Reviewed By
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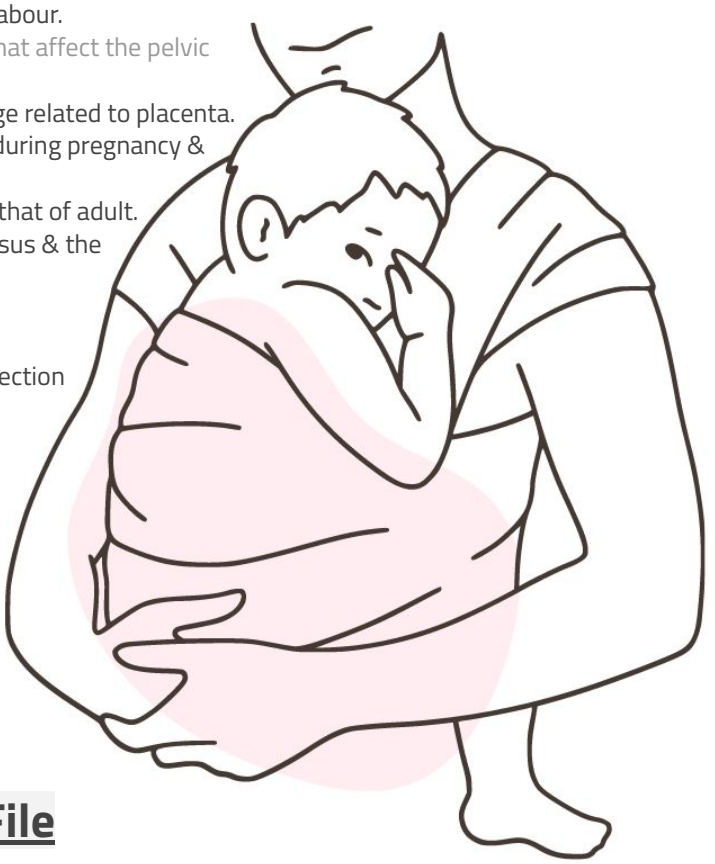
Anatomy of the Female Pelvic Organs

Objectives:

- → **Aim:** to fully understand the anatomy of the female pelvis in terms of bones and tissues, and fetal skull, this would help in explaining the mechanism of Labour & Delivery.
- → Describe anatomy of female bony pelvis and its diameters.
- → Discuss the important landmarks in the female pelvis and anatomical features in the female pelvis that play an important in progress of normal vaginal delivery.
- → List the types (shapes) of female pelvis and the importance of the pelvic shape in normal vaginal delivery.
- → Comprehend the normal female genital organs with their blood supply, venous drainage, innervation/nerves and lymphatic drainage.
- → Explain the relationship between pelvic organs.
- → Understand the relationship between the female pelvis (Bones & Soft Tissue) and fetal skull, in order to understand the mechanism of labour.
- → Describe the fetal skull anatomy, landmarks, diameters, that affect the pelvic capacity in normal vaginal delivery.
- → **Aim:** to predict and thus prevent postpartum haemorrhage related to placenta.
- → **Aim:** to understand the major events in fetal circulation; during pregnancy & after birth.
- → Understand the major variant in the fetal circulation than that of adult.
- → Know the significance of ductus venosus & ductus arteriosus & the first breath.
- → Explain the changes that occur after birth.
- → Familiarize yourself with the placental structure.
- → Know the significance of placental and umbilical cord inspection after birth.
- → Differentiate between the different types of placental abnormalities and their significance.



- → **Slides**
- → **Important**
- → **Golden notes**
- → **Extra**
- → **Doctor's notes**
- → **Previous Doctor's notes**
- → **Reference**

Editing File

Female External Genitalia

The Vulva[1]:

1. **Mons veneris (Mons pubis):**
   → A pad of fatty tissue covered by skin that lies over symphysis pubis (where hair grows after puberty).
2. **Labia majora:**
   → The terminal portion of round ligament are inserted into the fatty tissue.
      → **Inner aspects:** smooth and contain sweat and sebaceous glands.
      → **Outer aspect:** covered with hair after puberty.
3. **Labia minora:**
   → The area they inclose is the vestibule.
   → Smooth and have no covering of hair.
   → Contain few sweat and sebaceous glands.
   → **Each labia minora divide into 2 folds:**
      → Two **anteriorly upper fold:** surrounds the clitoris and unite to form prepuce.
      → Two lower folds: attached to the frenulum (under surface of the clitoris) and posteriorly unite to form thin fold of skin fourchette which is torn when first degree perineal tear is sustained during delivery (can be cut during delivery "*episiotomy*").
4. **The clitoris:**
   → A small extremely sensitive erectile structure, situated within the folds of prepuce and frenulum.
   → **Composed of 2 bodies:**
      → **Corpora cavernosa:** lies side by side and extends backwards to attach to periosteum of the body of the pubic bones.
      → **Clitoris:** structure that can be compared to male penis but it does not transmit to urethra.
         → Removed in some areas in Africa.
5. **The vestibule/introitus[2]:** has 6 openings:
   → Urethral meatus
   → Vaginal orifice
   → 2 Skene's ducts
   → 2 Bartholin ducts

→ **Bartholin glands:**
   → Lies on each side of the vagina, in the posterior lower third 1/3 of the introitus resting on triangular ligament, they are composed of racemose gland and secrete mucus (alkaline) to keep vagina moist.
   → It opens in hymen but normally not visible, we only see it if obstruction occurs and it becomes infected and painful (if an abscess forms → evacuate and clear it "*marsupialization*").

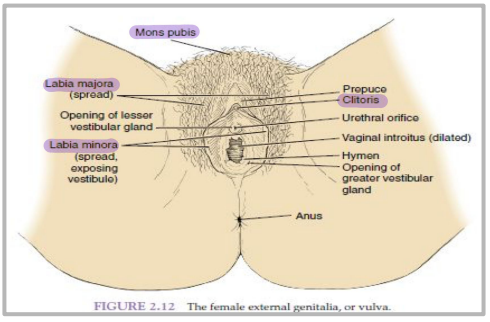
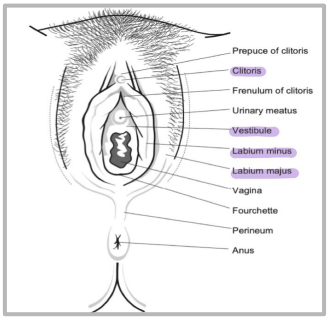
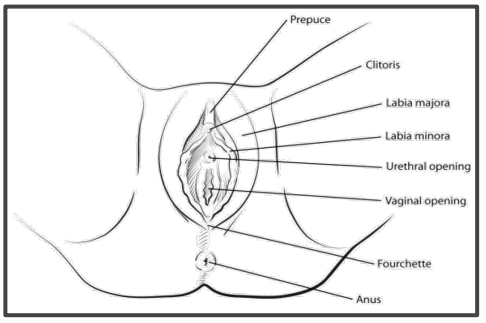


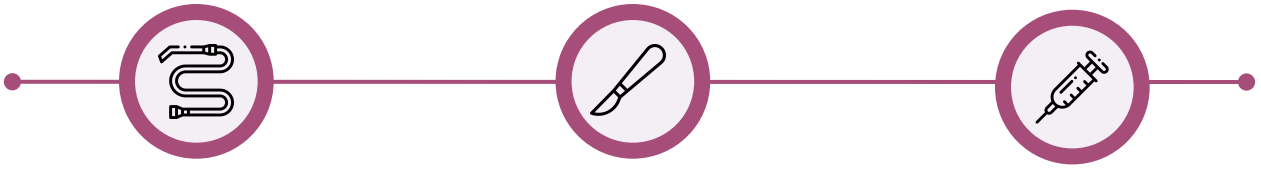
FIGURE 2.12 The female external genitalia, or vulva.





Procedures of the Vulva during Labor:

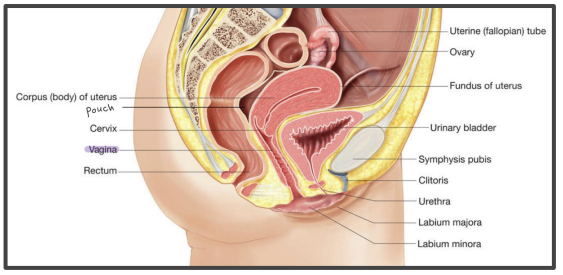
1. Catheterization
2. Episiotomy[3]
3. Anaesthetic infiltration



1. Any women comes to clinic with gynecological complaint we have to examine vulva.
2. An introitus is any type of entrance or opening. However, the term often refers to the opening of the vagina, which leads to the vaginal canal.
3. This is a surgical incision made in the perineum to enlarge the vaginal opening and assist in childbirth.

Female Internal Reproductive Organs

The Vagina[1]:



→ A canal/tube extend from the vulva to the uterus.
→ Runs upwards and backwards.
→ Walls lie in close contact, easily separated.

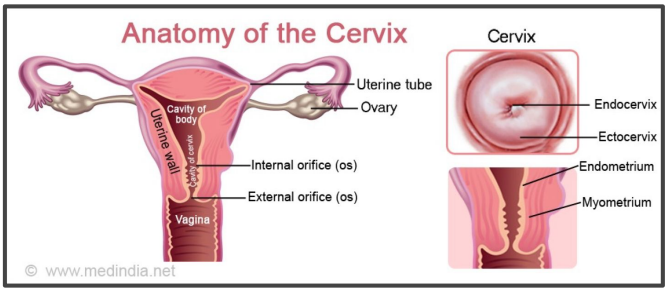
Speculum Examination:

→ Posterior vaginal wall is longer than the anterior: 11.5 cm (4.5 in) vs 7.5 cm
→ Cervix enters the vagina at a right angle.
→ Fornices = four (anterior - posterior - 2 laterals).
→ **Epithelium:** non-keratinized squamous epithelium, it's tough → acidity.
→ Acidic (low PH of 4.5) → very difficult to get bacterial infections.
→ Acidity is buffered by menstrual cycle so vagina becomes alkaline which makes it prone to infections.

Relations to Vagina:

Anterior	Posterior	Laterally
• **Upper ½:** base of the bladder (**cystocele**[2]) • **Lower ½:** urethra (urethrocele)	• **Upper ⅓ :** pouch of douglas. • **Middle ⅓ / centrally:** rectum (**rectocele**[3]) • **Lower ⅓ / centrally:** perineal body	• Ureters • Uterine arteries

The Cervix:

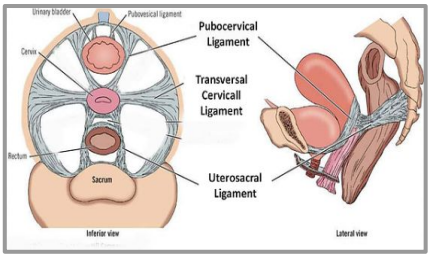


→ Forms the lower 1/3 of the uterus.
→ Enters the vagina at a right angle.
→ Barrel shape.
→ 2.5 cm (1 in) long.
→ **Two parts:**
  → **Supra vagina:** above and outside the vagina.
  → **Intra vaginal:** within the vagina.
→ **Two Cervical os:**
  → **Internal os**
  → **External os:** shape differ in nulliparous and multiparous.
→ **Cervical canal:** between the internal and external os, covered by columnar epithelium.
→ **Transformation zone / squamous-columnar junction[4]:** a meeting of the cervix (single layer of columnar epithelium) and the vagina (squamous epithelium).
→ Cervical Ectropion[5].

Ligament Supporting the Cervix:

1. **Cardinal ligaments / Transverse Cervical ligament:** extend from the cervix to the lateral wall of the pelvis.
2. **Pubocervical ligaments:** extend from the pubic bone to the cervix.
3. **Uterosacral ligaments:** extend from cervix to the sacrum.

→ All 3 ligaments insert into supra-vaginal cervix & upper vagina.



1. It is a potential tube walls are opposed to each other. Microscopically lined by modified squamous epithelium, there is vascular connective tissue and 2 muscle layers (inner circular and outer longitudinal) muscle fiber is thin but strong, walls of vagina fall into transverse folds which allow for distention
2. Cystocele/Stress incontinence: The bladder falls into the vagina and allows urine to leak with increased intra-abdominal pressure (sneezing, coughing, tennis). Cervical exam shows a Q-tip sign or an anterior prolapse (the bladder falling in). Tx: Sling/Reconstruction or Colporrhaphy.
3. Rectocele / Constipation: the rectum falls forward into the space occupied by the vagina. The patient can relieve the constipation by inserting fingers into her vagina and pressing. Cervical exam shows a posterior prolapse (the rectum). Tx: Colporrhaphy.
4. Significance: here we can take papanicolaou cervical smear. Cells here can change into abnormal cells (cervical carcinoma in situ) . Screen by Pap smear, use either ayre spatula (wooden spatula with 2 different ends for nulliparous and multiparous women) nowadays we use cytobrush.
5. Overgrowth of columnar epithelium over squamous part. It's a physiological phenomena for women in reproductive age who are on combined oral contraceptive pills, columnar epithelium is single layer and appears red.In the past was mistaken for erosion.

Female Internal Reproductive Organs

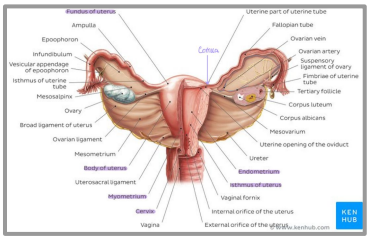
The Cervix:

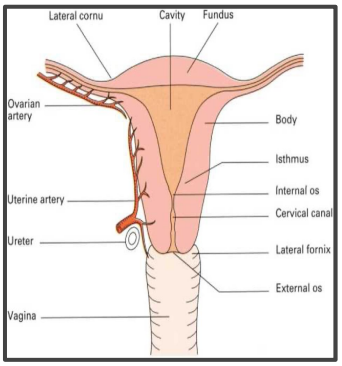
Cervix Description in Pregnancy and Labor:

In Pregnancy	Late in Pregnancy:	In Labor:
• Rich blood supply → **bluish** coloration • Soft • Cervical glands → mucus plug "**operculum**" fills cervical canal and helps prevent infection of the genital tract).	• Softer • Starts to dilate.	• Longitudinal smooth muscle fibres of uterus contract and retract → pulling upward → reducing cervix length "**Cervical Bishop Score**[1]" • **Fibrous** and **elastic** tissue. • Full dilatation = end of the first stage of labour.

The Uterus:

→ Lies in the true pelvis.
→ **Most common positions:** anteverted (A/V) and anteflexed (A/F) (tips slightly anterior in the pelvis).
→ **Other positions:** retroverted & mid position, position variation is normal.
→ The body of the uterus lies above the bladder, normally you don't feel the uterus, only cervix is felt.
→ **Layers:**
  → **Endometrium:** mucus membrane lining uterus cavity change each day of cycle.
  → **Myometrium:** important in labor and delivery, three layers:
    → Outer longitudinal fibers
    → Middle oblique
    → Inner circular
  → **Perimetrium and peritoneum:** covers uterus smoothly and almost entirely with some areas excluded (cervix - inner strip of lateral uterine wall) زي الشرشف تغطي الرحم من قدام وورا يسمونها **Broad ligament** مهم تعرفونها
  → Attached firmly except for the anterior portion of isthmus where its loose attachment allows bladder to expand and at time of cesarean we can open peritoneum and incise lower uterine segment.
    → **Adherent in:** lateral uterine wall.
    → **Loose in:** anterior isthmus allows loose cardinal ligament (allows c-section incision)





Uterus Size: you don't have to memorize numbers.

Length	Width	Thickness	Weight
7.5 cm	5 cm	2.5 cm	→ 50 - 75 gm → 1 Kg in pregnancy

Gross Structures of Uterus: describes the exact site of pathology

01 **Cervix**
→ Lower 1/3

02 **Isthmus**[2]

03 **Cavity**
→ Center of the organ
→ Triangle shape
→ Hallow

04 **Corpus / Body**

05 **Cornua**
→ Within Fallopian tube

06 **Fundus**
→ Above cornua

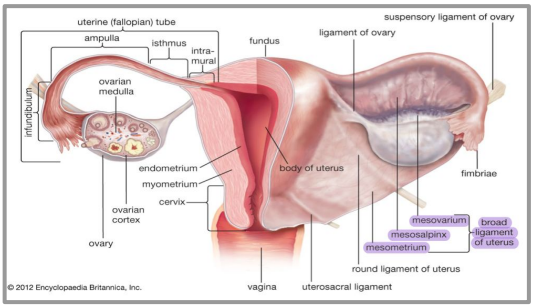
1. An assessment done later in pregnancy criteria include: length, internal Os dilation, direction of cervix, relation of presenting part to ischial spine (engagement). That's use to rates the readiness of cervix for labor
2. Narrowest construction of fallopian (7mm in non-pregnant), when woman is pregnant (around week 12) it becomes stretched can reach up to 7 cm long and forms "lower uterine segment" it's complete at week 32, so if we need to do c-section before week 32 we have to do uppercut (hysterotomy) as the lower segment isn't formed yet, but after 32 weeks we do lower cut.

Female Internal Reproductive Organs

The Fallopian Tubes: Supported by infundibulum pelvic ligament

→ Extend from the cornua of the uterus, travels towards the sidewalls of the pelvis then turns downwards and backwards.
→ Lies in the upper margin of the **broad ligaments**.
→ **Length:** 10 cm (4 in).
→ **Thickness:** 3 mm.
→ **Communication:**

Superiorly	Inferiorly
Uterine cavity	Peritoneal cavity



→ **Tubal patency checked by different means**.

