MEDICAL EDUCATION RESOURCE

Urinary Bladder and Urethra

Introduction

- The **urinary bladder** is a **musculomembranous sac** that serves as a **reservoir for urine**, situated in the **pelvic cavity**, behind the **pubic symphysis**.
- It is **distensible**, expanding into the abdominal cavity when filled.
- Functionally, it acts as a **temporary storage organ** for urine and plays a role in **micturition** (urination).

Position:

- In **adults**, when empty, it lies entirely in the **pelvis**.
- When distended, it rises into the **lower part of the abdomen**.
- In **children**, the bladder is more **abdominal** in position due to the shortness of the pelvis.

Capacity:

- Average capacity: **150–500 mL** (urge to void occurs around 300 mL).
- Maximum distension: Up to **1 liter** in pathological cases.

Shape:

- **Empty bladder:** Tetrahedral.
- **Full bladder:** Ovoid.

Parts:

1. **Apex** – directed upward and forward.
2. **Base (fundus)** – posterior surface.
3. **Neck** – lowest fixed part leading into the urethra.
4. **Body** – the main portion between apex and base.

Urinary Bladder

- The **urinary bladder** consists of a **mucous membrane**, **submucosa**, **detrusor muscle layer**, and an **outer adventitia (or serosa)**.
- The muscle coat, the **detrusor muscle**, is made of **interlacing smooth muscle fibers** arranged in three layers — outer longitudinal, middle circular, and inner longitudinal.
- The bladder mucosa is lined by **transitional epithelium (urothelium)**.
- The internal surface is thrown into folds (rugae) when empty, except at the **trigone**, which remains smooth.
- The **trigone** is a smooth triangular area on the internal surface of the bladder base between the two ureteric openings and the internal urethral orifice.

Functions:

- Storage of urine under low pressure.
- Contraction of detrusor and relaxation of sphincters during micturition expels urine.

External Features

When empty, the bladder appears **four-sided** (tetrahedral):

1. **Apex**
    - Points forward toward the upper border of the symphysis pubis.
    - Attached to the **median umbilical ligament** (remnant of urachus) extending up to the umbilicus.
2. **Base (Fundus or Posterior Surface)**
    - Triangular in shape and directed backward and downward.
    - In **males:** related to rectum and seminal vesicles.
    - In **females:** related to anterior wall of vagina and cervix of uterus.
3. **Neck**
    - Lowest and most fixed part of bladder, continuous with urethra.
    - Lies about **2.5 cm behind the lower border of the symphysis pubis**.
    - Surrounded by the **internal urethral sphincter** (in males).
    - Anchored by **puboprostatic (in males)** or **pubovesical (in females)** ligaments.
4. **Superior Surface**
    - Triangular and covered by **peritoneum**.
    - In **males:** related to sigmoid colon and coils of ileum.
    - In **females:** related to uterus; the **uterovesical pouch** lies between them.

5. **Inferolateral Surfaces**
    - Two in number, rest on the **levator ani**, **obturator internus**, and **pelvic fascia**.
    - Meet anteriorly at the apex and posteriorly at the base.

Relations

In Males:

- **Superior surface:** Covered by peritoneum; related to coils of ileum and sigmoid colon.
- **Base (posterior surface):** Related to rectum, separated by **rectovesical pouch**, **seminal vesicles**, and **vas deferens**.
- **Inferolateral surfaces:** Rest on levator ani, obturator internus, and fascia.
- **Neck:** Lies above prostate gland; continuous with prostatic urethra.

In Females:

- **Superior surface:** Related to body of uterus; separated by **uterovesical pouch**.
- **Base:** Related to anterior vaginal wall and cervix.
- **Inferolateral surfaces:** Rest on levator ani and obturator internus.
- **Neck:** Lies against urogenital diaphragm; continuous with urethra.

Anterior Relation (in both sexes):

- Separated from pubic symphysis by **retropubic space (space of Retzius)** containing **fat and loose areolar tissue**.

- This space allows bladder expansion and surgical access (suprapubic cystostomy).

Ligaments of the Bladder

The bladder is held in position by **true and false ligaments**.

1. False Ligaments (peritoneal folds):

- **Median umbilical fold:** Extends from apex of bladder to umbilicus; contains **urachus**.
- **Medial umbilical folds:** Contain **obliterated umbilical arteries**.
- **Lateral false ligaments:** Formed by peritoneal reflections on sides of bladder.
- **Rectovesical fold (in males)** and **uterovesical fold (in females):** Peritoneal reflections connecting bladder to rectum or uterus.

2. True Ligaments (condensations of pelvic fascia):

- **Puboprostatic ligaments** (in males) — connect neck of bladder and prostate to posterior surface of pubic bone.
- **Pubovesical ligaments** (in females) — connect neck of bladder to pubic bone.
- **Lateral true ligaments** — formed by thickening of fascia around the bladder neck and base, containing vesical veins.
- **Posterior ligament of bladder** — condensation of fascia behind base of bladder containing **vesical venous plexus**.

Clinical importance:

- These ligaments provide **support and fixation** to the bladder.

- Weakness or disruption (e.g., after childbirth or surgery) can cause **bladder descent or prolapse** (cystocele).

Interior of the Bladder

- The **internal surface** of the bladder is lined by **transitional epithelium (urothelium)**.
- When empty, the mucosa is **thrown into folds (rugae)** except in one region — the **trigone** — which is always smooth.

1. Trigone of the bladder:

- A **smooth triangular area** on the posterior wall.
- Its three angles correspond to:
    - **Upper two angles:** Openings of the **right and left ureters**.
    - **Lower angle: Internal urethral orifice.**
- The **interureteric ridge (bar of Mercier)** joins the two ureteric orifices and forms the base of the trigone.
- Beneath the trigone lies the **uvula vesicae**, a slight elevation caused by the median lobe of the prostate (in males).

2. Ureteric orifices:

- Slit-like openings at the posterolateral angles of the trigone.
- Function as **valves** preventing reflux of urine during bladder contraction.

3. Internal urethral orifice:

- Lies at the neck of the bladder.
- In **males**, surrounded by **internal urethral sphincter** (smooth muscle).
- In **females**, no distinct internal sphincter is present.

