MEDICAL EDUCATION RESOURCE

Contents of Vertebral Canal

Contents of Vertebral Canal

Introduction

- The **vertebral canal** is the **bony canal formed by vertebral foramina** of all the vertebrae.
- It extends from the **foramen magnum** above to the **sacral hiatus** below.
- It transmits and protects the **spinal cord**, its **meninges**, and related **neurovascular structures**.
- In the cervical region, the canal is **triangular and spacious** to accommodate the cervical enlargement of the spinal cord.

Contents

The main contents of the vertebral canal include:

1. **Spinal cord**
2. **Spinal meninges**
3. **Cerebrospinal fluid (CSF)**
4. **Spinal nerve roots** (dorsal and ventral)

5. **Blood vessels** of spinal cord and meninges
6. **Epidural fat and venous plexuses** (in epidural space)

Arrangement of Structures (from within outward)

1. **Spinal Cord** – the central nervous structure.
2. **Pia Mater** – thin vascular membrane adhering to the cord.
3. **Subarachnoid Space** – contains cerebrospinal fluid.
4. **Arachnoid Mater** – delicate, transparent membrane.
5. **Subdural Space** – potential space.
6. **Dura Mater** – thick fibrous membrane forming dural sheath.
7. **Epidural Space** – between dura mater and vertebral canal; contains **fat** and **internal vertebral venous plexus**.

Spinal Cord

- Extends from **foramen magnum to the lower border of L1 vertebra** in adults.
- In children, it extends up to **L3 vertebra**.
- Enlarged in **cervical (C4–T1)** and **lumbosacral (L1–S2)** regions due to limb innervation.
- Tapers below into the **conus medullaris**, continued as **filum terminale**.
- From conus, **cauda equina** (bundle of nerve roots) descends within lumbar cistern.

Meninges of Spinal Cord

1. **Pia Mater**
    - Closely invests the spinal cord.
    - Sends **denticulate ligaments** to dura mater for anchorage.
    - Continues downward as **filum terminale internum** (up to S2) and **externum** (to coccyx).
2. **Arachnoid Mater**
    - Thin, avascular membrane enclosing **subarachnoid space**.
    - CSF circulates in this space and cushions the cord.
3. **Dura Mater**
    - Tough outer sheath extending from **foramen magnum to S2**.
    - Fuses with **filum terminale externum** below.
    - Surrounds **spinal nerves** as dural sleeves.

Epidural Space

- Lies between the **dura mater** and **vertebral canal**.
- Contains **loose areolar tissue, fat, and internal vertebral venous plexus**.
- Clinically important for **epidural anesthesia**.

Blood Supply

- **Arteries:**
  - **One anterior spinal artery** and **two posterior spinal arteries** (from vertebral arteries).
  - Reinforced by **radicular arteries** from intercostal and lumbar arteries.
- **Veins:**
  - **Internal vertebral venous plexus** in epidural space ? communicates with **cranial venous sinuses** and **external vertebral plexus**.

Dissection

1. Remove the **posterior elements** (laminae and spinous processes) of vertebrae.
2. Expose the **dura mater** enclosing the cord.
3. Open dura longitudinally to display **arachnoid, CSF, and spinal cord**.
4. Identify **nerve roots**, **denticulate ligaments**, and **conus medullaris**.
5. Note **cauda equina** and **filum terminale** in the lumbar region.

Clinical Anatomy

- **Lumbar Puncture:**
  - Performed in the **L3–L4 or L4–L5 interspace**, below termination of spinal cord.

- Needle passes through **skin ? ligaments ? dura ? arachnoid** to reach **subarachnoid space**.
- Used for **CSF withdrawal** or **spinal anesthesia**.

- **Epidural Anesthesia:**
  - Injection into **epidural space** to block spinal nerves.
  - Common in **obstetrics and lower limb surgeries**.
- **Spinal Shock:**
  - Loss of motor and sensory function **below lesion** due to cord injury.
  - Reflexes are initially absent, later become exaggerated.
- **Cauda Equina Syndrome:**
  - Compression of cauda equina roots (e.g., herniated disc, tumor).
  - Causes **saddle anesthesia**, **loss of bladder and bowel control**, and **leg weakness**.
- **Meningitis:**
  - Inflammation of meninges; diagnosed by **CSF analysis via lumbar puncture**.
- **Epidural Abscess:**
  - Infection in epidural space ? compression of spinal cord ? **neurological deficits**.
- **CSF Leak:**

- Can occur after trauma or puncture ? **post-dural puncture headache** due to CSF pressure loss.

