The Reproductive System

Chapter 28

Reproductive System

- The reproductive system functions in gamete:
  - Production
  - Storage
  - Nourishment
  - Transport
- Fertilization, or conception, is the fusion of male and female gametes (n) to form a zygote (2n)

Components of the Reproductive System

- The reproductive system includes the following components:
- The gonads; reproductive organs that produce gametes
- Ducts that receive and transport gametes
- Accessory glands and organs that secrete fluids into ducts or into other excretory ducts
- External genitalia

Male Reproductive Structures

- In adult males, the testes or male gonads secrete androgens
- Testes also produce spermatozoa or sperm, the male gametes, half a billion a day
- During emission, sperm travel along a lengthy duct system where they are mixed with the secretions of accessory glands to create semen
- During ejaculation, semen is ejected from the body

Female Reproductive Structures

- In adult females, the ovaries typically release one mature oocyte each month
- This gamete travels along uterine tubes which end in the muscular uterus
- If fertilization occurs, the oocyte matures into an ovum.
- A short passageway the vagina, connects the uterus with the exterior
- During intercourse sperm are ejaculated into the vagina, and then ascend the female reproductive tract where fertilization may occur

The Male Reproductive System

- Proceeding from the testes the sperm travel within the epididymis, the ductus deferens (vas deferens), the ejaculatory duct, and the urethra before leaving the body
- The accessory organs; the seminal vesicles, the prostate gland, and the bulbourethral glands, secrete various fluids into the ejaculatory duct and urethra
- The external genitalia consists of the scrotum and the erectile penis
The Testes

- Each testis is the shape of a flattened egg roughly 5cm x 3cm x 2.5cm
- The testes hang within the scrotum, a fleshy pouch suspended inferior to the perineum, anterior to the anus, and posterior to the base of the penis
- During development the testes form inside the body
- As the fetus grows the testes move inferiorly and anteriorly
- During the seventh month of development each testis moves through the abdominal musculature to its external position in the scrotum
- This process is termed the descent of the testes

The Testes

- The scrotum is divided internally into two chambers
- Each testis lies in its own scrotal cavity
- Because the scrotal cavities are separate, infection rarely spreads between the testes
- The dermis of the scrotum contains a layer of smooth muscle, the dartos, that causes the characteristic wrinkling of the scrotal surface
- A layer of skeletal muscle, the cremaster, pulls the scrotum close to the body during sexual arousal and in response to changes in temperature

Structure of the Testes

- The testes are divided into lobules by septa formed from the tunica albuginea, a dense layer of connective tissue
- Roughly 800 tightly coiled seminiferous tubules are distributed among the lobules
- Each tubule averages about 80cm in length and is the site of sperm production

Sperm Production

- Within the areolar tissue surrounding the seminiferous tubules are large interstitial cells which produce androgens, the dominant sex hormone in males
- Sperm are produced through the process of spermatogenesis
- Spermatogenesis begins at the outermost later of cells in the seminiferous tubules and proceeds toward the lumen of the tubule
Sperm Production

- At each step in this process the daughter cells move closer to the lumen
- First, stem cells called spermatogonia divide by mitosis to produce two daughter cells, one remains a spermatogonium, the other is a primary spermatocyte
- Primary spermatocytes undergo meiosis to produce spermatids, immature gametes that subsequently differentiate into spermatozoa
- Spermatozoa lose contact with the wall of the seminiferous tubule and enter the fluid of the lumen

Spermatogenesis

- Spermatogenesis involves three integrated processes
- Mitosis of the spermatogonia, giving rise to a primary spermatocyte and a spermatogonium
- Meiosis, of the primary spermatocyte, which gives rise to four haploid spermatids
- Spermiogenesis, the differentiation of the spermatids into mature sperm
- The entire process takes about 9 weeks
Anatomy of Spermatozoa

- Each sperm has three regions;
- The head, containing the nucleus, at the tip of the head is the acrosome, or acrosomal cap, containing enzymes needed to penetrate the egg;
- The neck and middle piece containing microtubules and mitochondria;
- The tail, the only flagellum in the human body, provides a means of locomotion.

The Male Reproductive Tract

- The physically mature spermatozoa produced by the testes are incapable of fertilization of an oocyte;
- Other portions of the male reproductive tract are responsible for the functional maturity, nourishment, transport, and storage of the sperm.