Arterial Supply

- **Superior vesical arteries** — branches of the **umbilical artery** (from internal iliac).
- **Inferior vesical artery** (in males) — branch of **internal iliac artery**; supplies base, neck, prostate, and seminal vesicles.
- **Vaginal artery** (in females) — replaces the inferior vesical branch.
- **Obturator and inferior gluteal arteries** also give small branches to the bladder.

Clinical note:
During pelvic surgery, these small vessels must be carefully preserved to avoid bladder ischemia.

Venous Drainage

- Veins form a **rich vesical venous plexus** around the base and neck of the bladder.
- This plexus communicates with:
    - **Prostatic venous plexus** (in males).
    - **Uterovaginal venous plexus** (in females).

- **Internal iliac veins.**

Clinical importance:
In males, infections or cancer of the prostate can spread to the bladder through the **prostatic venous plexus**.

Lymphatic Drainage

- Lymph from the bladder drains mainly into:
  - **External iliac lymph nodes** (superior part).
  - **Internal iliac lymph nodes** (inferior part).
  - **Sacral lymph nodes** (posterior part).

Clinical correlation:
Bladder carcinoma spreads first to **external and internal iliac lymph nodes**; this helps guide surgical lymph node dissection.

Nerve Supply

1. Sympathetic (T11–L2):

- From **hypogastric plexus**.
- Function: Relaxes detrusor muscle and contracts internal sphincter ? promotes urine retention.

2. Parasympathetic (S2–S4):

- From **pelvic splanchnic nerves**.

- Function: Contracts detrusor and relaxes internal sphincter ? promotes micturition.

3. Somatic (pudendal nerve, S2–S4):

- Supplies **external urethral sphincter** (voluntary control).

Summary of control:

- **Filling phase:** Sympathetic active ? bladder relaxed, sphincters closed.
- **Voiding phase:** Parasympathetic active ? detrusor contracts, sphincters relax.

Reflex mechanism:

- **Micturition reflex** arises when bladder stretch receptors activate parasympathetic outflow.
- Under **pontine and cortical control** in adults; voluntary suppression possible.

Histology of Urinary Bladder

- **Epithelium:** Transitional epithelium (urothelium) that becomes thinner when distended.
- **Lamina propria:** Loose connective tissue with elastic fibers and blood vessels.
- **Muscular coat (detrusor muscle):**
  - Inner longitudinal, middle circular, and outer longitudinal smooth muscle layers.
  - Near the neck, middle circular fibers form **internal urethral sphincter** (in males).
- **Adventitia:** Loose connective tissue with veins, lymphatics, and nerves.

- **Serosa (superior surface):** Covered by peritoneum.

Dissection

- After reflecting the peritoneum from the anterior abdominal wall, the **superior surface** of the bladder can be exposed.
- Identify **median umbilical ligament** (urachus remnant) extending from the apex to the umbilicus.
- Trace **ureters** entering the posterior surface at the posterolateral angles of the trigone.
- Open the bladder longitudinally to observe:
    - **Trigone**,
    - **Interureteric ridge**,
    - **Ureteric and urethral orifices**, and
    - **Uvula vesicae** (in males).
- Note mucosal folds (rugae) except in the trigone region.

Clinical Anatomy

- **Cystitis:** Inflammation of the bladder mucosa due to bacterial infection; more common in females because of short urethra.
- **Urinary retention:** Failure of bladder emptying due to obstruction (prostatic enlargement, urethral stricture) or nerve injury.

- **Cystocele:** Herniation of bladder wall into the vagina due to pelvic floor weakness.
- **Vesicoureteral reflux:** Backflow of urine from bladder to ureters due to defective valve mechanism.
- **Bladder stones (vesical calculi):** Form when urine stagnates; may cause hematuria or obstruction.
- **Exstrophy of bladder:** Congenital anomaly where anterior bladder wall and lower abdominal wall fail to develop.
- **Neurogenic bladder:** Results from spinal cord injury; causes loss of voluntary control of micturition.
- **Suprapubic cystostomy:** Surgical drainage of urine through anterior bladder wall, accessed above pubic symphysis.
- **Bladder carcinoma:** Commonly transitional cell carcinoma; spreads via lymphatics to iliac nodes.
- **Rupture of bladder:** Can occur in pelvic fractures; urine may leak into peritoneal cavity (intraperitoneal rupture) or extraperitoneally (extraperitoneal rupture).

Urethra

- The **urethra** is a **musculomembranous tube** that conveys **urine** (and semen in males) to the exterior.
- Lined by **epithelium** that varies along its course and surrounded by **muscular coats**.

Length:

- **Male urethra:** ~18–20 cm.
- **Female urethra:** ~4 cm.

Functions:

- In **males**, it serves both **urinary and reproductive** functions.
- In **females**, it serves **only urinary** function.

Male Urethra

- Extends from **internal urethral orifice** (at bladder neck) to **external urethral orifice** (at tip of glans penis).
- Average length: **18–20 cm**.
- Divided into **posterior** and **anterior** parts.

Posterior Part (Proximal 4 cm)

Includes two segments:

1. **Prostatic urethra (3 cm):**
    - Lies within the **prostate gland**; widest and most dilatable portion.
    - **Shape:** Vertical slit on coronal section.
    - **Features on posterior wall (urethral crest):**

- **Verumontanum (seminal colliculus):** Median elevation on posterior wall.
    - **Prostatic utricle:** Small blind pouch (vestige of Müllerian duct) opens in midline.
    - **Openings of ejaculatory ducts:** One on each side of utricle.
- **Prostatic sinuses:** Grooves on either side of urethral crest; receive **openings of prostatic ducts**.

Relations:

- Anterior: Symphysis pubis (separated by venous plexus).
- Posterior: Rectal ampulla (separated by fascia).
- Surrounding gland: Prostate.

Epithelium: Transitional epithelium continuous with bladder mucosa.

