1 Anatomy of Female Reproductive System

The female reproductive organs can be subdivided into the internal and external genitalia. The internal genitalia are those organs that are within the true pelvis. These include the vagina, uterus, cervix, uterine tubes or fallopian tubes, and ovaries. The external genitalia lie outside the true pelvis. These include the perineum, mons pubis, clitoris, urethral (urinary) meatus, labia majora and minora, vestibule, greater vestibular (Bartholin) glands, Skene's glands, and periurethral area.

External Genitalia

The vulva, also known as the pudendum, is a term used to describe those external organs that may be visible in the perineal area. The boundaries include the mons pubis anteriorly, the rectum posteriorly, and the genitocrural folds laterally (Fig. 1.1).

Mons Pubis

The mons pubis is the rounded portion of the vulva where sexual hair development occurs at the time of puberty. This area may be described as directly anterosuperior to the pubic symphysis.

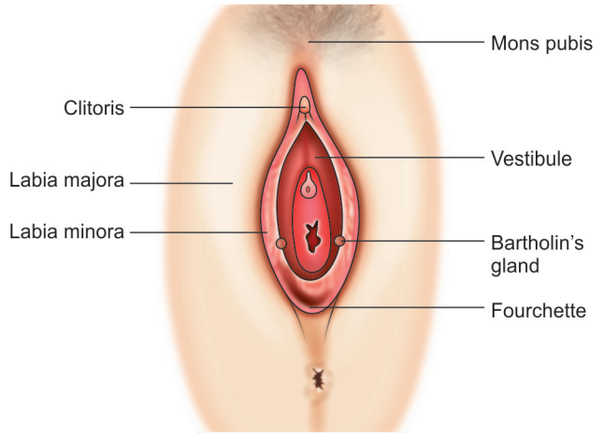


Fig. 1.1: External genitalia

Labia

The **labia majora** are two large, longitudinal folds of adipose and fibrous tissues. They vary in size and distribution from female to female, and the size is dependent upon adipose content. They extend from the mons anteriorly to the perineal body posteriorly. Posteriorly the majora do not join, they are separated by a depression known as the posterior commissure. The labia majora have hair follicles.

The **labia minora**, also known as nymphae, are two small cutaneous folds that are found between the labia majora and the introitus or vaginal vestibule. The medial part joins anteriorly in the midline behind the clitoris which is known as the frenulum of the clitoris. The lateral part joins anteriorly in the midline in front of the clitoris which is known as the clitoral hood or prepuce. Posteriorly, both folds join at the midline to form the fourchette (Fig. 1.2).

Hymen

The hymen is a thin membrane found at the entrance to the vaginal orifice. Often, this membrane is perforated before the onset of menstruation, allowing flow of menses. The hymen varies greatly in shape (Fig. 1.3).

Clitoris

The clitoris is an erectile structure found beneath the anterior joining of the labia minora. Its width in an adult female is approximately 1 cm, with an average length of 1.5–2.0 cm. The clitoris is made up of 2 crura, which attach to the periosteum of the ischiopubic rami. It is a very sensitive erectile structure, analogous to the male penis. It is innervated by the dorsal nerve of the clitoris, a terminal branch of the pudendal nerve.

Vestibule and Urethra

Between the clitoris and the vaginal opening is a triangular area known as the vestibule, which extends