4 Parts of the Fallopian Tube:

01 — Interstitial / intramural
→ Lies within / connected to wall of uterus

02 — Isthmus
→ Narrowest part

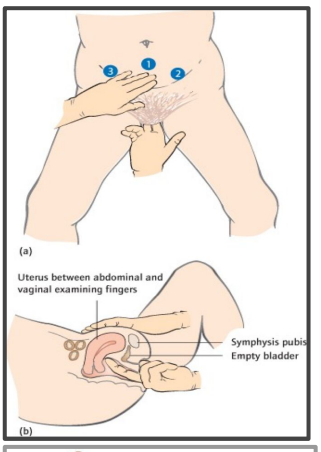
03 — Ampulla[1]
→ Wide area where fertilization occurs

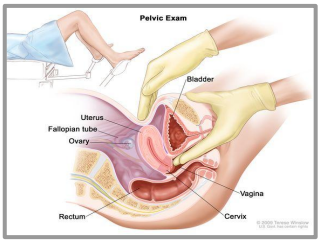
04 — Infundibulum
→ Has ciliated epithelium arranged in folds → facilitating sperm migration from the uterus to the ampulla + push the fertilized ovum to uterus.

05 — Fimbrial
→ Fingers like process, all the way to the end.

The Ovaries[2]:

→ Lies in the posterior (leaf) wall of the broad ligament at the fimbrial end of the fallopian tubes at the level of the pelvic brim.
→ **Size:** almond like = 3 x 2 x 1.5 cm (very small, can't feel it).
→ Dull white colour.
→ Corrugated surface.
→ Structure varies with woman's age.
  → **Pregnant:** bigger
  → **Post menopause:** tiny.
  → **Reproductive age:** normal size.





Ligament Supporting the ovaries:

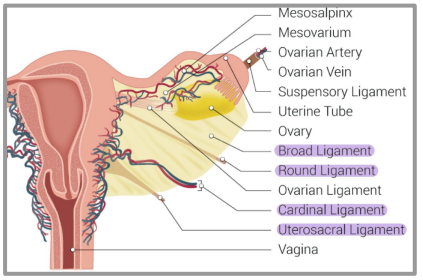
→ They lie in a fossa, posterior leaf of **broad ligament**
1. Attached to broad ligament → **meso ovarian**.
2. The broad ligament that extend between the fallopian tube and the ovary → **mesosalpinx**.
3. Attached by the ovarian ligament to the uterine fundus by the suspensory ligaments to the pelvic sidewall.

→ **Adenxa:** the fallopian tubes, ovaries and broad ligaments.
→ **Bimanual examination**.

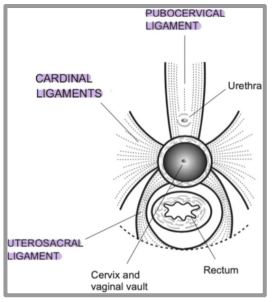
1. Widest part of fallopian, 95% of ectopic pregnancy happen in fallopian , 70% of these happen in the ampulla.(ectopic pregnancy is any pregnancy outside the uterine cavity)
2. Microscopically it's formed of germinal epithelium, tough fibrous outer coat tunica albuginea, cortex (functional part) mostly stroma with graffien follies, and corpus luteum, medulla is entry point for blood vessels, lymphatics .etc.consist mainly of fibrous elastic connective tissue.

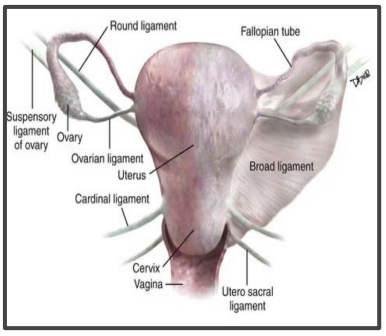
Female Internal Reproductive Organs

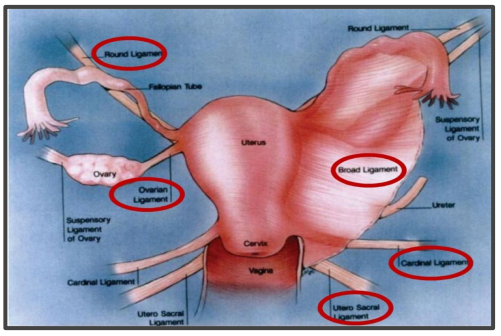
Ligaments:

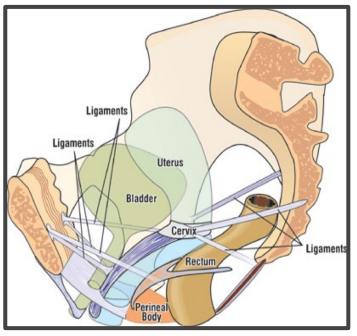


- → **Round ligaments:**
  - → Maintain uterus in Anteverted A/V + anteflexed A/F position.
  - → From the cornua of the uterus → pass downwards and insert in the tissue of the labia majora.
  - → **What is the artery runs in the round ligament? Simpson's**
- → **Broad ligaments:**
  - → Not a true ligament.
  - → Folds of peritoneum extend laterally from uterus to the pelvic side walls.
- → **Cardinal / transverse cervical / Mackenrodt ligaments:**
- → **Pubocervical ligament**
- → **Uterosacral ligament**
  - → The strongest and **most imp** one, it support the uterus.
- → Cardinal + uterosacral + pubocervical ligaments → provide support to prevent pelvic organ prolapse ligament.
  - → Overstretch in these ligaments cause uterine prolapse.









Relationships:

	Cervix	Uterus	Fallopian Tubes	Ovaries
Anterior	Uterovesical pouch, peritoneum and bladder	Urinary bladder	Perineal cavity and intestine	Broad ligaments
Posterior	Pouch of douglas and rectum	Uterosacral ligaments	Perineal cavity and intestine	-
Lateral	Broad ligaments and ureter	Fallopian tubes, ovaries and round ligaments	Infundibulum pelvic ligament	Fallopian tubes
Medial	-	-	Uterus	-
Superior	-	Intestine	Perineal cavity and intestine	-
Inferior	-	Vagina	Broad ligaments and ovary	-

Female Internal Reproductive Organs

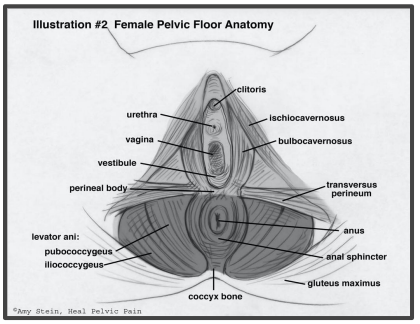
Blood Supply, Lymphatics and Innervation:

→ Uterine artery runs behind the peritoneum → cross cardinal ligament → passes anterior to and above the ureter 1.5 cm from lateral vaginal wall fornix.
→ **Important landmark:** water under the bridge.
→ **Most common ureter areas of injury in hysterectomy:**
  → Bifurcation of common iliac artery
  → Cardinal ligament
  → Uterine artery
  → Bladder

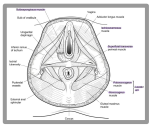
	Blood Supply	Venous Supply	Lymphatic Drainage	Nerve Supply
Vulva	- Pudendal artery from femoral artery	Corresponding veins	- Inguinal glands - External iliac glands	Branches of pudendal nerve and perineal nerve (T12, L1-2, S2-4)
Vagina	- Vaginal artery - Uterine artery - Middle haemorridal artery - Inferior vesical artery - Pudendal artery *Branches of the internal iliac artery.*	Corresponding veins	- Inguinal glands - Internal iliac glands - Sacral glands	Sympathetic (hypogastric plexus) and Parasympathetic (S2-S4)
Cervix	- Uterine artery	- Uterine veins	- Internal iliac glands - Sacral glands	Sympathetic and parasympathetic
Uterus	- **Fundus**: ovarian artery. **Collateral Artery** - **Body**: **uterine artery** from internal iliac artery.	- Right ovarian vein to inferior vena cava. - Left ovarian vein to renal vein.	- Internal and external iliac gland (usually endometrial cancer here) - Inguinal/sacral gland	Sympathetic and parasympathetic
Fallopian Tube	- Ovarian artery - Uterine artery	Corresponding veins	Lumbar gland	
Ovaries	- Ovarian artery	- Right ovarian vein to inferior vena cava. - Left ovarian vein to renal vein.	- Lumbar glands - Pelvic and paraaortic lymph nodes.	Ovarians plexus
	Both the artery and vein pass through the suspensory ligament of the ovary			

Normal Female Pelvis

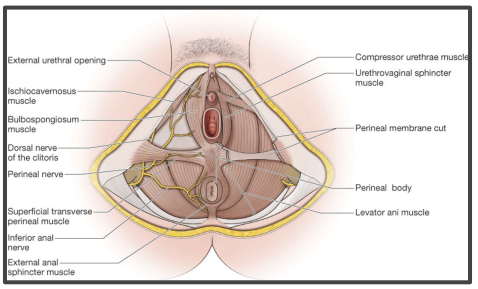
The Outlet of the Pelvis:



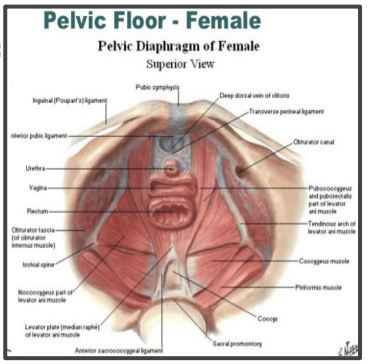
- → Outlet of the pelvis is filled with soft tissue that supports the pelvic and abdominal organs.
- → Outlet of the pelvis forms as a gutter-shaped structure **higher anteriorly** than posteriorly.
- → **Three canals, each with an external orifices, run through the tissue:**
  - → Urethra
  - → Vagina
  - → Rectum



The Pelvic Floor:



- → **Six layers of tissue:**
  1. Outer covering of skin
  2. Subcutaneous fat
  3. **Superficial muscles enclosed in fascia:**
     - → 1 transverse perinei muscle.
     - → 2 bulbocavernosus muscles.
     - → 1 ischiocavernosus muscle.
     - → Membranous sphincter of urethra & rectal sphincter.
  4. **Deep muscles enclosed in fascia (Levator ani / Coccygeus muscles):**
     - → 3 pairs of muscles all have their insertion around the coccyx.
     - → **Thickness:** 5 mm.
     1. Iliococcygeus
     2. Ischiococcygeus
     3. Pubococcygeus
  5. Pelvic fascia thickened to form pelvic ligaments
  6. Peritoneum

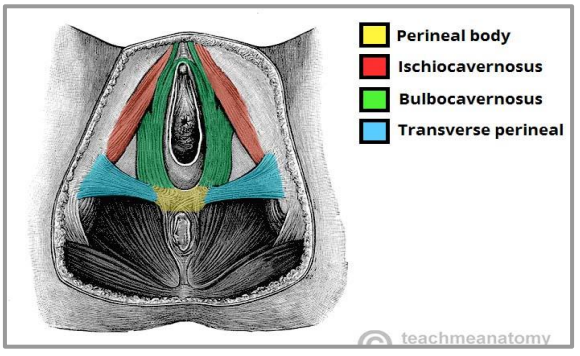


The Perineal Body:

- → Fibromuscular mass.
- → Lies between vaginal & rectal canals.
- → **Triangular:**
  - → **Base:** skin.
  - → **Apex:** pointing upward.
  - → **Length of each side:** 3.8 cm.
- → **3 layers of tissue:**
  - → Outer covering of skin
  - → Superficial pelvic floor:
    - → Bulbocavernosus muscles.
    - → Ischiocavernosus muscle.
    - → Transverse perinei muscle.
  - → Deep pelvic floor muscle (***above***).
- → Episiotomy, types, indications (*slide 13*).
- → **4 degrees of perineal tear:**
  1. Involves the skin.
  2. Skin + superficial muscles (*deep tear of this degree will also involve the deep muscles*)
  3. Skin + muscles + anal sphincter muscle.
  4. Extends to mucus membrane that lines the rectum.

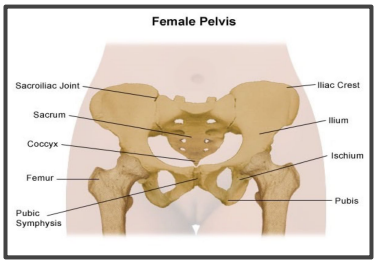
The Perineum:

- → **Bounded by:**
  - → **Above:** levator ani.
  - → **Below:** anus.
- → **Divided into:**
  - → **Anteriorly:** urogenital triangle.
  - → **Posteriorly:** anal sphincter.
- → **Covered by:** superficial and deep fascia.



Normal Female Pelvis

Normal Female Pelvis: *Pelvic Bone*



- → The pelvis is the largest bone in the body.
- → **Pelvis articulates with:**
  - → Fifth lumbar vertebra above.
  - → Head of each femur in the right and left acetabulum.
- → The weight of the trunk is transmitted through the pelvis into the legs.
- → Gives protection to the pelvic organs.
- → **Gross structure consists of 4 bones:**
  1. 5 fused **sacral** vertebrae.
  2. **Coccyx**.
  3. Left innominate bone.
  4. Right innominate bone.

1

Sacrum

- → Triangular shape
- → **Consists of:**
  - → 5 fused vertebrae.
  - → 4 pairs of holes for nerves, blood vessels and lymphs.
- → **Hollow:** smooth & concave.
- → **Ala:** appearance of wings.
- → **Sacral promontory:** center point of upper border of the 1st sacral vertebrae.
- → **Sacral canal:** a passage for spinal cord that opens at the level of 5th sacral vertebra.
- → **Cauda equina**: spread out nerves at the level of the 2nd and 3rd sacral vertebrae.
  - → Location of anaesthesia & analgesia in labour.

2

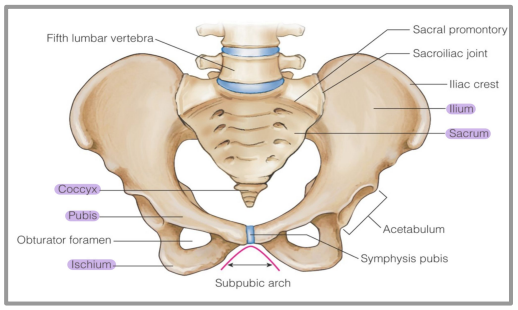
Coccyx

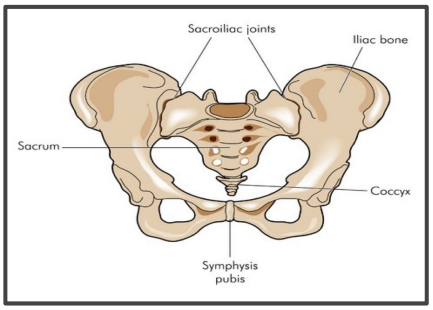
- → 4 Fused coccygeal vertebrae.
- → Triangular shape.
- → Articulate with sacrum.
- → Muscles are attached to its tip.
- → Easily broken in labour.
  - → It's a mobile structure → helps during delivery but also could break during labour.

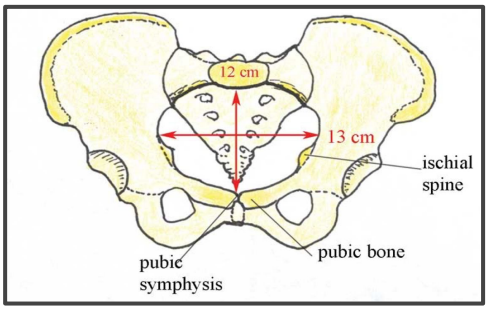
3

Innominate Bones

- → Left and right bones.
- → Each bone is made of 3 separate parts meet in the **acetabulum**.
  1. **Ilium:**
     - → **Upper part of the ilium:** iliac crest (anterior, posterior, & superior iliac crest)
  2. **Ischium:**
     - → Ischial tuberosity.
     - → **Ischial spines:** 2 cm above tuberosity.
  3. **Pubis:**
     - → Both meet the pubic body & fused by cartilage → **symphysis pubis**.



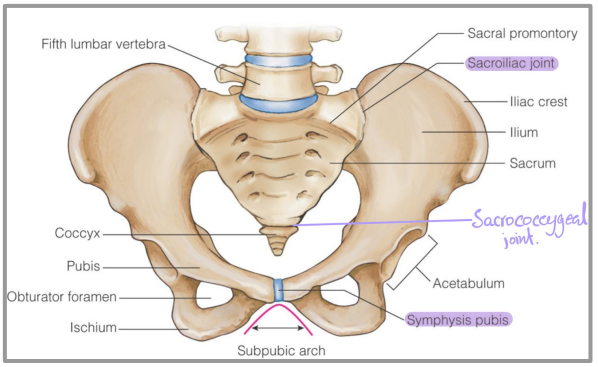




Normal Female Pelvis

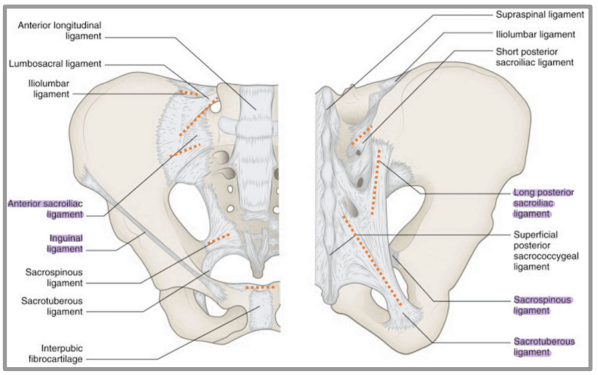
Pelvic Joints:

- → 2 sacroiliac joints.
- → Symphysis pubis (cartilage).
- → Sacrococcygeal joint.
- → All these joints increase power of movement during pregnancy by the effects of progesterone.



