Neuraxial Blockade Anatomy and Landmarks

Knowledge of anatomy and landmarks are essential to the safe administration of neuraxial blockade. The anesthesia provider should know intimately what structures they will be encountering/traversing with their needle before attempting neuraxial techniques. Landmarks are important in the identification of appropriate area's to insert the needle. This valuable knowledge will allow the anesthesia provider to confidently administer spinal/epidural anesthesia, as well as enhance patient safety.

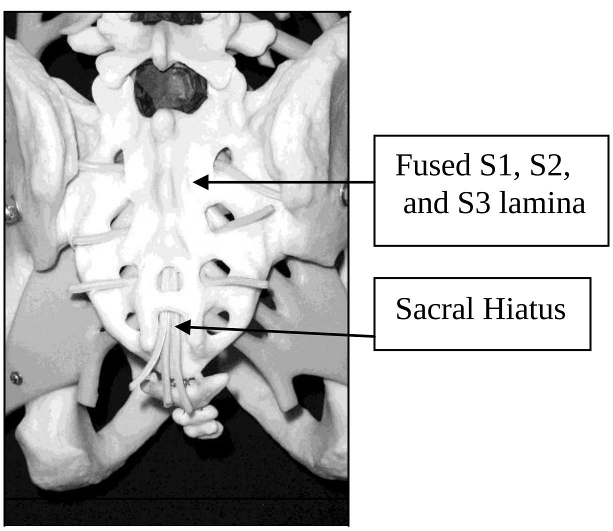
Anatomy

Vertebral Column

The bony vertebral column provides:

- structural support
- protection of the spinal cord and nerves
- mobility

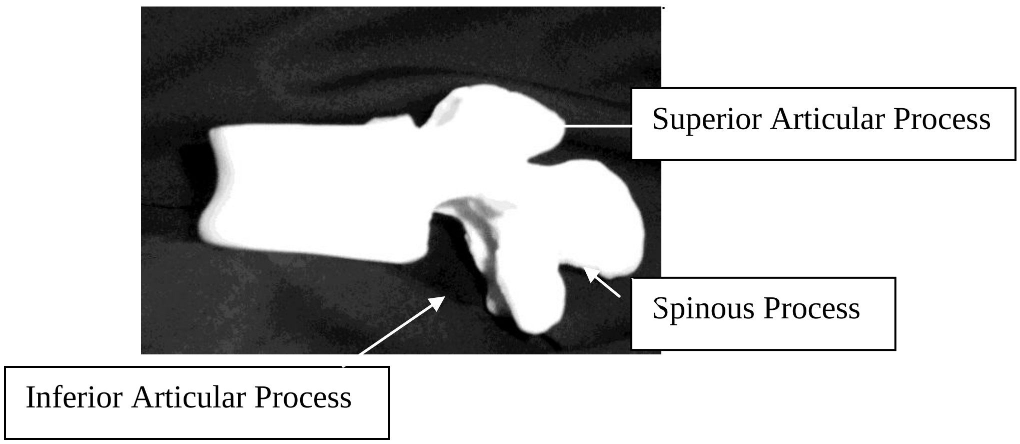
The vertebral column consists of 7 cervical, 12 thoracic, and 5 lumbar vertebrae as well as the sacrum (5), and coccyx (4). The first cervical vertebra is called the atlas. The atlas has a unique anatomical structure that allows for articulations to the base of the skull and second cervical vertebrae. The second cervical vertebra is called the axis. Each of the 12 thoracic vertebrae articulates with a corresponding rib.



