INTRODUCTION

Hip replacement surgery is common among elderly patients. These patients have increased risk for perioperative mortality and morbidity due to additional comorbidities, such as cardiac, endocrine, renal, cerebral and respiratory diseases ***(Learmonth et al., 2007).***

Spinal anesthesia provides nerve blockade in a large part of the body during surgery with a smaller dose of local anesthetic and shorter surgery onset time. However, spinal anesthesia may lead to adverse hemodynamic changes, such as severe and prolonged hypotension in high-risk patients ***(Moore, 2009).***

The placement of an epidural catheter and slow, careful titration of the local anesthetic has been shown to be more hemodynamically stable than single shot spinals, while allowing titration ofanesthesia. However, epidural placement can be technically difficult in the elderly ***(Bundgaard et al., 2005).***

Continuous spinal anesthesia (CSA) provides extending blockade during surgery and versatile pain control during the postoperative period via an indwelling catheter,allowing intermittent injection of local anesthetic into the subarachnoid space. Better cardiovascular stability, less local anesthetic requirement, better control of anesthesia level and lower risk of local anesthetic toxicity were reported in the CSA technique compared with a single-dose spinal anesthesia technique ***(Maurer et al., 2003).***

AIM OF THE WORK

This study aim to compare between continuous spinal anesthesia and combined spinal epidural anesthesia in patients scheduled for elective major hip surgeries as regards their effectiveness and possible complications during operation.

Chapter 1

ANATOMY

Anatomy

The **vertebral column**, also known as the spinal column or spine, consists of a sequence of vertebrae, each of which is separated and united by an intervertebral disc. Together, the vertebrae and intervertebral discs form the vertebral column. It is a flexible column that supports the head, neck, and body and allows their movements. It also protects the spinal cord, which passes down the back through openings in the vertebrae ***(Openstax, 2016).***

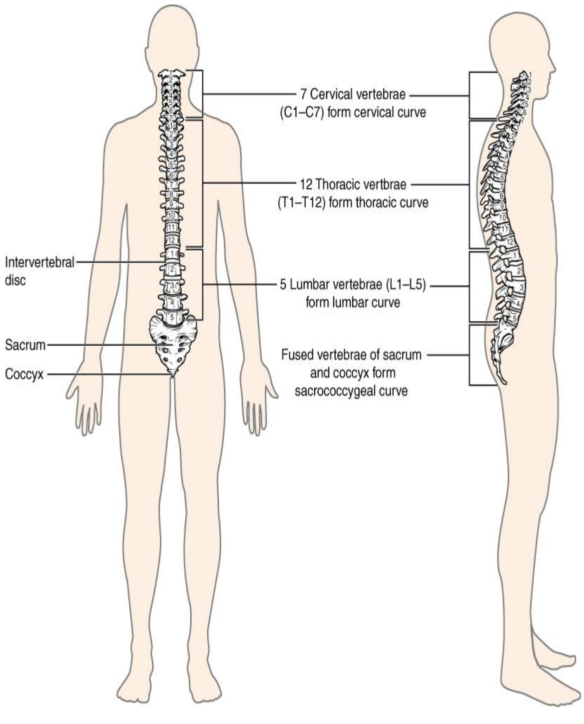

Figure (1): *Vertebral Column.* The adult vertebral column consists of 24 vertebrae, plus the sacrum and coccyx. The vertebrae are divided into three regions: cervical C1–C7 vertebrae, thoracic T1–T12 vertebrae, and lumbar L1–L5 vertebrae. The vertebral column is curved, with two primary curvatures (thoracic and sacrococcygeal curves) and two secondary curvatures (cervical and lumbar curves) ***(Openstax, 2016).***

The vertebral column originally develops as a series of 33 vertebrae, but this number is eventually reduced to 24 vertebrae, plus the sacrum and coccyx. The vertebral column is subdivided into five regions, with the vertebrae in each area named for that region and numbered in descending order. In the neck, there are seven cervical vertebrae, each designated with the letter “C” followed by its number. Superiorly, the C1 vertebra articulates with the occipital condyles of the skull. Inferiorly, C1 articulates with the C2 vertebra, and so on. Below these are the 12 thoracic vertebrae, designated T1–T12. The lower back contains the L1–L5 lumbar vertebrae. The single sacrum, which is also part of the pelvis, is formed by the fusion of five sacral vertebrae. Similarly, the coccyx results from the fusion of four small coccygeal vertebrae. However, the sacral and coccygeal fusions do not start until age 20 and are not completed until middle age ***(Openstax, 2016).***