Spinal Nerves

Formation

- Each **spinal nerve** is formed by the union of **anterior (motor)** and **posterior (sensory) roots** of the spinal cord.
- The union occurs **within the intervertebral foramen**.

Division

After emerging from the intervertebral foramen, each spinal nerve divides into:

1. **Dorsal (posterior) ramus** – supplies **muscles and skin of the back**.
2. **Ventral (anterior) ramus** – supplies **muscles and skin of limbs and anterior part of trunk**.
    - In cervical, brachial, lumbar, and sacral regions, these rami form **plexuses**.
3. **Meningeal branch** – re-enters the vertebral canal to supply **meninges, vertebrae, and blood vessels**.
4. **Ramus communicans** – connects to the **sympathetic ganglion**.

Functional Types of Fibres

Each spinal nerve carries **four functional types of fibres**:

- **Somatic efferent (motor)** – to skeletal muscles.
- **Somatic afferent (sensory)** – from skin and joints.
- **Visceral efferent** – to smooth muscle and glands (via sympathetic fibres).
- **Visceral afferent** – from viscera.

Number and Distribution of Spinal Nerves

- **Total:** 31 pairs.
    - **Cervical:** 8 pairs
    - **Thoracic:** 12 pairs
    - **Lumbar:** 5 pairs
    - **Sacral:** 5 pairs
    - **Coccygeal:** 1 pair
- The **first cervical nerve (C1)** emerges **above** the atlas, while the **eighth cervical nerve (C8)** emerges **below C7**.

Spinal Ganglia

- Each **posterior root** has a **spinal ganglion** that contains **sensory neuron cell bodies** (unipolar type).

- Located in the **intervertebral foramen**, outside the dura mater.
- The **anterior root** has **no ganglion**.

Coverings of Spinal Nerves

As they emerge, spinal nerves are covered by:

- **Pia mater** (inner vascular covering)
- **Arachnoid mater** (delicate membrane)
- **Dura mater** (fibrous sheath forming dural sleeve)

Clinical Anatomy

---

1. Root Compression

- **Intervertebral disc prolapse** or **osteophyte formation** can compress spinal nerve roots.
- Symptoms depend on level affected:
  - **Cervical:** Pain radiates to upper limb.
  - **Lumbar:** Sciatica due to L5 or S1 nerve compression.
  - **Cervical myelopathy** may occur if cord itself is compressed.

---

2. Nerve Injury

- **Trauma or surgical injury** can cause **loss of motor and sensory function** in the corresponding dermatome and myotome.
- **C5–T1** form brachial plexus ? injury leads to **limb weakness**.

---

3. Cauda Equina Syndrome

- Compression of lumbosacral nerve roots in **lumbar cistern** (L2–S2).
- Causes **urinary retention**, **saddle anesthesia**, and **paralysis of lower limbs**.
- Emergency surgical decompression required.

---

4. Shingles (Herpes Zoster)

- Reactivation of **varicella-zoster virus** in **spinal ganglion**.
- Painful vesicular eruption appears in the **dermatomal distribution** of affected nerve.

---

5. Lumbar Puncture Landmark

- Spinal cord ends at **L1 (adult)**; puncture done at **L3–L4 or L4–L5** to avoid injury.
- Allows safe access to **CSF in subarachnoid space**.

---

6. Epidural Block

- Injection into **epidural space** (outside dura mater).
- Used in **labor analgesia** or **pelvic surgery**.

---

7. Spinal Nerve Root Lesions

- **Anterior root lesion:** motor paralysis.
- **Posterior root lesion:** sensory loss.
- **Complete nerve lesion:** both motor and sensory loss in affected dermatome and myotome.

Vertebral System of Veins

Clinical Importance

- The **vertebral venous plexus** is of high clinical relevance because it provides a **pathway for the spread of infection and metastasis** between the **pelvis, vertebral column, and cranial cavity**.
- Common examples:
    - **Carcinoma of the prostate** ? spreads to **vertebral column and skull** via this system.
    - **Chronic empyema** ? may lead to **brain abscess** through septic emboli.

Anatomy of the Vertebral Venous Plexus

- The vertebral venous system is a **valveless, extensive network of veins** arranged **longitudinally**, parallel to the **vertebral column**.
- It communicates freely with the **superior and inferior venae cavae**.

- It consists of **three intercommunicating subdivisions**:

---

1. Internal (Epidural) Vertebral Venous Plexus

- Located **within the vertebral canal**, **outside the dura mater**.
- Divided into:
    - **Postcentral plexus** (behind vertebral bodies).
    - **Prelaminar plexus** (in front of the laminae).
- Drains **spinal structures** and empties into **segmental veins** — vertebral, posterior intercostal, lumbar, and lateral sacral veins.

