

# Contents of Vertebral Canal

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## Contents of Vertebral Canal

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### 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.
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### 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)
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### 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**.
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### 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.

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## 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.

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## 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**.
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## 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**.
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## 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.
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## 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

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### 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**.
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### 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**.
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### 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.
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## 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**.
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## 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**.
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## 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)
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## Clinical Anatomy

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### 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.
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### 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**.
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### 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.
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### 4. Shingles (Herpes Zoster)

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

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

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### 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.
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### 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**:
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### 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.
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### 2. Vertebral Body Plexus

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

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### 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.
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## Facts to Remember

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- 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**.
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## Clinicoanatomical Problems

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### 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).
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### 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**.
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### 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).
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#### 4. Meningitis

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

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

- Infection in **epidural space** ? compresses spinal cord ? **neurological deficits**.
  - Requires **prompt drainage and antibiotics**.
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## 8. Vertebral Venous Communication

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

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### Frequently Asked Questions — Contents of Vertebral Canal

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#### 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**
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#### 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.
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#### 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**.
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#### 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**.
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#### 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**.
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#### 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**.
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#### 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**.
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#### 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.
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## 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).
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## 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.
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## 11. What is the function of CSF?

- Protects and cushions the spinal cord.
  - Maintains constant intracranial pressure.
  - Provides nutrition and removes waste products.
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## 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**.
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### 13. Why are epidural veins clinically important?

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

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1. The spinal cord in adults terminates at the level of:

- A. L3
- B. L2
- C. L1
- D. L5

? **Answer:** C. L1

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2. The subarachnoid space in the spinal canal ends at:

- A. S2
- B. L5
- C. S1
- D. L3

?

**Answer:**

A.

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**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

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**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

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**5.** The filum terminale is derived from:

- A. Dura mater
- B. Pia mater
- C. Arachnoid mater
- D. Ligamentum flavum

? **Answer:** B. Pia mater

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**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

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**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

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**8.** The number of pairs of spinal nerves is:

A. 29

B. 30

C. 31

D. 32

? **Answer:** C. 31

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

A. L4

B. S1

C. S2

D. Coccyx

? **Answer:** C. S2

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**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

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**11.** The spinal cord ends at L3 in:

A. Adults

B. Children

C. Elderly

D. Fetuses only

? **Answer:** B. Children

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**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
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**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

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**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

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**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

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## Viva Voce — Contents of Vertebral Canal

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**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**.

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**Q2. What are the meninges of the spinal cord?**

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

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**Q4. What is the lumbar cistern?**

The **subarachnoid space** below **L1** up to **S2**, containing **CSF**, **cauda equina**, and **filum terminale**.

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**Q5. What is the filum terminale?**

A **fibrous prolongation of pia mater** extending from the **conus medullaris** to the **coccyx**.

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**Q6. What are denticulate ligaments?**

Lateral **tooth-like extensions of pia mater** that attach to **dura mater** and **anchor the spinal cord**.

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**Q7. What is the cauda equina?**

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

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**Q8. What is the extent of the dura mater in the vertebral canal?**

From **foramen magnum** to the level of **S2 vertebra**.

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**Q9. What does the epidural space contain?**

**Loose areolar tissue, fat, and internal vertebral venous plexus.**

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**Q10. What is the clinical importance of the epidural space?**

Site for **epidural anesthesia** and possible location for **epidural abscess**.

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**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**.

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**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.

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**Q13. What is the extent of the subarachnoid space?**

From **foramen magnum to S2**, enclosing **CSF**.

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**Q14. What is the function of CSF?**

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

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**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**.

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**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.

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**Q18. What are the common causes of spinal cord compression?**

**Tumors, disc prolapse, epidural abscess, or trauma.**

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

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