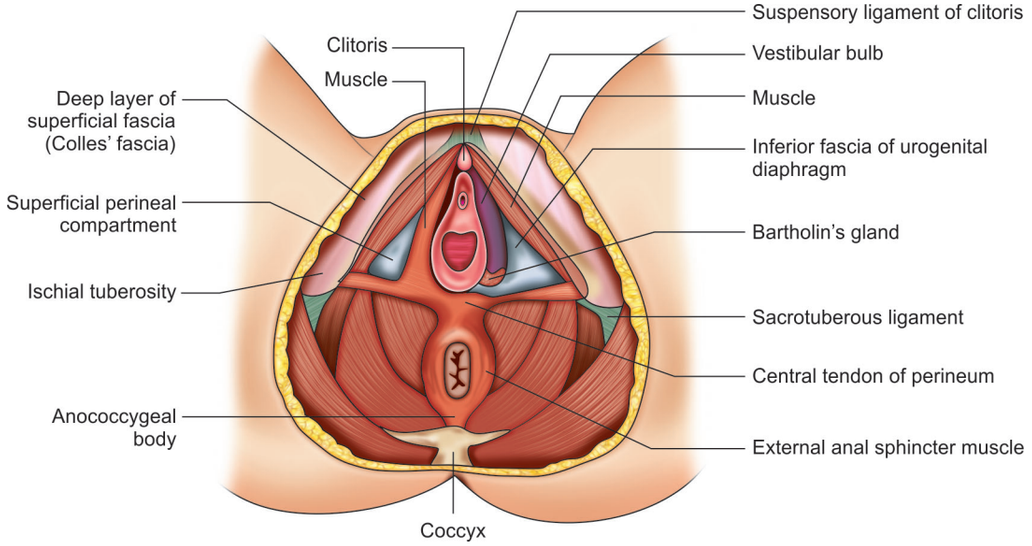


Fig. 1.2: Deeper view of external structures

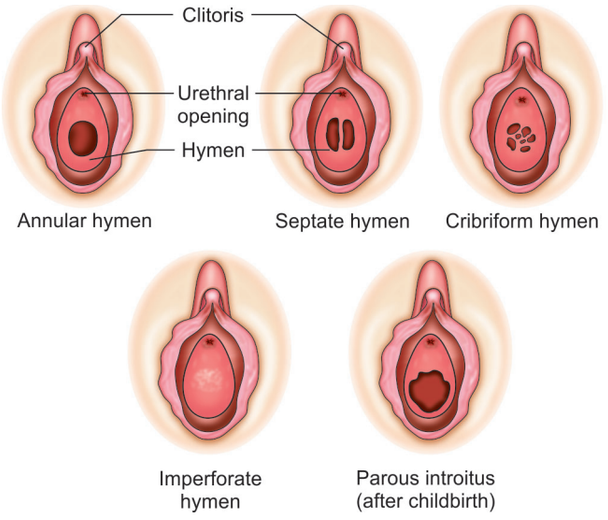


Fig. 1.3: Various types of hymens

to the posterior fourchette. The vestibule is where the urethral meatus is found, approximately 1 cm anterior to the vaginal orifice and it also gives rise to the opening of the Skene's glands bilaterally. The urethra is composed of membranous connective tissue and links the urinary bladder to the vestibule externally. A female urethra ranges in length from 3.5 to 4.0 cm.

Skene and Bartholin Glands

The Skene's glands secrete lubrication at the opening of the urethra. The greater vestibular (Bartholin) glands are also responsible for secreting lubrication to the vagina, with openings just outside the hymen, bilaterally, at the posterior aspect of the vagina. Each gland is small, similar to a kidney bean in shape. **The G-spot** (Gräfenberg spot) is considered to be an area around the urethra in the anterior wall of the vagina. Stimulation of the G-spot acts directly on the Skene's glands to lubricate vagina.

Greater Vestibule Gland

This is homologous to the Cowper's gland of the male. It produces mucus as a lubricant.

Vestibular Bulbs

The vestibular bulbs are to masses of erectile tissue that lie deep to the bulbocavernosus muscles bilaterally.

Urogenital triangle: Its base is the line between ischial tuberosities and apex is the pubic symphysis.

Anal triangle: Its base is the line between ischial tuberosities and apex is the coccyx.

Contents of urogenital triangle: The vulva, with labia majora and minora, clitoris, vaginal vault and vestibule.

Pelvic Floor

This helps in support of abdominal and pelvic viscera. It is composed of muscles and fascia.

The main muscle is the paired levator ani muscles which are joined in the midline by connective tissue. The levator ani muscles form the pelvic diaphragm. Each levator ani muscle is a combination of three muscles: Iliococcygeus, pubococcygeus and puborectalis. These names just indicate where the fibres attach, otherwise they work in combination. The other muscle of the pelvic diaphragm is the coccygeus muscle.

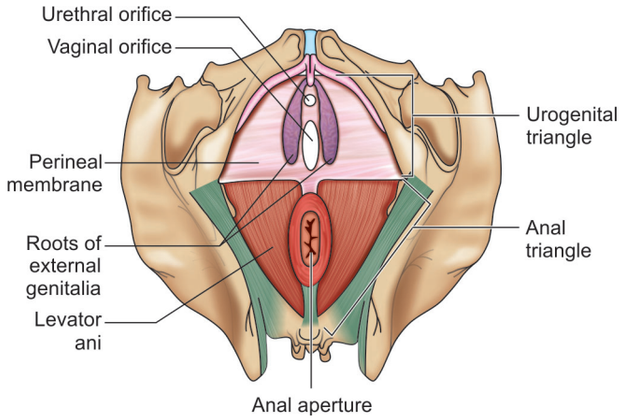


Fig. 1.4: Perineum

There are three apertures in the pelvic floor (two in males). From front to back, there is the urethra, vagina and then the rectum. All three apertures are enclosed by the puborectalis part of the levator ani muscle.

