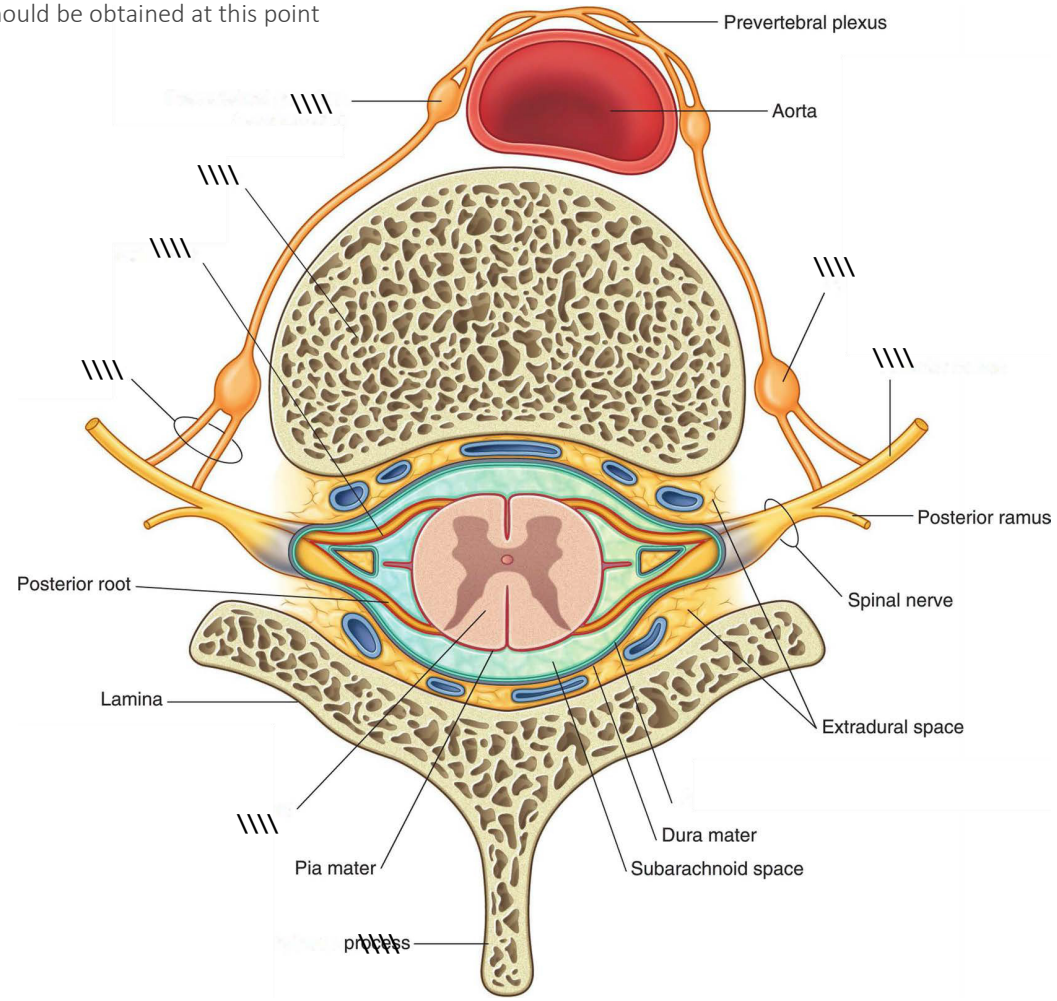
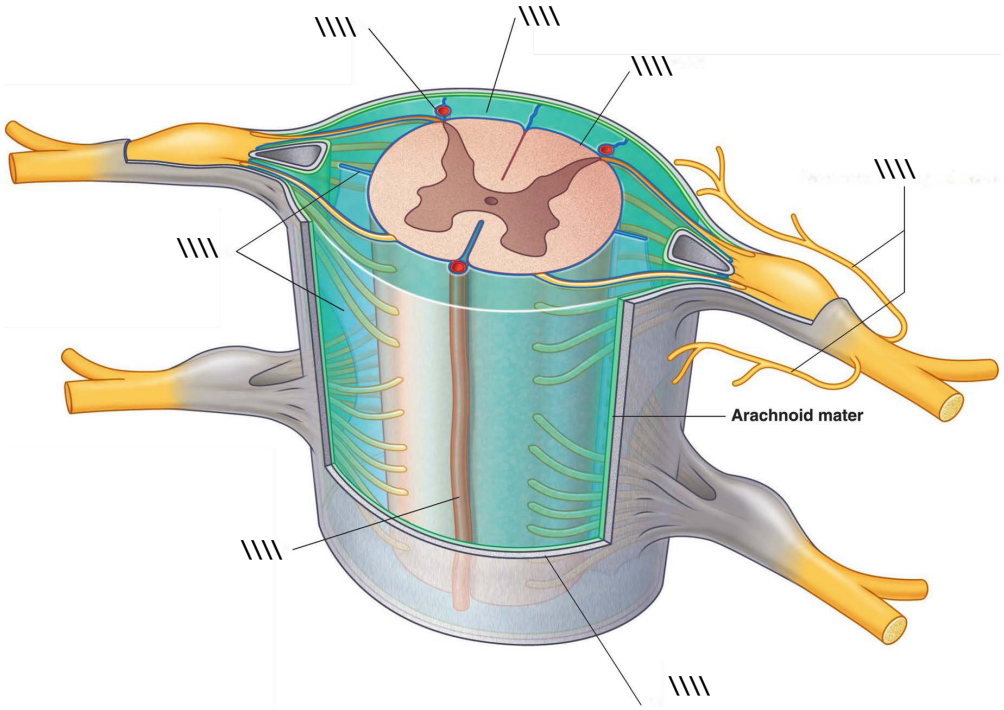
Lumbar puncture