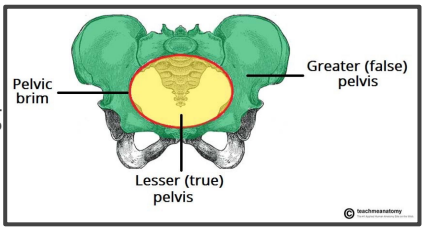
Pelvic Ligaments:

- → **Sacroiliac** ligament: the strongest in the body.
- → Sacrotuberous ligament.
- → Sacrospinous ligament.
- → Inguinal ligament.



Divisions of the Pelvis:

- → The pelvis has a birth canal consisting of brim (inlet), cavity, and an outlet.
  - → **Birth canal:** a curved canal through which the fetus pass during labour.
- → **The brim divides the pelvis into two parts:**



False / Greater

Lies **above** the pelvic brim
Not important in obstetrics

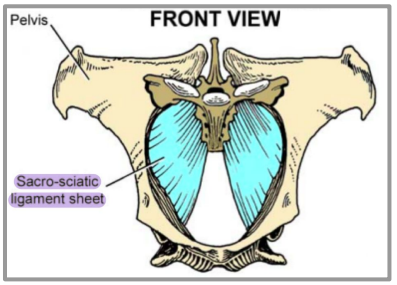
True / Lesser

What lies below the pelvic brim.

This area we usually care about in labor.

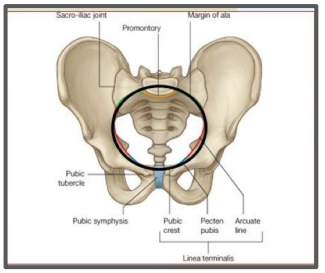
Average Measurements of Pelvis:

	Brim	Cavity	Outlet
Anteroposterior	11.5 cm	12.0 cm	12.5 cm
Transverse	13.0 cm	10.5 – 12 cm	11.0 cm



Normal Female Pelvis: Birth Canal

1. Pelvic Brim (Inlet):



- → Round in shape.
- → Partly bone & partly ligaments.
- → Fetal head enters the pelvis through this plane in the transverse position.
- → **Boundaries:** ***these bones make up the pelvic brim***

Anteriorly	Laterally	Posteriorly
Symphysis pubis (pubic crest)	Iliopectineal lines (acruate) of innominate bones	Sacral ala + sacral promontory

- → Pelvic inlet has eight points: **Figure 1**
- → **5 Diameters of Pelvic Inlet:**

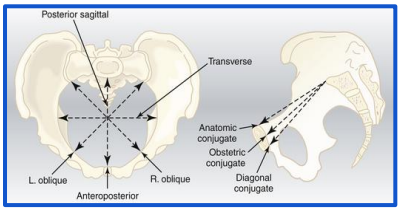
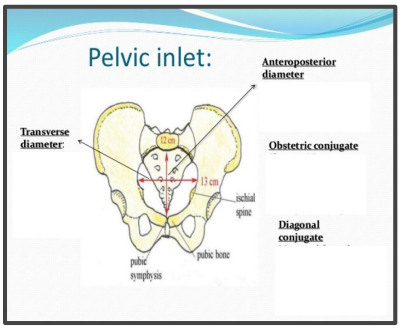
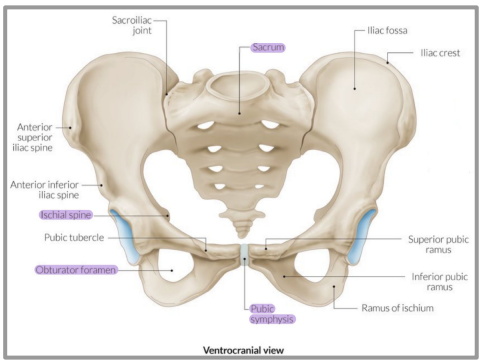


Figure 1



1. **Anteroposterior diameter:** described by 1 of 2 measurements.
   - → **True / Anatomic conjugate:**
     - → Extends from the middle of sacral promontory to the upper inner border of symphysis pubis.
     - → 11.5 - 12 cm.
     - → **Measured by:** erect lateral pelvimetry an x-ray.
   - → **Obstetric conjugate:**
     - → The actual space available to the fetus.
     - → Shortest AP diameter.
     - → Extends from the middle of sacral promontory to the inner/posterior surface of symphysis pubis (the closest point on the convex posterior surface).
     - → 11 - 11.5 cm.
   - → **Diagonal Conjugate:**
     - → 12.5 cm | ≥ 11.5 cm.
     - → Extends from the lower border of pubic symphysis to sacral promontory.
2. **Transverse diameter:**
   - → The widest diameter.
   - → 13 cm.
   - → Measured by the widest distance between the iliopectineal lines.
3. **Right & left oblique diameters:**
   - → Extend from the sacroiliac joint to the opposite iliopectineal eminence.
4. **Posterior sagittal diameter:**
   - → Extends from the anteroposterior and transverse intersection to the middle of the sacral promontory.

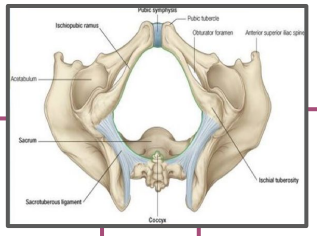
2. Pelvic Cavity (True Pelvis):



- → Extends from the brim above to the pelvic outlet below .
  - → **Posterior wall:** formed by hollow of the sacrum - 11 cm.
  - → **Anterior wall:** formed by symphysis pubis and obturator foramen - 3.8 cm.
  - → **Lateral walls:** formed by sacrosciatic ligament and ischial spines.
- → **Diameter of Pelvic Cavity:** interspinous diameter.

Normal Female Pelvis: Birth Canal

3. Pelvic Outlet:



A — Anatomical Outlet

Formed by:
- Fixed points useful landmarks for taking pelvic measurement.

Boundaries:
- **Anteriorly:** pubic arch of symphysis pubis
- **Anteriolaterally:** Ischial tuberosities / ischiopubic rami.
- **Posterolaterally:** sacrosciatic ligaments.
- **Posteriorly:** tip of coccyx.

B — Obstetrical Outlet

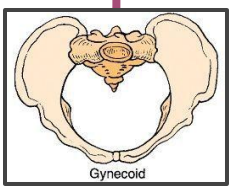
Landmarks:
- Lower border of symphysis pubis
- **Ischial spines:** used in vaginal exam to determine whether the fetal head is engaged.
- Lower border of the sacrum.

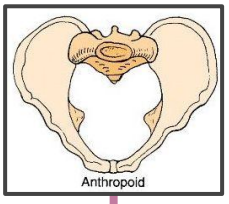
Abnormal Pelvis

Pelvis Shapes:

Gynecoid (50%)

Normal female pelvis
Favors occipito-anterior position

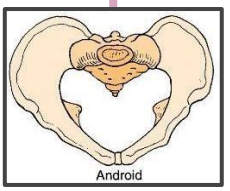


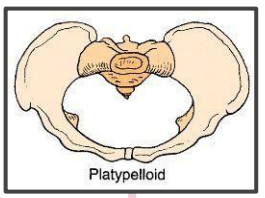


Anthropoid (25%)

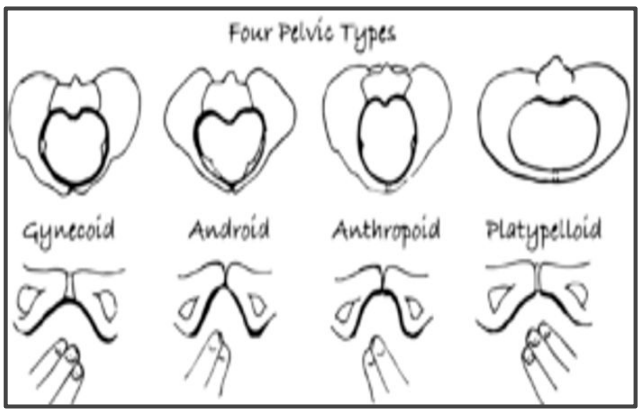
Android (20%)

In African-American women





Platypelloid/flat (5%)



Episiotomy

Episiotomy[1]:

	Midline episiotomy	Mediolateral episiotomy
Procedure	Incision is made in the middle of the vaginal opening, straight down toward the anus.	Incision begins the middle of the vaginal opening and extends down toward the buttocks at a 45-degree angle.
Advantage	Easy repair and improved healing	Risk for anal muscle tear is much lower
Disadvantage	Increased risk for tears that extend through the anal muscles	More severe pain and difficult repair
Indications	1. Fetal weight greater than 4 kg 2. **Operative delivery:** forceps or vacuum extractor 3. Non-reassuring fetal monitor tracing	1. Shoulder dystocia 2. Crowning of fetal head 3. Vaginal breech delivery or narrow birth canal

Fetal Skull

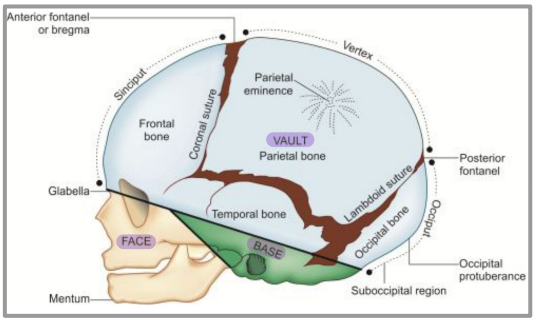
Definitions:

- **Lie of the fetus[2]:** the longitudinal axis of the fetus with respect to the longitudinal axis of the mother.
- **Attitude:** position of fetal limb, body and head with respect to each other.
- **Denominator:** occiput in cephalic presentation.
- **Presentation:** the part of the fetus nearest to pelvic inlet (**Normal:** the vertex "*head is down*").
- **Malpresentation:** any presentation other than vertex (brow - face - breech - shoulder) to maternal pelvis.
- **Position:** relationship of the denominator to maternal pelvis.
- **Malposition:** abnormal position of fetal head in relation to maternal pelvis.
- **Station:** the level of descent of the presenting part with respect to the maternal pelvis.
  - → **Zero station:** level of the ischial spines (reference point).
  - → **-1 to -3 station:** above ischial spines by 1 cm to 3 cm respectively.
  - → **+1 to +3 station:** below ischial spines by 1 cm to 3 cm respectively.
- **Engagement of the head:** passage of widest diameters of fetal head through pelvic inlet / brim.
  - → **Palpation of head by the abdomen:** performed in cephalic presentation, be 5/5 to 0/5 palpable.
    - → 3/5 to 1/5 means the baby is engaged.
    - → When is it 2/5 palpable? two-fifths palpable above pelvis brim, three-fifths below.

1. **Episiotomy:** a surgical incision to perineum which is carried out prior to delivery of fetal head. Indications: maternal distress, fetal distress, cardio respiratory complications, cord prolapse, 3rd and 4th degree tear, rigid perineum, if we need to prevent cerebral damage in prematurity and after coming of fetal head in breach.
   - → **Types of episiotomy:**
     - → **Midline:** easily done – start in the fourchette and go down – may extend to 3rd or 4th degree tear (danger) – **Advantages:** heals quickly + less blood + no pain & dyspareunia later.
     - → **Mediolateral:** avoid cutting bartholin duct - give at height of contraction when the head is crowning → less bleeding (***crowning:*** *when over distend introitus & doesn't recede back after contraction*).
     - → **Lateral:** disturbs bartholin duct → no one does it.
2. Weather it's straight, oblique or transverse.

Fetal Skull

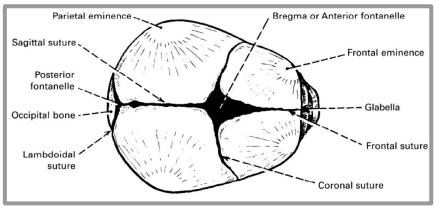
Fetal Skull:



Regions:

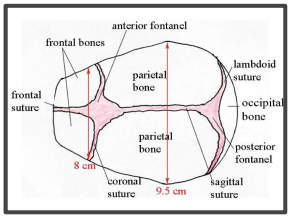
1. **Vault/cranium:** from orbital ridges to the nape of neck.
   → Formed from membrane and not cartilage.
2. **Face:** from orbital ridges to junction of chin & neck.
3. Base

→ There are 5 ossification centres / points.
→ Calcification begins as early as **5 weeks** after conception.
→ Premature baby is born → risk of **intracranial damage**.



Bones:

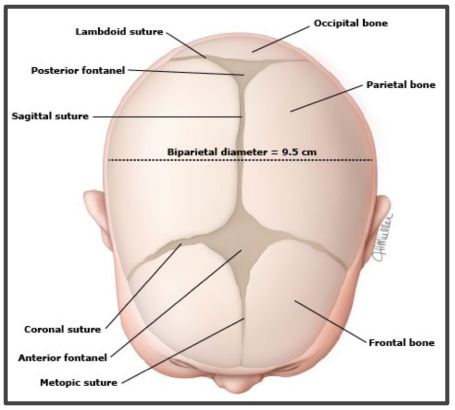
1. 2 frontal bones.
2. 2 parietal bones.
3. 1 occipital bone.



Sutures:

→ **Bones are separated by?** Sutures (*an area of membrane which has not ossified*).

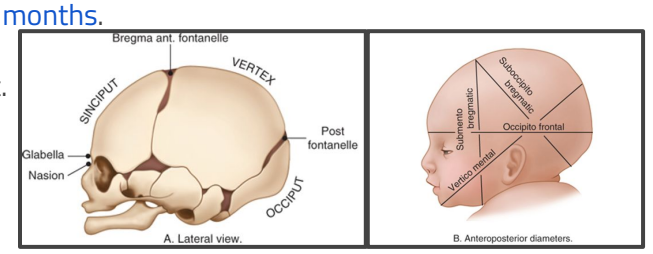
1. Lambdoidal suture (Occipito & Parietal)
2. Sagittal suture (**2 Parietals**)
3. Coronal suture (Frontal & Parietals)
4. Frontal suture (2 Frontals)
5. Temporal suture (Temporal & Parietal)



Fontanelles:

→ Areas where two or more sutures meet.
→ Very important **landmarks**.

1. **Anterior fontanelle (Bregma):**
   → Where sagittal, coronal and frontal sutures meet.
   → Diamond in shape, looks like Mercedes logo.
   → **Closure:** does not become ossified until ≈18 months.
→ **Posterior fontanelle (Lambda):**
   → Where lambdoidal and sagittal sutures meet.
   → Y- or T-shaped.
   → **Closure:** at 6 to 8 weeks of life / after birth.



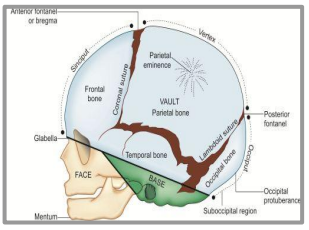
Areas / Landmarks:

Glabella: bridge of the nose (*elevated area between orbital ridges*)

Sinciput/brow: forehead (*area between anterior fontanelle & glabella*)

Bregma: anterior fontanelle

Vertex: area between the fontanelles (*anterior & posterior*) area.
- Bounded laterally by 2 parietal eminences (*most common presentation*)



Lambda: posterior fontanelle

Occiput: area behind & inferior to posterior fontanelle & lambdoid sutures.

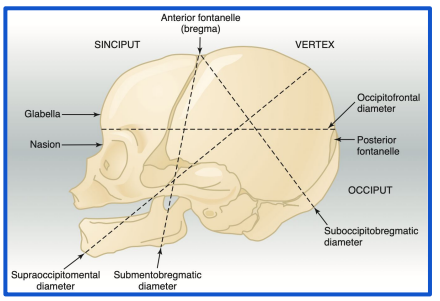
Suboccipital area

Mentum: chin

Fetal Skull

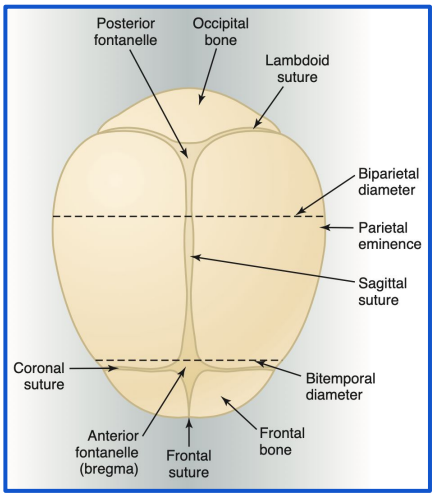
Fetal Skull:

Circumferences:



- → The engaging diameters of fetal skull varies with the part presenting to maternal pelvis.
- → **Vertex position (well flexed head):** suboccipitobregmatic diameter + biparietal diameter = 9.5 cm.
- → **Occipitoposterior position (deflexed or partly extended head):** occipitofrontal diameter + biparietal diameter = 11.5 cm.