---

2. Vertebral Body Plexus

- Lies **within the vertebral bodies**.
- Drains **backwards** into the **epidural plexus** and **anterolaterally** into the **external vertebral plexus**.

---

3. External Vertebral Venous Plexus

- Lies **outside the vertebral column**.
- Divided into:
    - **Anterior external plexus** — in front of vertebral bodies.
    - **Posterior external plexus** — on the posterior arches and adjacent muscles.

- Drains into **segmental veins**.

Suboccipital Venous Plexus

- Part of the **external plexus**, situated in the **suboccipital triangle**.
- Receives **occipital veins of the scalp**.
- Communicates with the **transverse sinus** via **emissary veins**.
- Ultimately drains into the **subclavian veins**.

Communications

The valveless vertebral venous system communicates:

1. **Superiorly** – with **intracranial venous sinuses**.
2. **Inferiorly** – with **pelvic veins** and **portal venous system**.

These communications explain the **bidirectional flow of blood**, facilitating both **normal venous return** and **pathological spread** of infection or tumor.

Clinical Correlations

- **Metastasis pathway:** Tumors (e.g., from prostate or breast) may spread to the **brain and vertebrae** via this plexus.
- **Raised intra-abdominal pressure** (coughing, straining) ? reverses venous flow ? allows retrograde spread.
- **Absence of valves** allows **free communication** between cranial and pelvic cavities.

Facts to Remember

- The **vertebral canal** extends from **foramen magnum** to **sacral hiatus**, enclosing and protecting the **spinal cord**, **meninges**, and **neurovascular structures**.
- The **spinal cord** ends at the **lower border of L1** in adults and **L3** in children.
- Below the cord lies the **lumbar cistern**, containing **cauda equina** and **CSF**.
- **Meninges of spinal cord:**
    - **Pia mater** ? forms **filum terminale** and **denticulate ligaments**.
    - **Arachnoid mater** ? encloses **CSF** in subarachnoid space.
    - **Dura mater** ? extends up to **S2**, continuous with cranial dura.
- **CSF** is formed in **choroid plexuses** and circulates in the **subarachnoid space** around the brain and cord.
- **Epidural space** (between dura and vertebral canal) contains **fat** and **internal vertebral venous plexus**.
- **Blood supply of spinal cord:**
    - One **anterior spinal artery** and two **posterior spinal arteries**, supported by **radicular arteries**.
- **31 pairs of spinal nerves:**

- 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, 1 coccygeal.

- **Vertebral venous plexus** is **valveless**, connecting **pelvic veins**, **vertebral veins**, and **cranial venous sinuses**, forming an important route for **spread of infection or cancer**.

Clinicoanatomical Problems

---

1. Spinal Cord Compression

- **Causes:** Tumors (meningioma, neurofibroma, glioma, metastasis).
- **Effect:** Depending on the level, produces **paraplegia or quadriplegia**.
- **Diagnostic clue:** Low CSF pressure below the block (Froin's syndrome).

---

2. Cauda Equina Syndrome

- **Cause:** Compression of cauda equina roots (herniated disc, tumor).
- **Symptoms:**
  - Flaccid paralysis of lower limbs.
  - **Saddle anesthesia** (loss of sensation in perineum).
  - Loss of bladder and bowel control.
- **Emergency:** Requires **urgent decompression**.

---

3. Intervertebral Disc Prolapse

- **Mechanism:** Nucleus pulposus herniates through annulus fibrosus.
- **Common levels:** L4–L5, L5–S1.
- **Effect:** Compression of nerve roots ? **sciatica** (shooting pain along leg).

---

4. Meningitis

- **Inflammation of meninges** (bacterial or viral).
- **Symptoms:** Headache, neck stiffness, fever, vomiting.
- **Diagnosis: Lumbar puncture** and **CSF examination**.

---

5. Spinal Anesthesia / Lumbar Puncture

- Done in **L3–L4 or L4–L5** level (below spinal cord).
- Used for **CSF sampling**, **drug administration**, or **spinal block**.

---

6. Spread of Malignancy

- Due to **valveless vertebral venous plexus**, cancers of **prostate, breast, or thyroid** can metastasize to **vertebral column or skull**.

---

7. Epidural Abscess

- Infection in **epidural space** ? compresses spinal cord ? **neurological deficits**.
- Requires **prompt drainage and antibiotics**.