The Epididymis

- The epididymis is an elongated (7m) tubule with three regions, the head, body and tail;
- The functions of the epididymis are:
  - It monitors and adjusts fluid produced by the seminiferous tubules;
  - It acts as a recycling center for damaged sperm;
  - It stores and protects spermatozoa and facilitates functional maturation of the spermatozoa.
Ductus Deferens

- The ductus deferens, also known as the vas deferens, begins at the tail of the epididymis, and, as part of the spermatic cord, ascends through the inguinal canal
- Inside the abdominal cavity it passes posteriorly, curving inferiorly across the bladder toward the superior margin of the prostate
- As it approaches the prostate its lumen enlarges in a region called the ampulla

Ductus Deferens

- A thick layer of smooth muscle in the wall of the ductus deferens propels sperm and fluid along the duct
- The ductus deferens can also store sperm for several months in a state of suspended animation
- The junction of the ampulla with the duct of the seminal vesicles marks the beginning of the ejaculatory duct, a short passageway that empties into the urethra

Accessory Glands

- The seminal vesicles are active secretory glands that contribute ~60% of the total volume of semen
- Its secretions contain fructose (sperm fuel), prostaglandins (stimulates smooth muscle contraction), and fibrinogen (dissolves vaginal clots)
- The prostate gland secretes slightly acidic prostatic fluid that contributes 20-30% of the volume of semen and secretes seminalplasmin, an antibiotic
- The bulbourethral glands, or Cowper’s glands, at the base of the penis secrete an alkaline mucus with lubricating properties

Semen

- A typical ejaculation contains 2-5 ml of semen, called the ejaculate
- This volume contains
  - 20-100 million sperm
  - Seminal fluid, a mixture of glandular secretions
  - Enzymes, including a protease that may dissolve vaginal secretions, seminalplasmin, an antibiotic, a prostatic enzyme that converts fibrinogen to fibrin after ejaculation, and fibrinolysin, which subsequently liquifies the clotted semen

Types of Sperm

- The sperm of many animals, including humans, are polymorphic. They come in a variety of shapes and sizes, some of which are patently unsuited for penetrating an egg.
  - “Fertilizers,” the egg-penetration specialists,
  - “Blockers,” the ones that construct copulatory plugs to prevent further insemination,
  - “Seek-and-destroy sperm” that hunt down and kill “enemy” sperm from other sources,
  - “Family-planning sperm” that kill all sperm.
- It is suggested that the numbers of each sperm type are a response to social cues. For example, where promiscuity is observed, as is common in chimpanzee troops, the numbers of seek-and-destroy sperm are very high.
External Genitalia of the Male

- Male external genitalia consist of the scrotum and the penis
- The penis is a tubular organ through which the distal portion of the urethra passes
- It conducts urine to the exterior and introduces semen into the vagina during intercourse
- Its design may function in the removal of sperm from competing partners

External Genitalia of the Male

- The penis contains three cylindrical columns of erectile tissue
- The anterior surface of the penis contains two corpora cavernosa beneath fascia
- The relatively slender corpus spongiosum surrounds the urethra
- During sexual excitement, Blood vessels in the erectile tissues become dilated and the penis becomes engorged with blood and erect

Hormones and male reproductive function

- FSH and LH are released from the anterior pituitary when it is stimulated by GnRH from the hypothalamus
- FSH targets sustentacular cells and promotes spermatogenesis
- LH causes the secretion of testosterone and other androgens, which maintain libido, secondary sex characteristics, and maintain the accessory glands
Reproductive System of the Female

- The principle organs of the female reproductive system are:
  - Ovaries
  - Uterine tubes
  - Uterus
  - Vagina

The Ovaries

- The paired ovaries are small, lumpy, almond-shaped organs near the lateral wall of the pelvic cavity.
- The ovaries perform three main functions:
  - The production of immature female gametes, oocytes.
  - Secretion of female sex hormones, including estrogens and progestins.
  - Secretion of inhibin, involved in the feedback control of pituitary FSH production.

Oogenesis

- Ovum production, or oogenesis, begins before birth, accelerates at puberty, and ends at menopause.
- Between puberty and menopause, oogenesis occurs on a monthly basis as part of the ovarian cycle.

- Oogonia complete mitotic division before birth.
- The daughter cells, primary oocytes, begin meiosis and proceed as far as prophase of meiosis I and halt.
- At puberty, rising levels of FSH trigger the ovarian cycle and thereafter some primary oocytes undergo further development.
Oogenesis

• Note that division of the cytoplasm is asymmetrical during meiosis and that only one ovum (secondary oocyte) is produced along with 2-3 polar bodies that are nonfunctional and disintegrate
• Further, the ovary releases a secondary oocyte rather than a mature ovum
• The secondary oocyte is suspended in metaphase of meiosis II and only completes meiosis if fertilization occurs

The Ovarian Cycle

• Ovarian follicles are specialized structures in which oocyte growth and meiosis I occurs
• The primary oocyte and associated follicular cells form a primordial follicle within the ovary
• After puberty, a different group of primordial follicles is activated each month in a process known as the ovarian cycle