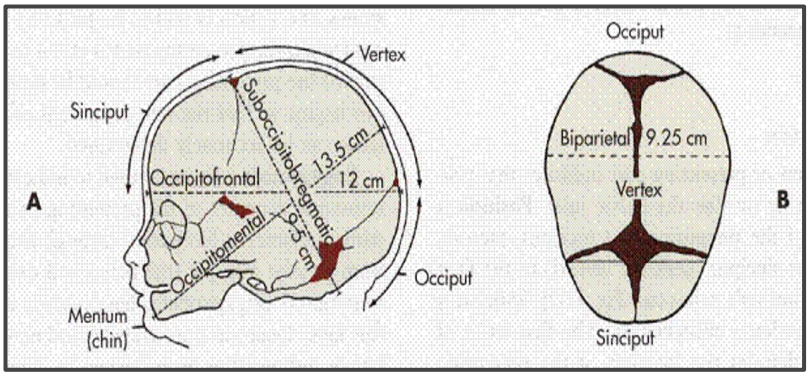
Diameters:



1. **Anteroposterior diameters:** depends on degree of flexion or extension of the head.
   - → **Suboccipitobregmatic diameter (9.5 cm):** well flexed head.
     - → Occipitotransverse position
     - → Occipitoanterior position
   - → **Occipitofrontal diameter (11 - 11.5 cm):** deflexed or partly extended head.
     - → Occipitoposterior position
   - → **Mentovertical / supraoccipitomental diameter (13-14 / 13.5 cm):** from point of chin to vertex / posterior fontanelle, the longest anteroposterior diameter of head.
     - → Brow presentation[1].
   - → **Submentobregmatic diameter (9.5 cm):** from root of nose to the junction of head & neck.
     - → Face presentations[2].
2. **Transverse diameters:**
   - → **Biparietal diameter (9.5 cm):** the longest transverse diameter of head.
   - → **Bitemporal diameter (8 cm)**

Effect of Labour and Delivery:

1. Engagement
2. **Molding:** alteration of the relationship of the fetal cranial bones to each other as a result of the compressive forces exerted by the bony maternal pelvis.
3. **Caput succedaneum[3]:** a localized, edematous swelling of scalp caused by pressure of cervix on the presenting portion of the fetal head.
4. **Cephalhematoma[4]:** a typically harmless condition that causes blood to pool under a newborn's scalp after a difficult vaginal delivery.

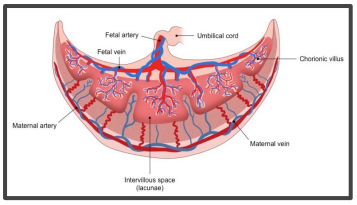


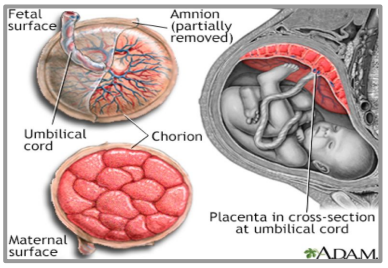
1. Only way to deliver is c-section (unless pelvis is spacious).
2. Anterior face presentation we can deliver vaginally but posterior usually cesarean (can try vaginally but DON'T compromise life of mother and baby).
3. Swelling of the scalp in a newborn resulting from normal pressure and compression on the baby's head as it passes through the birth canal. It's normal presentation not a pathology.
4. Usually in instrumental delivery.

Placenta and Fetal Circulation

The Structure of a Mature Placenta:

→ Flat, Roughly circular.
→ **Diameter:** 22 cm.
→ **Central thickness:** 2 cm.
→ **Weight:** 1/6 of baby's weight.



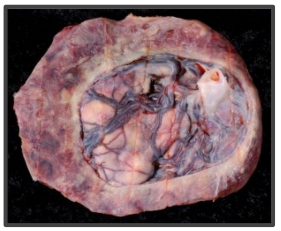


Maternal Surface	Fetal Surface

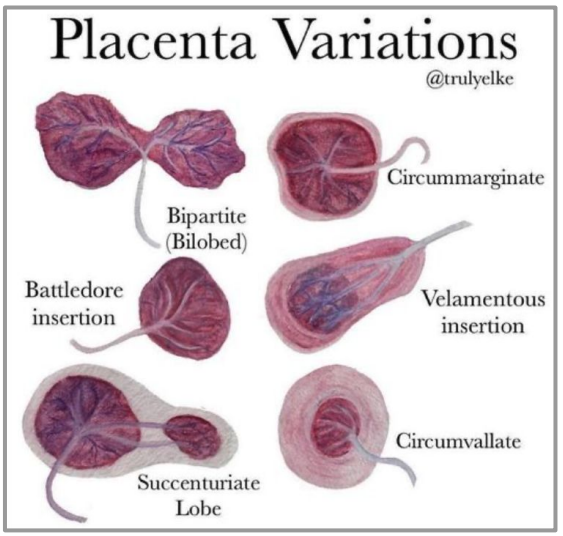
- Lies next to the uterus on inspection.
- **Color:** dark red.
- **Surface:** rough.
- Chorionic villi are arranged in **lobes** / **cotyledons**[1].
  - **Number:** 20.
  - **Lobules:** 200 lobules.
- **Sulci:** grooves separating the lobes.
	- Faces the baby.
	- **Color:** bluish gray.
	- **Surface:** smooth and shiny.
	- Umbilical cord inserted in the center.
	- Blood vessels seen radiating from the cord.
	- Amniotic membranes covers the fetal surface.

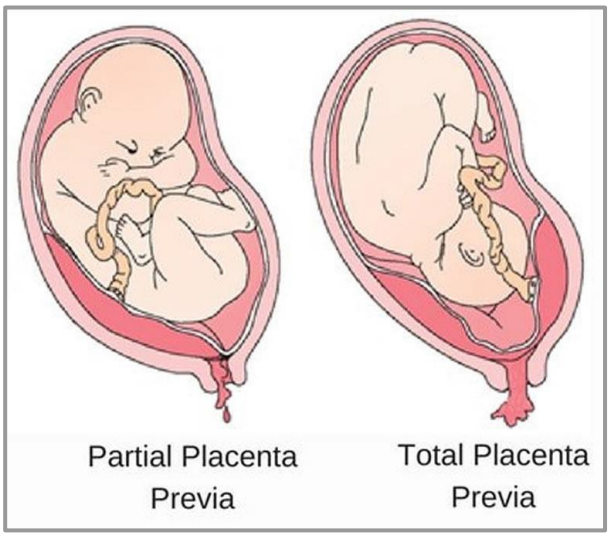
The Structure of a Mature Placenta:

→ **Placenta succenturiata:** extra lobe.
→ **Placenta bipartita:** 2 placenta with 1 cord (twins).
→ **Placenta circumvallata:** cord inserted away from vessels, if it rupture it is fetal blood.
→ **Placenta velamentosa:** most dangerous one.



→ **Placenta succenturiata / placenta velamentosa and Vasa previa:** antepartum haemorrhage.

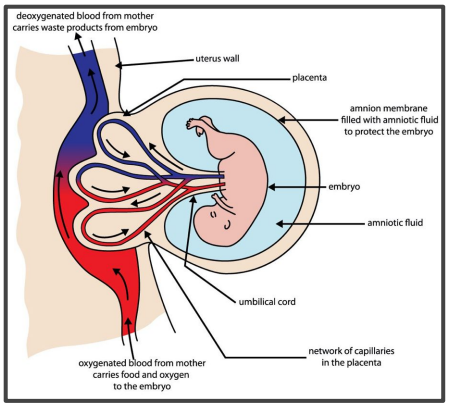




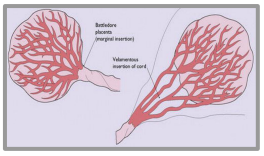
1. If missing uterus can't contract and retract efficiently and becomes soft, we call it "atony". Mother will end up having primary postpartum hemorrhage (immediate, within 24 hr), don't miss it if you miss it she will end up having secondary bleeding (after 24 hr to 10 days).

Placenta and Fetal Circulation

The Umbilical Cord:



- → **At full term:** 40 - 50 cm long, 1.5 cm in diameter
- → Twisted in appearance.
- → **Two umbilical arteries:** if only 1 artery → inform pediatrician as baby likely to have CVS and renal abnormalities.
- → **One umbilical vein**.
- → Wharton jelly.
- → Abnormal insertion of the cord:
  - → Battledore insertion
  - → Velamentous insertion



Fetal Circulation:

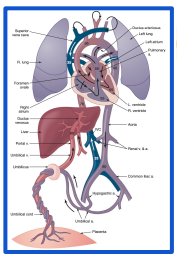
Recommended:
- → Fetal circulation right before birth
- → Baby circulation right after birth

- → **Cardiovascular system:** major variant are explained by:
  - → Presence of umbilical-placental circulation
  - → Absence of significant pulmonary circulation.
- → **Respiratory function of placenta:** oxygenated blood returned via umbilical vein into fetal circulation. through this journey:
- → Three shunts of fetal circulatory system:
  - → **Ductus venosus:** shunts highly oxygenated blood from umbilical vein to IVC → carries oxygen to fetal organs).
  - → **Foramen ovale:** shunts highly oxygenated blood from right atrium to left atrium.
  - → **Ductus arteriosus:** right-left shunt that shunts mildly oxygenated blood from pulmonary artery to descending aorta.

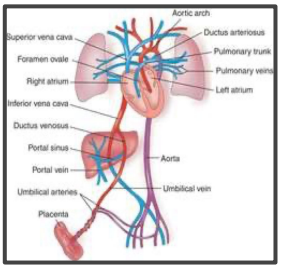
01 → High venous return from **placenta** (**oxygenated** blood, **O_2 saturation:** 70 - 80%) → the **umbilical vein** (*maintains the right-left shunt through the foramen ovale which delivers most oxygenated blood to fetal heart and brain*) → hepatic microcirculation (*portion*) + **portal** system (*majority*) through the **ductus venosus**[1] → **inferior vena cava** (mixes with returning **non oxygenated** blood from lower limbs, kidney and liver -*only **partial** mixing of the two streams*-).
- Delivers most **oxygenated** blood to fetal heart and brain.

02 → Most of **oxygenated** blood is directed to **crista dividens** at the upper end of the inferior vena cava → **right atrium** → **foramen ovale** → **left atrium** → **left ventricle** → **ascending aorta** → **brain, heart and upper extremities**/limbs.

03 → Remainder of the blood from **superior vena cava** mixes with that of **IVC** → **right ventricle** → 10% to pulmonary artery & lung + **ductus arteriosus** (majority) → **descending aorta** (beyond vessels supplying the head) → **systemic circulation** → **viscera and lower limbs** → **umbilical arteries** (*branches of left and right internal iliac arteries*).



Golden Summary:
- → Placenta → **umbilical vein** → hepatic microcirculation (*portion*) + portal system (*majority*) → **ductus venosus** → inferior vena cava.
- → **IVC** (*majority*) → crista dividens → right atrium → foramen ovale → left atrium → left ventricle → ascending aorta → **brain, heart and upper limbs**.
- → IVC (*portion*) + **SVC** → right ventricle → **pulmonary artery & lung** (*portion*) + **ductus arteriosus** (*majority*) → descending aorta → **viscera and lower limbs** → **umbilical arteries**.



1. **Ductus venosus:** a shunt that allows oxygenated blood in the umbilical vein to bypass the liver and is essential for normal fetal circulation

Placenta and Fetal Circulation At Birth

At Birth:

Blood Circulation After Birth:

- Closure of 2 shunts (**ductus arteriosus** & **foramen ovale**) completes the transition of fetal circulation to newborn circulation.

Umbilical Vessels Contract:

- **Foramen ovale:** a valvular opening, functioning from right to left.
- Cessation of umbilical blood flow → fall in pressure in right atrium → left atrial pressure rises → closure of the **foramen ovale**.

Umbilical Vessels Contract:

Lung ventilation → negative thoracic pressure → opens the pulmonary circulation → diverts blood from ductus arteriosus → gradually closes.

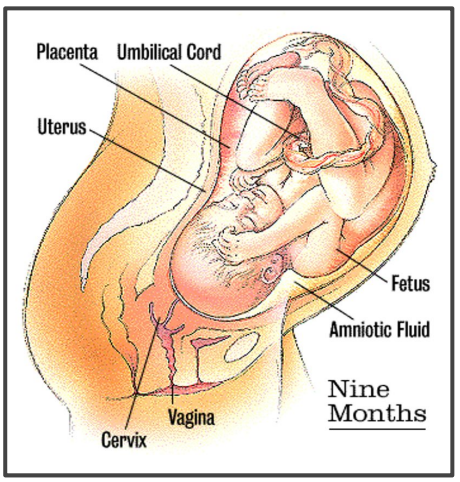
Obliteration of Ductus Arteriosus:

- Gradual constriction & eventual obliteration of the ductus arteriosus.
- **What maintains patency of ductus arteriosus in utero?** high pulmonary vascular resistance maintains the right-left shunt through the ductus arteriosus.

TABLE 6-6

COMPONENTS OF THE FETAL CIRCULATION

Fetal Structure	From/To	Adult Remnant
Umbilical vein	Umbilicus/ductus venosus	Ligamentum teres hepatis
Ductus venosus	Umbilical vein/inferior vena cava (bypasses liver)	Ligamentum venosum
Foramen ovale	Right atrium/left atrium	Closed atrial wall
Ductus arteriosus	Pulmonary artery/descending aorta	Ligamentum arteriosum
Umbilical artery	Common iliac artery/umbilicus	Superior vesical arteries; lateral vesicoumbilical ligaments



Examination:

Vulvar Examination (Inspection):

Any women comes to clinic with gynecological complaint we have to examine vulva.

- → Hair distribution
- → Normal vulva features
- → Ulceration → chancre (syphilis)
- → Chancroid
- → Herpes simplex
- → Condyloma acuminata (HBV)
- → Warts (2ry Syphilis)
- → Varicose veins
- → Sometimes female comes with vaginal bleeding don't assume it's coming from internal organ.
  - → Could be just coming from vulva (laceration, 1st time sexual intercourse, sexual inter course in menopausal women, rupture).

Vaginal Examination:

- → Either digital examination or by using speculum (preferred).
- → There's smaller version for children chaperone must be present.
- → **Cusco (bivalve):**
  - → Patient lying on back bringing foot together and knees apart.
  - → Always lubricate unless doing a pap smear insert device gently, use it to expand cervix slowly retract while inspecting the area don't rotate while inside (painful)
  - → **Done for:** urinary incontinence - inspect vaginal walls (laxity).
- → **Huffman:**
  - → Patient lying in left lateral position stretch 1 leg and fold the other.
  - → How to know if head at ischial spine level? vaginal examination.
- → **Caput:** fluid collection (mistaken for head of baby) → check level of head in lower abdomen.
- → **Gartner cyst:** remnant of caudal end of mesonephric duct(wolffian)(it's an incidental finding).

Cervix Examination:

- → Visualize cervix and external os (internal os can't be seen but only felt).
- → **Describe cervix:** healthy - polyps (necrotic, bleed with touch) - ectropion.

C- section:

- → **Upper cut:**
  - → Longitudinal cuts only, transverse cuts are very dangerous.
  - → Rarely done as they don't heal very well & likely to rupture during pregnancy.
  - → Upper segment is adherent to peritoneum and bowel → mostly cause adhesions.
  - → Women can do up to 2 cesarean upper cuts and there's still danger of rupture.
- → **Lower cut:**
  - → Transverse cuts.
  - → If it ruptures it's usually in labour.
  - → Women can do up to 8 cesarean lower cuts.

Bimanual examination:

1. Inspection of vulva.
2. Inspection of vagina (*cusco speculum*).
3. Pap smear (*if needed*).
4. Observe abnormal vaginal discharge (*do swab if needed*).
5. Observe bleeding (*inspect amount*).
6. Observe water leakage (*if pregnant*).
7. Start bimanual examination:

Examination:

Bimanual examination:

7. Start bimanual examination:
   - → **Explain** the procedure to the patient.
   - → Insert finger (*nulliparous → insert one finger then the other*) + other hand abdominally (*suprapubic*).
   - → **Feel vagina:**
     - → Postmenopausal → relaxed vaginal wall.
     - → Postmenopausal woman presents with bleeding → she might have forgotten pessary (a loop to treat uterine prolapse).
   - → **Feel uterus:**
     - → **Size:** relate to number of weeks.
     - → **Consistency:**
       - → **Normally:** firm.
       - → **Adenomiosis:** soft.
     - → Tenderness
     - → **Mobility:**
       - → **Adhesions:** fixed to one place
         - → **Causes:** previous c-section - previous laparoscopy - previous pelvic surgery - previous PID - cancer).
     - → **Position:**
       - → Important before procedures (inserting IUD - evacuation - curate) to prevent perforation.
   - → **Feel fornix:**
     - → **Normally:** not felt.
     - → **Cyst:** felt → be careful not to rupture it during examination.
   - → **Examine adnexa:** the space containing fallopian and ovaries and broad ligament.

Pelvimetry:

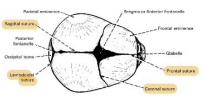
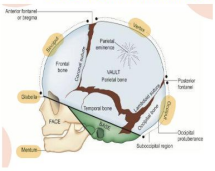
- → How to know if pelvis is adequate for vaginal delivery?
  - → **Currently:** by doing pelvimetry.
  - → **Before:** take X-ray for patient in erect lateral position (cumulative dangerous effect).
- → **Last 2 weeks of pregnancy (preferably) or during labour:**
  1. Insert finger in vagina and aim to reach sacral promontory.
     - → **Normally:** can't reach it
  2. Run fingers along sacrum.
     - → Should be curved, flat is abnormal
  3. Reach the side bones and try to feel ischial spine.
     - → **Normally:** can't feel it.
     - → **Android pelvis:** felt.
  4. Feel sacrospinous ligament.
     - → **Normally:** relaxed not tight.
  5. Feel subpubic arch.
     - → **Normally:** accommodate 2 fingers.
     - → **Abnormal pelvis:** narrow.