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2. **Membranous urethra (1–2 cm):**
    - Narrowest and least dilatable part, except at external meatus.
    - Passes through the **deep perineal pouch**.
    - Surrounded by **external urethral sphincter (voluntary muscle)**.
    - Pierces the **perineal membrane** and lies anterior to the bulbourethral glands (Cowper's glands).

Epithelium: Pseudostratified columnar.

Clinical note:

- This is the most easily **injured part** in pelvic fractures.
- Bleeding at the external meatus and inability to pass urine indicate rupture here.

Anterior Part (Distal 15–16 cm)

Includes two segments:

1. **Bulbar urethra:**
   - Begins at the **base of the bulb of penis**.
   - Slightly dilated (called **ampulla of urethra**).
   - Receives ducts of **bulbourethral glands (Cowper's glands)**.
2. **Penile (spongy) urethra:**
   - Runs through the **corpus spongiosum** up to the **external urethral meatus**.
   - **Longest part** of urethra (~15 cm).
   - Dilated at two points:
     - **Bulbar fossa (posterior)**.
     - **Navicular fossa (anterior)** just within glans penis.
   - **External urethral meatus:** Narrowest part of entire urethra, with vertical slit-like opening at tip of glans.

Epithelium:

- Proximal: Pseudostratified columnar.
- Distal: Stratified squamous continuous with skin.

Mucous glands:

- Numerous small **urethral glands of Littre** open into the lumen.

Clinical Anatomy

- **Urethral Stricture:**
  - Fibrotic narrowing of urethra (usually after infection or trauma).
  - Common in **bulbar urethra**; causes poor urine stream and retention.
- **Rupture of Membranous Urethra:**
  - Occurs in pelvic fractures; urine and blood collect in **deep perineal pouch**.
  - Patient unable to void; blood at external meatus.
- **Rupture of Spongy (Bulbar) Urethra:**
  - Common in “straddle injury” (fall on crossbar of bicycle).
  - Urine extravasates into **superficial perineal pouch**, **scrotum**, **penis**, and **lower abdominal wall**, but not into thighs or anal triangle (limited by fascia).
- **Congenital Anomalies:**

- **Hypospadias:** External meatus opens on ventral surface of penis (failure of urethral folds to fuse).
- **Epispadias:** External meatus opens on dorsal surface (usually associated with exstrophy of bladder).

- **Catheterization:**
  - Urethra is curved in males; during catheterization, penis must be held upward to straighten the curve.
  - The narrowest and least dilatable point is the **external urethral meatus**.
- **Prostatic Enlargement:**
  - Compresses prostatic urethra ? difficulty in micturition and incomplete bladder emptying.
- **Urethral Calculus:**
  - Small stones may lodge at constrictions:
    1. Internal urethral orifice,
    2. Membranous part,
    3. External urethral meatus.
- **Cystoscopy and Urethroscopy:**
  - Endoscopic procedures to visualize mucosa, identify obstructions or tumors.

Female Urethra

- The **female urethra** is a **short, straight tube** about **4 cm long** and **6 mm wide**, extending from the **internal urethral orifice** (at the bladder neck) to the **external urethral orifice** (in the vestibule of the vagina).
- It serves **only urinary function** (unlike the male urethra).

Course:

- Begins at the **neck of the bladder**, runs downward and forward, and opens in the **vestibule**, between the **clitoris** and **vaginal orifice**.
- It is embedded in the **anterior vaginal wall**.

Relations:

- **Anteriorly:** Pubic symphysis and retropubic venous plexus.
- **Posteriorly:** Anterior vaginal wall.
- **Laterally:** Pubourethral ligaments and paraurethral glands.

Openings:

- **External urethral orifice** lies about **2.5 cm behind the clitoris** and **2.5 cm in front of the vaginal opening**.

Epithelium:

- **Proximal part:** Transitional epithelium.
- **Middle part:** Stratified columnar epithelium.

- **Distal part:** Stratified squamous epithelium.

Special glands:

- **Paraurethral glands (Skene's glands):**
    - Homologous to male **prostate**.
    - Open near the external meatus on either side.
    - Secrete mucus for lubrication.

Sphincters:

- **Internal urethral sphincter (functional):** Smooth muscle at bladder neck.
- **External urethral sphincter:** Skeletal muscle fibers from **sphincter urethrae** and **compressor urethrae** in the deep perineal pouch; provides voluntary control of micturition.

Walls of the Urethra

The wall of the female urethra (and structurally similar layers in the male urethra) is composed of:

1. **Mucous membrane:**
    - Highly elastic; forms longitudinal folds.
    - Lined by transitional to stratified squamous epithelium.
    - Contains numerous **urethral glands (glands of Littre)**.

2. **Submucosa:**
    - Rich in **venous plexus**, which contributes to urethral closure pressure.
3. **Muscular coat:**
    - **Inner longitudinal** and **outer circular** smooth muscle layers.
    - In the lower part, circular fibers are thickened to form a **sphincter urethrae**.
    - External voluntary muscle (striated) surrounds the lower half — supplied by the **pudendal nerve (S2–S4)**.

Micturition

Definition:

- The **process of emptying urine** from the bladder through the urethra.

Phases:

1. **Storage phase:**
    - Controlled by **sympathetic system (T11–L2)**.
    - **Detrusor muscle** relaxed; **internal sphincter** contracted.
    - **External sphincter** (voluntary control via pudendal nerve) remains contracted.
2. **Voiding phase:**
    - Controlled by **parasympathetic system (S2–S4)**.

- **Detrusor contracts** ? increased bladder pressure.
- **Internal sphincter relaxes**.
- **External sphincter** voluntarily relaxed.

Micturition reflex:

- Initiated when bladder fills (~300 mL); stretch receptors activate parasympathetic fibers.
- Reflex centers located in **sacral spinal cord (S2–S4)**.
- **Higher control:**
  - **Pontine micturition center** (brainstem) coordinates reflex.
  - **Cerebral cortex** allows voluntary initiation or suppression.

In infants:

- Reflex is automatic (spinal).
  In adults:
- Voluntary control developed through cortical regulation.

Clinical Anatomy

- **Urinary tract infection (UTI):**
  - Common in females due to short urethra and proximity to vagina and anus.
  - Leads to dysuria (painful urination), frequency, urgency, and suprapubic pain.