Lumbar punctures are performed to obtain cerebrospinal fluid. In adults, the procedure is best performed at the level of L3/L4 or L4/5 interspace. These regions are below the termination of the spinal cord at L1.

During the procedure the needle passes through:

- The **supraspinous ligament** which connects the tips of spinous processes and the interspinous ligaments between adjacent borders of spinous processes
- Then the needle passes through the ligamentum flavum, which may cause a give as it is penetrated
- A second give represents penetration of the needle through the dura mater into the subarachnoid space. Clear CSF should be obtained at this point





Vertebral column

- There are 7 cervical, 12 thoracic, 5 lumbar, and 5 sacral vertebrae.
- The spinal cord segmental levels do not necessarily correspond to the vertebral segments. For example, while the C1 cord is located at the C1 vertebra, the C8 cord is situated at the C7 vertebra. While the T1 cord is situated at the T1 vertebra, the T12 cord is situated at the T8 vertebra. The lumbar cord is situated between T9 and T11 vertebrae. The sacral cord is situated between the T12 to L2 vertebrae.

Cervical vertebrae

The interface between the first and second vertebra is called the atlanto-axis junction. The C3 cord contains the phrenic nucleus.

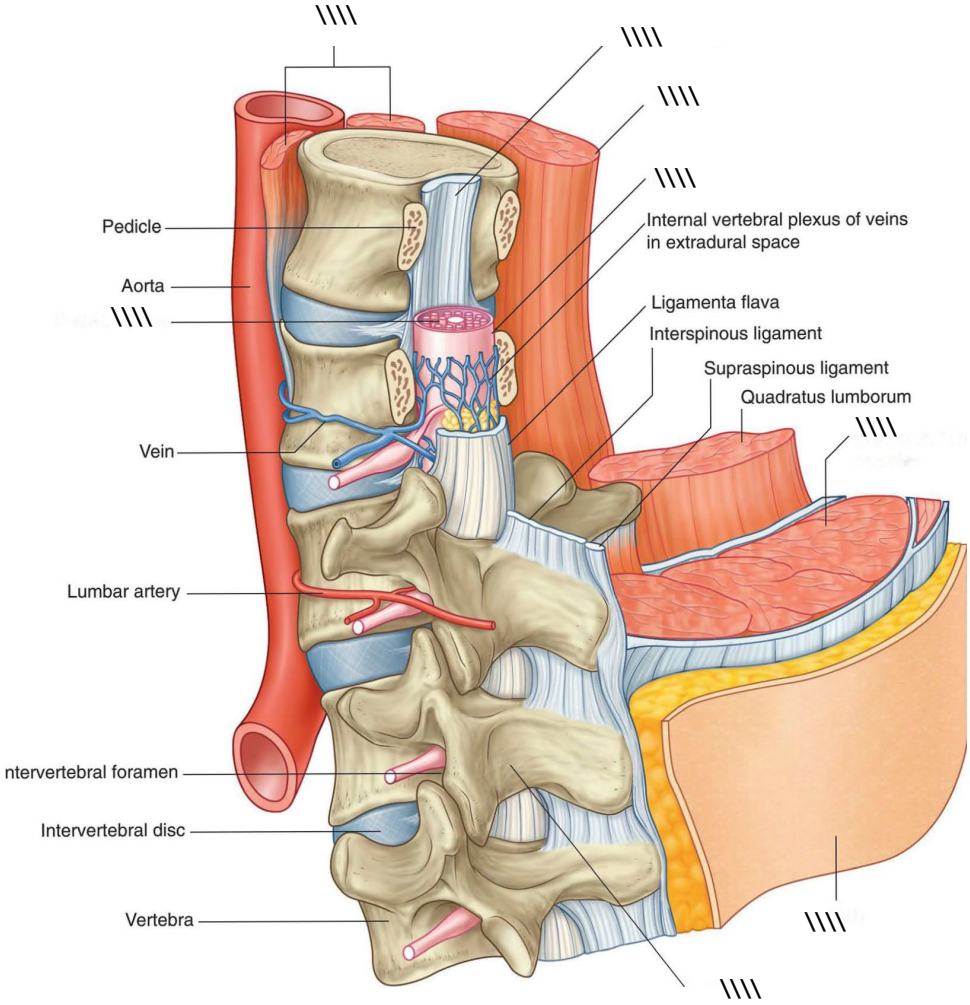
Muscle	Root value
Deltoid	C5,6
Biceps	C5,6
Wrist extensors	C6-8
Triceps	C6-8
Wrist flexors	C6-T1
Hand muscles	C8-T1