Molding:

- → Overlapping of infant skull bones.
- → **Grading:**
  - → **Grade 1:** just touching.
  - → **Grade 2:** over each other but can separate them.
  - → **Grade 3:** over each other but can't separate them (*increase intracranial pressure*).

439 Summary

Anatomy of fetal skull

Bones	• 2 frontal bones • 2 parietal bones • One occipital bone
Sutures	• Frontal suture: between two frontals • Sagittal suture: between two parietals • Coronal suture: between frontals and parietals • Lambdoidal suture: between occipital and parietals • **Fontanelle** is where two or more sutures meet ○ Anterior Fontanelle/**bregma** 
Skull areas	• Mentum: chin • Glabella: bridge of the nose • Sinciput: forehead • **Vertex:** between anterior & posterior fontanelles & the two parietal eminences 

Circumferences	• Sub-mento-bregmatic (9.5 cm) → face presentation → landmark: mentum
	  ○ Presents as hyperextended fetal neck
	  ○ Mentoanterior? Can be delivered by flexion and forceps
	  ○ Mentoposterior? CS
	• Sub-occipito-bregmatic (9.5 cm) → well flexed head → vertex presentation → landmark: occipital bone
	• Mento-vertical/mento-vertex (13 cm) → brow presentation → landmark: frontal bone
	  ○ Delivered by CS
	• Occipito-frontal: 11.5 cm

Anatomy of placenta and fetal circulation

Placenta:

- Structure of a mature placenta: flat, roughly circular, thick in the center
- Maternal surface:
  - Dark red color, rough surface
  - Chorionic villi are arranged in lobes/cotyledons, groove separating the lobes are sulci
- Fetal surface:
  - Bluish gray color, smooth, shiny surface
  - Umbilical cord is inserted in the the center
  - Covered by the amniotic membranes

Umbilical cord:

- Twisted in appearance
- Covered by wharton jelly
- Carries two umbilical arteries and one umbilical vein

- Abnormalities in cord insertion:
  - Battledore insertion
  - Velamentous insertion

Fetal circulation

Umbilical arteries (2 arteries): carries deoxygenated blood
Umbilical vein (1 vein): carries oxygenated blood

Oxygenated blood - Flow of blood direction:

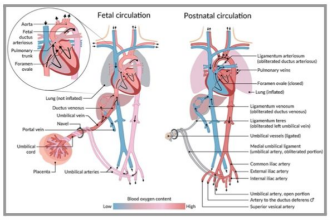
- Placenta (highest O2 saturation) → umbilical vein → liver → inferior vena cava → right atrium → foramen ovale → left atrium → left ventricle → ascending aorta → vessels of the head, neck, and arm

Deoxygenated blood - Flow of blood direction:

- Vessels of the head, neck, and arm → superior vena cava → right atrium→ right ventricle → pulmonary trunk → ductus arteriosus → aortic arch and descending aorta → common iliac artery → internal iliac artery
- Return of deoxygenated blood to the placenta: internal iliac artery → umbilical artery (lowest O2 saturation) → placenta

Shunts of the fetal circulatory system:

1. 1st bypass: **ductus venosus**
   a. **50%** of the highly **oxygenated blood** bypasses the liver via ductus venosus.
   b. **Umbilical vein → ductus venosus → inferior vena cava**
2. 2nd bypass: **foramen ovale**
   a. Oxygenated blood bypasses the non ventilated lungs and enters the systemic circulation directly
   b. **Right atrium → foramen ovale → left atrium**
3. 3rd bypass: **ductus arteriosus**
   a. Ductus arteriosus connects the pulmonary trunk with the aorta and conducts most of the mildly oxygenated blood directly **from the right ventricle to the aorta, bypassing the lungs** because of the increased pulmonary artery resistance.
   b. **Right ventricle** → pulmonary trunk → **ductus arteriosus → descending aorta**



Postnatal circulation

- Formed under the influence of postnatal pulmonary ventilation and the disconnection of umbilical vessels.
- These alterations cause a change in pressure within the circulatory system, leading to the opening of the pulmonary circulation and obliteration of the umbilical vessels and bypass structures (ductus venosus, foramen ovale, and ductus arteriosus).

EXTRA:

	Functional Closure	Anatomical Closure	Remnant / adult derivatives of fetal vascular structures
Umbilical Arteries	Few minutes after birth	2-3 months	- Medial Umbilical Ligament(distal part). - Superior Vesical Arteries (proximal part).
Umbilical Veins	Shortly after umbilical arteries	-	Ligamentum Teres Hepatis
Ductus Venosus	Shortly after umbilical arteries	-	Ligamentum Venosum
Foramen Ovale	First few breaths/few days	3rd month(ELM), 1 Year (Sangaon)	Fossa Ovalis (in 20% probe patent foramen ovale)
Ductus Arteriosus	Almost immediately after birth	1-3 months	Ligamentum Arteriosus

Quiz

Question 1:

→ **Thirty minutes after normal vaginal delivery of twins, a 35-year-old woman, gravida 5, para 4, has heavy vaginal bleeding with clots. Physical examination shows a soft, enlarged, and boggy uterus. Despite bimanual uterine massage, administration of uterotonic drugs, and placement of an intrauterine balloon for tamponade, the bleeding continues. A hysterectomy is performed. Vessels running through which of the following structures must be ligated during the surgery to achieve hemostasis?**

A. Suspensory ligament
B. Uterosacral ligament
C. Cardinal ligament
D. Round ligament

Question 2:

→ **A 42-year-old woman comes to the physician because of right flank pain that started 3 days following a procedure. Her vital signs are within normal limits. Physical examination shows right costovertebral angle tenderness. An intravenous pyelogram shows a dilated renal pelvis and ureter on the right with a lack of contrast in the lower third of the ureter. This patient most likely recently underwent which of the following procedures?**

A. Cesarean delivery
B. Hysterectomy
C. Foley catheter insertion
D. Inguinal hernia repair

Question 3:

→ **A 36-year-old woman, gravida 2, para 2, comes to the emergency department because of sudden-onset, severe right flank pain. She was in her aerobics class when the pain started but denies any trauma to the region. She has a history of recurrent ovarian cysts. Menses occur regularly at 28-day intervals. Her temperature is 37.1°C (99.3°F). Abdominal examination shows tenderness in the right lower quadrant with guarding. Pelvic ultrasound shows a large simple cyst on the right ovary. Right ovarian artery flow is detectable on Doppler, but there is no flow detected in the right ovarian vein. Which of the following ligaments is most likely to have been involved?**

A. Broad ligament
B. Round ligament of the uterus
C. Ovarian ligament
D. Infundibulopelvic ligament

Question 4:

→ **A 33-year-old woman comes to the emergency department because of a 1-hour history of severe pelvic pain and nausea. She was diagnosed with a follicular cyst in the left ovary 3 months ago. The cyst was found incidentally during a fertility evaluation. A pelvic ultrasound with Doppler flow shows an enlarged, edematous left ovary with no blood flow. Laparoscopic evaluation shows necrosis of the left ovary, and a left oophorectomy is performed. During the procedure, blunt dissection of the left infundibulopelvic ligament is performed. Which of the following structures is most at risk of injury during this step of the surgery?**

A. Ureter
B. Bladder trigone
C. Uterosacral ligament
D. Uterine artery

A	D	B	C
4	3	2	1

Reference

Female Reproductive Anatomy and Embryology

JOSEPH C. GAMBONE

CLINICAL KEYS FOR THIS CHAPTER

- The upper vagina, cervix, uterus, and fallopian tubes are formed from the paramesonephric (müllerian) ducts. The absence of the Y chromosome leads to the development of the müllerian (female) system with virtual total regression of the mesonephric (wolffian) or male system. With the Y chromosome present, a testis is formed and müllerian-inhibiting substance is produced, creating the reverse situation.
- The vagina is a flattened tube extending from the hymenal ring at the vaginal introitus up to the fornices that surround the uterine cervix. The vaginal epithelium, which is stratified squamous in type, and not mucosal, is nonkeratinized and devoid of mucous glands and hair follicles.
- The blood supply to the ovaries is provided by the ovarian arteries, which arise from the abdominal aorta immediately below the renal arteries. The venous drainage of each ovary differs in that the right ovary drains directly into the inferior vena cava whereas the left ovary drains into the left renal vein.
- At the time of pelvic examination when a woman is in the dorsal-lithotomy position, the uterus may be palpated to be tilted forward in an anterior or anteverted position, in a midline position, or tilted backward in a posterior or retroverted position. The top or corpus of the uterus may also be folded forward (anteflexed) or backward (retroflexed). Most of the time this represents normal anatomic variation.
- Gynecologic surgeons use several types of skin incisions for the performance of "open" surgical procedures. The most common is the low transverse or Pfannenstiel incision. When more exposure is needed than anticipated, the skin incision can be extended and the rectus abdominis muscles divided with diathermy. This is called a Maylard incision. For most open operations for cancer, vertical incisions are desirable, because they can be readily extended to allow access to the upper abdomen.

Other chapters in this book deal with the disruptive deviations from normal female anatomy and physiology, whether they be congenital, functional, traumatic, inflammatory, neoplastic, or even iatrogenic. As the etiology and pathogenesis of clinical problems are considered in these other chapters, each should be studied in the context of normal anatomy, development, and physiology. A physician cannot practice obstetrics and gynecology effectively without understanding the physiologic processes that transpire in a woman's life as she passes through infancy, adolescence, reproductive maturity, and the climacteric. As the various clinical problems are addressed, it is important to consider those anatomic, developmental, and physiologic changes that normally take place at key points in a woman's life cycle.

This chapter presents the normal anatomy of the female reproductive tract along with its embryologic development and the anatomy of some important surrounding structures. Applied anatomic issues, such as the normal variation in uterine position and the types of surgical incisions used by gynecologic surgeons, are also covered.

Anatomy of the External Genitalia

The perineum represents the inferior boundary of the pelvis. It is bounded superiorly by the levator ani muscles and inferiorly by the skin between the thighs (Figure 3-2). Anteriorly, the perineum extends to the symphysis pubis and the inferior borders of the pubic bones. Posteriorly, it is limited by the ischial tuberosities, the sacrotuberous ligaments, and the coccyx. **The superficial and deep transverse perineal muscles cross the pelvic outlet between the two ischial tuberosities and come together at the perineal body. They divide the space into the urogenital triangle anteriorly and the anal triangle posteriorly.**

The urogenital diaphragm is a fibromuscular sheet that stretches across the pubic arch. It is pierced by the vagina, the urethra, the artery of the bulb, the internal pudendal vessels, and the dorsal nerve of the clitoris. Its inferior surface is covered by the crura of the clitoris, the vestibular bulbs, the greater vestibular (Bartholin) glands, and the superficial perineal muscles. The Bartholin glands are situated just posterior to the vestibular bulbs, and their ducts empty into the introitus just below the labia minora. They are often the site of gonococcal infections and painful abscesses.

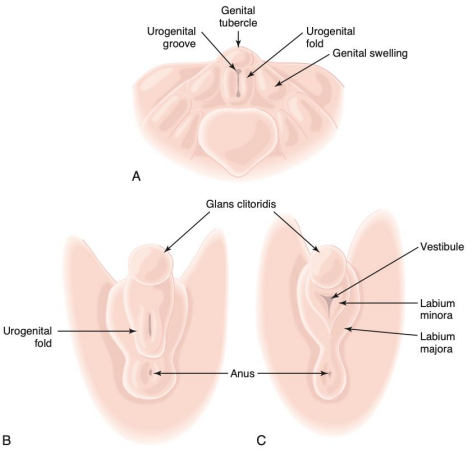


FIGURE 3-1 Development of the external female genitalia. **A,** Indifferent stage (approximately 7 weeks). **B,** Approximately 10 weeks. **C,** Approximately 12 weeks.

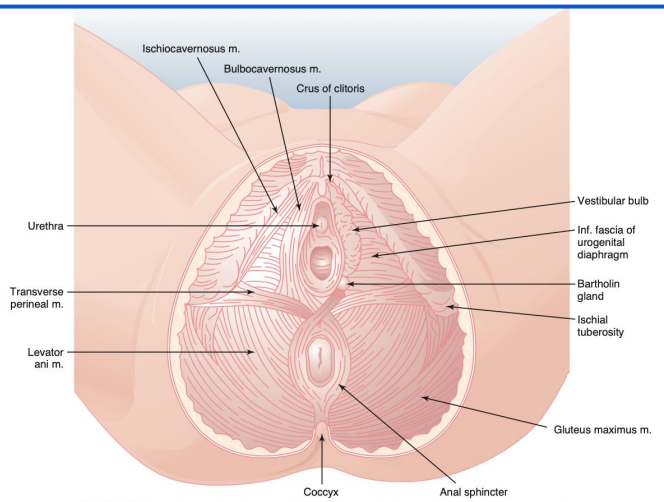


FIGURE 3-2 The perineum, showing superficial structures on the left and deeper structures on the right.

VULVA

The external genitalia are referred to collectively as the vulva. As shown in Figure 3-3, **the vulva includes the mons veneris, labia majora, labia minora, clitoris, vulvovaginal (Bartholin) glands, fourchette, and perineum.** The most prominent features of the vulva, the labia majora, are large, hair-covered folds of skin that contain sebaceous glands and subcutaneous fat and lie on either side of the introitus. The labia minora lie medially and contain no hair but have a rich supply of venous sinuses, sebaceous glands, and nerves. The labia minora may vary from scarcely noticeable structures to leaf-like flaps measuring up to 3 cm in length. Anteriorly, each splits into two folds. The posterior pair of folds attach to the inferior surface of the clitoris, at which point they unite to form the frenulum of the clitoris. The anterior pair are united in a hoodlike configuration over the clitoris, forming the prepuce. Posteriorly, the labia minora may extend almost to the fourchette.

The clitoris lies just in front of the urethra and consists of the glans, the body, and the crura. Only the glans clitoris is visible externally. The body, composed of a pair of corpora cavernosa, extends superiorly for a distance of several centimeters and divides into two crura, which are attached to the undersurface of either pubic ramus. Each crus is covered by the corresponding ischiocavernosus muscle. Each vestibular bulb (equivalent to the corpus spongiosum of the penis) extends posteriorly from the glans on either side of the lower vagina. Each bulb is attached to the inferior surface of the perineal membrane and covered by the bulbocavernosus muscle. These muscles aid in constricting the venous supply to the erectile vestibular bulbs and also act as the sphincter vaginae.

As the labia minora are spread, the vaginal introitus, guarded by the hymenal ring, is seen. Usually, the hymen is represented only by a circle of carunculae myrtiformes around the vaginal introitus. The hymen

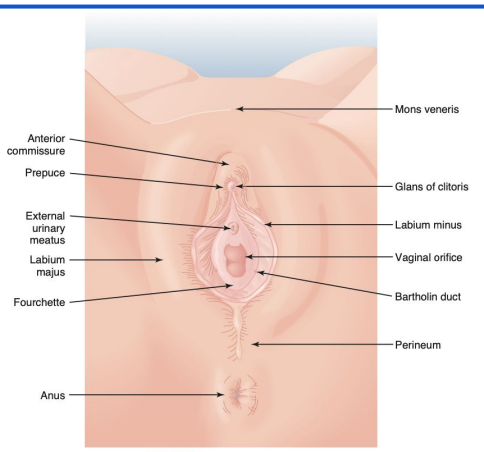


FIGURE 3-3 Female external genitalia.

may take many forms, however, such as a cribriform plate with many small openings or a completely imperforate diaphragm.

The vestibule of the vagina is that portion of the introitus extending inferiorly from the hymenal ring between the labia minora. The fourchette represents the posterior portion of the vestibule just above the perineal body. **Most of the vulva is innervated by the branches of the pudendal nerve. Anterior to the urethra, the vulva is innervated by the ilioinguinal and genitofemoral nerves.** This area is not anesthetized adequately by a pudendal block, and repair of paraurethral tears should be supplemented by additional subcutaneous anesthesia.

Internal Genital Development

The upper vagina, cervix, uterus, and fallopian tubes are formed from the paramesonephric (müllerian) ducts. Although human embryos, whether male or female, possess both paired paramesonephric and mesonephric (wolffian) ducts, **the absence of Y chromosomal influence leads to the development of the paramesonephric system** with virtual total regression of the mesonephric system. With a Y chromosome present, a testis is formed and müllerian-inhibiting substance is produced, creating the reverse situation.

Mesonephric duct development occurs in each urogenital ridge between weeks 2 and 4 and is thought to influence the growth and development of the paramesonephric ducts. **The mesonephric ducts terminate caudally by opening into the urogenital sinus.** First evidence of each paramesonephric duct is seen at 6 weeks' gestation as a groove in the coelomic epithelium of the paired urogenital ridges, lateral to the cranial pole of the mesonephric duct. **Each paramesonephric duct opens into the coelomic cavity cranially** at a point destined to become a tubal ostium. Coursing caudally at first, parallel to the developing mesonephric duct, the blind distal end of each paramesonephric duct eventually crosses dorsal to the mesonephric duct, and the two ducts approximate in the midline. **The two paramesonephric ducts fuse terminally at the urogenital septum, forming the uterovaginal primordium.** The distal point of fusion is known as the **müllerian tubercle (Müller tubercle)** and can be seen protruding into the urogenital sinus dorsally in embryos at 9 to 10 weeks' gestation (Figure 3-4). **Later**

Reference

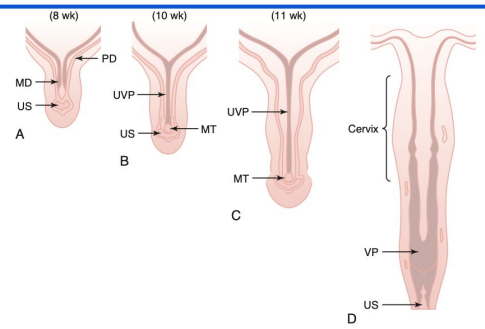


FIGURE 3-4 Early embryologic development of the genital tract **(A-C)** and vaginal plate **(D).** *MD,* Mesonephric duct; *MT,* müllerian tubercle; *PD,* paramesonephric duct; *US,* urogenital sinus; *UVP,* uterovaginal primordium; *VP,* vaginal plate. (Redrawn from Didusch JF, Koff AK: Development of the vagina in the human fetus. *Contrib Embryol Carnegie Inst* 24:61, 1933.)

dissolution of the septum between the fused paramesonephric ducts leads to the development of a single uterine fundus, cervix, and, according to some investigators, the upper vagina.