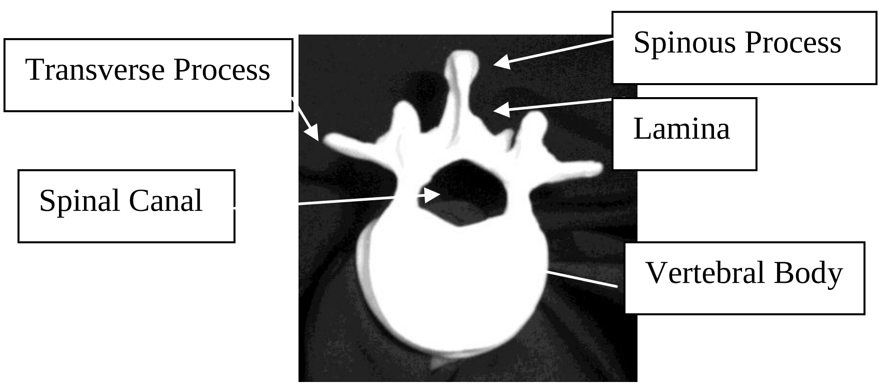
Sacral vertebrae are fused into one bone but retain individual intervertebral foramina. The lamina of a portion of S4 and S5 usually does not fuse, forming the sacral hiatus.

Individual vertebral anatomy consists of the pedicle, transverse process, superior and inferior articular processes, and spinous process. Each vertebral body is connected to the other by intervertebral disks. There are 2 superior and 2 inferior articular processes (synovial joints) on each vertebra. Articular processes allow for articulation to the vertebrae above and below. Pedicles have notches superiorly and inferiorly, allowing the spinal nerve to exit the vertebral column.

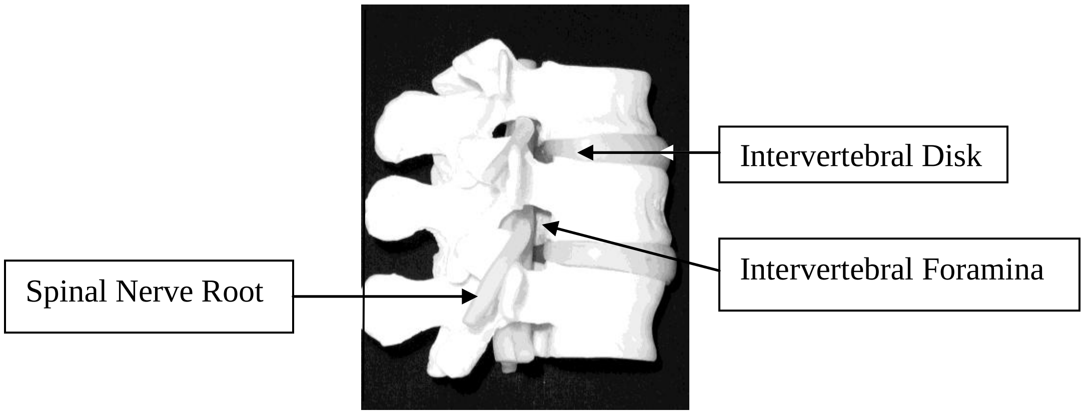
Side View of the Lumbar Vertebrae



Top View of Lumbar Vertebrae

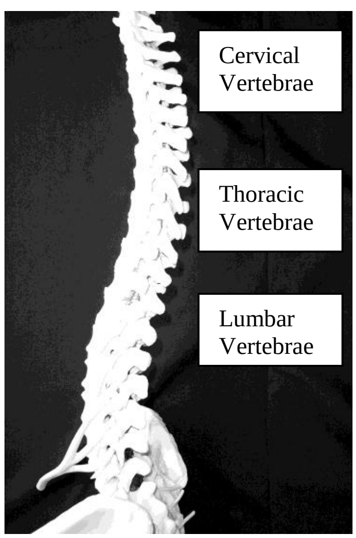


Side View of Lumbar Vertebrae



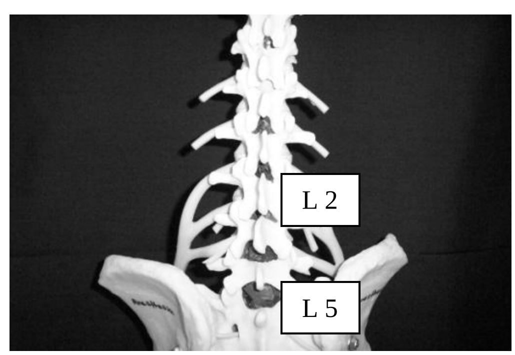
The bony spinal canal contains the following boundaries:

- Anterior boundary- vertebral body
- Lateral boundary- pedicles
- Posterior boundary- spinous process and laminae



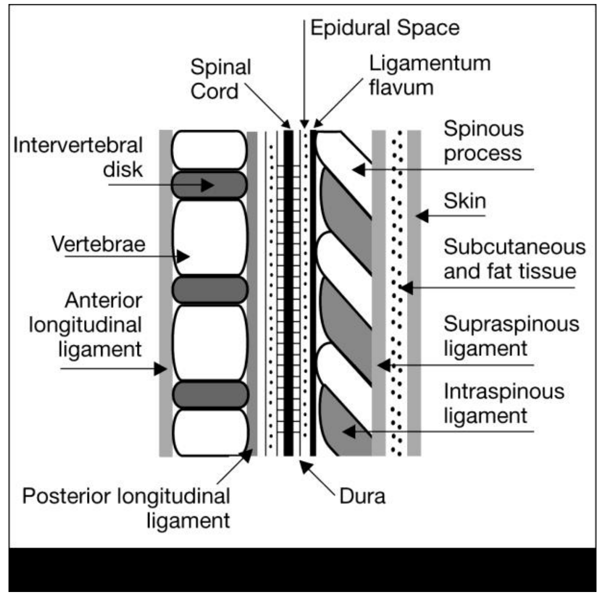
The angle of the transverse process in the lumbar and thoracic vertebrae impacts how the anesthesia provider will orientate the needle when performing an epidural. The spinous process in the lumbar region is almost horizontal with flexion; in the thoracic region they are angled in a slightly caudad direction.

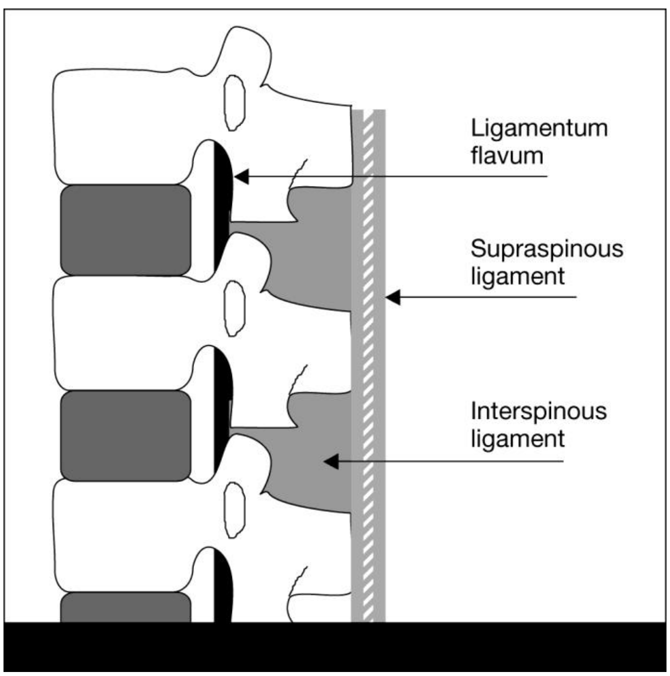
Interlaminar spaces differ in size. In general, the higher up the vertebral column, the smaller the interlaminar space. This is important to remember. If the anesthesia provider is having trouble placing a spinal/epidural at L2-L3, moving down a space will provide a larger intervertebral space, increasing success.