Thoracic vertebrae

The thoracic vertebral segments are defined by those that have a rib. The spinal roots form the intercostal nerves that run on the bottom side of the ribs and these nerves control the intercostal muscles and associated dermatomes.

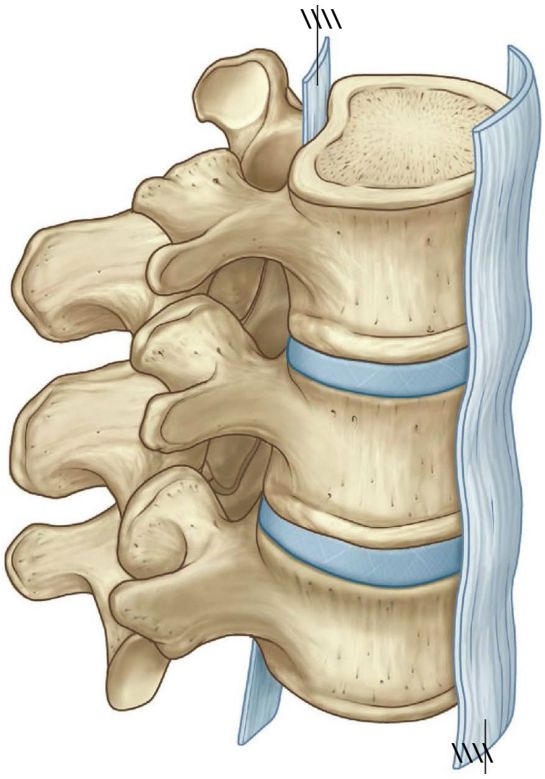
Lumbosacral vertebrae

Form the remainder of the segments below the vertebrae of the thorax. The lumbosacral spinal cord, however, starts at about T9 and continues only to L2. It contains most of the segments that innervate the hip and legs, as well as the buttocks and anal regions.



Cauda Equina

The spinal cord ends at L1-L2 vertebral level. The tip of the spinal cord is called the conus. Below the conus, there is a spray of spinal roots that is called the cauda equina. Injuries below L2 represent injuries to spinal roots rather than the spinal cord proper.



