INTRODUCTION

Hypotension following spinal anaesthesia is mainly occurs due to sympathetic blockade leading to peripheral vasodilatation and venous pooling of blood. As a result, there is decreased venous return and cardiac output leading to hypotension ***(Williamson et al., 2009).***

The spectrum of morbidity associated with hypotension may include but is not limited to a higher incidence of nausea, vomiting, dizziness, aspiration, syncope and cardiac arrhythmias ***(Ngan Kee et al., 2005).***

One of the most commonly used methods to reduce spinal anaesthesia induced hypotension is administration of fluids before implementation of spinal anaesthesia, a technique named 'pre-loading' first described by Wollman and Marx. This preloading with intravenous fluids offset the vasodilating effects of sympathetectomy caused by spinal anaesthesia thereby maintaining the venous return and thus the drop in blood pressure is prevented ***(Wollman and Marx, 1968).***

Crystalloids have shorter half-life in the intravascular compartment and generally exit the intravascular space within 1 hour so that their ability to expand the intravascular volume is limited due to shorter duration of action. Pre-loading with crystalloids has been found to be less effective due to the shorter half-life as they are less successful in maintaining the intravascular volume during the dynamic establishment of spinal anaesthesia effect and the resulting vasodilatation ***(Bajwa et al., 2013).***

Colloids, on the other hand, have a longer half-life in the intravascular compartment and are able to maintain the increase in intravascular volume for longer durations ***(Tamilselvan et al., 2009).***

Aim of the Work

To aid in making appropriate therapeutic decisions in the prophylaxis and management of post spinal hypotension and decreasing hazards of hypotension and the use of vasopressor.

Chapter 1

SPINAL ANESTHESIA

A- <u>Functional Anatomy of Spinal Blockade:</u>

In reviewing the functional anatomy of spinal blockade, an intimate knowledge of the spinal column, spinal cord, and spinal nerves must be present. This chapter briefly reviews the anatomy, surface anatomy, and sonoanatomy of the spinal cord.

The vertebral column consists of 33 vertebrae: 7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal segments. The vertebral column usually contains three curves. The cervical and lumbar curves are convex anteriorly, and the thoracic curve is convex posteriorly. The vertebral column curves, along with gravity, baricity of local anesthetic, and patient position, influence the spread of local anesthetics in the subarachnoid space. (**Figure 1**) depicts the spinal column, vertebrae, and intervertebral disks and foramina (1).