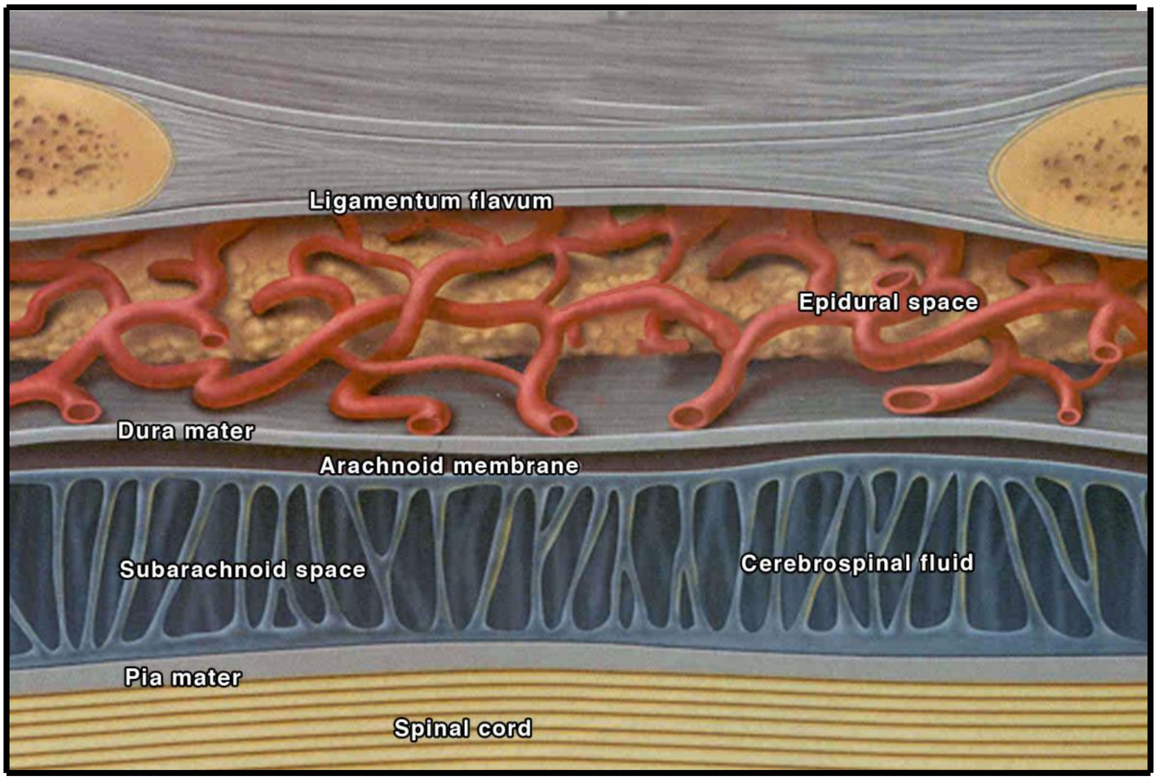
Supportive Structures

Ligaments maintain the shape of the vertebral column and provide support. Vertebral bodies and disks are connected and supported on the ventral side by anterior and posterior longitudinal ligaments.





On the dorsal side of the vertebral column the ligamentum flavum, interspinous ligament, and supraspinous ligament provide support. These dorsal ligaments are structures that the anesthesia provider will pass through when placing a needle for neuraxial blockade. With experience the anesthesia provider will be able to identify these structures through tactile feel.



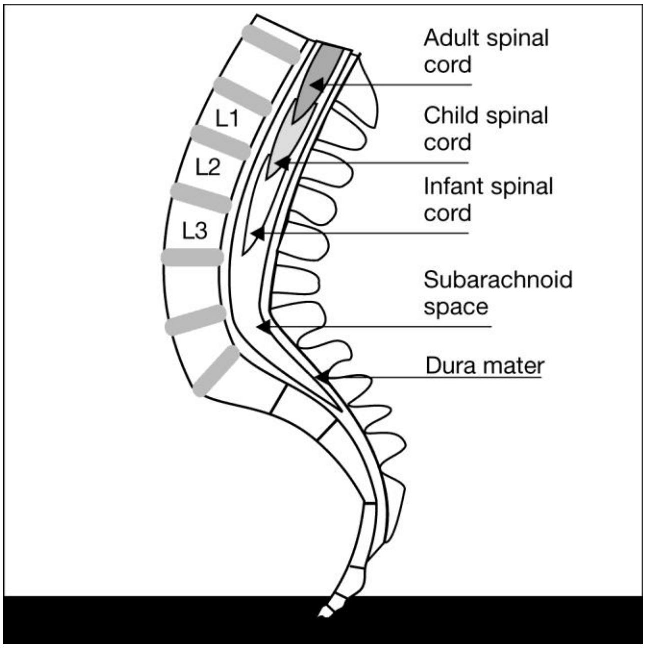
Adapted with permission from “Unintended subdural injection: a complication of epidural anesthesia- a case report”, AANA Journal, vol. 74, no. 3, 2006.

