Second Edition

Step by Step®
Regional Anaesthesia

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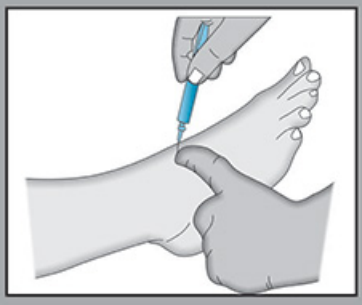

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chapter

4 Spinal Anaesthesia

❒ DEFINITION

Spinal anaesthesia may be defined as that regional anaesthesia obtained by blocking the spinal nerves in the subarachnoid space. Local anaesthetic is deposited in subarachnoid space to act on the spinal nerve roots.

❒ ANATOMICAL CONSIDERATIONS OF SPINE

Vertebral Column (Fig. 4.1)

The vertebral column consists of 33 bones, seven cervical, twelve thoracic, five lumbar, five sacral and four coccygeal vertebrae. Five are fused to form sacrum and four to form coccyx. The sacrum and coccyx are said to be the distal extensions of the vertebral column.

Vertebra

A *vertebra* consists of a body and an arch that comprises two pedicles anteriorly and two laminae posteriorly. Transverse processes arise from the junction of pedicles and laminae. Spinous process arises from the point of union of the laminae in the posterior midline. The laminae and spinous processes are

joined by ligament. But the pedicles form gaps (intervertebral foramina) through which the spinal nerves exit the spinal canal. In the lumbar region the spinous processes are mostly horizontal. So the needle should be introduced at this region and directed at right angles to the sagittal plane.

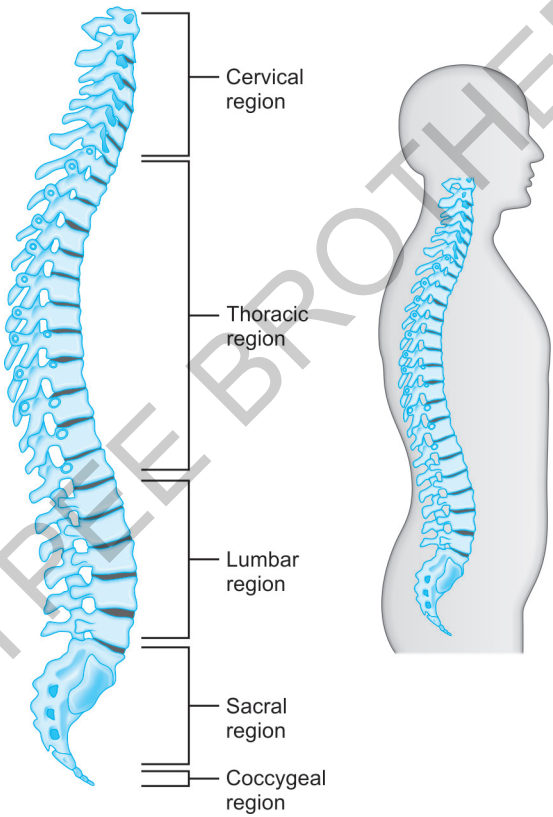

Fig. 4.1: Vertebral column

Intervertebral Fibrocartilages

Intervertebral fibrocartilages (discs) are interposed between adjacent surfaces of the vertebral bodies. The vertebral column is lengthened by these discs. These may comprise one-third to a quarter of its total length and give the vertebral column its flexibility. The shape of column largely dependent on these discs.

Vertebral column has 4 curves (Fig. 4.2). Thoracic and sacral curves are primary and exist at birth. These are concave anteriorly. Cervical and lumbar curves are secondary, develop after birth. These are convex anteriorly. When the patient is lying supine and horizontal, the high point of the spinal curve is at the level of L_3 and the low point is at T_5. The degree of curvature may vary in different individuals and can be modified by posture. In fully flexed spine, the cervical and lumbar curves are obliterated. Pregnant women have an exaggerated lumbar curve. In old age discs atrophy and this may give rise to bowed back of old age. Abnormal curves may include kyphosis, lordosis or scoliosis and these may cause difficulty in lumbar puncture.