The shape of the diaphragm is U-shape anteriorly due to the urogenital system. The anterior portion is supported by the perineal membrane and muscles of the deep perineal pouch. Vagina and urethra pass through the perineal membrane. The anal canal passes posteriorly through the pelvic diaphragm.

There are two triangles in the perineum—urogenital and anal. The urogenital triangle is covered by the perineal membrane, whereas the anal triangle is not (Fig. 1.4).

Internal Genital Organs

Vagina

The vagina is a muscular, hollow tube that extends from the vaginal opening to the cervix of the uterus. It is situated between the urinary bladder and the rectum. It is about three to five inches long in an adult woman. The muscular wall allows the vagina to expand and contract. The muscular walls are lined with mucous membranes of stratified squamous epithelium which keep it protected and moist. A thin sheet of tissue with one or more holes in it, called the hymen, partially covers the opening of the vagina.

The vagina is composed of three layers. The first layer is made up of a stratified squamous non-keratinized epithelium and is an underlying lamina propria of connective tissue (a layer of connective tissue that is highly vascular under the base area lining the epithelium). This layer forms the folds or rugae and facilitates the vagina's ability to expand large enough for child birth. The rugae are a series of ridges produced by folding of the wall of the outer third of the vagina; they are transverse epithelial ridges and their function is to provide the vagina with increased surface area for extension and stretching. The second layer is the muscular layer, which is composed of smooth muscle fibers and situated longitudinally and circularly. The third layer is the adventitia, which is a dense connective tissue that blends with the fascia surrounding the area.

Cervix

The cervix (from Latin "neck") is the lower, narrow portion of the uterus where it joins with the top end of the vagina. The location where they meet forms an almost 90° angle (angle of version). It is cylindrical or conical in shape and protrudes through the upper anterior vaginal wall.

During menstruation, the cervix stretches open slightly to allow the endometrium to be shed. This stretching is believed to be part of the cramping pain that many women experience. The portion projecting into the vagina is referred to as the portio vaginalis or exocervix. On an average, the exocervix is 3 cm long and two and a half cm wide. It has a convex, elliptical surface and is divided into anterior and posterior lips. In women who have not had a vaginal birth, the external os appears as a small, circular opening. In women who have had a vaginal birth, the exocervix appears bulkier and the external os appears wider, more slit-like and gaping. The endocervical canal varies widely in length and width and is flattened anterior to posterior, the endocervical canal measures 7 to 8 mm at its widest in reproductive-aged women. The endocervical canal terminates at the internal os which opens into the uterine cavity. During childbirth, contractions of the uterus will dilate the cervix up to 10 cm in diameter to allow the child to pass through. During orgasm, the cervix convulses and the external os dilates.

Uterus

The uterus is shaped like an upside-down pear, with a thick lining and muscular walls. Located near the floor of the pelvic cavity, it is hollow to allow a blastocyte, or fertilized egg, to implant and grow. It also allows for the inner lining of the uterus to build up until a fertilized egg is implanted, or it is sloughed off during menses (Fig. 1.5).

The uterus contains some of the strongest muscles in the female body. These muscles are able to expand and contract to accommodate a growing fetus and then help push the baby out during labor. These muscles also contract rhythmically during an orgasm in a wave-like action. It is presumed to help push or guide the