Degeneration of the mesonephric ducts is progressive from 10 to 16 weeks in the female fetus, although vestigial remnants of the latter may be noted in the adult (Gartner duct cyst, paroöphoron, epoöphoron) (Figure 3-5). The myometrium and endometrial stroma are derived from adjacent mesenchyme; the glandular epithelium of the fallopian tubes, uterus, and cervix is derived from the paramesonephric duct.

Solid vaginal plate formation and lengthening occur from the 12th through the 20th weeks, followed by caudad to cephalad canalization, which is usually completed in utero. Controversy surrounds the relative contribution of the urogenital sinus and paramesonephric ducts to the development of the vagina, and it is uncertain whether the whole of the vaginal plate is formed secondary to growth of the endoderm of the urogenital sinus or whether the upper vagina is formed from the paramesonephric ducts.

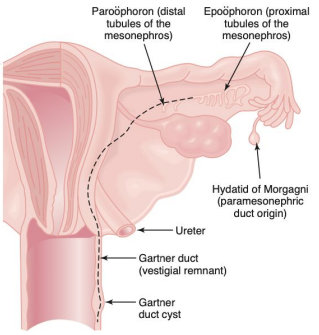


FIGURE 3-5 Remnants of the mesonephric (wolffian) ducts that may persist in the anterolateral vagina or adjacent to the uterus within the broad ligament or mesosalpinx.

VAGINA

The vagina is a flattened tube extending posterosuperiorly from the hymenal ring at the introitus up to the fornices that surround the cervix (Figure 3-6). **Its epithelium, which is stratified squamous in type, is normally devoid of mucous glands and hair follicles and is nonkeratinized.** Gestational exposure to diethylstilbestrol (taken by the mother) may result in columnar glands interspersed with the squamous epithelium of the upper two-thirds of the vagina (vaginal adenosis). Deep to the vaginal epithelium are the muscular coats of the vagina, which consist of an inner circular and an outer longitudinal smooth muscle layer. Remnants of the mesonephric ducts may sometimes be demonstrated along the vaginal wall in the subepithelial layers and may give rise to **Gartner duct cysts.** The adult vagina averages about 8 cm in length, although its size varies considerably with age, parity, and the status of ovarian function. An important anatomic feature is the immediate proximity of the posterior fornix of the vagina to the pouch of Douglas, which allows easy access to the peritoneal cavity from the vagina, by either culdocentesis or colpotomy.

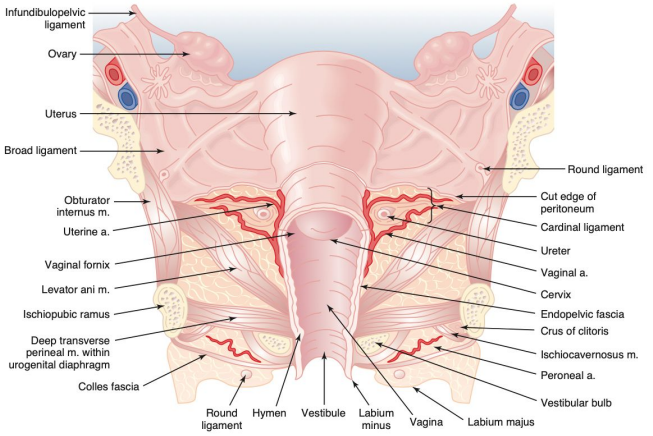


FIGURE 3-6 Coronal section of the pelvis at the level of the uterine isthmus and ischial spines, showing the ligaments supporting the uterus.

UTERUS

The uterus consists of the cervix and the uterine corpus, which are joined by the isthmus. The uterine isthmus represents a transitional area wherein the endocervical epithelium gradually changes into the endometrial lining. In late pregnancy, this area elongates and is referred to as the lower uterine segment.

The cervix is generally 2 to 3 cm in length. In infants and children, the cervix is proportionately longer than the uterine corpus (Figure 3-7). The portion that protrudes into the vagina and is surrounded by the fornices is covered with a nonkeratinizing squamous epithelium. **At about the external cervical os, the squamous epithelium covering the exocervix (or ectocervix) changes to simple columnar epithelium, the site of transition being referred to as the squamocolumnar junction.** The cervical canal is lined by irregular, arborized, simple columnar epithelium, which extends into the stroma as cervical "glands" or crypts.

The uterine corpus is a thick, pear-shaped organ, somewhat flattened anteroposteriorly, that consists of largely interlacing smooth muscle fibers. The endometrial lining of the uterine corpus may vary from 2 to 10 mm in thickness (which may be measured by ultrasonic imaging), depending on the stage of the menstrual cycle. Most of the surface of the uterus is covered by the peritoneal mesothelium.

Four paired sets of ligaments are attached to the uterus (Figure 3-8). Each round ligament inserts on the anterior surface of the uterus just in front of the

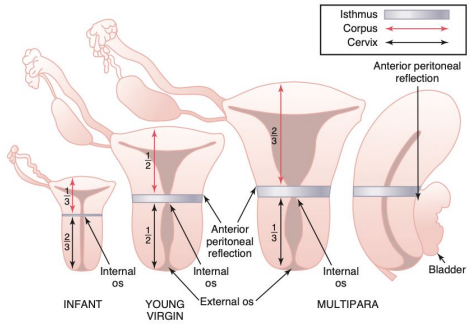


FIGURE 3-7 Changing proportion of the uterine cervix and corpus from infancy to adulthood. (Modified from Cunningham FG, MacDonald PC, Gant NF, et al, editors: *Williams obstetrics,* ed 20, East Norwalk, Conn, 1997, Appleton & Lange.)

fallopian tube, passes to the pelvic side wall in a fold of the broad ligament, traverses the inguinal canal, and ends in the labium majus. **The round ligaments are of little supportive value in preventing uterine prolapse** but help to keep the uterus anteverted. **The uterosacral ligaments** are condensations of the endopelvic fascia that arise from the sacral fascia and insert into the posteroinferior portion of the uterus at about the level of the isthmus. These ligaments contain sympathetic and parasympathetic nerve fibers that supply the uterus. They provide important support for the uterus and are also significant in precluding the development of an enterocele. **The cardinal ligaments (Mackenrodt)** are the other important supporting structures of the uterus that prevent prolapse. They extend from the pelvic fascia on the lateral pelvic walls and insert into the lateral portion of the cervix and vagina, reaching superiorly to the level of the isthmus. **The pubocervical ligaments** pass anteriorly around the bladder to the posterior surface of the pubic symphysis.

In addition, there are four peritoneal folds. Anteriorly, **the vesicouterine fold** is reflected from the level of the uterine isthmus onto the bladder. Posteriorly, **the rectouterine fold** passes from the posterior wall of the uterus, to the upper fourth of the vagina, and thence onto the rectum. The pouch between the cervix and vagina anteriorly and rectum posteriorly forms a cul-de-sac, called the pouch of Douglas. Laterally, the **two broad ligaments** each pass from the side of the uterus to the lateral wall of the pelvis. Between the two leaves of each broad ligament are contained the fallopian tube, the round ligament, and the ovarian ligament, in addition to nerves, blood vessels, and lymphatics. **The fold of broad ligament containing the fallopian tube is called the mesosalpinx.** Between the end of the tube and ovary and the pelvic side wall, where the ureter passes over the common iliac vessels, is the infundibulopelvic ligament, which contains the vessels and nerves for the ovary. The ureter may be injured when this ligament is ligated during a salpingo-oophorectomy procedure if it is not clearly identified first.

The anatomic position of the uterus may vary within the pelvic cavity as palpated during a pelvic examination. With respect to the horizontal plane on the surface of the examination table, the straight line axis extending from the cervix to the fundal end of the uterine corpus may be in one of three positions. The uterus may tilt in a forward position (anteverted), it may be only slightly forward and in mid-position, or it may tilt in a backward direction (retroverted). Additionally, the fundal portion of the uterus may fold forward (anteflexed) or backward (retroflexed). Most of the time this variation in position is normal and without clinical significance. On occasion the identification of this anatomic variation is important. For example, extreme flexion (ante or retro) may make insertion of an instrument or of an intrauterine device (IUD) higher risk. A retroverted and retroflexed uterus may also be a finding in a woman with pelvic adhesions due to endometriosis or pelvic inflammation due to infection. Figure 3-9 illustrates the potential positions of the uterus within the pelvis.

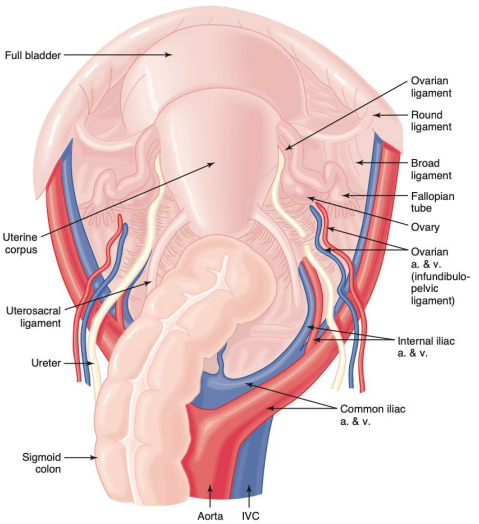


FIGURE 3-8 View of the internal genital organs in the female pelvis. *IVC,* Inferior vena cava.

FALLOPIAN TUBES

The oviducts are bilateral muscular tubes (about 10 cm in length) with lumina that connect the uterine cavity with the peritoneal cavity. They are enclosed in the medial four-fifths of the superior aspect of the broad ligament. The tubes are lined by a ciliated, columnar epithelium that is thrown into branching folds. That segment of the tube within the wall of the uterus is referred to as the **interstitial portion.** The medial portion of each tube is superior to the round ligament, anterior to the ovarian ligament, and relatively fixed in position. This nonmobile portion of the tube has a fairly narrow lumen and is referred to as the **isthmus.** As the tube proceeds laterally, it is located anterior to the ovary; it then passes around the lateral portion of the ovary and down toward the cul-de-sac. The **ampullary and fimbriated portions** of the tube are suspended from the broad ligament by the mesosalpinx and are quite mobile. The mobility of the fimbriated end of the tube plays an important role in fertility. The ampullary portion of the tube is the most common site of ectopic pregnancies.

Reference

Anatomy of the Ovaries

The ovaries are oval, flattened, compressible organs, approximately 3 × 2 × 2 cm in size. They are situated on the superior surface of the broad ligament and are suspended between the ovarian ligament medially and the suspensory ligament of the ovary or infundibulopelvic ligament laterally and superiorly. Each occupies a position in the ovarian fossa (of Waldeyer), which is a shallow depression on the lateral pelvic wall just posterior to the external iliac vessels and anterior to the ureter and hypogastric vessels. In endometriosis and salpingo-oophoritis, the ovaries may be densely adherent to the ureter. Generally, the serosal covering and the tunica albuginea of the ovary are quite thin, and developing follicles and corpora lutea are readily visible.

The blood supply to the ovaries is provided by the long ovarian arteries, which arise from the abdominal aorta immediately below the renal arteries. These vessels course downward and cross laterally over the ureter at the level of the pelvic brim, passing branches to the ureter and the fallopian tube. The ovary also receives substantial blood supply from the uterine artery through the uterine-ovarian arterial anastomosis. **The venous drainage from the right ovary is directly into the inferior vena cava, whereas that from the left ovary is into the left renal vein** (Figure 3-11).

TABLE 3-1

STRUCTURAL HOMOLOGUES IN MALES AND FEMALES

Primordia	Female	Male	Major Determining Factors
Gonadal			
Germ cells	Oogonia	Spermatogonia	Sex chromosomes
Coelomic epithelium	Granulosa cells	Sertoli cells	
Mesenchyme	Theca cells	Leydig cells	
Mesonephros	Rete ovarii	Rete testis	
Ductal			
Paramesonephric (müllerian) duct	Fallopian tubes Uterus Superior ⅔ of vagina Gartner duct	Hydatid testis	Absence of Y chromosome
Mesonephric (wolffian) duct Mesonephric tubules	Epoöphoron Paroöphoron	Vas deferens Seminal vesicles Epididymis Efferent ducts	Testosterone Müllerian inhibiting factor
External Genitalia			
Urogenital sinus	Vaginal contribution Skene glands Bartholin glands	Prostate Prostatic utricle Cowper glands Penis Corpora spongiosa Scrotum	Presence or absence of testosterone, dihydrotestosterone, and 5α-reductase enzyme
Genital tubercle Urogenital folds Genital folds	Clitoris Labia minora Labia majora		

Anatomy of the Ureters

The ureters extend 25 to 30 cm from the renal pelves to their insertion into the bladder at the trigone. Each descends immediately under the peritoneum, crossing the pelvic brim beneath the ovarian vessels just anterior to the bifurcation of the common iliac artery. In the true pelvis, the ureter initially courses inferiorly, just anterior to the hypogastric vessels, and stays closely attached to the peritoneum. It then passes forward along the side of the cervix and beneath the uterine artery toward the trigone of the bladder.

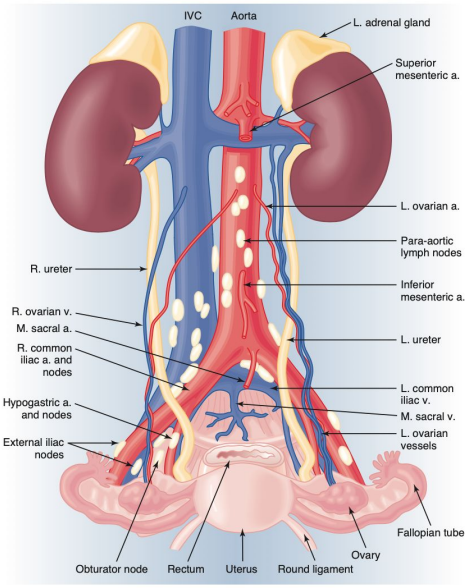


FIGURE 3-11 Lymphatic drainage of the internal genital organs. *IVC,* Inferior vena cava.

Lymphatic Drainage

The lymphatic drainage of the vulva and lower vagina is principally to the inguinofemoral lymph nodes and then to the external iliac chains (see Figure 3-11). The lymphatic drainage of the cervix takes place through the parametria (cardinal ligaments) to the pelvic nodes (the hypogastric, obturator, and external iliac groups) and then to the common iliac and para-aortic chains. The lymphatic drainage from the endometrium is through the broad ligament and infundibulopelvic ligament to the pelvic and para-aortic chains. The lymphatics of the ovaries pass via the infundibulopelvic ligaments to the pelvic and para-aortic nodes (see Figure 3-11).

Anatomy of the Bony Pelvis

The bony pelvis (Figure 3-12) is made up of the **two paired innominate bones and the sacrum.** The symphysis pubis is formed anteriorly at the attachment of both innominate bones. The sacrum has five to six vertebrae that are fused in the adult. **The sacrum articulates posteriorly with each innominate bone at the sacroiliac joints. The sacrum also articulates inferiorly with the coccyx and superiorly with the fifth lumbar vertebra.** The true (lesser) pelvis is formed by the sacrum and coccyx posteriorly and by the pubis anteriorly and ischium laterally. The true pelvis contains the pelvic organs; the uterus, vagina, bladder, fallopian tubes, ovaries, and part of the rectum and anus. The false (greater) pelvis is bounded by the lumbar vertebrae posteriorly, iliac fossae bilaterally, and the abdominal wall anteriorly.

The bony pelvis is particularly important during pregnancy and labor. It is clinically important to determine the adequacy of the pelvis for vaginal birth by performing pelvimetry. This may be done during a pelvic examination or using computed tomography, which is more accurate (see Chapter 8).

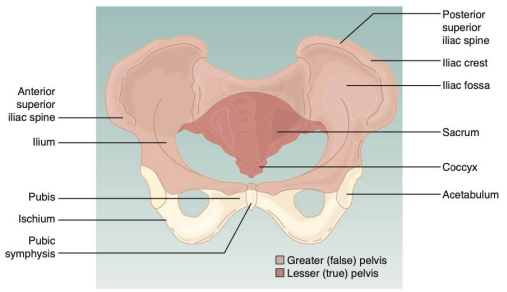


FIGURE 3-12 The bony pelvis.

