion ↑ fluid retention and leads to ↑ in mother’s blood volume and can increase blood pressure
The Breasts

• Breast tissue overlays the pectoralis major muscle.
• Suspensory ligaments attach breast tissue to skin and muscle.
• Size of breasts is mostly due to fat tissue, not the amount of glandular tissue.
• If nonlactating, glandular tissue is reduced.
• Glandular tissue consists of acini that drain into lactiferous ducts that come to confluence at lactiferous sinuses at the nipple.
• Nipple is surrounded by the areola (colored zone)
  – melanocytes of areola (and other skin) may darken during pregnancy due to elevated estrogen levels.
Anatomy of a Lactating Breast

- Rib
- Adipose tissue
- Intercostal muscles
- Pectoralis minor muscle
- Pectoralis major muscle
- Deep fascia
- Suspensory ligaments
- Nipple
- Lactiferous sinus
- Lactiferous duct
Development of Mammary Glands

- Lactation = synthesis of milk from mammary glands.
- Estrogen during pregnancy cause ducts to grow and branch.
- Progesterone stimulates budding and development of the acini that produce milk.
- Prolactin stimulates milk production after birth.
- Oxytocin triggers milk ejection from breast tissue during nursing.
Breast Milk

- Colostrum
  - first milk produced after delivery of the baby
  - contains less fat than the milk that comes after a few days
  - contains abundant immunoglobulins (especially IgA) that boost the baby’s immunity
- Colostrum and breast milk have a laxative effect that clears intestine of meconium (green, bile-rich fecal material in newborn).
- Nursing colonizes the baby’s intestine with beneficial bacteria obtained from the breast skin.
- Nursing woman can produce 1.5L of milk per day.
- Only 5-10% of women become pregnant again while nursing because nursing inhibits GnRH and reduces ovarian cycling.
- Cow’s milk is significantly different than human milk:
  - Cow’s milk has about 3 times more protein which makes it harder to digest.
  - Difficult digestion leads to more nitrogenous waste in urine and feces (which can cause worse diaper rash because there is more for bacteria to feed on).
Breast Cancer

• Affects 1 out of every 8 American women.
• Tumors usually begin with cells from mammary ducts and may metastasize by way of lymphatics.
• Symptoms may include a palpable lump, skin puckering, change in skin texture or drainage from the nipple.
• Most breast cancer is nonhereditary
  – some forms are stimulated by estrogen
• Risk factors include aging, ionizing radiation, carcinogenic chemicals, alcohol abuse, smoking, high fat intake.
• However, as many as 70% of cases lack identifiable risk factors.
End of Chapter 28