---

8. Vertebral Venous Communication

- Explains **spread of infection** from **pelvic organs** or **abdomen** to **brain** or **vertebrae**, bypassing systemic circulation.

Frequently Asked Questions — Contents of Vertebral Canal

---

1. What are the contents of the vertebral canal?

The vertebral canal contains:

- **Spinal cord**
- **Meninges** (dura mater, arachnoid mater, pia mater)
- **Cerebrospinal fluid (CSF)**
- **Spinal nerves and roots**
- **Epidural fat and venous plexus**
- **Blood vessels of spinal cord**

---

2. What is the extent of the spinal cord?

- **In adults:** From **foramen magnum** to the **lower border of L1** vertebra.
- **In children:** Extends down to the **L3** vertebra.

---

3. What is the conus medullaris?

- The **conical lower end** of the spinal cord, situated opposite **L1 vertebra**.
- It gives rise to the **filum terminale** and **cauda equina**.

---

4. What is the cauda equina?

- A **bundle of descending lumbar, sacral, and coccygeal nerve roots** that continue below the conus medullaris within the **lumbar cistern**.

---

5. What is the lumbar cistern?

- The portion of the **subarachnoid space** below the termination of the spinal cord (L1–S2).
- It contains **CSF**, **cauda equina**, and **filum terminale**.
- Common site for **lumbar puncture**.

---

6. What is the extent of the dura mater in the spinal canal?

- The **dural sac** extends from the **foramen magnum** down to the **S2 vertebra**.

---

7. What is the epidural space?

- The space between the **dura mater** and **vertebral canal**.
- Contains **fat** and **internal vertebral venous plexus**.
- Site for **epidural anesthesia**.

---

8. What are denticulate ligaments?

- **Lateral extensions** of pia mater that attach to dura mater between nerve roots.
- They **anchor the spinal cord** centrally within the vertebral canal.

---

9. What is the filum terminale?

- **Fibrous prolongation of pia mater** from the conus medullaris.
- Extends to **S2** (filum terminale internum), then attaches to **coccyx** (filum terminale externum).

---

10. How is CSF obtained safely for examination?

- By **lumbar puncture** at **L3–L4 or L4–L5** interspace, below the end of the spinal cord.

---

11. What is the function of CSF?

- Protects and cushions the spinal cord.
- Maintains constant intracranial pressure.
- Provides nutrition and removes waste products.

---

12. What is the vertebral venous plexus and its importance?

- A **valveless network of veins** surrounding the spinal cord and vertebral column.
- Provides **bidirectional flow**, allowing **spread of infection or metastasis** between the **pelvis, vertebrae, and brain**.

---

13. Why are epidural veins clinically important?

- They can become **engorged in pregnancy or portal hypertension**, making **epidural anesthesia** technically difficult or risky.

---

14. What is the difference between subdural and epidural spaces?

- **Subdural space:** Potential space between dura and arachnoid mater.
- **Epidural space:** Actual space outside the dura, containing fat and veins.

---

15. What are the common sites for disc herniation?

- **L4–L5** and **L5–S1** intervertebral discs are most commonly affected, compressing corresponding spinal roots.

Multiple Choice Questions — Contents of Vertebral Canal

---

1. The spinal cord in adults terminates at the level of:
A. L3
B. L2
C. L1
D. L5
? **Answer:** C. L1

---

2. The subarachnoid space in the spinal canal ends at:
A. S2
B. L5
C. S1
D. L3

? **Answer:** A.