- **Urethral stricture:**
    - Narrowing of the urethra, rare in females; usually follows infection or trauma.
- **Stress urinary incontinence:**
    - Leakage of urine during coughing or exertion.
    - Caused by weakness of pelvic floor or sphincter urethrae, commonly after childbirth or aging.
- **Urethral diverticulum:**
    - Outpouching of urethral wall into the vaginal wall; may cause post-void dribbling and infection.
- **Cystocele:**
    - Downward displacement of bladder and urethra into anterior vaginal wall due to levator ani weakness.
- **Neurogenic bladder:**
    - Occurs in spinal cord injury or multiple sclerosis.
    - Loss of voluntary micturition; bladder may become spastic or flaccid.
- **Catheterization:**
    - Easier in females because urethra is short, straight, and wide.
    - Care required to avoid infection or injury to mucosa.

- **Urethral caruncle:**
    - Small, red, painful growth near external urethral meatus in postmenopausal women due to estrogen deficiency.
- **Urinary retention:**
    - Inability to void urine; may result from urethral obstruction, prolapse, or nerve lesion.
    - Treated by **catheterization** or **suprapubic cystostomy** if prolonged.

Development of the Urinary Bladder

- The **urinary bladder** develops mainly from the **vesicourethral part of the cloaca**, which is derived from the **endoderm of the urogenital sinus**.
- The **cloaca**, an endodermal cavity, is divided during development by the **urorectal septum** into:
    - **Anterior part: Primitive urogenital sinus** (gives rise to bladder and urethra).
    - **Posterior part: Anorectal canal** (forms rectum and anal canal).

Steps in Development:

1. **Vesicourethral portion of urogenital sinus:**
    - Forms the **urinary bladder**.
    - The **upper part of the allantois** becomes the **urachus**, which later obliterates to form the **median umbilical ligament** connecting bladder apex to the umbilicus.

2. **Mesonephric ducts (Wolffian ducts):**
    - Initially open into the posterior wall of the bladder.
    - Later, they are absorbed into the wall of the bladder to form part of the **trigone** region.
    - Their lower ends become the **ejaculatory ducts** in males.
3. **Ureters:**
    - Develop separately as **outgrowths from the mesonephric ducts**.
    - Their orifices are shifted cranially and laterally to open independently into the posterior wall of the bladder.

Lining epithelium:

- Derived from **endoderm** (urogenital sinus).
- The **trigone**, however, initially has **mesodermal origin** (from absorbed mesonephric ducts), but later becomes **endodermal** as the mucosa overgrows it.

Development of the Urethra

1. In Males:

- Develops from **both endodermal urogenital sinus** and **ectodermal invagination**.
- Divided into three developmental regions:

  a. **Prostatic and membranous urethra:**
  - Develop from **pelvic part of urogenital sinus** (endodermal).

b. **Spongy (penile) urethra:**
- Develops from **phallic part of urogenital sinus** (endodermal).
- The distal part within the glans develops from an **ectodermal invagination** called the **glandular plate**, which later canalizes and joins the endodermal urethra.

c. **Ejaculatory ducts:**
- Formed from the **lower parts of mesonephric ducts**, which open into the prostatic urethra.

d. **Prostatic utricle:**
- Small midline pouch in the prostatic urethra, homologous to the **uterus and vagina** (from paramesonephric duct).

Epithelium:

- Entirely **endodermal**, except the very terminal part (in glans), which is **ectodermal**.

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2. In Females:

- The **female urethra** develops entirely from the **pelvic part of the urogenital sinus** (endodermal).
- The surrounding connective tissue and smooth muscle are derived from **splanchnic mesoderm**.
- The **paraurethral glands (Skene's glands)** develop as outgrowths from the urethral wall; they are homologous to the **prostate gland** in males.

Developmental Anomalies

1. **Exstrophy of the bladder:**
    - Due to failure of the anterior abdominal wall and anterior bladder wall to fuse.

- Leads to exposure of the posterior bladder wall and ureteric orifices on the surface.

2. **Patent urachus (Urachal fistula):**
   - Failure of the **urachus** to close ? urine discharges from the **umbilicus**.
   - Partial closure may result in a **urachal sinus** or **urachal cyst**.
3. **Duplication of bladder:**
   - Rare; occurs due to abnormal division of the cloaca or allantois.
4. **Ectopic ureteric openings:**
   - Ureter may open into vagina, vestibule, or urethra due to abnormal incorporation of the mesonephric ducts.
5. **Hypospadias:**
   - Failure of fusion of the urethral folds ? external urethral meatus opens on **ventral surface** of penis.
6. **Epispadias:**
   - Urethral opening on **dorsal surface** of penis, often associated with **exstrophy of bladder**.
7. **Congenital absence of urethra:**
   - Extremely rare; results from complete failure of urogenital sinus development.
8. **Urethral diverticulum:**

- Outpouching from urethral wall, may arise congenitally or secondarily from infection of paraurethral glands.

Summary Insight

- The **urinary bladder** is primarily **endodermal** in origin (urogenital sinus), with **mesodermal contribution** to its trigone.
- The **male urethra** has **dual origin** — mostly endodermal, with distal ectodermal contribution.
- The **female urethra** is wholly **endodermal**.
- Developmental defects often reflect **failure of midline fusion** or **malformation of cloacal derivatives**, producing clinically significant anomalies such as **exstrophy, urachal fistula, hypospadias,** and **epispadias**.

Facts to Remember

- The **urinary bladder** develops mainly from the **vesicourethral part of the urogenital sinus**, which is derived from **endoderm**.
- The **trigone of the bladder** is initially formed from the **mesoderm** of the absorbed mesonephric ducts, but later becomes lined by **endodermal epithelium**.
- The **allantois** becomes the **urachus**, which later fibroses to form the **median umbilical ligament**, connecting the bladder apex to the umbilicus.
- The **epithelium of the bladder** is **transitional (urothelium)**, allowing great distensibility.