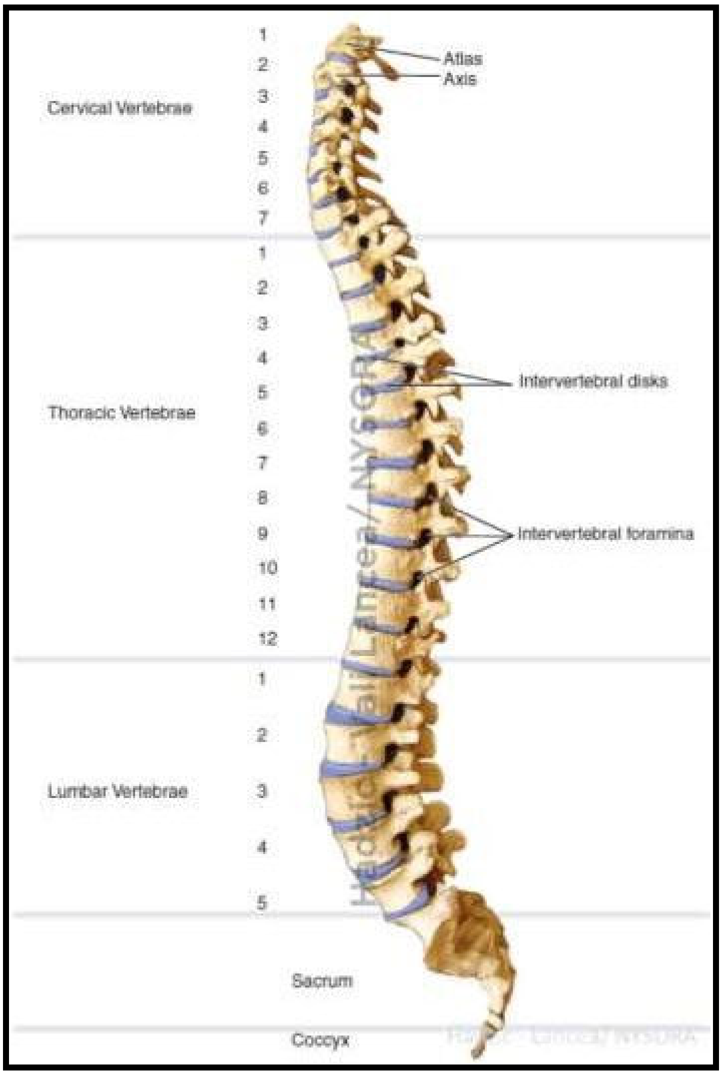

Figure (1): Spinal column, vertebrae, and intervertebral disks and foramina

Five ligaments hold the spinal column together (**Figure 2**). The supraspinous ligaments connect the apices of the spinous processes from the seventh cervical vertebra (C7) to the sacrum. The supraspinous ligament is known as the ligamentum nuchae in the area above C7. The interspinous ligaments connect the spinous processes together. The ligamentum flavum, or yellow ligament, connects the laminae above and below together. Finally, the posterior and anterior longitudinal ligaments bind the vertebral bodies together[2].

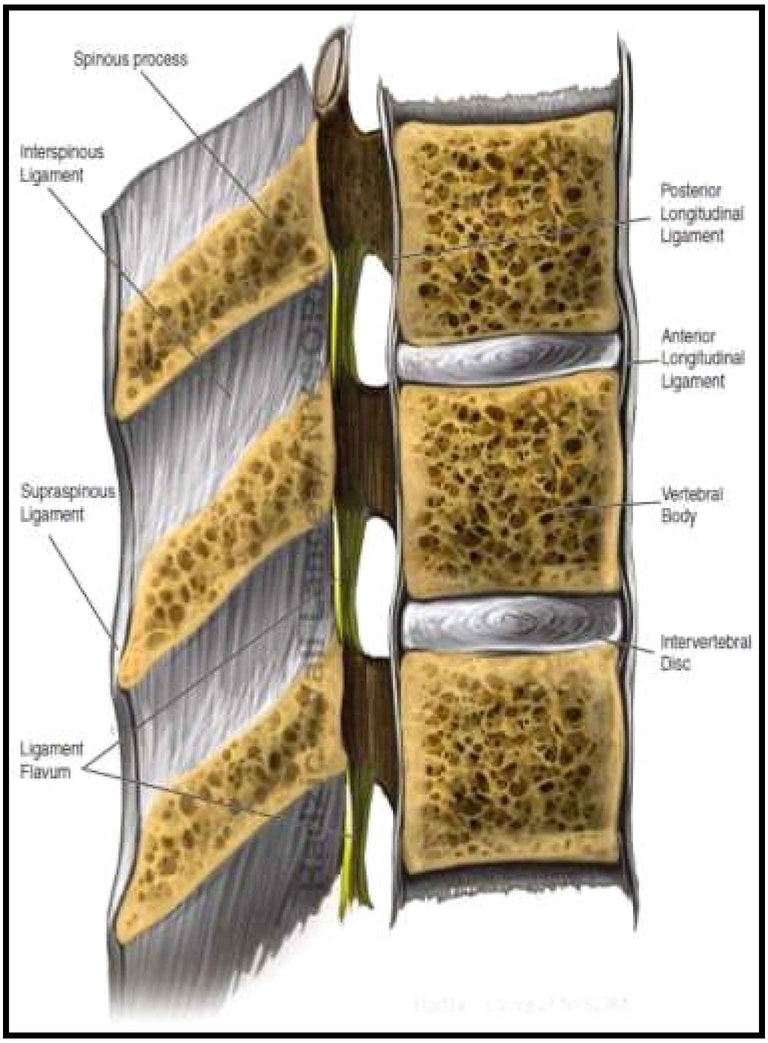

Figure (2): Cross section of the spinal canal and adjacent ligaments.

The three membranes that protect the spinal cord are the dura mater, arachnoid mater, and pia mater. The dura mater, or tough mother, is the outermost layer. The dural sac extends to the second sacral vertebra (S2). The arachnoid mater is the middle layer, and the subdural space lies between the dural mater and arachnoid mater. The arachnoid mater, or cobweb mother, also ends at S2, like the dural sac. The pia mater, or soft mother, clings to the surface of the spinal cord and ends in the filum terminale, which helps to hold the spinal cord to the sacrum. The space between the arachnoid and pia mater is known as the subarachnoid space, and spinal nerves run in this space, as does CSF. (**Figure 3**) depicts the spinal cord, dorsal root ganglia and ventral rootlets, spinal nerves, sympathetic trunk, rami communicantes, and pia, arachnoid, and dura maters(3).