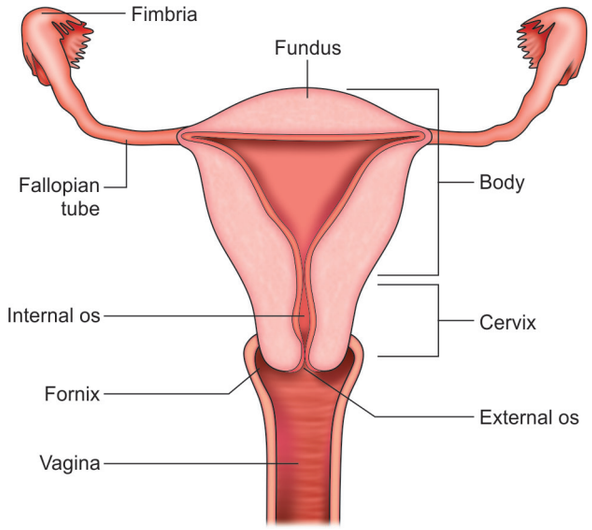


Fig. 1.5: Uterus

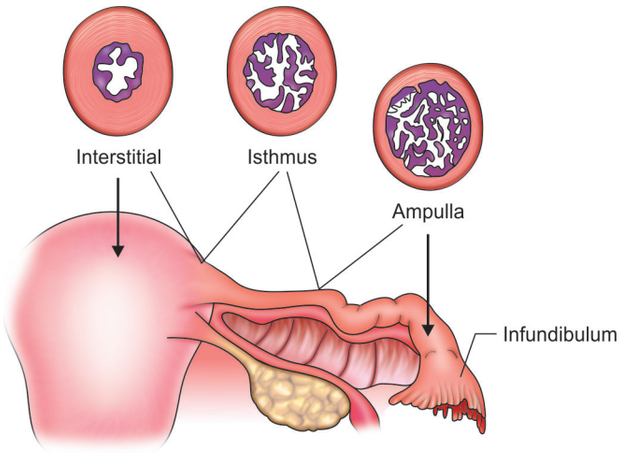


Fig. 1.6: Fallopian tubes

sperm up the uterus to the fallopian tubes where fertilization may be possible.

The uterus is only about 3 inches long and two inches wide, but during pregnancy it changes rapidly and dramatically.

Uterus has a rounded superior end—fundus. The uterine cavity is a narrow slit in the lateral view and triangular in the anterior view. At the inferior end is the cervix. The uterus is usually anteflexed (125°) on the cervix and is anteverted (90°) on the vagina. The cervix projects into the vagina and as a result a gutter is formed known as the fornix. The canal in the cervix has two openings—the external os into the vagina and an internal os into the uterine cavity.

Fallopian Tubes

At the upper corners of the uterus are the fallopian tubes. They are placed one on each side of the uterus attached to cornu of the uterus and connects to the ovary on the same side. They are positioned between the ligament of the ovary posteriorly and round ligament anteriorly (Fig. 1.6).

The fallopian tubes are about 4 inches (10 cm) long. At the other end of each uterine tube is a fringed area that looks like a funnel. This fringed area, called the infundibulum, lies close to the ovary, but is not attached. Starting from the uterus and proceeding outward, these are the:

- Interstitial segment—extends from the uterine cavity through the uterine muscle (1.25 cm)
- Isthmic segment—narrow muscular portion adjacent to the uterus (3 cm)
- Ampullary segment—wider and longer middle part of the tube (5 cm)
- Infundibular segment—funnel-shaped segment next to the fimbrial end (1.25 cm)
- Fimbrial segment—wide opening at the end of the tube facing the ovary.

The ovaries generally alternately release an egg every month. When an ovary ovulate, or release an egg, it is swept into the lumen of the uterine tube by the fimbriae. Once the egg is in the uterine tube, ciliated epithelium in the tube helps push it down the narrow passageway toward the uterus. The oocyte, or developing egg cell, takes four to five days to travel down the length of the uterine tube. Fertilization most often occurs in the ampullary segment of the fallopian tube. After fertilization occurs, the zygote, or fertilized egg, continues down to the uterus and implants itself in the uterine wall where it will grow and develop until birth. If a zygote does not move down to the uterus and implants itself in the uterine tube, it is called a ectopic or tubal pregnancy.

Ovaries

The ovaries are paired, oval organs located within the pelvic cavity lateral to the uterus. In an adult, ovaries are slightly larger than an almond about 2 to 3 cm long, 2 cm wide, and 1 to 1.5 cm thick. Their size usually varies during each menstrual cycle as well as during pregnancy.

The ovaries are anchored within the pelvic cavity by special "cords" and sheets of tissue. A double fold of peritonuem called the mesovarium, attaches to each ovary at its hilum. The hilum is the anterior surface of the ovary where blood vessels and nerves enter the ovary.

The mesovarium secures each ovary to a broad ligament, which is a drape of peritonuem that hangs over the uterus. Each ovary is anchored to the posterior aspect of the broad ligament by an ovarian ligament.

A suspensory ligament attaches to the lateral edge of each ovary and projects superolaterally to the pelvic wall. The ovarian blood vessels and nerves are housed within each suspensory ligament, and they join the ovary at its hilum.