Within the different regions of the vertebral column, vertebrae vary in size and shape, but they all follow a similar structural pattern. A typical vertebra will consist of a body, a vertebral arch, and seven processes **(Figure 2).** The body is the anterior portion of each vertebra and is the part that supports the body weight. Because of this, the vertebral bodies progressively increase in size and thickness going down the vertebral column. The bodies of adjacent vertebrae are separated and strongly united by an intervertebral disc. The vertebral arch forms the posterior portion of each vertebra. It consists of four parts, the right and left pedicles and the right and left laminae. Each pedicle forms one of the lateral sides of the vertebral arch. The pedicles are anchored to the posterior side of the vertebral body. Each lamina forms part of the posterior roof of the vertebral arch. The large opening between the vertebral arch and body is the vertebral foramen, which contains the spinal cord (***OpenStax, 2016).***

In the intact vertebral column, the vertebral foramina of all of the vertebrae align to form the vertebral (spinal) canal, which serves as the bony protection and passageway for the spinal cord down the back. When the vertebrae are aligned together in the vertebral column, notches in the margins of the pedicles of adjacent vertebrae together form an intervertebral foramen, the opening through which a spinal nerve exits from the vertebral column **(Figure 3)** (***OpenStax, 2016).***

Seven processes arise from the vertebral arch. Each paired transverse process projects laterally and arises from the junction point between the pedicle and lamina. The single spinous process (vertebral spine) projects posteriorly at the midline of the back. The vertebral spines can easily be felt as a series of bumps just under the skin down the middle of the back. The transverse and spinous processes serve as important muscle attachment sites (***OpenStax, 2016).***

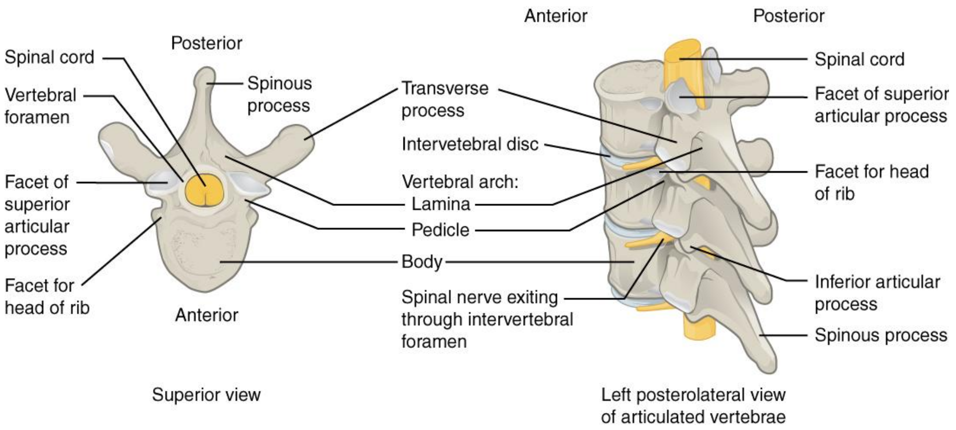

Figure (2): ***Parts of a Typical Vertebra.*** A typical vertebra consists of a body and a vertebral arch. The arch is formed by the paired pedicles and paired laminae. Arising from the vertebral arch are the transverse, spinous, superior articular, and inferior articular processes. The vertebral foramen provides for passage of the spinal cord. Each spinal nerve exits through an intervertebral foramen, located between adjacent vertebrae. Intervertebral discs unite the bodies of adjacent vertebrae ***(Openstax, 2016)***

An intervertebral disc is a fibrocartilaginous pad that fills the gap between adjacent vertebral bodies. Each disc is anchored to the bodies of its adjacent vertebrae, thus strongly uniting these. The discs also provide padding between vertebrae during weight bearing. Because of this, intervertebral discs are thin in the cervical region and thickest in the lumbar region, which carries the most body weight **(figure3)** ***(McMinn, 2005)***.