Blood Supply

The spinal cord and nerve roots access their blood supply from a single anterior spinal artery and paired posterior arteries. The vertebral artery at the base of the skull forms the anterior spinal artery and travels down the spinal cord supplying 2/3rds of the anterior spinal cord. Posterior spinal arteries are formed by the posterior inferior cerebellar arteries and travel down the dorsal surface of the spinal cord medial to the dorsal nerve roots. The two posterior spinal arteries supply 1/3rd of the posterior cord. Additional blood flow is supplied by anterior and posterior spinal arteries from intercostal and lumbar arteries. The artery of Adamkiewicz is a radicular artery arising from the aorta. It is a large, unilateral artery, generally found on the left side, providing blood supply to the lower anterior 2/3rds of the spinal cord. Injury to this structure can result in anterior spinal artery syndrome.

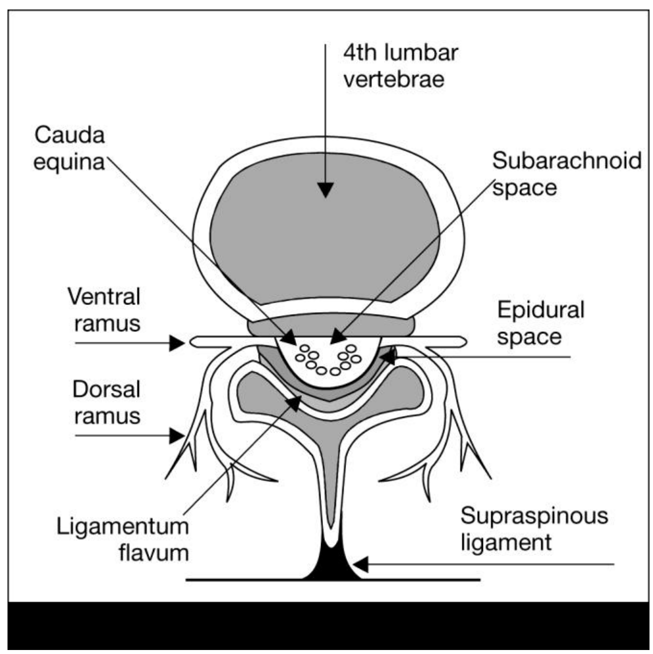
Subarachnoid Space

The subarachnoid space is a continuous space containing cerebral spinal fluid (CSF), spinal cord, and conus medullaris. It is in direct communication with the brainstem through the formen magnum and ends with the conus medullaris at the sacral hiatus. The subarachnoid space extends from the cerebral ventricles down to S2. Asepsis and sterile technique are essential! Since the anesthesia provider places a needle directly into the subarachnoid space, infectious microbes can easily be introduced. If there is any doubt about potential or actual contamination, stop, then start again with fresh sterile supplies.



The spinal cord effectively ends at L1 in the adult and L3 in the infant. However, there are anatomical variations that influence the level that the spinal cord ends and the conus medullaris begins. In the adult, it is generally safe to place a spinal needle below L2, unless there is a known anatomical variation. Needle trauma to the cauda equina is unlikely. Individual nerves of the cauda equina are in a fluid environment and not likely to be pierced by a needle.

The anterior and posterior spinal nerve roots join each other and exit the intervertebral foramina, forming spinal nerves from C1-S5. At the level of the cervical vertebrae, the spinal nerves rise above the foramina, resulting in 8 cervical spinal nerves but only 7 cervical vertebrae. At T1 and below, each spinal nerve exits below the foramina. At L1 the spinal nerves form the cauda equina and course down the spinal canal until they exit their respective foramina. A dural sheath covers most nerve roots for a small distance after they exit the foramina.