Smooth muscle fibers within both the mesovarium and the suspensory ligaments contract at the time of ovulation to bring the ovaries into close proximity with the uterine tube openings. Each ovary is supplied by an ovarian vein and artery. The ovarian arteries are branches that come directly off the aorta immediately inferior to the renal vessel. The ovarian veins exit the ovary and drain into either the inferior cava (right) or one of the renal veins (left).

Traveling with the ovarian artery and vein are autonomic nerves. Sympathetic axons come from the T10 segments of the spinal cord whereas para-sympathetic axons come from 10th cranial nerve.

Arterial Supply to Pelvis (Table 1.1 and Fig. 1.7)

Internal iliac artery is the major artery feeding the pelvis. It arises from and the common iliac at L5–S1 level and passes anteromedial to the sacroiliac joint into the pelvic inlet where it bifurcates into an anterior and posterior trunk.

Posterior Trunk

It supplies the lower posterior abdominal wall, posterior pelvic wall and the gluteal region. Branches are:

- *Iliolumbar artery:* This turns back up and out of the pelvic cavity to supply the posterior abdominal wall (lumbar) and iliac fossa (iliac).
- *Lateral sacral arteries:* Two from each side to supply areas of the sacrum and posterior pelvic wall.
- *Superior gluteal artery:* Terminal continuation of the posterior trunk and is the largest branch. It leaves the pelvic cavity through the greater sciatic foramen to supply the gluteal region.

Anterior Trunk

Supplies the pelvic viscera, perineum, gluteal region and adductor region of the thigh as well as placenta and fetus in pregnancy. Branches in order are:

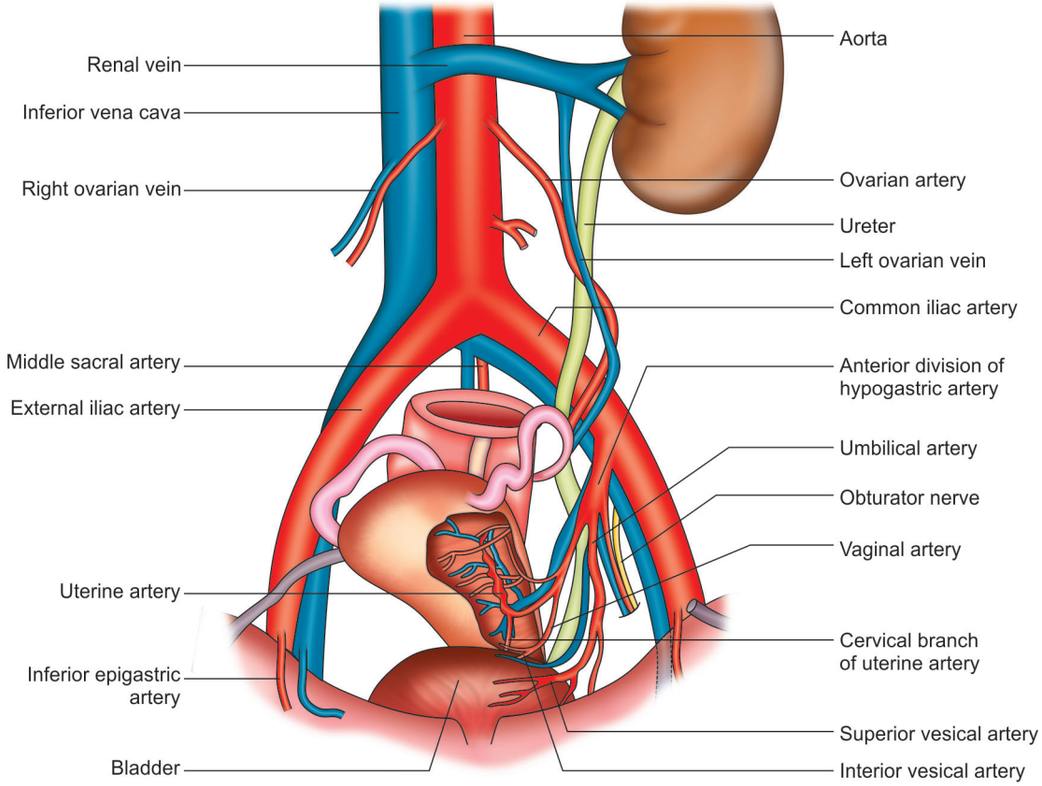
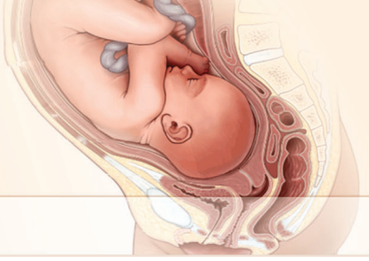


Fig. 1.7: Arterial supply to pelvis



Umbilical artery: This gives rise to the **superior vesical artery** which supplies the superior region of the bladder and distal parts of the ureter. The umbilical artery carries blood from fetus to placenta and is large (there are two arteries, one on each side). After birth, the umbilical arteries fibrose and become the medial umbilical ligaments. It also leaves a fold in the peritoneum—medial umbilical fold.