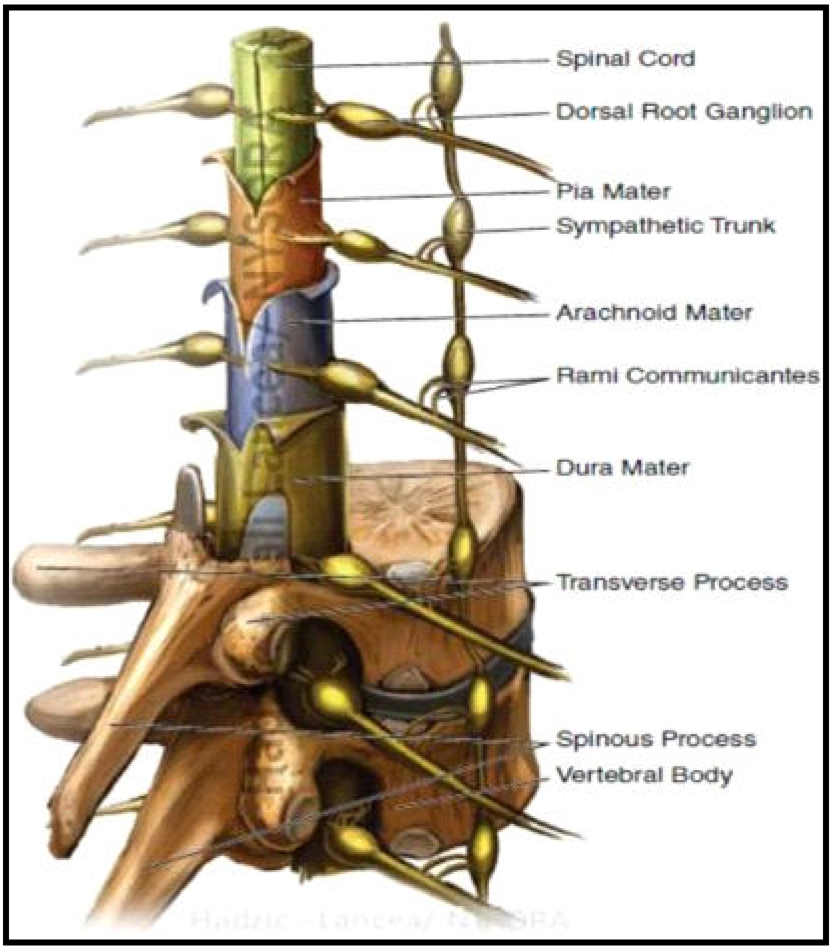

Figure (3): Spinal cord with meningeal layers, dorsal root ganglia, and the sympathetic nerve trunk.

When performing a spinal anesthetic using the midline approach, the layers of anatomy that are traversed (from posterior to anterior) are skin, subcutaneous fat, supraspinous ligament, interspinous ligament, ligamentum flavum, dura mater, subdural space, arachnoid mater, and finally the subarachnoid space. When the paramedian technique is applied, the spinal needle should traverse the skin, subcutaneous fat, paraspinous muscle, ligamentum flavum, dura mater, subdural space, and arachnoid mater and then pass into the subarachnoid space[(4)].

The anatomy of the subdural space requires special attention. The subdural space is a meningeal plane that lies between the dura and the arachnoid mater, extending from the cranial cavity to the second sacral vertebrae. Ultrastructural examination has shown this is an acquired space that only becomes real after tearing of neurothelial cells within the space. The subdural space extends laterally around the dorsal nerve root and ganglion. There is less potential capacity of the subdural space adjacent to the ventral nerve roots. This may explain the sparing of anterior motor and sympathetic fibers during subdural block (SDB) (**Figure 4**)[(5)].