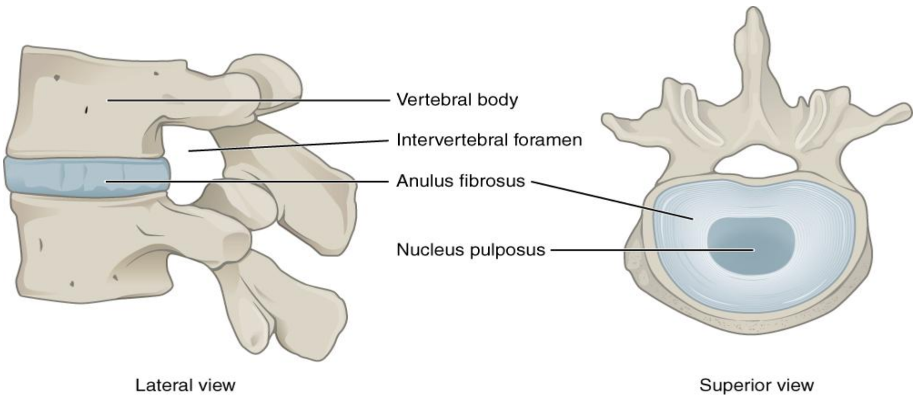

Figure (3): ***Intervertebral Disc.*** The bodies of adjacent vertebrae are separated and united by an intervertebral disc, which provides padding and allows for movements between adjacent vertebrae. The disc consists of a fibrous outer layer called the annulus fibrosus and a gel-like center called the nucleus pulposus. The intervertebral foramen is the opening formed between adjacent vertebrae for the exit of a spinal nerve ***(OpenStax, 2016).***

Adjacent vertebrae are united by ligaments that run the length of the vertebral column along both its posterior and anterior aspects **(Figure 4).** These serve to resist excess forward or backward bending movements of the vertebral column, respectively. The anterior longitudinal ligament runs down the anterior side of the entire vertebral column, uniting the vertebral bodies. It serves to resist excess backward bending of the vertebral column. The supraspinous ligament is located on the posterior side of the vertebral column, where it interconnects the spinous processes of the thoracic and lumbar vertebrae. This strong ligament supports the vertebral column during forward bending motions ***(Openstax, 2016).***

Additional ligaments are located inside the vertebral canal, next to the spinal cord, along the length of the vertebral column. The posterior longitudinal ligament is found anterior to the spinal cord, where it is attached to the posterior sides of the vertebral bodies. Posterior to the spinal cord is the ligamentum flavum (“yellow ligament”). This consists of a series of short, paired ligaments, each of which interconnects the lamina regions of adjacent vertebrae. The ligamentum flavum has large numbers of elastic fibers, which have a yellowish color, allowing it to stretch and then pull back. Both of these ligaments provide important support for the vertebral column when bending forward ***(Openstax, 2016).***

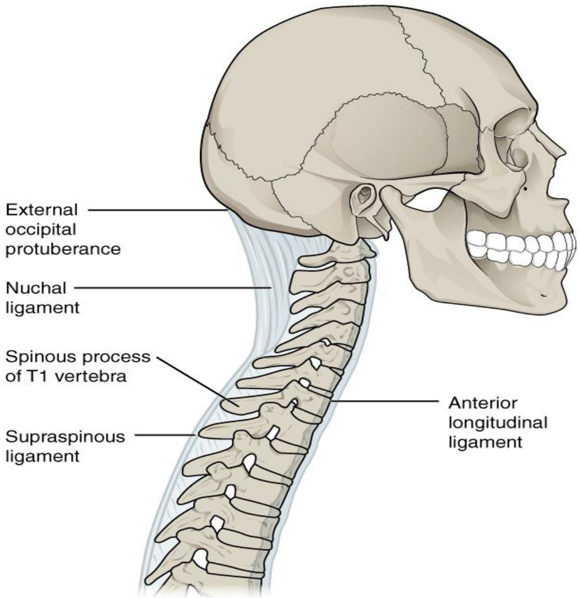

Figure (4): Ligaments of Vertebral Column. The anterior longitudinal ligament runs the length of the vertebral column, uniting the anterior sides of the vertebral bodies. The supraspinous ligament connects the spinous processes of the thoracic and lumbar vertebrae. In the posterior neck, the supraspinous ligament enlarges to form the nuchal ligament, which attaches to the cervical spinous processes and to the base of the skull ***(Openstax, 2016).***

Anatomy of the Spinal Cord

The spinal cord is located inside the vertebral canal, which is formed by the foramina of 7 cervical, 12 thoracic, 5 lumbar, and 5 sacral vertebrae, which together form the spine . It extends from the foramen magnum down to the level of the first and second lumbar vertebrae and at birth, down to second and third lumbar vertebrae ***(Backes, 2008)***.

The spinal cord is composed of 31 segments: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 1 coccygeal, mainly vestigial .The spinal nerves comprise the sensory nerve roots, which enter the spinal cord at each level, and the motor roots, which emerge from the cord at each level. The spinal nerves are named and numbered according to the site of their emergence from the vertebral canal. C1-7 nerves emerge above their respective vertebrae. C8 emerges between the seventh cervical and first thoracic vertebrae. The remaining nerves emerge below their respective vertebrae ***(McKinley et al., 2002)***.