Anatomy of the Lower Abdominal Wall

Because most intraabdominal gynecologic operations are performed through lower abdominal incisions, it is important to review the anatomy of the lower abdominal wall with special reference to the muscles and fasciae. After transecting the skin, subcutaneous fat, superficial fascia (Camper), and deep fascia (Scarpa) the anterior rectus sheath is encountered (Figure 3-13). **The rectus sheath is a strong fibrous compartment formed by the aponeuroses of the three lateral abdominal wall muscles.** The aponeuroses meet in the midline to form the linea alba and partially encase the two rectus abdominis muscles. The composition of the rectus sheath differs in its upper and lower portions. Above the midpoint between the umbilicus and the symphysis pubis, the rectus muscle is encased anteriorly by the aponeurosis of the external oblique and the anterior lamina of the internal oblique aponeurosis and posteriorly by the aponeurosis of the transversus abdominis and the posterior lamina of the internal oblique aponeurosis. **In the lower fourth of the abdomen, the posterior aponeurotic layer of the sheath terminates in a free crescentic margin, the semilunar fold of Douglas.**

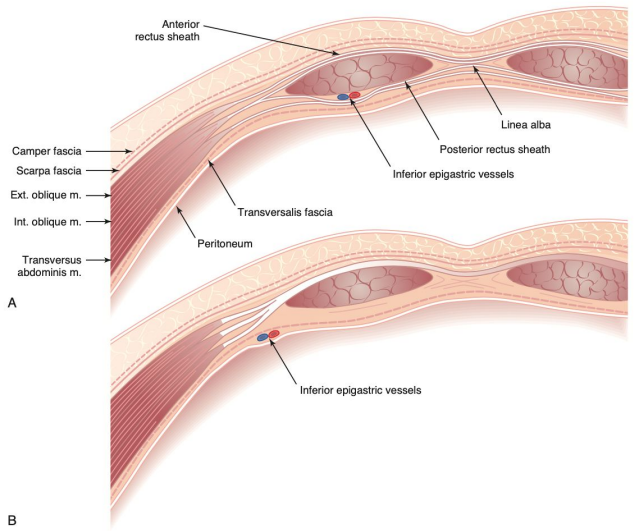


FIGURE 3-13 Transverse section through the anterior abdominal wall just below the umbilicus **(A)** and just above the pubic symphysis **(B).** Note the absence of the posterior rectus sheath in **B.**

Each rectus abdominis muscle, encased in the rectus sheath on either side of the midline, extends from the superior aspect of the symphysis pubis to the anterior surface of the fifth, sixth, and seventh costal cartilages. A variable number of tendinous intersections (three to five) crosses each muscle at irregular intervals, and any transverse rectus surgical incision forms a new fibrous intersection during healing. The muscle is not attached to the posterior sheath and, following separation from the anterior sheath, can be retracted laterally, as in the Pfannenstiel incision. **Each rectus muscle has a firm aponeurosis at its attachment to the symphysis pubis, and this tendinous aponeurosis can be transected if necessary to improve exposure, as in the Cherney incision,** and resutured securely during closure of the abdominal wall.

The **inferior epigastric arteries** arise from the external iliac arteries and proceed superiorly just lateral to the rectus muscles between the transversalis fascia and the peritoneum. They enter the rectus sheaths at the level of the semilunar line and continue their course superiorly just posterior to the rectus muscles. In a transverse rectus muscle–cutting (Maylard) incision, the epigastric arteries can be retracted laterally or ligated to allow a wide peritoneal incision.

Reference

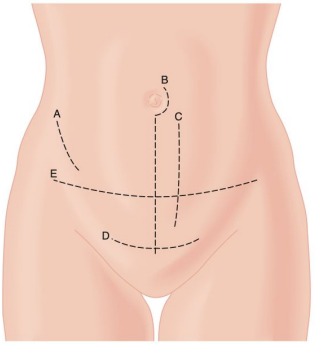


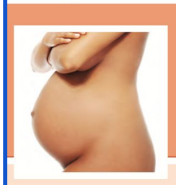
FIGURE 3-14 Abdominal wall incisions: McBurney **(A)**, lower midline **(B)**, left lower paramedian **(C)**, Pfannenstiel or Cherney **(D)**, and transverse, Maylard or Bardenheuer **(E)**.

Abdominal Wall Incisions

The most commonly used lower abdominal incision in gynecologic surgery is the Pfannenstiel incision (Figure 3-14). Although it does not always give sufficient exposure for extensive operations, it has cosmetic advantages in that it is generally only 2 cm above the symphysis pubis, and the scar is later covered by the pubic hair. Because the rectus abdominis muscles are not cut, eviscerations and wound hernias are extremely uncommon. **For extensive pelvic procedures (e.g., radical hysterectomy and pelvic lymphadenectomy), a transverse muscle–cutting incision (Bardenheuer or Maylard) at a slightly higher level in the lower abdomen gives sufficient exposure.** In addition, the skin incision falls within the lines of Langer, so a good cosmetic result can be expected.

When it is anticipated that upper abdominal exploration will be necessary, such as in a patient with suspected ovarian cancer, a midline incision through the linea alba or a paramedian vertical incision is indicated.

CHAPTER 8



Normal Labor, Delivery, and Postpartum Care

Anatomic Considerations, Obstetric Analgesia and Anesthesia, and Resuscitation of the Newborn

CALVIN J. HOBEL • MARK ZAKOWSKI

CLINICAL KEYS FOR THIS CHAPTER

- Knowledge of the characteristics of the fetal head and maternal pelvis is necessary to understand the dynamic relationship between these two anatomic structures during labor. The fetal head, through a process of molding and flexion followed by internal rotation, passes through the maternal pelvis during the first and second stages of labor. At delivery (expulsion), there is external rotation of the fetal head.
- After the delivery of the fetal head at the end of the second stage of labor, attention must be directed to the management of the third and fourth stages of labor. The third stage of labor is a period when women are at risk for postpartum hemorrhage. Hemorrhage is the leading cause of maternal death worldwide and is among the top three causes of maternal death in the United States. Uterine atony is the leading cause of postpartum hemorrhage, and its prevention and/or early management are essential.
- Women rate pain during labor as one of the most uncomfortable experiences in life. Oxytocin is commonly used to increase the frequency and strength of uterine contractions, which also increases labor pain. Catecholamine release and maternal hyperventilation occur during labor. The resulting vasoconstriction of the uterine arteries decreases uterine blood flow and oxygen dissociation from hemoglobin, causing respiratory alkalosis. Whereas alternative methods offer some degree of pain relief, the gold standard during labor and childbirth is epidural (or combined spinal-epidural) analgesia, which not only provides near-complete relief but also improves uterine blood flow, fetal oxygenation, and the release of stress hormones. Fluid administration before neuraxial analgesia helps prevent hypotension, which, if it does occur, may be treated with small doses of vasopressors.
- Approximately one in three women have a cesarean delivery in the United States. Although the use of general anesthesia for cesarean delivery is very safe, it has increased maternal and neonatal side effects as well as maternal mortality. Most intravenous and inhaled anesthetics cross the placenta. Regional anesthesia (spinal or epidural) is preferable. Some neonatal assistance is required in 10% of births, and vigorous resuscitation is required in 1%. Newborns are ventilated with lower concentrations of oxygen and titrated up as needed to achieve their normal physiologic oxygen saturation of 85-95% in the first minutes of life.

Normal labor is a process that permits a series of extensive physiologic changes in the mother to allow for the delivery of her fetus through the birth canal. ***Labor* is defined as progressive cervical effacement and dilation resulting from regular uterine contractions that occur at least every 3 minutes and last 30 to 60 seconds each.**

The role of the obstetrician and health care team is to anticipate and manage abnormalities that may occur during either the maternal or fetal birth process. When a decision is made to intervene, it must be considered carefully because each intervention carries not only potential benefits but also potential risks. In the vast majority of cases, the best management may be close observation and, when necessary, cautious intervention.

Anatomic Characteristics of the Fetal Head and Maternal Pelvis

Successful vaginal delivery requires the accommodation, by molding and rotation, of the descending fetal head to the maternal pelvis.

FETAL HEAD

The head is the largest and least compressible part of the fetus. Thus, from an obstetric viewpoint, it is the most important part, whether the presentation is cephalic or breech.

The fetal skull consists of a base and a vault (the cranium). The base of the skull has large, ossified, firmly united, and noncompressible bones. This serves to protect the vital structures contained within the brain stem and its spinal connections.

The cranium consists of the occipital bone posteriorly, two parietal bones bilaterally, and two frontal and temporal bones anteriorly. The cranial bones at birth are thin, weakly ossified, easily compressible, and interconnected only by membranes. These features allow them to overlap under pressure and to change shape to conform to the maternal pelvis, a process known as ***molding.***

Sutures

The membrane-occupied spaces between the cranial bones are known as *sutures.* The **sagittal suture** lies between the parietal bones and extends in an anteroposterior direction between the fontanelles, dividing the head into right and left sides (Figure 8-1). The **lambdoidal suture** extends from the posterior fontanelle laterally and serves to separate the occipital from the parietal bones. The **coronal suture** extends from the anterior fontanelle laterally and serves to separate the parietal and frontal bones. The **frontal suture** lies between the frontal bones and extends from the anterior fontanelle to the glabella (the prominence between the eyebrows).

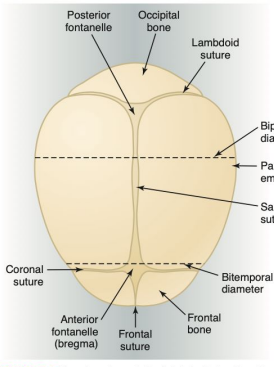


FIGURE 8-1 Superior view of the fetal skull showing the sutures, fontanelles, and transverse diameters.

Fontanelles

The membrane-filled spaces located at the point where the sutures intersect are known as *fontanelles,* the most important of which are the **anterior and posterior fontanelles.** Clinically, they are even more useful than the sutures for determining the fetal head position.

The **posterior fontanelle** closes at 6 to 8 weeks of life, whereas the **anterior fontanelle** does not become ossified until approximately 18 months. This allows the skull to accommodate the tremendous growth of the infant's brain after birth.

The anterior fontanelle **(bregma)** is found at the intersection of the sagittal, frontal, and coronal sutures. It is diamond-shaped, measures approximately 2 × 3 cm, and is much larger than the posterior fontanelle. The posterior fontanelle is Y- or T-shaped and is found at the junction of the sagittal and lambdoid sutures.

Landmarks

The fetal skull is characterized by a number of landmarks. From front to back, they include the following (Figure 8-2):

1. **Nasion:** the root of the nose
2. **Glabella:** the elevated area between the orbital ridges
3. **Sinciput (brow):** the area between the anterior fontanelle and the glabella
4. **Anterior fontanelle (bregma):** diamond-shaped
5. **Vertex:** the area between the fontanelles and bounded laterally by the parietal eminences
6. **Posterior fontanelle (lambda):** Y- or T-shaped
7. **Occiput:** the area behind and inferior to the posterior fontanelle and lambdoid sutures

Diameters

Several diameters of the fetal skull are important (see Figures 8-1 and 8-2). The **anteroposterior diameter** presenting to the maternal pelvis depends on the degree of flexion or extension of the head. It is important because the various diameters differ in length. The following measurements are considered average for a term fetus:

1. **Suboccipitobregmatic (9.5 cm):** the presenting anteroposterior diameter when the **head is well flexed,** as in an occipitotransverse or occipitoanterior position; it extends from the undersurface of the occipital bone at the junction with the neck to the center of the anterior fontanelle.

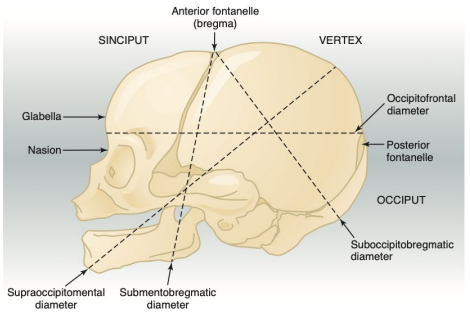


FIGURE 8-2 Lateral view of the fetal skull showing the prominent landmarks and the anteroposterior diameters.

2. **Occipitofrontal (11 cm):** the presenting anteroposterior diameter when the head is deflexed, as in an occipitoposterior presentation; it extends from the external occipital protuberance to the glabella.
3. **Supraoccipitomental (13.5 cm):** the presenting anteroposterior diameter in a brow presentation and the longest anteroposterior diameter of the head; it extends from the vertex to the chin.
4. **Submentobregmatic (9.5 cm):** the presenting anteroposterior diameter in face presentations; it extends from the junction of the neck and lower jaw to the center of the anterior fontanelle.

The transverse diameters of the fetal skull are as follows:

1. **Biparietal (9.5 cm):** the largest transverse diameter; it extends between the parietal bones.
2. **Bitemporal (8 cm):** the shortest transverse diameter; it extends between the temporal bones.

The average circumference of the term fetal head, measured in the occipitofrontal plane, is 34.5 cm.

PELVIC ANATOMY

Bony Pelvis

The bony pelvis is made up of four bones: the sacrum, coccyx, and two innominates (composed of the ilium, ischium, and pubis). These are held together by the sacroiliac joints, the symphysis pubis, and the sacrococcygeal joint. The union of the pelvis and the vertebral column stabilizes the pelvis and allows weight to be transmitted to the lower extremities.

The **sacrum** consists of five fused vertebrae. The anterior superior edge of the first sacral vertebra is called the **promontory,** which protrudes slightly into the cavity of the pelvis. The anterior surface of the sacrum is usually concave. It articulates with the ilium at its upper segment, with the coccyx at its lower segment, and with the sacrospinous and sacrotuberous ligaments laterally.

The **coccyx** is composed of three to five rudimentary vertebrae. It articulates with the sacrum, forming a joint, and occasionally the bones are fused.

The pelvis is divided into the false pelvis above and the true pelvis below the linea terminalis (the edge of the pelvic inlet). The false pelvis is bordered by the lumbar vertebrae posteriorly, an iliac fossa bilaterally, and the abdominal wall anteriorly. Its only obstetric function is to support the pregnant uterus.

The true pelvis is a bony canal and is formed by the sacrum and coccyx posteriorly and by the ischium and pubis laterally and anteriorly. Its internal borders are solid and relatively immobile. The posterior wall is twice the length of the anterior wall. The true pelvis is the area of concern to the obstetrician because its dimensions are sometimes not adequate to permit passage of the fetus.

Pelvic Planes

The pelvis is divided into the following four planes for descriptive purposes (Table 8-1 and Figures 8-3 and 8-4):

1. **The pelvic inlet**
2. **The plane of greatest diameter**
3. **The plane of least diameter**
4. **The pelvic outlet**

These planes are imaginary, flat surfaces that extend across the pelvis at different levels. Except for

Reference

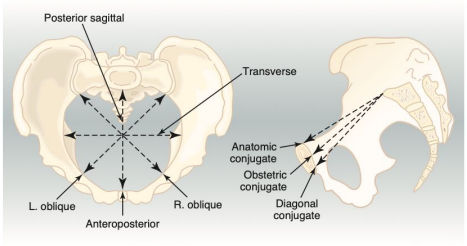


FIGURE 8-3 Pelvic inlet and its diameters.

TABLE 8-1
AVERAGE LENGTH OF PELVIC PLANE DIAMETERS

Pelvic Plane	Diameter	Average Length (cm)
Inlet	True conjugate	11.5
	Obstetric conjugate	11
	Transverse	13.5
	Oblique	12.5
	Posterior sagittal	4.5
Greatest diameter	Anteroposterior	12.75
	Transverse	12.5
Midplane	Anteroposterior	12
	Bispinous	10.5
	Posterior sagittal	4.5-5
Outlet	Anatomic anteroposterior	9.5
	Obstetric anteroposterior	11.5
	Bituberous	11
	Posterior sagittal	7.5

the plane of greatest diameter, each plane is clinically significant.

The **plane of the inlet** is bordered by the pubic crest anteriorly, the iliopectineal line of the innominate bones laterally, and the promontory of the sacrum posteriorly. The fetal head enters the pelvis through this plane in the transverse position.

The **plane of greatest diameter** is the largest part of the pelvic cavity. It is bordered by the posterior midpoint of the pubis anteriorly, the upper part of the obturator foramina laterally, and the junction of the second and third sacral vertebrae posteriorly. The fetal head rotates to the anterior position in this plane.

The **plane of least diameter** is the most important from a clinical standpoint because most instances of arrest of descent occur at this level. It is bordered by the lower edge of the pubis anteriorly, the ischial spines and sacrospinous ligaments laterally, and the lower sacrum posteriorly. Low transverse arrests generally occur in this plane.

The **plane of the pelvic outlet** is formed by two triangular planes with a common base at the level of the ischial tuberosities. The anterior triangle is bordered by the subpubic angle at the apex, the pubic rami on the sides, and the bituberous diameter at the base. The posterior triangle is bordered by the sacrococcygeal joint at its apex, the sacrotuberous ligaments on the sides, and the bituberous diameter at the base. This plane is the site of a low pelvic arrest.

Pelvic Diameters

The diameters of the pelvic planes represent the amount of space available at each level. The key measurements for assessing the capacity of the maternal pelvis include the following:

1. **The obstetric conjugate of the inlet**
2. **The bispinous diameter of the midplane**
3. **The bituberous diameter of the outlet**
4. **The anteroposterior sagittal diameter of the outlet**

The average lengths of the diameters of each pelvic plane are listed in Table 8-1.

Pelvic Inlet

The pelvic inlet has five important diameters (see Figure 8-3). The anteroposterior diameter is described by one of two measurements. The **true conjugate (anatomic conjugate)** is the anatomic diameter and extends from the middle of the sacral promontory to the superior surface of the pubic symphysis. The **obstetric conjugate** represents the actual space available to the fetus and extends from the middle of the sacral promontory to the closest point on the convex posterior surface of the symphysis pubis.