The Ovarian Cycle

• The ovarian cycle can be divided into a follicular phase (preovulatory) and a luteal phase (postovulatory)
• Steps in the ovarian cycle can be summarized as:
  – Formation of primary, secondary, and tertiary follicles
  – Ovulation
  – Formation and secretion of the corpus luteum
  – If no fertilization, degradation of the corpus luteum into the corpus albicans
The Uterine Tubes

- The uterine tube is a hollow, muscular tube about 13cm in length that opens directly into the uterine cavity.
- The uterine tubes are the site of fertilization.
- It can be divided into three segments:
  - The infundibulum, the end closest to the ovary with numerous fimbriae.
  - The ampulla, the middle portion.
  - The isthmus, a short segment connected to the uterine wall.

The Uterus

- The uterus is a muscular organ that provides mechanical protection, nutritional support, and waste removal for the developing embryo and fetus.
- Contraction of the muscular wall of the uterus are important in ejecting the fetus at term.

Uterine wall

- The uterine wall consists of three layers:
- The myometrium, the outer muscular layer.
- The endometrium, a thin, inner, glandular mucosa.
- The perimetrium, an incomplete serosa continuous with the peritoneum.

Uterus

- Major anatomical landmarks of the uterus include:
  - Body.
  - Isthmus.
  - Cervix.
  - Cervical os (external orifice).
  - Uterine cavity.
  - Cervical canal.
  - Internal os (internal orifice).
Uterine cycle

- The uterine cycle is a repeating series of changes in the endometrium
- It begins with the onset of Menstruation, marked by the degeneration of the endometrium and menstruation
- The proliferative phase of the uterine cycle involves the restoration of the endometrium
- During the secretory phase the Endometrial glands enlarge and accelerate their rates of secretion

The vagina

- The vagina is an elastic muscular tube extending between the cervix and the vestibule, a space bounded by the external genitalia
- Major functions of the vagina include
  - Passageway for elimination of menstrual fluids
  - Receives the penis during sexual intercourse
  - Forms the inferior portion of the birth canal

External genitalia

- The area containing the female external genitalia is the Vulva
- External genitalia includes:
  - Vestibule
  - Labia minora and majora
  - Paraurethral glands (histological homologue of the prostate)
  - Clitoris
  - Lesser and greater vestibular glands

Mammary glands

- Milk production, or lactation, occurs in the mammary glands
- Mammary glands in females are specialized organs of the integumentary system, that are controlled by hormones from the reproductive system and placenta
- Each mammary gland lies in the subcutaneous pectoral fat pad
- Each has a nipple surrounded by the areola
Hormones of the Female reproductive cycle

- The activity of the female reproductive tract is under hormonal control that involves an interplay between secretions of both the pituitary and the gonads.
- Control is complicated because it must coordinate both the ovarian and uterine cycles in order for pregnancy to occur.

Key hormones include:
- FSH: Stimulates follicular development
- LH: Maintains structure and secretory function of corpus luteum
- Estrogens: Multiple functions (see 1064 rt hand column)
- Progesterones: Stimulate endometrial growth and secretion

Male sexual function

- Arousal leads to erection of the penis
- Emission and ejaculation:
  - Occur under sympathetic stimulation
  - Results in semen being pushed toward external urethral opening
- Detumescence:
  - Subsidence of erection
  - Mediated by the sympathetic nervous system
Female sexual function

- Stages are comparable to those of male sexual function
- Arousal causes clitoral erection and secretion by cervical mucous and greater vestibular glands
- Vaginal surfaces are moistened
- Parasympathetic stimulation causes engorgement of blood vessels in the nipples

During intercourse, rhythmic contact of the penis with the clitoris and vaginal walls provides stimulation that leads to orgasm
- Female orgasm is accompanied by peristaltic contractions of the uterine and vaginal walls and rhythmic contraction of the bulbospongiosus and ischiocavernous muscles
- The latter of which give rise to the sensations of orgasm

Menopause

- Menopause is defined as the time that ovulation and menstruation cease
- Typically between 45-55 years of age
- Menopause is accompanied by a decline in circulating concentrations of estrogens and progesterone and a sharp and sustained rise in the production of GnRH, FSH, and LH

- The decline in estrogen leads to a reduction in the size of the uterus and breasts, as well as a thinning of the urethral and vaginal epithelia
- Hot flashes typically begin as estrogen levels are declining and cease when estrogen levels bottom out
- These intervals of elevated body temperature are associated with surges of LH production

Andropause

- Men also show declining reproductive function during male climacteric or andropause
- Circulating levels of testosterone begin declining between the ages of 50 and 60, while circulating FSH and LH increase
- Although sperm production continues, older men experience a reduction in sexual activity which is probably linked to declining testosterone levels