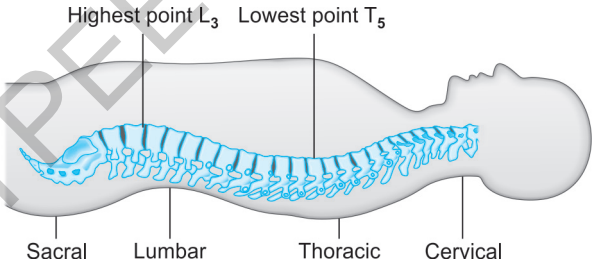

Fig. 4.2: Curves of vertebral canal

Vertebral Canal

Vertebral canal is bounded anteriorly by vertebral bodies and discs, posteriorly by arch bearing spinous processes and

interspinous ligament and laterally by pedicles and laminae. It contains:

1. Spinal nerve roots
2. Spinal cord with enclosing membranes
3. Blood vessels, fat, areolar tissue in extradural space.

Vertebral Ligaments

Vertebral ligaments bounding the vertebral canal are as follows:

1. Supraspinous ligament: They connect the tips of spinous processes.
2. Interspinous ligament: It connects the posterior spinous processes.
3. Ligamentum flavum: It connects the laminae of the vertebrae. They become progressively thicker from above downwards.
4. Posterior longitudinal ligament: It is within the vertebral canal on the posterior surface of vertebral bodies.
5. Anterior longitudinal ligament: It runs in front of the vertebral bodies and intervertebral discs.

- During midline insertion of a needle into the subarachnoid space the following structures are traversed:
  1. Skin
  2. Subcutaneous tissue
  3. Supraspinous ligament
  4. Interspinous ligament
  5. Ligamentum flavum
  6. Areolar tissue of epidural space
  7. Dura mater of spinal cord.

  In lateral approach supraspinous ligament and interspinous ligament are not encountered.

Spinal Cord

It is the elongated part of the central nervous system, an ovoid column of nervous tissue about 45 cm long, flattened

anteroposteriorly extending from the medulla at foramen magnum upto the second lumbar vertebra in the spinal canal. It ends in conus medullaries from which filum terminale descends down to coccyx. Cauda equina is the terminal part of spinal cord along with lower lumbar and sacral nerve roots within the spinal canal (Fig. 4.3).

Lumbar puncture above L_2 and L_3 interspace should be avoided as it may cause cord injury. The spinal cord is enclosed three membrane from outside inwards, dura mater, arachnoid mater and pia mater.

Spinal dura mater is the continuation downward of the inner meningeal layer of cranial dura mater. Above it is attached to the margins of foramen magnum and below it ends at the level

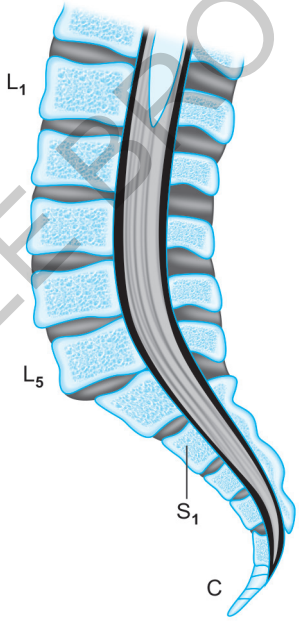

Fig. 4.3: Lower part of vertebral canal and spinal cord

of S_2. It is separated from the bony wall of vertebral column by the *extradural space*. Actually it is formed by splitting of two layers of dura. It contains fat, areolar tissue, a venous plexus and anterior and posterior roots of spinal nerves. Dura is mainly composed of longitudinal fibres so the spinal needle should be introduced with the bevel to separate the fibres rather than be dividing the fibres.

Arachnoid mater is thin, delicate, nonvascular and transparent membrane closely adherent to dura mater. The space (subdural) is usually a capillary layer.

Pia mater is the innermost layer closely adherent to the spinal cord. Pia mater is separated from arachnoid mater by the subarachnoid space. Pia mater ends as filum terminale which pierces the distal end of dural sac and is attached to coccyx.

The *subarachnoid space* is annular in the cervical and thoracic region and about 3 mm deep, below the first lumbar the space is circular. Local anaesthetic solution is deposited here in spinal analgesia. The space is filled with cerebrospinal fluid and traversed by cobweb trabeculae, denticulate ligaments and by spinal nerve roots. It communicates with the ventricular system of brain by foramen of Magendie, foramen of Luschka and foramina of Key and Retzius.

The spinal cord consists 31 pairs spinal segments according to spinal nerves which arise from it. The nerve roots within the dura mater have no epineural sheaths.

a. Cervical–8 pairs
b. Thoracic–12 pairs
c. Lumbar–5 pairs
d. Sacral–5 pairs
e. Coccygeal–1 pair.

Spinal Nerves (Fig. 4.4)

There are 31 pairs of spinal nerves each arising from the cord by anterior and posterior roots. Each spinal nerve supplies a specific skin area or dermatome and skeletal muscles.