- The **urinary bladder** first lies in the **abdomen** in the fetus and gradually descends into the **pelvis** after birth.
- The **male urethra** develops from both **endodermal and ectodermal sources**:
    - **Prostatic and membranous parts** ? endoderm (pelvic part of urogenital sinus).
    - **Spongy part** ? endoderm (phallic part of urogenital sinus).
    - **Terminal part within glans** ? ectoderm (glandular plate).
- The **female urethra** develops entirely from the **endodermal pelvic part of the urogenital sinus**.
- The **surrounding muscle and connective tissue** of bladder and urethra are derived from **splanchnic mesoderm**.
- The **paraurethral glands (Skene's glands)** in females are homologous to the **prostate gland** in males.
- The **bulbourethral glands (Cowper's glands)** in males are homologous to the **greater vestibular glands (Bartholin's glands)** in females.
- The **ureters** arise as **outgrowths of the mesonephric ducts**, later attaining a separate opening in the bladder wall.
- **Exstrophy of the bladder** results from failure of fusion of the **anterior abdominal wall** and **anterior bladder wall**.
- **Patent urachus** leads to **urine leakage from the umbilicus**.
- **Hypospadias** results from **incomplete fusion of urethral folds**, causing ventral urethral opening.

- **Epispadias** results from **abnormal positioning of the genital tubercle**, leading to a dorsal urethral opening and association with **bladder exstrophy**.

- The **internal urethral sphincter** (smooth muscle) is **involuntary** and present in males; the **external sphincter** (skeletal muscle) is **voluntary** and present in both sexes.

- **Micturition** is a reflex act controlled by **parasympathetic fibers (S2–S4)** and regulated by **pontine centers** and the **cerebral cortex**.

- **Lymphatic drainage** of the bladder is primarily to **external and internal iliac nodes**, while the urethra drains to **inguinal nodes (distal part)**.

- The **urethral epithelium** changes along its course — **transitional ? pseudostratified columnar ? stratified squamous** near the external orifice.

- In both sexes, congenital or acquired abnormalities (strictures, diverticula, prolapse) are closely linked to developmental variations in these embryonic structures.

Clinicoanatomical Problem

Case 1:
A newborn infant passes urine through the umbilicus instead of the urethral opening.

Question:
What is the developmental defect and its embryological basis?

Explanation:

- The condition is due to a **patent urachus** — persistence of the **allantoic canal**, which normally obliterates to form the **median umbilical ligament**.

- Urine escapes through the umbilicus because the channel between the **bladder apex** and **umbilicus** remains open.

Clinical management:
Surgical excision of the patent urachus and repair of the bladder wall are required to prevent infection and urine leakage.

Case 2:
A male infant presents with the urethral opening on the **ventral surface of the penis**.

Question:
What is the diagnosis, and what is its embryological cause?

Explanation:

- Diagnosis: **Hypospadias.**
- Caused by **failure of fusion of the urethral folds** during development of the penile urethra.
- The external urethral meatus opens on the **underside of the penis**, scrotum, or perineum depending on the severity.

Clinical importance:
Hypospadias may cause abnormal urine stream and difficulty during sexual intercourse; corrected by **surgical reconstruction** (urethroplasty).

Case 3:
A child is born with the urethral opening on the **dorsal surface of the penis**, associated with **exstrophy of the bladder**.

Question:
Name the condition and explain its cause.

Explanation:

- Condition: **Epispadias**, often occurring with **bladder exstrophy**.
- Caused by **abnormal positioning of the genital tubercle** posterior to the urogenital membrane during development.
- Leads to failure of midline fusion of the abdominal wall and exposure of the bladder mucosa.

Clinical insight:
Requires **reconstructive surgery** to restore urethral continuity and close the anterior bladder wall.

Case 4:
A 30-year-old woman complains of **continuous urinary leakage** despite normal urination. Examination reveals a small opening in the **anterior vaginal wall**.

Question:
What is the probable diagnosis, and how does it arise embryologically?

Explanation:

- Diagnosis: **Urethrovaginal fistula** (or ectopic ureteric opening).
- May result from **abnormal incorporation of mesonephric duct** into the bladder wall or defective partition of the cloaca.
- The ureter opens ectopically into the **vagina or urethra**, leading to continuous dribbling of urine.

Treatment:
Surgical repositioning of the ureteric opening into the bladder.

Case 5:
A neonate shows a large defect in the lower abdominal wall with exposed, everted bladder mucosa.

Question:
What is the condition and embryological explanation?

Explanation:

- Condition: **Exstrophy of the urinary bladder.**
- Caused by **failure of mesodermal migration** between ectoderm and endoderm in the infraumbilical region, preventing formation of the anterior bladder wall and lower abdominal muscles.
- The posterior bladder wall (mucosa) remains exposed through the abdominal wall defect.

Clinical importance:
Requires **early surgical repair** to cover the bladder and prevent infection or urinary leakage.

Case 6:
A young adult male presents with a **midline suprapubic swelling** that occasionally discharges clear fluid.

Question:
What is the possible diagnosis, and what structure is involved?

Explanation:

- Diagnosis: **Urachal cyst or sinus.**
- Caused by **partial persistence of the urachus**, where a cyst forms between the bladder and umbilicus.
- May become infected or communicate intermittently with the bladder or umbilicus.

Treatment:
Complete surgical excision of the cyst and fibrous tract.

Case 7:
A male patient develops **urinary retention** following pelvic fracture. Imaging shows a tear in the **membranous urethra**.

Question:
Why is this site particularly vulnerable?

Explanation:

- The **membranous urethra** passes through the **urogenital diaphragm (deep perineal pouch)** and is **fixed** at both ends — by the prostate above and bulb of penis below.
- Sudden pelvic displacement causes rupture at this immobile segment.

Clinical consequence:

- Urine and blood accumulate in the **deep perineal pouch** and **pelvic region**.
- Immediate suprapubic cystostomy is required to drain urine and prevent extravasation.

Summary Insight:
Most **developmental anomalies of the bladder and urethra** result from:

- Incomplete **fusion of midline structures**,
- **Abnormal descent or incorporation** of ducts, or
- **Failure of canal closure** (urachus or cloacal defects).
  Understanding their embryological basis is vital for **accurate diagnosis and surgical correction**.