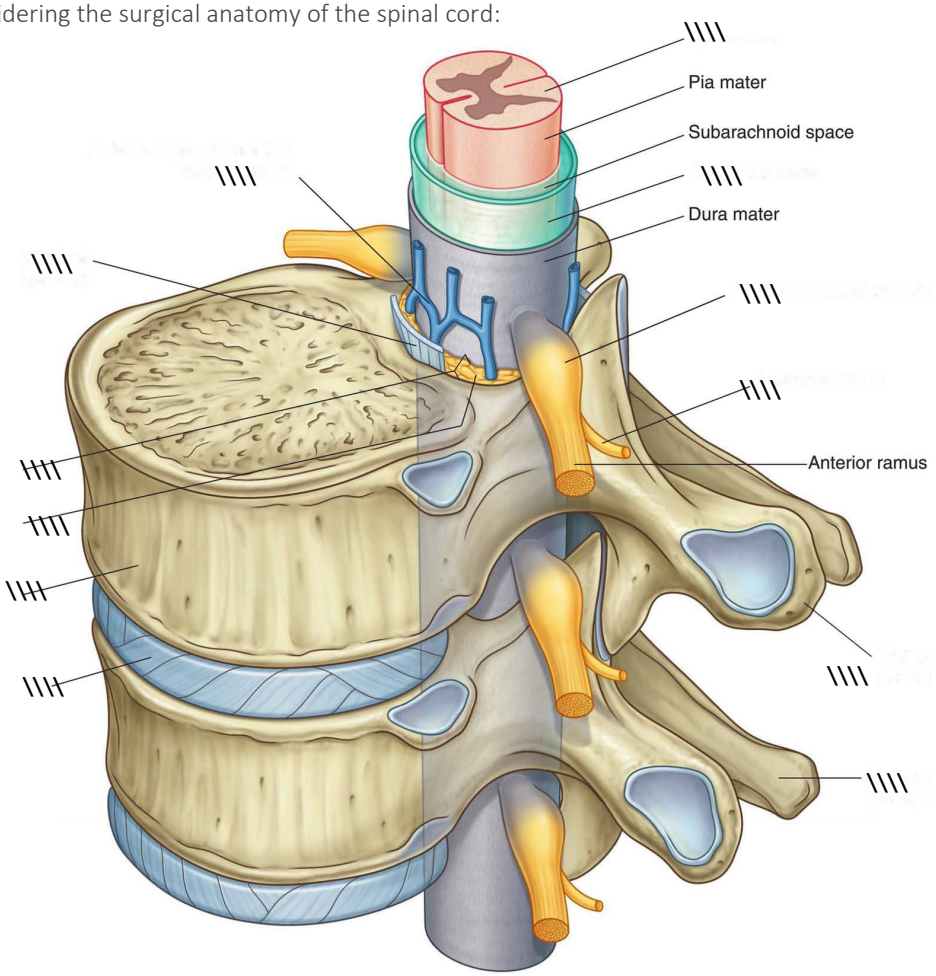
Spinal cord

- Located in a canal within the vertebral column that affords it structural support.
- Rostrally it continues to the medulla oblongata of the brain and caudally it tapers at a level corresponding to the L1-2 interspace (in the adult), a central structure, the filum terminale anchors the cord to the first coccygeal vertebra.
- The spinal cord is characterised by cervico-lumbar enlargements and these, broadly speaking, are the sites which correspond to the brachial and lumbar plexuses respectively.

The spinal cord is approximately 45cm in men and 43cm in women. The **denticulate ligament** is a continuation of the pia mater (innermost covering of the spinal cord) which has intermittent lateral projections attaching the spinal cord to the dura mater and **suspends the spinal cord in the dural sheath**.

There are some key points to note when considering the surgical anatomy of the spinal cord:

- During foetal growth the spinal cord becomes shorter than the spinal canal, hence the adult site of cord termination at the L1-2 level, while in neonates it's L3.
- Due to growth of the vertebral column the spine segmental levels may not always correspond to bony landmarks as they do in the cervical spine.
- The spinal cord is incompletely divided into two symmetrical halves by a dorsal median sulcus and ventral median fissure. Grey matter surrounds a central canal that is continuous rostrally with the ventricular system of the CNS.
- The grey matter is sub divided cytoarchitecturally into Rexeds laminae.
- Afferent fibres entering through the dorsal roots usually terminate near their point of entry but may travel for varying distances in Lissauers tract. In this way they may establish synaptic connections over several levels
- At the tip of the dorsal horn are afferents associated with nociceptive stimuli. The ventral horn contains neurones that innervate skeletal muscle.



The key point to remember when revising CNS anatomy is to keep a clinical perspective in mind. So it is worth classifying the ways in which the spinal cord may become injured. These include:

- **Trauma** either direct or as a result of disc protrusion
- **Neoplasia** either by direct invasion (rare) or as a result of pathological vertebral fracture
- **Inflammatory diseases** such as Rheumatoid disease, or OA (formation of osteophytes compressing nerve roots etc.
- **Vascular** either as a result of stroke (rare in cord) or as complication of aortic dissection
- **Infection** historically diseases such as TB, epidural abscesses.