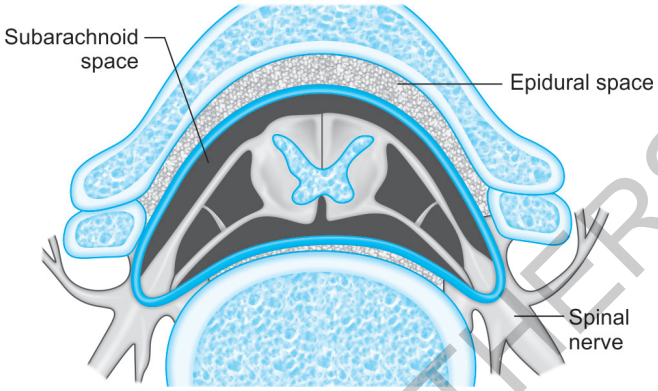

Fig. 4.4: Subarachnoid and epidural space

Anterior spinal root is efferent containing:

a. Motor to voluntary muscles.
b. Preganglionic sympathetic fibres (T_1 – L_2 or L_3) travel with spinal nerves before leaving to form the sympathetic chain. The sympathetic chain extends the whole length of spinal cord along the anterolateral side of the vertebral bodies. It gives rise to stellate ganglion, splanchnic nerves and coeliac plexus.

Posterior Spinal Root

All the afferent impulses from the entire body including viscera pass into the posterior roots. Each porterior root has a ganglion.

The anterior and posterior roots join in the intervertebral foramina to form spinal nerve trunks. They divide into anterior and posterior divisions of mixed nerves.

The dermatome of the body signifies a segmental skin area innervated by various spinal cord segments. Segmental levels of some important regions are as follows:

1. Clavicle C_3
2. Second intercostal space T_2

3. Nipple line T_4 T_5
4. Subcostal arch T_7 T_8
5. Umbilicus T_{10}
6. Inguinal region L_1
7. Perineum S_{1-4}.

The Epidural Space

It is formed by the splitting of the two layers of the spinal dura. The space is limited above by the fusion of two layers of dura at foramen magnum and below by the sacrococcygeal ligament closing the sacral hiatus. It contains:

1. 31 pairs of spinal nerve roots with their dural prolongations.
2. Venous plexuses of the vertebral canal.
3. Areolar and fatty tissues between arteries, veins and nerves.

   Greatest depth of fatty tissue in epidural space lies posteriorly and anterolaterally. It is continuous with the fat around the spinal nerves in the intervertebral foramina.

The negative intrathoracic pressure is transmitted through the paravertebral spaces to the thoracic epidural space. It is diminished to some extent in cervical and lumbar regions. The presence of negative pressure in epidural space often aids to detect the space during administration of epidural injections.

Cerebrospinal Fluid

It is derived from the choroid plexuses of the third, fourth and lateral ventricles either by secretion, filtration or dialysation. A small amount may be obtained from perivascular spaces.

The fluid is passed into the venous sinuses by arachnoid villi, granulation and mesothelial cells. It is also removed into lymph stream through the pacchionian bodies.

- Circulation of cerebrospinal fluid: The fluid formed by choroid plexuses in lateral ventricles passes through foramen of Monro. It mixes with the fluid formed in third ventricle. Thereafter it passes through aqueduct of Sylvius to the fourth ventricle. Then it reaches the subarachnoid space through the central foramen of Magendie and the lateral foramina of Luschka, Key and Retzius to reach the cisterna magna. It circulates the whole brain and is absorbed in venous sinuses through the arachnoidal villi. It should be noted that this circulation does not affect the spinal analgesia in any way.

Physical Properties of CSF

1. Clear, colourless fluid
2. Specific grasity 1003 to1009
3. Quantity 120 to 150 in adult
   a. volume of spinal CSF about 25 to 30 ml
   b. volume in ventricles 60 to 75 ml
   c. volume in large cisternal reservoirs 35 to 45 ml.
4. Average pressure 100 to 150 mm water
5. Alkaline: pH 7.6
6. Chemical:
   Protein 24 to 40 mg/100 ml
   Sugar 45 to 80 mg%
   Sodium Chloride 750 mg%
   Urea 10 to 30 mg%
   Bicarbonate 24 mEq/l.
7. Drugs are not secreted into it
8. Bile is not found in it even in deep jaundice
9. Antibiotics are not found in CSF.