Spinal nerve roots vary in size and structure from patient to patient. This may play a role in the quality of neuraxial blockade between patients when similar techniques are used. Dorsal roots are responsible for sensory blockade. They are larger than the anterior root that is responsible for motor blockade. Even though the dorsal root is larger, it is blocked more easily than the smaller anterior root. This is due to the organization of the dorsal root into bundles which expose a larger surface area to local anesthetic solutions. Thus, sensory nerves are blocked easier than motor.

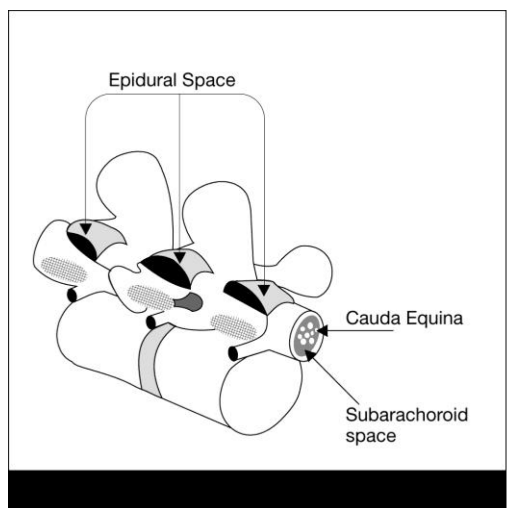
CSF is a clear fluid that fills the subarachnoid space. The total volume of CSF in the adult varies between 100-150 ml. CSF volume within the subarachnoid space is approximately 25-35 ml. Cerebral spinal fluid is continually produced at a rate of 450 ml per day by the choroid plexuses, which are located in the lateral. 3rd, and 4th ventricles. Cerebral spinal fluid is reabsorbed into the bloodstream through the arachnoid villi and granulations and to a small extent through epidural veins. The specific gravity of CSF ranges from 1.00028-1.001, playing a crucial role in choosing the baracity of local anesthetic solution. CSF volume also plays a role in patient to patient variability in relation to block height and motor/sensory regression and accounts for 80% of patient variability. Body weight is the only patient measurement that coincides with CSF volume. This becomes important when administering neuraxial blockade to the obese and during pregnancy. In these patient populations the amount of CSF is usually less.

Three membranes surround the spinal cord within the vertebral column. Starting at the spinal cord and moving out they are:

- pia mater
- arachnoid mater
- dura mater

Pia mater is highly vascular and covers the spinal cord and brain. The filum terminale is an extension of the pia mater, attaching to the periosteum of the coccyx. The arachnoid mater is non vascular and attached to the dura mater, functioning as the principal barrier to the migration of medications in and out of the CSF. Dura mater, the outermost membrane, is a fibrous and elastic membrane. It is an extension of cranial dura mater, extending from the foramen magnum to S2. The subdural space is a potential space found between dura and arachnoid mater. This space contains a small amount of serous fluid, which acts as a lubricant allowing the two surfaces to glide over each other during movement. Inadvertent injection of local anesthetics into this space may result in a failed spinal anesthetic or high neuraxial blockade after injection of an epidural anesthetic. Aspiration before injection may yield a small amount of serous fluid or be negative prior to the initiation of epidural anesthesia. With an epidural catheter present there is a risk of migration into this space.

Epidural Space



The epidural space extends from the foramen magnum to the sacral hiatus. It is segmented, not uniform in distribution. The epidural space surrounds the dura mater anteriorly, laterally, and posteriorly. Boundaries of the epidural space are as follows:

- anterior- posterior longitudinal ligaments
- lateral- pedicles and intervertebral foramina
- posterior- ligamentum flavum and vertebral laminae

The epidural space contains the following structures:

- fat
- nerve roots
- areolar tissue
- lymphatics
- blood vessels

As patients age, adipose tissue in the epidural space diminishes, and intervertebral foramina decrease in size. A decrease in adipose tissue results in decreased local anesthetic requirements in the elderly.

Posterior to the epidural space is the ligamentum flavum, which extends from the foramen magnum to the sacral hiatus. The ligamentum flavum is not one continuous ligament. It is composed of a right and left ligamenta flava which meet in the middle, forming an acute angle with a vertebral opening. The two ligamenta flava may or may not be fused in the middle at variable levels within the same patient. The ligamentum flavum varies in respect to thickness, distance to dura, skin to surface distance, and the size of the vertebral canal. The ligamentum flavum also varies in thickness from cephalad to caudad. It is thicker in the lumbar region compared to the thoracic region.