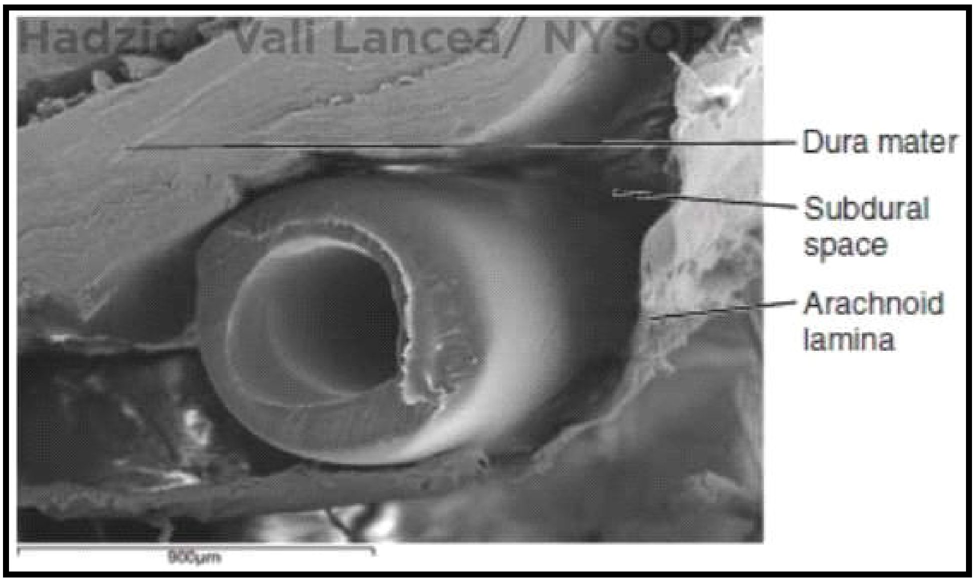

Figure (4): Epidural catheter in subdural space. Enhanced view of an epidural catheter inside a subdural space obtained from a cadaver under scanning electron microscopy.

The length of the spinal cord varies according to age. In the first trimester, the spinal cord extends to the end of the spinal column, but as the fetus ages, the vertebral column lengthens more than the spinal cord. At birth, the spinal cord ends at approximately L3. In the adult, the terminal end of the cord, known as the conus medullaris, lies at approximately L1. However, MRI and cadaveric studies have reported a conus medullaris below L1 in 19%–58% and below L2 in 0%–5%. The conus medullaris may lie anywhere between T12 and L3[6].

The typical position of the conus medullaris, cauda equina, termination of the dural sac, and filum terminale are shown. A sacral spinal cord in an adult has been reported, although this is extremely rare. The length of the spinal cord must always be kept in mind when a neuraxial anesthetic is performed, as injection into the cord can cause great damage and result in paralysis[7].

There are eight cervical spinal nerves and seven cervical vertebrae. Cervical spinal nerves 1 to 7 are numbered according to the vertebral body below. The eighth cervical nerve exits from below the seventh cervical vertebral body. Below this, spinal nerves are numbered according to the vertebral body above. The spinal nerve roots and spinal cord serve as the target sites for spinal anesthesia[9].

SURFACE ANATOMY

When preparing for spinal anesthetic blockade, it is important to accurately identify landmarks on the patient. The midline is identified by palpating the spinous processes. The iliac crests usually are at the same vertical height as the fourth lumbar spinous process or the interspace between the fourth and fifth lumbar vertebrae. An intercristal line can be drawn between the iliac crests to help locate this interspace. Care must be taken to feel for the soft area between the spinous processes to locate the interspace. Depending on the level of anesthesia necessary for the surgery and the ability to feel for the interspace, the L3–L4 interspace or the L4–L5 interspace can be used to introduce the spinal needle. Because the spinal cord commonly ends at the L1-to-L2 level, it is conventional not to attempt spinal anesthesia at or above this level. More recently, segmental thoracic spinal anesthesia has been described(10).

It would be incomplete to discuss surface anatomy without mentioning the dermatomes that are important for spinal anesthesia. A dermatome is an area of skin innervated by sensory fibers from a single spinal nerve. The tenth thoracic (T10) dermatome corresponds to the umbilicus, the sixth thoracic (T6) dermatome the xiphoid, and the fourth thoracic (T4) dermatome the nipples. (**Figure 5**) illustrates the dermatomes of the human body. To achieve surgical anesthesia for a given procedure, the extent of spinal anesthesia must reach a certain dermatomal level.

Dermatomal levels of spinal anesthesia for common surgical procedures are listed in (**Table 1**)[11].

Table (1): Dermatomal levels of spinal anesthesia for common surgical procedures.

Procedure	Dermatomal Level
Upper abdominal surgery	T4
Intestinal, gynecologic, and urologic surgery	T6
Transurethral resection of the prostate	T10
Vaginal delivery of a fetus and hip surgery	T10
Thigh surgery and lower leg amputations	L1
Foot and ankle surgery	L2
Perineal and anal surgery	S2 to S5 (saddle block)