Functions of CSF

1. Acts as fluid cushion to protect the brain
2. Regulates the volume of cranial contents

3. May have little effect in metabolic exchanges of nervous tissue.

❒ INDICATIONS OF SPINAL ANAESTHESIA

1. *Location and nature of surgery*: It is particularly helpful in abdominal surgery and surgery of pelvis, perineum and lower extremities as it provides excellent muscular relaxation. Surgery of upper abdomen, chest, shoulder and upper extremities can be done, but with some difficulty as it may interfere with respiration and circulation.
2. *Patient's choice attitude*: Patient's cooperation is highly desired. Anxious apprehensive patients or patients with psychological disorders are bad choice for spinal anaesthesia.
3. *Age of the patient*: Adult patients are good subjects and geriatric patients may be benefitted with spinal/epidural block. Children may need light general anaesthesia along with regional anaesthesia.
4. *Medical disorders*: Patients with heart, lung, liver and kidney diseases tolerate spinal anaesthesia better in comparison to general anaesthesia. However, the relative merits and demerits are to be wisely balanced.
5. *Pain evaluation with differential spinal block*.
6. *Therapeutic management in patients with chronic pain syndromes*.

❒ CONTRAINDICATIONS OF SPINAL ANAESTHESIA

1. Patients with marked disorders of central nervous system such as brain tumour, meningitis, etc. Patients with increased intracranial pressure may have a risk of brainstem herniation.
2. Infected skin condition in lumbar region.

3. Septicaemia, bacteremia.
4. Patients with documented allergy with local anaesthetics.
5. Patients with shock, hypovolaemia.
6. Patients with clotting abnormalities.
7. Preexisting neurologic diseases.
8. Inability to obtain valid consent for spinal anaesthesia is the absolute contraindication.

❒ PHYSIOLOGICAL EFFECTS OF SPINAL ANALGESIA

1. Spinal anaesthesia blocks sensory, motor and sympathetic nerve fibres. The small diameter nonmyelinated fibres (sympathetic) are more sensitive than larger myelinated (sensory and motor) fibres. Sympathetic block usually exceeds somatic sensory by two or more dermatomes.

Weaker concentration of local anaesthetic may block sensation without providing motor paralysis. With the sufficient increase in dose and concentration, both anterior and posterior nerve roots are blocked with intense anaesthesia (sensory) and motor paralysis.

Differences in levels of block for the different nerve modalities can occur following spinal anaesthesia. Preganglionic sympathetic block is usually more diffuse and may extend 2 to 4 segments above the block. It is usually first in onset and last to abolish. Motor nerve block is mostly 1 to 4 segments below the sensory levels.

Sequence of different nerve fibre block is usually in the following order:

a. Vasomotor block
b. Pain
c. Tactile
d. Motor
e. Pressure
f. Proprioception.

2. Vasomotor paralysis is proportional to the degree of sympathetic paralysis.
3. A reduction of blood loss is most common in case of spinal anaesthesia. It is mostly due to sympathetic nervous system block which causes decreased venous return to the heart and decreased cardiac output. Decreased systemic vascular resistance and bradycardia are also the other factors.
4. Resting alveolar ventilation is mostly unchanged, but in high spinal block abdominal and intercostal muscles are paralysed leading to decreased ability to cough and expel the secretions. The patient may complain of difficulty in breathing.
5. Spinal anaesthesia above the level of T_5 inhibits sympathetic nerves of gastrointestinal tract. Unopposed parasympathetic activity causes contraction of intestine and released sphincters. Ureters are contracted and ureterovesical sphincters are relaxed.
6. Adrenocortical response to surgery is absent due to block of afferent impulses in spinal anaesthesia.
7. There is overall reduction of bleeding at the site of operation due to decreased blood pressure.
8. Increased blood flow to lower extremities following sympathetic nervous system block is observed.
9. In low spinal anaesthesia, bladder and urogenital dysfunction may result due to lower thoracolumbar sympathetic and sacral parasympathetic inactivation.

❒ ADVANTAGES OF SPINAL ANAESTHESIA OVER GENERAL ANAESTHESIA

1. Spinal anaesthesia permits the patient to remain awake during surgery.
2. Spinal analgesia is technically easy to perform and provides reliable and rapid anaesthesia.

Step by Step®

Regional Anaesthesia

Salient Features

- *Step by Step Regional Anaesthesia* provides a comprehensive practical coverage of the speciality and a source of fundamental information
- Illustrated with lots of line drawings and diagrams for better understanding and practice of conduction block
- Essential for all anaesthetists in training and in practice
- The present edition is intended to update the First Edition and include some essential information regarding practical aspects related to the subject.

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ISBN 978-93-5152-077-1