The conus medullaris is the cone - shaped termination of the caudal cord .The pia mater continues caudally as the filum terminale through the dural sac and attaches to the coccyx .The coccyx has only one spinal segment .The cauda equina is the collection of lumbar and sacral spinal nerve roots that travel caudally prior to exiting at their respective intervertebral foramina .The cord ends at vertebral levels L1-L2 ***(Kubo et al., 2007).***

The spinal cord is nearly cylindrical in shape though its girth increases considerably in the regions giving rise to the large nerves of the limbs; because of the increased number of nerve cells within the spinal cord at these regions:

a) The cervical enlargement: extends from C4 to T1 (maximum transverse diameter is 14 mm at C6); it gives rise to nerve roots which form the brachial plexus.

b) The lumber enlargement: extends from L2 to S3 (maximum transverse diameter is 12 mm at T12); it gives rise to fibers that form the lumbar plexus (L1-L4) and sacral plexus (L4-S2) ***(Kojima et al., 2007).***

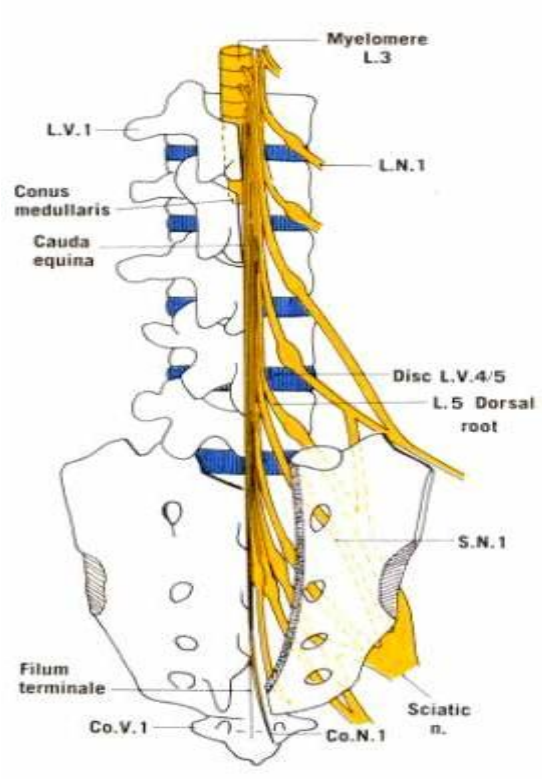

Figure (5): The spinal cord and cauda equina in situ. Posterior aspect, made visible by a laminectomy on the right-hand side. The dorsal rami are omitted. The intervertebral discs are shown in blue. It can be seen that prolapse of disc L4/5, for example, would be likely to damage L5 roots ***(O'Rahilly, 2008).***

Spinal cord vascular supply

Arterial supply

The spinal cord is supplied by descending branches of the vertebral arteries (i.e., anterior spinal arteries) and multiple radicular arteries derived from segmental vessels.

Paired anterior spinal arteries unite to form a single descending vessel (i.e., anterior spinal artery) which enters the anterior median fissure of the spinal cord and supplies the anterior two thirds of the cord. It also supplies midline rami to the lower medulla. Like the basilar artery, it has smaller penetrating and circumferential branches.

Two posterior spinal arteries each supply the ipsilateral posterior one sixth of the cord or combined, the posterior one third. (They receive varied contribution from the posterior radicular arteries and form two longitudinal plexiform channels near the dorsal root entry zone).

Radicular arteries are derived from segmental vessels e.g., ascending cervical, deep cervical, intercostal, lumbar, and sacral arteries that pass the intervertebral foramina and give rise to anterior and posterior radicular arteries. Segmental radicular arteries supply blood to the roots, and segmental radiculospinal arteries supply the roots as well as the cord. Usually a few large segmental radiculospinal arteries are noted, including the artery of Adamkiewicz, artery of the lumbar enlargement, (Which is larger than the others; it usually originates between T9 and T12) In 75% of cases)and supplies the lower one third of the cord.

Where two anterior radicular arteries reach the same level of the spinal cord, a diamond-shaped arterial configuration develops. The distance between radicular arteries is greatest in the thoracic spinal segments, thus occlusion of one thoracic radicular artery may seriously compromise the circulation. Therefore, the upper thoracic T1-4 and L1 segments are particularly vulnerable to vascular insultsm ***(McMinn, 2005)***.