Site	Skin to ligament in cm	Thickness of ligament in mm
Thoracic		3.0-5.0
Lumbar	3.0-8.0	5.0-6.0

Anatomical structures located posterior to the ligamentum flavum are the:

- lamina and spinous processes
- interspinous ligament
- supraspinous ligament

The supraspinous ligament extends from the occipital protuberance to the coccyx, joining the vertebral spines together.

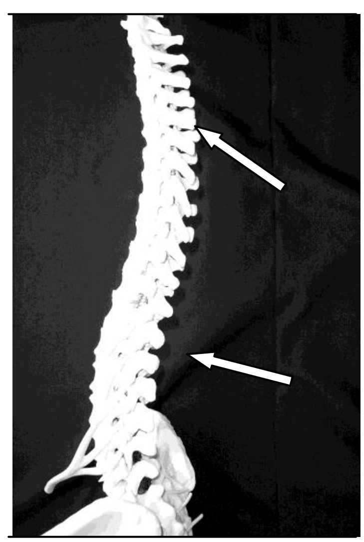
Unilateral Anesthesia and Epidurals

Varied anatomy of the epidural space may lead to a non uniform spread of local anesthetic solution, resulting in the uncommon but frustrating problem of unilateral anesthesia. Anatomical causes include a dorsomedian band in the midline of the epidural space, presence of epidural septa, or the presence of a midline posterior epidural fat pad.

Surface Anatomy

Surface anatomy is important to help identify the correct area to place a neuraxial block.

When locating the midline the following should be noted:



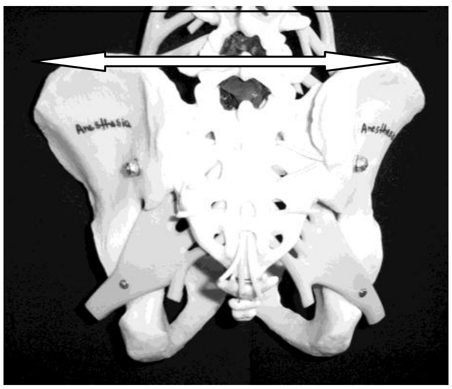
- Spinal processes are generally palpable and define midline.
- If the anesthesia provider is unable to palpate the spinous process, identifying the gluteal crease may help identify midline. This will not be accurate if the patient has scoliosis or other deformities of the spine.
- Spinous processes in the cervical and lumbar areas are almost horizontal with flexion. Needle placement will be in a slightly cephalad direction. In the thoracic area the spinous processes are slanted in a caudad direction. With flexion, the anesthesia provider will need to direct

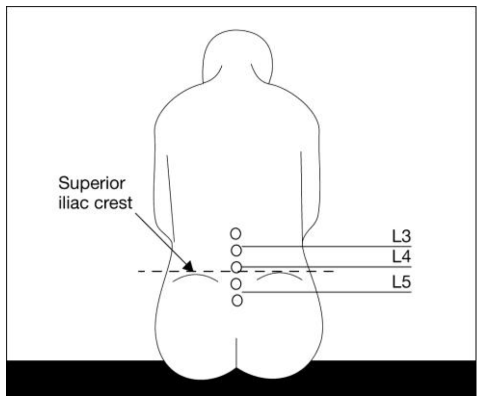
the needle more cephalad.

Anatomical landmarks can be identified by noting prominent vertebrae and landmarks:

- C2 is the first palpable spinous process
- C7 is the most prominent vertebrae
- The tip of the scapula, when the patients arms are at their side, corresponds with T7

These landmarks are helpful in finding the "correct" level to place thoracic epidurals. It is helpful to count down and up to identify the correct level for placement.





A line drawn from the top of the iliac crest is known as "Tuffier's" line. This line generally crosses the body of L4 or the L4-L5 interspace. A line drawn across the posterior superior iliac spine will generally cross S2.

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