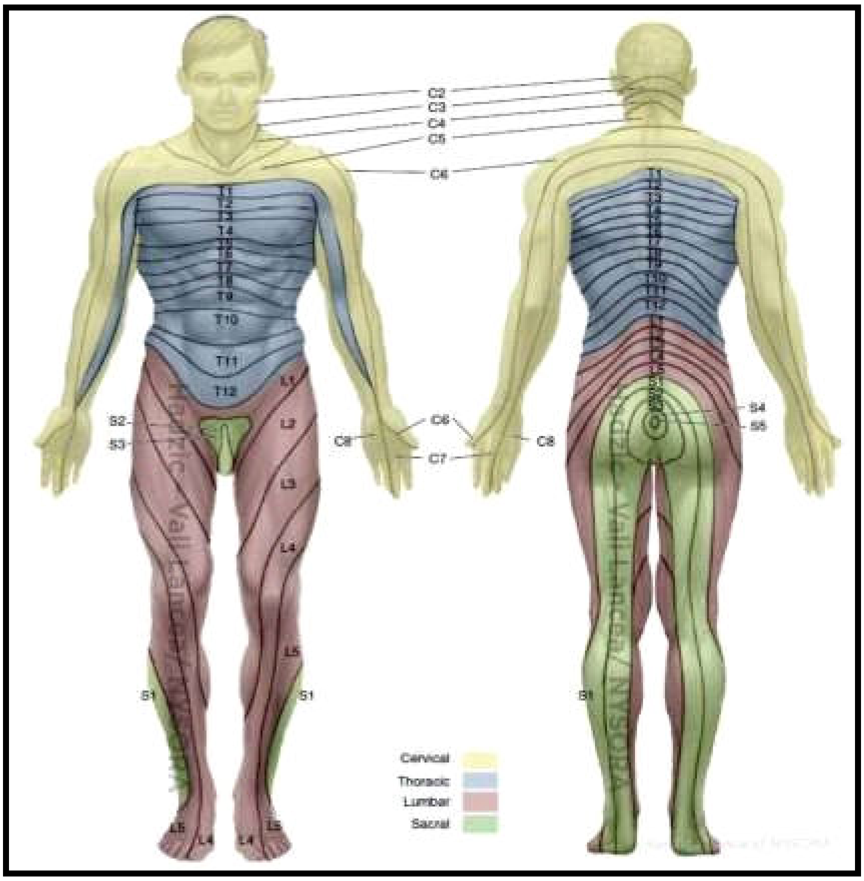

Figure (5): Dermatomes of the human body.

❖ <u>Sonoanatomy</u>

"Surface" anatomy refers to structures close enough to the integument that they are palpable. However, due to body habitus, this may not be possible. Neuraxial ultrasound allows sonoanatomical visualization of these structures and deeper structures. However, as the ultrasound beam cannot penetrate the bony vertebrae, specialized ultrasonic windows are required to visualize the neuraxis. The technique of neuraxial ultrasound is discussed elsewhere (see section on recent developments in spinal anesthesia)[12].

B- Indications and Benefits of Spinal Anesthesia:

- *Indications*

Spinal anesthesia provides excellent operating conditions for surgery below the umbilicus. Thus, it has been used in the fields of urological, gynecological, obstetric, and lower abdominal and perineal general surgery. Likewise, it has been used in lower limb vascular and orthopedic surgery. More recently, spinal anesthesia has been used in surgery above the umbilicus[13].

- ***Benefits of Spinal Anesthesia***

Although spinal anesthesia is a commonly used technique, with an estimated 324,950 spinal anesthetics each year in the United Kingdom alone, mortality and morbidity benefits are difficult to prove or disprove. It was hypothesized that due to beneficial modulation of the stress response, regional anesthesia would be safer than general anesthesia. However, clinical trials have been contradictory, and debates continue over the superiority of one technique over the other. Evaluations of the benefits of spinal blockade are troubled by the heterogeneity of studies and arguments about whether analysis should include intention to treat[14].

In addition, much of the evidence for the benefits of neuraxial blockade pertains to epidurals, and some reviews do not differentiate between spinal and epidural anesthesia. For example, CNB has been shown to reduce blood loss and thromboembolic events. However, the authors of these studies were wise not to analyze spinal and epidural anesthesia individually, as the subgroup sample size would have been inadequate. Further studies are required to elucidate the relative benefits of each technique[15].

An obvious benefit of spinal anesthesia is the avoidance of the many risks of general anesthesia. However, it must be remembered that there is always the possibility of conversion to general anesthesia, and an emergent general anesthesia may be riskier than a planned general anesthesia[16].

Spinal anesthesia is advantageous in certain clinical settings. It is now commonplace for women having cesarean delivery to have a neuraxial block. Spinal anesthesia avoids the problems associated with general anesthesia in the pregnant patient, notably risks of difficult airway, awareness, and aspiration. Maternal blood loss has been found to be lower with spinal compared with general anesthesia. Falling maternal mortality rates have been attributed to the increase in the practice of regional anesthesia. Moreover, regional anesthesia allows a mother to be awake for childbirth and a partner to be present if desired. However, a Cochrane review found no evidence of the superiority of regional anesthesia over general