Frequently Asked Questions

Q1. From which embryonic structure does the urinary bladder develop?
A. The bladder develops mainly from the **vesicourethral part of the urogenital sinus**, which is derived from **endoderm**.

Q2. What is the origin of the trigone of the bladder?
A. It is initially formed from **mesoderm** of the absorbed **mesonephric ducts**, but later becomes lined by **endodermal epithelium**.

Q3. What is the embryological origin of the urachus?
A. The **urachus** is a fibrous remnant of the **allantois**, which connects the apex of the bladder to the umbilicus and later becomes the **median umbilical ligament**.

Q4. How does the bladder position change after birth?
A. In the **fetus and infant**, the bladder lies **abdominal**, and as the pelvis develops, it gradually descends to become a **pelvic organ** in adults.

Q5. From what part of the urogenital sinus does the urethra develop?
A.

- **In males:** From **pelvic and phallic parts** of the urogenital sinus (endoderm).
- **In females:** Entirely from the **pelvic part** of the urogenital sinus.

Q6. What is the embryological origin of the male urethra?
A.

- **Prostatic and membranous urethra:** Endodermal (pelvic part of urogenital sinus).
- **Spongy urethra:** Endodermal (phallic part).
- **Terminal part within glans:** Ectodermal (from glandular plate).

Q7. What is the origin of the female urethra?
A. Entirely from the **pelvic part of the urogenital sinus (endoderm)**.

Q8. What is the origin of the connective tissue and smooth muscle of bladder and urethra?
A. They are derived from **splanchnic mesoderm**.

Q9. What are paraurethral (Skene's) glands, and what is their male homolog?
A. The **paraurethral glands** in females are small mucus-secreting glands homologous to the **prostate gland** in males.

Q10. What are the bulbourethral (Cowper's) glands, and what is their female homolog?
A. The **bulbourethral glands** in males correspond to the **greater vestibular (Bartholin's) glands** in females.

Q11. How are ureters formed embryologically?
A. Each **ureter** develops as a **bud from the mesonephric duct**, which grows cranially and later opens independently into the posterior bladder wall.

Q12. What is exstrophy of the bladder?
A. A congenital defect where the **anterior abdominal wall and anterior bladder wall** fail to develop, leaving the **posterior bladder wall exposed** through a midline defect.

Q13. What is a patent urachus, and what are its effects?
A. A **persistent urachus** that remains open from the bladder to the umbilicus, causing **urine to discharge from the umbilicus**.

Q14. What are urachal anomalies other than patent urachus?
A.

- **Urachal cyst:** Central part of urachus remains open.
- **Urachal sinus:** Opens at the umbilical end only.

- **Urachal fistula:** Entire canal remains open to both bladder and umbilicus.

Q15. What is hypospadias?
A. A condition where the **external urethral opening** appears on the **ventral (underside) surface** of the penis due to **failure of fusion of urethral folds**.

Q16. What is epispadias?
A. A defect where the **urethral opening** is on the **dorsal surface** of the penis, usually associated with **bladder exstrophy** and abnormal development of the **genital tubercle**.

Q17. What is the difference between hypospadias and epispadias?
A.

- **Hypospadias:** Ventral opening, failure of urethral fold fusion.
- **Epispadias:** Dorsal opening, due to misplaced genital tubercle.

Q18. What is a urachal cyst, and where is it located?
A. A **fluid-filled cystic swelling** in the midline between the **bladder and umbilicus**, caused by **partial persistence of urachus**.

Q19. What is the embryological origin of the prostatic utricle?
A. Derived from the **Müllerian (paramesonephric) ducts**, homologous to the **uterus and vagina** in females.

Q20. What causes duplication of the bladder?
A. Abnormal **division of the cloaca or allantois** during early embryonic development.

Q21. What are the possible sites of ectopic ureteric openings?
A. In males — prostatic urethra, seminal vesicle, or vas deferens;
In females — vagina, vestibule, or urethra.

Q22. What is the significance of trigone formation in the bladder?
A. The **trigone** marks the site of incorporation of **mesonephric ducts and ureteric buds**, forming a smooth area important for the **orientation of ureteric orifices** and prevention of reflux.

Q23. What is the embryological explanation for a urachal sinus opening at the umbilicus?
A. Failure of the **upper part of the urachus** to close, leaving a **blind-ending tract** open at the umbilicus.

Q24. Why are urinary anomalies often midline defects?
A. Because the **urinary system** develops from **midline endodermal structures** (cloaca, urogenital sinus, allantois), and failure of fusion or closure along the midline leads to such anomalies.

Q25. What is the clinical importance of knowing bladder and urethral development?
A. It helps in diagnosing and surgically managing **congenital anomalies** like **exstrophy, hypospadias, patent urachus, and ectopic ureters** accurately.

Summary Insight:
Understanding the **developmental anatomy** of the **bladder and urethra** explains many **congenital disorders**. Most anomalies result from **persistence of embryonic channels**, **faulty fusion of midline folds**, or **misplacement of duct openings**, all of which are correctable with precise surgical intervention.

Multiple Choice Questions

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1. The urinary bladder develops from which embryonic structure?
A. Mesonephric duct
B. Metanephric blastema
C. Vesicourethral part of the urogenital sinus
D. Allantois
? Answer: C. Vesicourethral part of the urogenital sinus

2. The epithelium of the urinary bladder is derived from:

A. Mesoderm

B. Endoderm

C. Ectoderm

D. Neural crest

? Answer: B. Endoderm

---

3. The trigone of the bladder is formed from:

A. Cloaca

B. Allantois

C. Absorbed mesonephric ducts

D. Metanephric blastema

? Answer: C. Absorbed mesonephric ducts

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4. What is the adult derivative of the allantois?