The anatomy of the cord will, to an extent dictate the clinical presentation. Some points/ conditions to remember:

- Brown- Sequard syndrome-Hemisection of the cord producing ipsilateral loss of proprioception and upper motor neurone signs, plus contralateral loss of pain and temperature sensation. The explanation of this is that the fibres decussate at different levels.
- Lesions below L1 will tend to present with lower motor neurone signs

Upper Vs Lower motor neurone lesions - Facial nerve

The nucleus of the facial nerve is located in the caudal aspect of the ventrolateral pontine tegmentum. Its axons exit the ventral pons medial to the spinal trigeminal nucleus.

Any lesion occurring within or affecting the corticobulbar tract is known as an upper motor neuron lesion. Any lesion affecting the individual branches (temporal, zygomatic, buccal, mandibular and cervical) is known as a lower motor neuron lesion.

Branches of the facial nerve leaving the facial motor nucleus (FMN) for the muscles do so via both left and right posterior (dorsal) and anterior (ventral) routes. In other words, this means lower motor neurons of the facial nerve can leave either from the left anterior, left posterior, right anterior or right posterior facial motor nucleus. The temporal branch travels out from the left and right posterior components. The inferior four branches do so via the left and right anterior components. The left and right branches supply their respective sides of the face (ipsilateral innervation). Accordingly, the posterior components receive motor input from both hemispheres of the cerebral cortex (bilaterally), whereas the anterior components receive strictly contra-lateral input. This means that the temporal branch of the facial nerve receives motor input from both hemispheres of the cerebral cortex whereas the zygomatic, buccal, mandibular and cervical branches receive information from only contralateral hemispheres.

Now, because the anterior FMN receives only contralateral cortical input whereas the posterior receives that which is bilateral, a corticobulbar lesion (UMN lesion) occurring in the left hemisphere would eliminate motor input to the right anterior FMN component, thus removing signaling to the inferior four facial nerve branches, thereby paralyzing the right mid- and lower-face. The posterior component, however, although now only receiving input from the right hemisphere, is still able to allow the temporal branch to sufficiently innervate the entire forehead. This means that the forehead will not be paralyzed.

The same mechanism applies for an upper motor neuron lesion in the right hemisphere. The left anterior FMN component no longer receives cortical motor input due to its strict contralateral innervation, whereas the posterior component is still sufficiently supplied by the left hemisphere. The result is paralysis of the left mid- and lower-face with an unaffected forehead.

On the other hand, a lower motor neuron lesion is a bit different.

A lesion on either the left or right side would affect both the anterior and posterior routes on that side because of their close physical proximity to one another. So, a lesion on the left side would inhibit muscle innervation from both the left posterior and anterior routes, thus paralyzing the whole left side of the face (Bells Palsy). With this type of lesion, the bilateral and contalateral inputs of the posterior and anterior routes, respectively, become irrelevant because the lesion is below the level of the medulla and the facial motor nucleus. Whereas at a level above the medulla a lesion occurring in one hemisphere would mean that the other hemisphere could still sufficiently innervate the posterior facial motor nucleus, a lesion affecting a lower motor neuron would eliminate innervation altogether because the nerves no longer have a means to receive compensatory contralateral input at a downstream decussation.

Upper motor neurone lesions of the facial nerve- Paralysis of the lower half of face.
Lower motor neurone lesion- Paralysis of the entire ipsilateral face.

Sympathetic Nervous System - Anatomy

The cell bodies of the pre-ganglionic efferent neurones lie in the lateral horn of the grey matter of the spinal cord in the thoraco-lumbar regions.
The pre-ganglionic efferents leave the spinal cord at levels T1-L2. These pass to the sympathetic chain.
Lateral branches of the sympathetic chain connect it to every spinal nerve. These post ganglionic nerves will pass to structures that receive sympathetic innervation at the periphery.

Sympathetic chains

These lie on the vertebral column and run from the base of the skull to the coccyx.