Venous drainage

Veins draining the spinal cord have a distribution similar to that of the arteries. Anterior longitudinal trunks consist of anteromedian and anterolateral veins. Sulcal veins drain the anteromedian portions of the spinal cord. Anterolateral regions of the spinal cord drain into anterolateral veins. Posterior longitudinal venous trunks drain the posterior funiculi. The internal vertebral venous plexuses i.e., (epidural venous plexuses) are located between the dura matter and the vertebral periosteum and consist of two or more anterior and posterior longitudinal venous channels that are interconnected at many levels from the clivus to the sacral region ***(Romanes, 2004)***.

At each intervertebral space are connections with thoracic, abdominal and intercostal veins and external vertebral venous plexuses. These spinal veins have no valves and blood passes directly into the systemic venous system. The continuity of this venous plexus with the prostatic plexus is probably the path along, which prostatic neoplastic cells metastasize ***(McMinn, 2005)***.

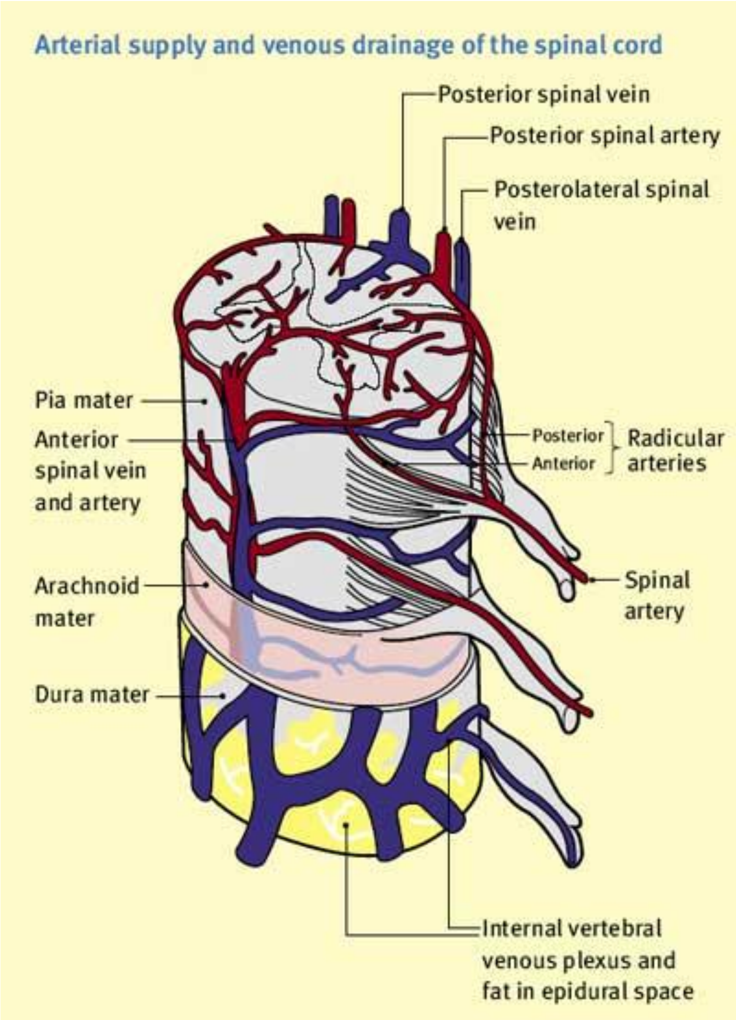

Figure (6): Arterial supply and venous drainage of the spinal cord ***(Romanes, 2004).***

Meninges of the spinal cord

The spinal cord, like the brain, is surrounded by the three meninges**. The dura mater** extends from the foramen magnum to the sacrum and coccyx **(Figure 5).** The dura is attached to the foramen magnum and the periosteum covering the uppermost cervical vertebrae and their ligaments. Through the remainder of the vertebral canal, the dura is not attached to the vertebrae, being separated by the epidural (or peridural or extradural) space, which contains fat and the internal vertebral venous plexus. Extensions of dura (dural sheaths) surround the nerve roots and spinal ganglia, and continue into the connective tissue coverings (epineurium) of the spinal nerves ***(Kojima et al., 2007).***

The arachnoid invests the spinal cord loosely. Continuous with the cerebral arachnoid above, it traverses the foramen magnum and descends to about the S2 vertebral level. The subarachnoid space, which contains cerebrospinal fluid (C.S.F.), is a wide interval between the arachnoid and pia. Because the spinal cord ends at about the level of the L2 vertebra, whereas the subarachnoid space continues to S2, access can be gained to the C.S.F. by inserting a needle between the vertebral lamina below the end of the cord; a procedure termed lumbar puncture ***(Romanes, 2004).***

The pia mater invests the spinal cord closely, ensheathes the anterior spinal artery (as the lineasplendens),