A. Median umbilical ligament

B. Medial umbilical ligament

C. Lateral umbilical ligament

D. Round ligament of liver

? Answer: A. Median umbilical ligament

---

5. The urachus connects which two structures during development?

A. Umbilicus and rectum

B. Bladder and umbilicus

C. Cloaca and urethra

D. Ureter and kidney

? Answer: B. Bladder and umbilicus

---

6. The prostatic and membranous parts of the male urethra develop from:

A. Pelvic part of urogenital sinus

B. Phallic part of urogenital sinus

C. Ectodermal invagination

D. Mesonephric duct

? **Answer:** A. Pelvic part of

---

7. The spongy part of the male urethra develops from:

A. Mesonephric duct

B. Pelvic part of urogenital sinus

C. Phallic part of urogenital sinus

D. Glandular plate (ectodermal)

? Answer: C. Phallic part of urogenital sinus

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8. The terminal part of the male urethra in the glans penis develops from:

A. Endoderm

B. Mesoderm

C. Ectoderm

D. Neural crest

? Answer: C. Ectoderm

---

9. The female urethra develops from which embryonic structure?

A. Pelvic part of the urogenital sinus

B. Phallic part of the urogenital sinus

C. Mesonephric duct

D. Paramesonephric duct

? Answer: A. Pelvic part of the urogenital sinus

---

10. The connective tissue and smooth muscle of the bladder are derived from:

A. Endoderm

B. Ectoderm

C. Splanchnic mesoderm

D. Somatic mesoderm

? Answer: C. Splanchnic mesoderm

---

11. Which of the following glands in females is homologous to the prostate gland in males?

A. Bartholin’s gland

B. Skene’s gland (paraurethral gland)

C. Vestibular gland

D. Cowper’s gland

? Answer: B. Skene’s gland (paraurethral gland)

---

12. Which of the following glands in females corresponds to the bulbourethral (Cowper’s) glands of males?

A. Skene’s glands

B. Bartholin’s glands

C. Vestibular glands

D. Urethral glands

? Answer: B. Bartholin’s glands

---

13. The ureters develop as outgrowths from:

A. Urogenital sinus

B. Mesonephric ducts

C. Metanephric blastema

D. Cloaca

? Answer: B. Mesonephric ducts

---

14. Failure of the anterior abdominal wall and bladder wall to develop results in:

A. Epispadias

B. Hypospadias

C. Exstrophy of bladder

D. Patent urachus

? Answer: C. Exstrophy of bladder

---

15. Urine leakage from the umbilicus in a newborn is due to:

A. Patent urachus

B. Hypospadias

C. Epispadias

D. Bladder exstrophy

? Answer: A. Patent urachus

---

16. Hypospadias occurs due to:

A. Failure of fusion of urethral folds

B. Failure of descent of testes

C. Abnormal position of genital tubercle

D. Persistence of urachus

? Answer: A. Failure of fusion of urethral folds

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17. Epispadias is associated with:

A. Failure of urethral fold fusion

B. Abnormal position of genital tubercle

C. Incomplete cloacal division

D. Failure of mesonephric duct absorption

? Answer: B. Abnormal position of genital tubercle

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18. The prostatic utricle in males is homologous to which female structure?

A. Vagina

B. Uterus and vagina

C. Uterine tube

D. Ovary

? Answer: B. Uterus and vagina

---

19. Which of the following is a remnant of the mesonephric duct in males?

A. Ureter

B. Ejaculatory duct

C. Urachus

D. Seminal vesicle

? Answer: B. Ejaculatory duct

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20. The most common site for ectopic ureteric opening in females is:

A. Urethra

B. Vestibule

C. Vagina

D. Uterus

? Answer: C. Vagina

---

21. Duplication of the bladder results from:

A. Abnormal division of the cloaca

B. Incomplete descent of ureter

C. Failure of urachus closure

D. Fusion of mesonephric ducts

? Answer: A. Abnormal division of the cloaca

---

22. The lumen of the urachus normally disappears during:

A. 2nd month of intrauterine life

B. 4th month of intrauterine life

C. 6th month of intrauterine life

D. At birth

? Answer: B. 4th month of intrauterine life

---

23. Which of the following anomalies is due to partial persistence of the urachus?

A. Urachal fistula

B. Urachal sinus or cyst

C. Patent urachus

D. Exstrophy of bladder

? Answer: B. Urachal sinus or cyst

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24. Which congenital anomaly causes a dorsal urethral opening?

A. Epispadias

B. Hypospadias

C. Urachal fistula

D. Cloacal malformation

? Answer: A. Epispadias

---

25. Which congenital anomaly causes a ventral urethral opening?

A. Hypospadias

B. Epispadias

C. Patent urachus

D. Urethral diverticulum

? Answer: A. Hypospadias

26. The epithelial lining of the urinary bladder is:

A. Stratified squamous

B. Transitional epithelium

C. Cuboidal epithelium

D. Columnar epithelium

? Answer: B. Transitional epithelium

---

27. Micturition reflex is mediated mainly by:

A. Sympathetic fibers (T11–L2)

B. Parasympathetic fibers (S2–S4)

C. Somatic fibers (L4–S1)

D. Hypogastric plexus alone

? Answer: B. Parasympathetic fibers (S2–S4)

---

28. The muscle responsible for bladder contraction during urination is:

A. Levator ani

B. Detrusor muscle

C. Sphincter urethrae

D. Obturator internus

? Answer: B. Detrusor muscle

---

29. The external urethral sphincter is supplied by:

A. Sympathetic nerves

B. Pelvic splanchnic nerves

C. Pudendal nerve

D. Hypogastric plexus

? Answer: C. Pudendal nerve

---

30. The lymphatic drainage of the bladder primarily reaches:

A. Inguinal nodes

B. Internal and external iliac nodes

C. Para-aortic nodes

D. Sacral nodes only

? **Answer:** B. Internal and external

Viva Voce

Q1. What is the embryological origin of the urinary bladder?
A. It develops from the **vesicourethral part of the urogenital sinus**, which is **endodermal** in origin.

Q2. What forms the trigone of the bladder?
A. The **trigone** is formed by the **absorption of the mesonephric ducts** into the posterior wall of the bladder.
It is initially **mesodermal** but later lined by **endodermal epithelium**.

Q3. What is the fate of the allantois?
A. The allantois becomes the **urachus**, which later fibroses to form the **median umbilical ligament** connecting the bladder apex to the umbilicus.