Inferior vesical artery: This occurs in men only, in females it is the **vaginal artery**. In men, it supplies inferior region of bladder, ureter, seminal vesicle and prostate. In females, the vaginal artery supplies the vagina and surrounding parts of the bladder and rectum.

Middle rectal artery: Supplies the rectum and anastomoses with superior rectal (from inferior mesenteric) and inferior rectal (which is the branch of internal pudendal) arteries.

Obturator artery: Leaves pelvic cavity through obturator canal supplying adductor region of thigh.

Internal pudendal artery: Leaves pelvic cavity through greater sciatic foramen but re-enters through the lesser sciatic foramen with the pudendal nerve. It supplies the perineum region as well as erectile tissues of penis and clitoris. It also gives rise to **inferior rectal** artery.

Inferior gluteal artery: Large terminal branch of anterior trunk. Supplies lower gluteal and hip region.

Uterine artery: It travels along the root of the broad ligament and crosses above and in front of the ureter approximately 2 cm anteromedially from the cervix. It reaches the lateral fornices and then supplies the cervix. From here, it travels tortuously along the lateral margin of the uterus and then the fallopian tubes. Here it anastomoses with the ovarian artery. Uterine artery supplies most of the uterus and cervix. One of its branches anastomoses with the vaginal artery to produce azygos artery of vagina. It enlarges during pregnancy.

Ovarian artery: This originates from the abdominal aorta and enters the pelvic inlet to supply the ovaries. It anastomoses with the uterine arteries. It is found traveling in the suspensory ligament of the ovary. The reason for a different supply is due to the descent of ovaries from the abdomen during development.

Table 1.1: Artery supply of pelvic organs

Organ	*Artery*	*Origin*
Uterus	Uterine	Anterior division of internal iliac artery
	Ovarian	Direct branch from abdominal aorta
Ovary	Ovarian	Abdominal aorta
	Uterine	Anterior division of internal iliac artery
Fallopian tube	Ovarian	Abdominal aorta
	Uterine	Anterior division of internal iliac artery
Vagina	Vaginal	All from anterior division of internal iliac artery
	Uterine	
	Internal pudendal	
	Middle rectal	
Vulva	Internal pudendal	Anterior division of internal iliac artery
	External pudendal	Femoral artery
Ureter	Renal	Aorta
	Ovarian	Aorta
	Uterine	Internal iliac artery
	Superior vesical	Internal iliac artery
	Inferior vesical	Internal iliac artery
Bladder	Superior vesical	Internal iliac artery
	Inferior vesical	Internal iliac artery
Urethra	Interior vesical	Internal iliac artery
	Internal pudendal	Internal iliac artery
Sigmoid colon	Left colic	Interior mesenteric artery
Rectum	Superior rectal	Inferior mesenteric artery
	Middle rectal	Internal iliac artery
	Inferior rectal	Internal pudendal (branch of anterior division of internal iliac) artery

Median sacral artery: Descends from the bifurcation of the aorta in the midline from L4 to the coccyx. It gives rise to last pair of lumbar arteries and anastomoses with lateral sacral and iliolumbar artery.

Veins

Veins follow arteries except for umbilical and iliolumbar. The other veins drain into the internal iliac veins. Drainage from the pelvic cavity is through plexuses of veins and the name given depends on the region. Internal and external rectal plexuses can give rise to hemorrhoids if enlarged. Other veins are:

Deep dorsal vein: It is a single vein that drains the penis and clitoris. It does not follow the internal pudendal artery. Instead it drains into the prostatic plexus in males and vesical plexus in females.

Umbilical vein is present only in the fetus. It travels from the umbilicus to the liver. It travels alongside the falciform ligament to the liver and then splits into two branches. A larger branch joins the portal vein. The smaller branch ductus venosus joins the IVC. After birth, the umbilical vein obliterates to become the round ligament of the liver (or the ligamentum teres). This is continuous with the ligamentum venosum which splits the liver into left and right lobes.

Lymphatics

Main drainage is either through nodes associated with internal iliac artery or external iliac artery.