---

3. The cauda equina is formed by:

A. Cervical nerve roots

B. Lumbar, sacral, and coccygeal nerve roots

C. Thoracic nerve roots

D. Sympathetic trunks

? **Answer:** B. Lumbar, sacral, and coccygeal nerve roots

---

4. Lumbar puncture is performed at the level of:

A. L1–L2

B. L2–L3

C. L3–L4 or L4–L5

D. L5–S1

? **Answer:** C. L3–L4 or L4–L5

---

5. The filum terminale is derived from:

A. Dura mater

B. Pia mater

C. Arachnoid mater

D. Ligamentum flavum

? **Answer:** B. Pia mater

---

6. The epidural space contains:

A. CSF

B. Lymph

C. Fat and internal vertebral venous plexus

D. Gray matter

? **Answer:** C. Fat and internal vertebral venous plexus

---

7. The vertebral venous plexus is important because it is:

A. Lined by valves

B. Valveless, allowing retrograde spread of infection

C. Drains only cranial cavity

D. Drains only thorax

? **Answer:** B. Valveless, allowing retrograde spread of infection

---

8. The number of pairs of spinal nerves is:

A. 29

B. 30

C. 31

D. 32

? **Answer:** C. 31

---

9. The lowest part of the dural sac lies opposite:

A. L4

B. S1

C. S2

D. Coccyx

? **Answer:** C. S2

---

10. Which of the following is not a meningeal layer of the spinal cord?

A. Pia mater

B. Arachnoid mater

C. Endosteal layer

D. Dura mater

? **Answer:** C. Endosteal layer

---

11. The spinal cord ends at L3 in:

A. Adults

B. Children

C. Elderly

D. Fetuses only

? **Answer:** B. Children

---

12. The denticulate ligaments are:

A. Modifications of arachnoid mater

B. Modifications of dura mater

C. Modifications of pia mater

D. Collagen fibers in CSF

? **Answer:** C. Modifications of pia mater

---

13. Lumbar puncture needle passes through all except:

A. Skin

B. Supraspinous ligament

C. Dura mater

D. Body of vertebra

? **Answer:** D. Body of vertebra

---

14. The main arterial supply to the spinal cord is by:

A. Posterior cerebral arteries

B. Anterior and posterior spinal arteries

C. Vertebral venous plexus

D. Radicular veins

? **Answer:** B. Anterior and posterior spinal arteries

---

15. The clinical significance of the vertebral venous plexus is:

A. Causes meningitis

B. Allows spread of pelvic carcinoma to skull or brain

C. Collects CSF

D. Stores lymph

? **Answer:** B. Allows spread of pelvic carcinoma to skull or brain

Viva Voce — Contents of Vertebral Canal

Q1. What is the vertebral canal?

A continuous canal formed by the **vertebral foramina** of all vertebrae; it encloses the **spinal cord, meninges, and related vessels**.

Q2. What are the meninges of the spinal cord?

- **Dura mater** – outer tough covering.
- **Arachnoid mater** – thin, delicate middle layer.
- **Pia mater** – inner vascular membrane closely adherent to the cord.

Q3. What is the extent of the spinal cord?
From the **foramen magnum** to the **lower border of L1** in adults and **L3** in children.

Q4. What is the lumbar cistern?
The **subarachnoid space below L1 up to S2**, containing **CSF, cauda equina, and filum terminale**.

Q5. What is the filum terminale?
A **fibrous prolongation of pia mater** extending from the **conus medullaris** to the **coccyx**.

Q6. What are denticulate ligaments?
Lateral **tooth-like extensions of pia mater** that attach to dura mater and **anchor the spinal cord**.

Q7. What is the cauda equina?
A **bundle of descending lumbar, sacral, and coccygeal nerve roots** within the lumbar cistern below the conus medullaris.

Q8. What is the extent of the dura mater in the vertebral canal?
From **foramen magnum** to the level of **S2 vertebra**.

Q9. What does the epidural space contain?
Loose areolar tissue, fat, and internal vertebral venous plexus.

Q10. What is the clinical importance of the epidural space?
Site for **epidural anesthesia** and possible location for **epidural abscess**.

Q11. What is the vertebral venous plexus?
A **valveless network of veins** around the vertebral column that connects the **pelvic, vertebral, and cranial venous systems**.

Q12. Why is the vertebral venous plexus clinically important?
Because its **valveless nature allows retrograde spread** of **infection or carcinoma** from pelvis or abdomen to brain and vertebrae.

Q13. What is the extent of the subarachnoid space?
From **foramen magnum to S2**, enclosing **CSF**.

Q14. What is the function of CSF?

- Cushions and protects brain and spinal cord.
- Maintains **intracranial pressure** and chemical balance.

Q15. What is the significance of the lumbar puncture site?
The needle is introduced **below L2**, usually at **L3–L4 or L4–L5**, to avoid injury to the spinal cord.

Q16. What are the coverings of spinal nerves as they leave the canal?
Each spinal nerve is covered by **pia, arachnoid, and dura mater** forming a **dural sleeve**.

Q17. What is Froin's syndrome?
A sign of **spinal block** where CSF below the block becomes **xanthochromic (yellow) and coagulated** due to protein accumulation.

Q18. What are the common causes of spinal cord compression?
Tumors, disc prolapse, epidural abscess, or trauma.

Q19. What is the difference between epidural and subarachnoid anesthesia?

- **Epidural:** Injection into **epidural space**; segmental block.
- **Subarachnoid (spinal):** Injection into **subarachnoid space**; complete lower body block.

Q20. What is the conus medullaris and where is it located?

The **tapered end of the spinal cord**, opposite the **L1 vertebra** in adults.