Q4. What is the epithelial lining of the urinary bladder?
A. The bladder is lined by **transitional epithelium (urothelium)** that allows stretching during filling.

Q5. What is the position of the bladder in infants and adults?
A.

- In **infants**, the bladder is **abdominal** in position.
- In **adults**, it becomes a **pelvic organ** as the pelvis enlarges.

Q6. From which structure does the male urethra develop?
A. The **male urethra** develops from both **endodermal urogenital sinus** and **ectodermal invagination** at the glans penis.

Q7. From which structure does the female urethra develop?
A. The **female urethra** develops entirely from the **pelvic part of the urogenital sinus** (endodermal).

Q8. What is the embryological origin of the ureters?
A. The **ureters** develop as **outgrowths from the mesonephric ducts**, which later open separately into the bladder wall.

Q9. What is the function of the detrusor muscle?
A. The **detrusor muscle** contracts during **micturition** to expel urine from the bladder.

Q10. What is the nerve supply of the urinary bladder?
A.

- **Parasympathetic (S2–S4):** Motor to detrusor, inhibitory to sphincter.
- **Sympathetic (T11–L2):** Inhibitory to detrusor, motor to internal sphincter.
- **Somatic (pudendal nerve):** Voluntary control of external sphincter.

Q11. What initiates the micturition reflex?
A. Stretch receptors in the bladder wall stimulate **parasympathetic centers (S2–S4)** when the bladder fills (~300 mL).

Q12. What is the difference between the internal and external urethral sphincters?
A.

- **Internal sphincter:** Smooth muscle, involuntary, located at bladder neck.
- **External sphincter:** Skeletal muscle, voluntary, located in deep perineal pouch.

Q13. What are the homologous structures of the prostate and paraurethral glands?
A. The **paraurethral (Skene's) glands** in females are homologous to the **prostate gland** in males.

Q14. What are the homologous structures of Cowper's and Bartholin's glands?
A. The **Cowper's glands (bulbourethral glands)** in males correspond to the **Bartholin's glands (greater vestibular glands)** in females.

Q15. What are the common congenital anomalies of the urinary bladder?
A.

- **Exstrophy of bladder**
- **Patent urachus**
- **Urachal cyst or sinus**
- **Duplication of bladder**

Q16. What causes urine leakage from the umbilicus in a newborn?
A. It is due to a **patent urachus**, where the connection between the bladder and umbilicus fails to close.

Q17. What is exstrophy of the bladder?
A. A condition in which the **anterior bladder wall and anterior abdominal wall fail to fuse**, exposing the bladder mucosa.

Q18. What is hypospadias?
A. An abnormality where the **urethral opening is on the ventral surface of the penis**, due to **failure of fusion of urethral folds**.

Q19. What is epispadias?
A. An abnormality where the **urethral opening is on the dorsal surface of the penis**, usually

associated with **bladder exstrophy**.

Q20. What is the difference between hypospadias and epispadias?
A.

- **Hypospadias:** Ventral opening; due to failed fusion of urethral folds.
- **Epispadias:** Dorsal opening; due to misplacement of the genital tubercle.

Q21. What is a urachal cyst?
A. A **fluid-filled midline swelling** between the bladder and umbilicus due to **partial persistence of urachus**.

Q22. What is the prostatic utricle, and what is its significance?
A. The **prostatic utricle** is a small midline pouch in the prostatic urethra, homologous to the **uterus and vagina** in females.

Q23. What are the common sites of ectopic ureteric openings?
A.

- **Males:** Prostatic urethra, seminal vesicle, or vas deferens.
- **Females:** Vagina, vestibule, or urethra.

Q24. What is the most dilatable part of the male urethra?
A. The **prostatic urethra**.

Q25. What is the narrowest part of the male urethra?
A. The **external urethral meatus**.

Q26. Which part of the male urethra is most prone to injury in pelvic fractures?
A. The **membranous urethra**.

Q27. Which part of the male urethra is most commonly affected in stricture formation?
A. The **bulbar urethra**.

Q28. What is the function of the urethral glands (glands of Littre)?
A. They secrete mucus to **lubricate the urethra** and facilitate passage of urine or semen.

Q29. Which nerve provides voluntary control of micturition?
A. The **pudendal nerve** (S2–S4) controlling the **external urethral sphincter**.

Q30. What is the lymphatic drainage of the bladder?
A. Mainly to **internal and external iliac lymph nodes**; the trigone may also drain to **sacral nodes**.

Q31. What is the lymphatic drainage of the distal urethra?
A. To the **superficial inguinal lymph nodes**.

Q32. What are the main differences between male and female urethra?
A.

- **Length:** Male 18–20 cm; Female 4 cm.
- **Function:** Male – urinary and reproductive; Female – urinary only.
- **Course:** Male – curved; Female – straight.
- **Sphincter:** Both have external sphincter; internal sphincter present only in males.

Q33. What is the clinical significance of knowing urethral curvatures in males?
A. During **catheterization**, the penis must be lifted to straighten the urethral curve and prevent injury or false passage.

Q34. What is the nerve root value of the micturition reflex?
A. S2, S3, and S4 spinal segments.

Q35. Why is urinary infection more common in females?

A. Because the **urethra is short, straight, and close to the vagina and anus**, facilitating ascending infection.

Q36. What is stress urinary incontinence?

A. Involuntary leakage of urine during coughing or exertion due to **weakness of pelvic floor or sphincter urethrae**, commonly after childbirth.

Q37. What is cystocele?

A. Downward protrusion of the **urinary bladder into the anterior vaginal wall** due to weakness of **levator ani** and **pelvic fascia**.

Q38. What is the developmental cause of exstrophy–epispadias complex?

A. Failure of **mesodermal migration** between ectoderm and endoderm in the infraumbilical region, resulting in absence of the **anterior bladder wall** and **pubic separation**.

Q39. What is the importance of trigone smoothness in cystoscopy?

A. A **smooth trigone** indicates normal development; irregularity or elevation may suggest **pathology such as inflammation or tumor**.

Q40. What is the homology of male and female urethra?

A. Both are derived from the **urogenital sinus**, though the male urethra extends further due to the development of external genitalia.

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