Lymph drainage from the ovaries and parts of the uterus and fallopian tubes leave the pelvic cavity with the ovarian artery and drain in lateral aortic and pre-aortic nodes.

Important Nerves of Pelvis and Perineum (Fig. 1.8)

Pudendal nerve: Comes from the sacral plexus (S2–S4)

Motor nerve

- Skeletal muscles in the perineum
- External urethral sphincter and external anal sphincter
- Levator ani

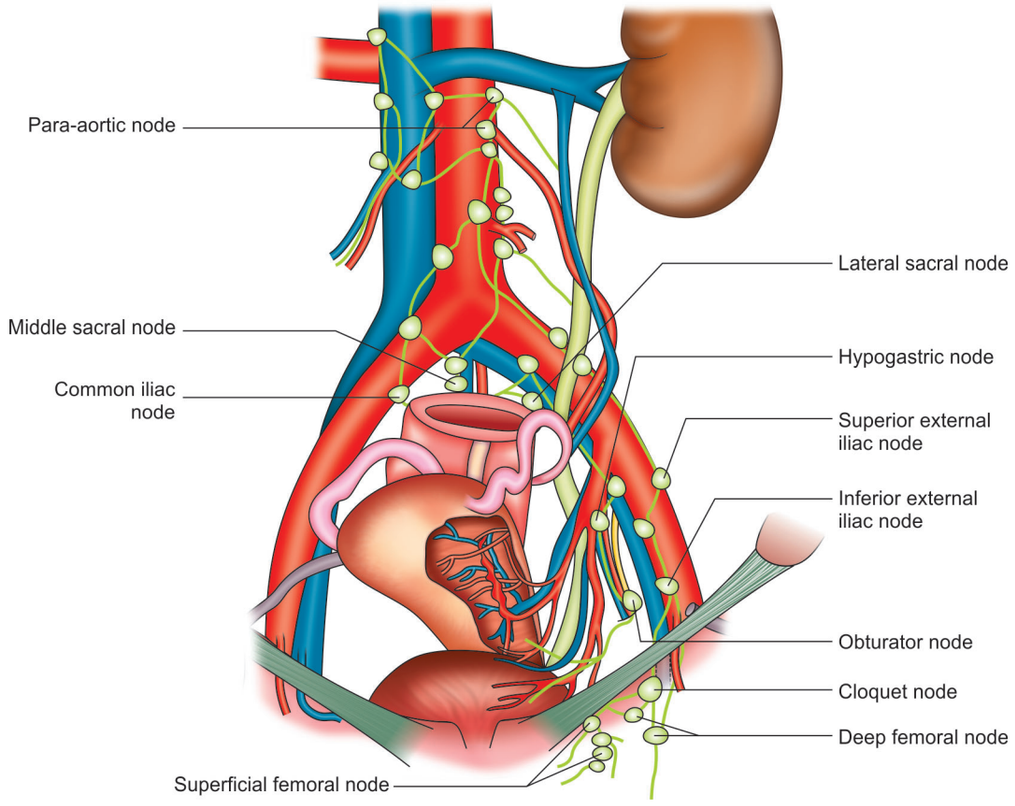


Fig. 1.8: Lymph nodes distribution from pelvis

Sensory nerve

- To supply skin of the perineum, penis and clitoris.

A pudendal block helps relieve pain during childbirth.

Apart from the pudendal nerve, there are fibers that go straight from the S4 spinal nerve to the levator ani, coccygeus and external anal sphincter as well as sensory function to the patch of skin between the anus and coccyx.

There is also the anococcygeal nerve from the coccygeal plexus (S4 to coccyx) which has sensory function to the perianal area.

The organs receive parasympathetic and sympathetic stimulation from the inferior hypogastric plexus. This is formed by fibres from the hypogastric nerve (which comes from the superior hypogastric plexus). The hypogastric nerve carries sympathetic fibers from the lumbar splanchnic nerves. The hypogastric nerve forms the inferior hypogastric plexus by joining the sacral splanchnic nerves (sympathetic) and the pelvic splanchnic nerves (parasympathetic).

The inferior hypogastric plexus is located on either side of the rectum and vagina in females (rectum in males). The inferior hypogastric plexus gives rise to smaller plexuses—rectal, uterovaginal, prostatic, vesical. The terminal branches of the inferior hypogastric plexus penetrate the deep perineal pouch and innervate erectile tissues in the penis or clitoris.