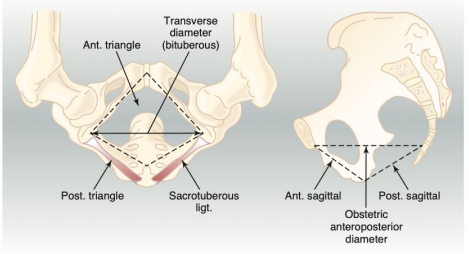


FIGURE 8-4 Pelvic outlet and its diameters.

The **transverse diameter** is the widest distance between the iliopectineal lines. Each **oblique diameter** extends from the sacroiliac joint to the opposite iliopectineal eminence.

The **posterior sagittal diameter** extends from the anteroposterior and transverse intersection to the middle of the sacral promontory.

Plane of Greatest Diameter

The plane of greatest diameter has two noteworthy diameters. The **anteroposterior diameter** (see Figure 8-4) extends from the midpoint of the posterior surface of the pubis to the junction of the second and third sacral vertebrae. The **transverse diameter** is the widest distance between the lateral borders of the plane.

Plane of Least Diameter (Midplane)

The plane of least diameter has three important diameters. The **anteroposterior diameter** extends from the lower border of the pubis to the junction of the fourth and fifth sacral vertebrae. The **transverse (bispinous) diameter** extends between the ischial spines. The **posterior sagittal diameter** extends from the midpoint of the bispinous diameter to the junction of the fourth and fifth sacral vertebrae.

Pelvic Outlet

The pelvic outlet has four important diameters (see Figure 8-4). The **anatomic anteroposterior diameter** extends from the inferior margin of the pubis to the tip of the coccyx, whereas the **obstetric anteroposterior diameter** extends from the inferior margin of the pubis to the sacrococcygeal joint. The **transverse (bituberous) diameter** extends between the inner surfaces of the ischial tuberosities, and the **posterior sagittal diameter** (not listed) extends from the middle of the transverse diameter to the sacrococcygeal joint.

PELVIC SHAPES

Based on the general bony architecture, the pelvis may be classified into four basic types (Figure 8-5): gynecoid, android, anthropoid, and platypelloid.

Gynecoid

The gynecoid pelvis is the classic female type of pelvis and is found in approximately **50% of women.** It has the following characteristics:

1. Round at the inlet, with the widest transverse diameter only slightly greater than the anteroposterior diameter
2. Sidewalls straight
3. Ischial spines of average prominence
4. Large **sacrospinous notch** (depicted in Figure 8-5)
5. Well-curved sacrum
6. Spacious subpubic arch with an angle of approximately 90 degrees

These features create a cylindrical shape that is spacious throughout. The fetal head generally rotates into the occipitoanterior position in this type of pelvis.

Android

The android pelvis is the typical male type of pelvis. It is found in **less than 30% of women** and has the following characteristics:

1. Triangular inlet with a flat posterior segment and the widest transverse diameter closer to the sacrum than in the gynecoid type
2. Convergent sidewalls with prominent spines
3. Shallow sacral curve
4. Long and narrow (small) sacrospinous notch (noted in Figure 8-5 in a gynecoid pelvis)
5. Narrow subpubic arch

This type of pelvis has limited space at the inlet and progressively less space as the fetus moves down the

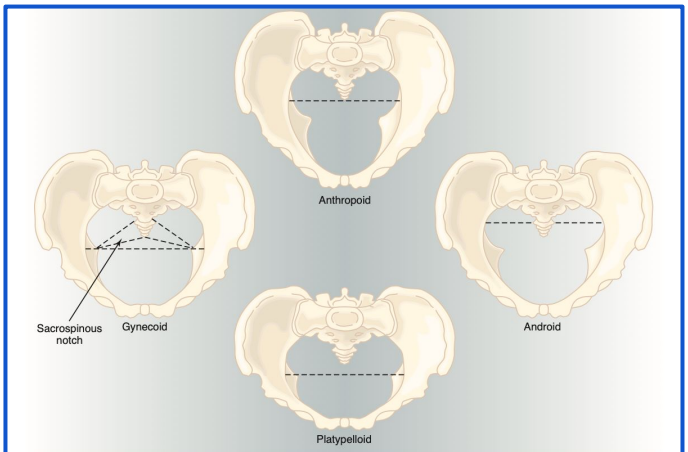


FIGURE 8-5 The four basic pelvic types. The *dashed lines* indicate the transverse diameter of the **inlet**. Note that the widest diameter of the inlet is posteriorly situated in an android or anthropoid pelvis. The gynecoid pelvis illustrates the location of the sacrospinous notch, present in all pelvic types.

pelvis, because of the funneling effect of the sidewalls, sacrum, and pubic rami. Thus, the amount of space is restricted at all levels. The fetal head is forced to be in the occipitoposterior position to conform to the narrow anterior pelvis. Arrest of descent is common at the midpelvis.

Anthropoid

The anthropoid pelvis resembles that of the anthropoid ape. It is found in **approximately 20% of women** and has the following characteristics:

1. A much larger anteroposterior than transverse diameter, creating a long, narrow oval at the inlet
2. Sidewalls that do not converge
3. Ischial spines that are not prominent but are close, because of the overall shape
4. Variable, but usually posterior, inclination of the sacrum
5. Small sacrospinous notch
6. Narrow, outwardly shaped subpubic arch

The fetal head can engage only in the anteroposterior diameter and usually does so in the occipitoposterior position because there is more space in the posterior pelvis.

Platypelloid

The platypelloid pelvis is best described as being a flattened gynecoid pelvis. It is found in **only 3% of women,** and it has the following characteristics:

1. A short anteroposterior and wide transverse diameter, creating an oval-shaped inlet
2. Straight or divergent sidewalls
3. Posterior inclination of a flat sacrum
4. A wide bispinous diameter
5. Long but small sacrospinous notch
6. A wide subpubic arch

The overall shape is that of a gentle curve throughout. The fetal head has to engage in the transverse diameter.

ENGAGEMENT

Engagement occurs when the widest diameter of the fetal presenting part has passed through the pelvic inlet. In cephalic presentations, the widest diameter is biparietal; in breech presentations, it is intertrochanteric.

The station of the presenting part in the pelvic canal is defined as its level above or below the plane of the ischial spines. The level of the ischial spines is assigned as "zero" station, and each centimeter above or below this level is given a minus or plus designation, respectively.

In the majority of women, the bony presenting part is at the level of the ischial spines when the head has become engaged. The fetal head usually engages with its sagittal suture in the transverse diameter of the pelvis. The head position is considered to be **synclitic** when the biparietal diameter is parallel to the pelvic plane and the sagittal suture is midway between the anterior and posterior planes of the pelvis. When this relationship is not present, the head is considered to be **asynclitic** (Figure 8-6).

There is a distinct advantage to having the head engage in asynclitism in certain situations. In a synclitic presentation, the biparietal diameter entering the pelvis measures 9.5 cm; when the parietal bones enter the pelvis in an asynclitic manner, however, the presenting diameter measures 8.75 cm. Therefore, asynclitism permits a larger head to enter the pelvis than would be possible in a synclitic presentation.

CLINICAL PELVIMETRY

The diameters that can be clinically evaluated can be assessed at the time of the first prenatal visit to screen for obvious pelvic contractions, although some obstetricians believe that it is better to wait until later in pregnancy, when the soft tissues are more distensible and the examination is less uncomfortable and possibly more accurate.

The clinical evaluation is started by assessing the pelvic inlet. The pelvic inlet can be evaluated clinically for its anteroposterior diameter. The obstetric conjugate can be estimated from the diagonal conjugate, which is obtained during clinical examination (see Figure 8-3).

The diagonal conjugate is approximated by measuring from the lower border of the pubis to the sacral promontory, using the tip of the second finger and the point where the base of the index finger meets the pubis (Figure 8-7). The obstetric conjugate is then estimated by subtracting 1.5 to 2 cm, depending on the height and inclination of the pubis. Often the middle finger of the examining hand cannot reach the sacral promontory; thus, the obstetric conjugate is considered adequate. If the diagonal conjugate is greater than or equal to 11.5 cm, the anteroposterior diameter of the inlet is considered to be adequate.

The anterior surface of the sacrum is then palpated to assess its curvature. The usual shape is concave. A flat or convex shape may indicate anteroposterior constriction throughout the pelvis.

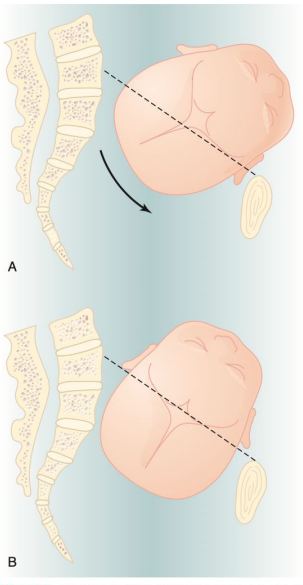


FIGURE 8-6 Anterior asynclitism entering the pelvis **(A)** and synclitism in the pelvis **(B)**. The *curved arrow* shows the direction to correct asynclitism, and the *dashed lines* show the axis that defines synclitism.

The midpelvis cannot be measured accurately clinically in either the anteroposterior or transverse diameter. A reasonable estimate of the size of the midpelvis, however, can be obtained as follows. **The pelvic sidewalls can be assessed to determine if they are convergent rather than having the normal, almost parallel, configuration.** The ischial spines are palpated carefully to assess their prominence, and several passes are made between the spines to approximate the bispinous diameter. The length of the sacrospinous ligament is assessed by placing one finger on the ischial spine and one finger on the sacrum in the midline. The average length is three fingerbreadths. If the sacrospinous

Reference

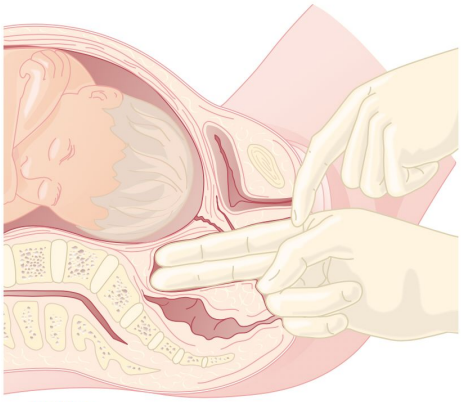


FIGURE 8-7 Clinical estimation of the diagonal conjugate diameter of the pelvis.

notch that is located lateral to the ligament can accommodate two-and-one-half fingers, the posterior midpelvis is most likely of adequate dimensions. A short ligament suggests a forward inclination of the sacrum and a narrowed sacrospinous notch.

Finally, the pelvic outlet is assessed. This is done by first placing a fist between the ischial tuberosities. An 8.5-cm distance is considered to indicate an adequate transverse diameter. The posterior sagittal measurement should also be greater than 8 cm. The infrapubic angle is assessed by placing a thumb next to each inferior pubic ramus and then estimating the angle at which they meet. An angle of less than 90 degrees is associated with a contracted transverse diameter in the midplane and outlet.

Radiologic Assessment of the Pelvis

When an accurate measurement of the pelvis is indicated, nuclear magnetic resonance imaging (MRI) may be used. The advantage of MRI over x-ray or computed tomography for pelvic assessment is the lack of ionizing radiation exposure.

Indications

1. **Clinical evidence or obstetric history suggestive of pelvic abnormalities**
2. **A history of pelvic trauma**

It should always be questioned whether the results obtained by radiologic assessment will have sufficient influence on the patient's management to make the investigation worthwhile.

PREPARATION FOR LABOR

Before actual labor begins, a number of preparatory physiologic events usually occur.

Lightening

Two or more weeks before labor, the fetal head in most primigravid women settles into the brim of the pelvis. In multigravida, this often does not occur until early in labor. **Lightening** may be noted by the mother as a flattening of the upper abdomen and an increased prominence of the lower abdomen.

False Labor

During the last 4 to 8 weeks of pregnancy, the uterus undergoes irregular contractions that normally are painless. Such contractions appear unpredictably and sporadically and can be rhythmic and of mild intensity. In the last month of pregnancy, these contractions may occur more frequently, sometimes every 10 to 20 minutes, and with greater intensity. **These Braxton Hicks contractions are considered false labor in that they are not associated with progressive cervical**

Fetal Circulation

Several anatomic and physiologic factors must be noted in considering the fetal circulation (Table 6-6 and Figure 6-3).

The normal adult circulation is a series circuit with blood flowing through the right heart, the lungs, the left heart, the systemic circulation, and finally the right heart. In the fetus, the circulation is a parallel system with the cardiac outputs from the right and left ventricles directed primarily to different vascular beds. For example, the right ventricle, which contributes about 65% of the combined output, pumps blood primarily through the pulmonary artery, ductus arteriosus, and descending aorta. Only a small fraction of right ventricular output flows through the pulmonary circulation. The left ventricle supplies blood mainly to the tissues supplied by the aortic arch, such as the brain. **The fetal circulation is a parallel circuit characterized by channels (ductus venosus, foramen ovale, and**

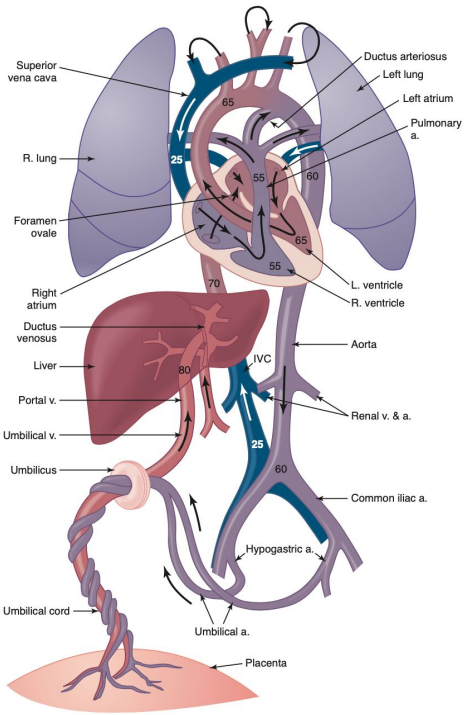


FIGURE 6-3 The fetal circulation. Numbers represent approximate values of percentage saturation of blood with oxygen in utero. *IVC*, Inferior vena cava. (Adapted from Parer JJ: Fetal circulation. In Sciarra JJ, editor: *Obstetrics and gynecology, vol 3: maternal and fetal medicine,* Hagerstown, Md, 1984, Harper & Row, p 2.)

TABLE 6-6

COMPONENTS OF THE FETAL CIRCULATION

Fetal Structure	From/To	Adult Remnant
Umbilical vein	Umbilicus/ductus venosus	Ligamentum teres hepatis
Ductus venosus	Umbilical vein/inferior vena cava (bypasses liver)	Ligamentum venosum
Foramen ovale	Right atrium/left atrium	Closed atrial wall
Ductus arteriosus	Pulmonary artery/descending aorta	Ligamentum arteriosum
Umbilical artery	Common iliac artery/umbilicus	Superior vesical arteries; lateral vesicoumbilical ligaments

Data from Main DM, Main EK: *Obstetrics and gynecology: a pocket reference,* Chicago, 1984, Year Book, p 34.

ductus arteriosus) and preferential streaming, which function to maximize the delivery of more highly oxygenated blood to the upper body and brain, less highly oxygenated blood to the lower body, and very low blood flow to the nonfunctional lungs.

The umbilical vein, carrying oxygenated (80% saturated) blood from the placenta to the fetal body, enters the portal system. A portion of this umbilical-portal blood passes through the hepatic microcirculation, where oxygen is extracted, and thence through the hepatic veins into the inferior vena cava. **The majority of the blood bypasses the liver through the ductus venosus, which directly enters the inferior vena cava, which also receives the unsaturated (25% saturated) venous return from the lower body.** Blood reaching the heart via the inferior vena cava has an oxygen saturation of about 70%, which represents the most highly oxygenated blood in the heart. Approximately one-third of blood returning to the heart from the inferior vena cava preferentially streams across the foramen ovale into the left atrium, where it mixes with the relatively meager pulmonary venous return. Blood flows from the left atrium into the left ventricle, and then to the ascending aorta.

The proximal aorta, carrying the most highly saturated blood leaving the heart (65%) gives off branches to supply the brain and upper body. Most of the blood returning via the inferior vena cava enters the right atrium, where it mixes with the unsaturated blood returning via the superior vena cava (25% saturated). Right ventricular outflow (O_2 saturation of 55%) enters the aorta via the ductus arteriosus, and the descending aorta supplies the lower body with blood having less O_2 saturation (about 60%) than that flowing to the brain and the upper body.

The role of the ductus arteriosus must be emphasized. **Right ventricular output enters the pulmonary trunk, from which its major portion, because of the high vascular resistance of the pulmonary circulation, bypasses the lungs by flowing through the ductus arteriosus to the descending aorta.** Although the descending aorta supplies branches to the lower fetal body, the major portion of descending aortic flow goes to the umbilical arteries, which carry deoxygenated blood to the placenta.

CHANGES IN THE ANATOMY OF THE CARDIOVASCULAR SYSTEM AFTER BIRTH

The following changes occur after birth (see Table 6-6):

1. **Elimination of the placental circulation, with interruption and eventual obliteration of the umbilical vessels**
2. **Closure of the ductus venosus**
3. **Closure of the foramen ovale**
4. **Gradual constriction and eventual obliteration of the ductus arteriosus**
5. **Dilation of the pulmonary vessels and establishment of the pulmonary circulation**

The elimination of the umbilical circulation, closure of the vascular shunts, and establishment of the pulmonary circulation will change the vascular circuitry of the neonate from an "in parallel" system to an "in series" system.

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Members:

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Good Luck!

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