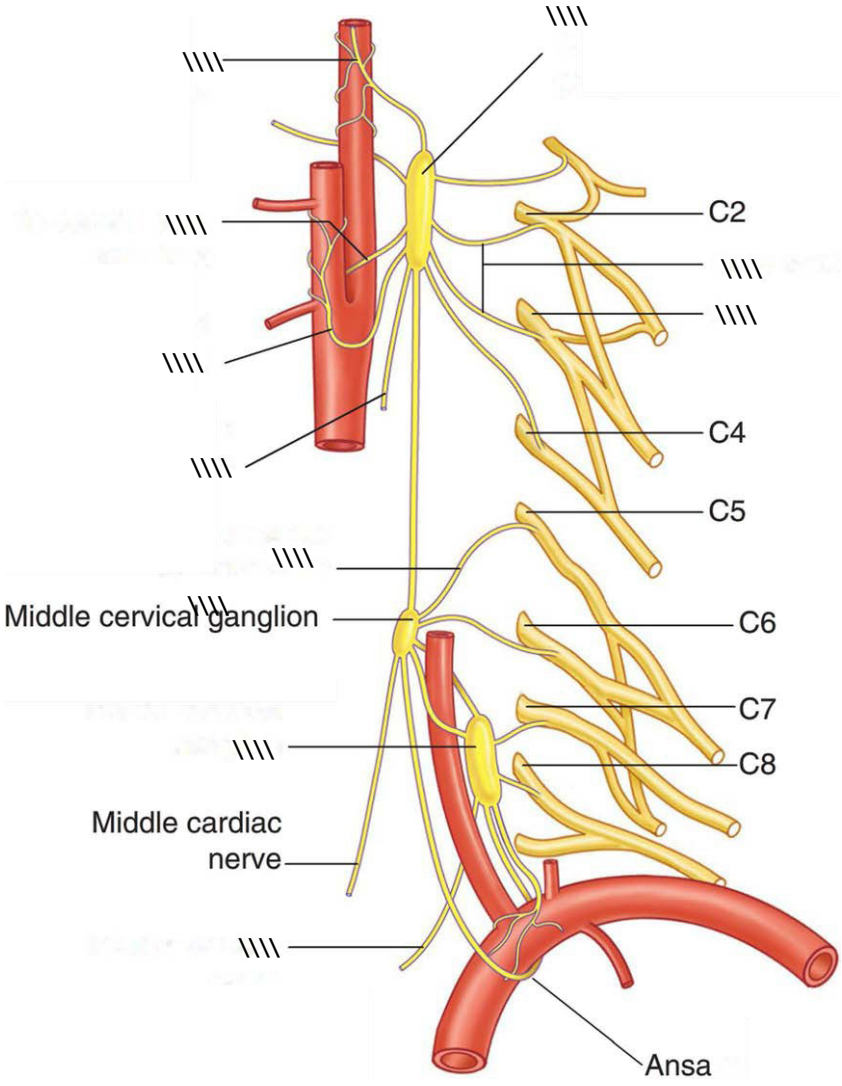
Cervical region	Lie anterior to the transverse processes of the cervical vertebrae and posterior to the carotid sheath.
Thoracic region	Lie anterior to the neck of the upper ribs and lateral sides of the lower thoracic vertebrae. They are covered by the parietal pleura
Lumbar region	Enter by passing posterior to the medial arcuate ligament. Lie anteriorly to the vertebrae and medial to psoas major.

Sympathetic ganglia

- Superior cervical ganglion lies anterior to C2 and C3.
- Middle cervical ganglion (if present) C6
- Stellate ganglion- anterior to transverse process of C7, lies posterior to the subclavian artery, vertebral artery and cervical pleura.
- Thoracic ganglia are segmentally arranged.
- There are usually 4 lumbar ganglia.

Clinical importance

- Interruption of the head and neck supply of the sympathetic nerves will result in an ipsilateral Horner's syndrome.
- For **treatment of hyperhidrosis** the sympathetic denervation can be achieved by **removing the second and third** thoracic ganglia with their rami. Removal of T1 will cause a Horners syndrome and is therefore not performed.
- In patients with **vascular disease of the lower limbs** a lumbar sympathetomy may be performed, either radiologically or (more rarely now) surgically. The ganglia of **L2 and below** are disrupted. If L1 is removed, then ejaculation may be compromised (and little additional benefit conferred as the preganglionic fibres do not arise below L2.



Pharyngeal arches

These develop during the fourth week of embryonic growth from a series of mesodermal outpouchings of the developing pharynx.
They develop and fuse in the ventral midline. Pharyngeal pouches form on the endodermal side between the arches.
There are 6 pharyngeal arches, the fifth does not contribute any useful structures and often fuses with the sixth arch.