Sympathetic stimulation of the organs (from hypogastric nerve and sacral splanchnic nerves) results in:

- Vasoconstriction
- Smooth muscle contraction of internal urethral sphincter in men and internal anal sphincter in men and women.
- Smooth muscle contraction of the reproductive tract and accessory glands of reproductive system.
- Secretion from epididymis and other glands to urethra to form semen during ejaculation.

Parasympathetic stimulation of organs (from pelvic splanchnic nerves) causes:

- Vasodilatation
- Bladder contraction (detrusor muscle)
- Stimulate erection
- Communicate with enteric nervous system in the inferior mesenteric plexus.

Breast

Mammary glands are composed of glandular tissue and a variable amount of fat. They have a complex secretory product called breast milk. Breast milk travels through a passageway called the lactiferous duct, which travels from the alveoli to the nipple. The nipple is a centrally located projection on the breast comprised partly of erectile tissue. The areola is the darkened region of the breast that surrounds the nipple. An areola may vary in color depending on whether or not a woman has given birth.

The breast overlies the pectoralis major muscle between the second and sixth ribs as well as the uppermost portion of the rectus abdominis muscle inferomedially. The gland is anchored to the pectoralis major fascia by the suspensory ligaments first described by Astley Cooper in 1840. These ligaments run throughout the breast tissue parenchyma from the deep fascia beneath the breast and attach to the dermis of the skin. Since they are not taut, they allow for the natural motion of the breast. These ligaments relax with age and time, eventually resulting in breast ptosis. The lower pole of the breast is fuller than the upper pole. The tail of Spence extends obliquely up into the medial wall of the axilla (Fig. 1.9).

The nipple should lie above the inframammary crease and is usually level with the fourth rib and just lateral to the midclavicular line. The average nipple-to-sternal notch measurement in a young well-developed breast is 21–22 cm; an equilateral triangle formed between the nipples and sternal notch measures an average of 21 cm per side.

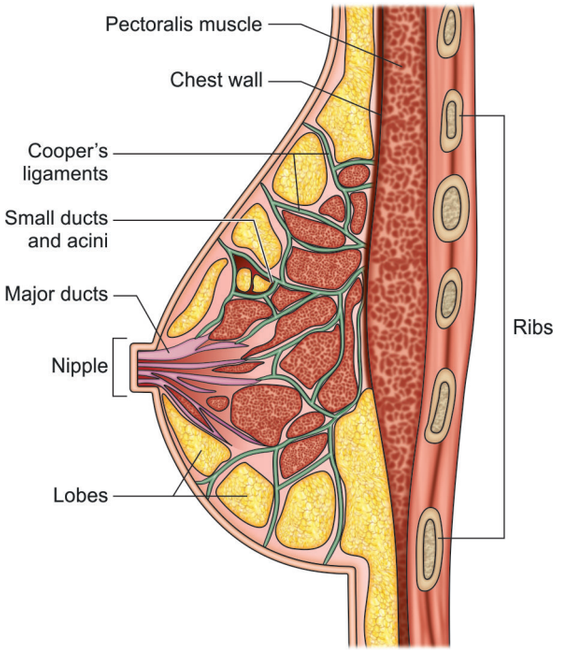
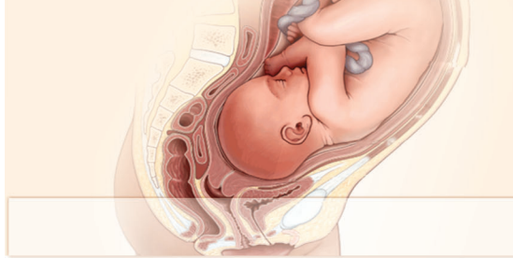


Fig. 1.9: Breast



The blood supply to the breast skin depends on the subdermal plexus, which is in communication with deeper underlying vessels supplying the breast parenchyma. The blood supply is derived from the following:

- The internal mammary perforators (most notably the second to fifth perforators)
- The thoracoacromial artery
- The vessels to serratus anterior
- The lateral thoracic artery
- The terminal branches of the third to eighth intercostal perforators

The superomedial perforator supply from the internal mammary vessels is particularly robust and accounts for some 60% of the total breast blood supply.

Sensory innervation of the breast is dermatomal in nature. It is mainly derived from the anterolateral and anteromedial branches of thoracic intercostal nerves T3–T5. Supraclavicular nerves from the lower fibers of the cervical plexus also provide innervation to the upper and lateral portions of the breast to the nipple derives largely from the lateral cutaneous branch of T4.