Pharyngeal arches

Arch	Muscular contributions	Skeletal	Endocrine	Artery	Nerve
First	• Muscles of mastication • Ant. belly of digastric • Mylohyoid • Tensor tympanic • Tensor veli palatini	• Maxilla • Meckel's cartilage • Incus • Malleus	N/A	• Maxillary • External carotid	• Mandibular
Second	• Buccinator • Platysma • Muscles of facial expression • Stylohyoid • Posterior belly of digastric • Stapedius	• Stapes • Styloid process • Lesser horn and upper body of hyoid	N/A	• Inferior branch of superior thyroid artery • Stapedial artery	• Facial
Third	• Stylopharyngeus	• Greater horn and lower part of hyoid	• Thymus • Inferior parathyroids	• Common and Internal carotid	• Glossopharyngeal
Fourth	• Cricothyroid • All intrinsic muscles of the soft palate	• Thyroid and epiglottic cartilages	• Superior parathyroids	• Right Subclavian artery • Left aortic arch	• Vagus
Sixth	• All intrinsic muscles of the larynx (except cricothyroid)	• Cricoid, arytenoid and corniculate cartilages	n/a	• Right: Pulmonary artery • Left: Pulmonary artery and ductus arteriosus	• Vagus and recurrent laryngeal nerve

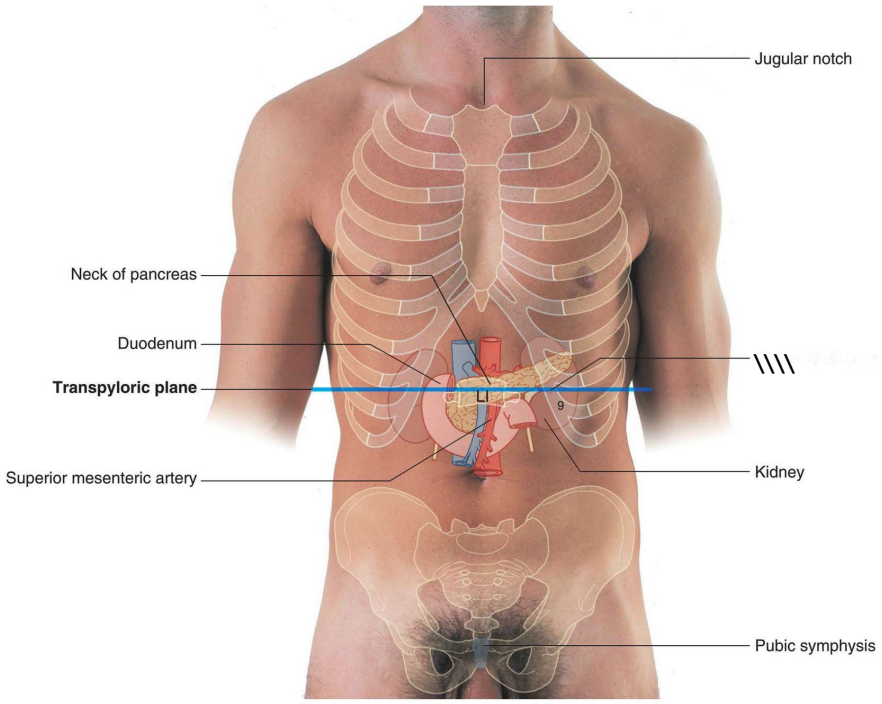
Levels

Transpyloric plane

Level of the body of L1

- Pylorus stomach
- Left kidney hilum (L1- left one!)
- Fundus of the gallbladder
- Neck of pancreas
- Duodenojejunal flexure
- Superior mesenteric artery
- Portal vein
- Left and right colic flexure
- Root of the transverse mesocolon
- 2nd part of the duodenum
- Upper part of conus medullaris
- Spleen

Can be identified by asking the supine patient to sit up without using their arms. The plane is located where the lateral border of the rectus muscle crosses the costal margin.



Anatomical planes

Subcostal plane	Lowest margin of 10th costal cartilage
Intercristal plane	Level of body L4 (highest point of iliac crest)
Intertubercular plane	Level of body L5

Common level landmarks

Inferior mesenteric artery	L3
Bifurcation of aorta into common iliac arteries	L4
Formation of IVC	L5 (union of common iliac veins)
Diaphragm apertures	• Vena cava T8 • Oesophagus T10 • Aortic hiatus T12