INTRODUCTION

The introduction of laparoscopy in the field of surgery in the mid-1950s revolutionised surgical techniques due to reduction in overall medical costs, reduced bleeding, less post-operative surgical and pulmonary complications, and early recovery. The gradual shift of laparoscopy to include more complicated surgical procedures resulted in modifications of existing anesthetic techniques. The various effects of induction of pneumoperitoneum, an integral part of laparoscopy, can result in respiratory embarrassment and cardiovascular changes best managed by the use of general anesthesia (GA). ***(Gerges et al., 2006).***

Laparoscopic cholecystectomy (LC) was first introduced by Phillipe Mouret in 1987 and is now generally performed by many surgeons. Unlike previous open surgery, this procedure requires only very little incisions and has benefits such as less pain and shorter hospital stay due to less tissue damage and swift return to everyday life due to fast recovery. However, considerable difficulties in anesthetic management could be encountered since wide hemodynamic fluctuation may develop due to pneumoperitoneum and position changes. ***(Vecchio et al., 2000).***

Pneumoperitoneum induces systemic effects due to the absorption of CO_2 and affect venous return due to the increase in intra-abdominal pressure. Initially, absorption of CO_2

increases its elimination in the expired air, in the arterial and venous blood. This carboxemia induces metabolic and respiratory acidosis decreasing arterial and mixed venous pH and arterial PO_2. Absorption of CO_2 affects negatively the respiratory function which is not observed with inert gases such as helium and argon. Minute ventilation, peak inspiratory pressure, pulmonary vascular resistance, alveolar concentration of CO_2, central venous pressure, diastolic and systolic blood pressure, systemic vascular resistance and cardiac index are all increased. ***(Junghans et al., 1997).***

Since the initiation of the application of laparoscopy in various day-care surgeries, a more favourable anesthetic technique is required allowing early recovery and ambulation. ***(Bagwa et al., 2014).***

LC with pneumoperitoneum has traditionally been performed under GA, however, owing in part to the advancement of surgical and anesthetic techniques, many LC have been successfully performed under the regional anesthetic techniques. Generally, regional anesthesia (RA) has lower postoperative mortality and fewer complications than GA, so RA seems more suitable for the minimally invasive laparoscopic surgery. ***(Yuksek et al., 2008).***

In recent years, advanced laparoscopic surgery has targeted older and high risk patients for GA; in these patients, RA offers several advantages with improved patient satisfaction ***(Lee et al., 2007)***.

AIM OF THE WORK

The aim of this work is to compare epidural anesthesia versus GA as regard intraoperative hemodynamics and postoperative pain control for LC.

REVIEW OF LITERATURE

Anatomic Considerations

Anatomy of the vertebral column

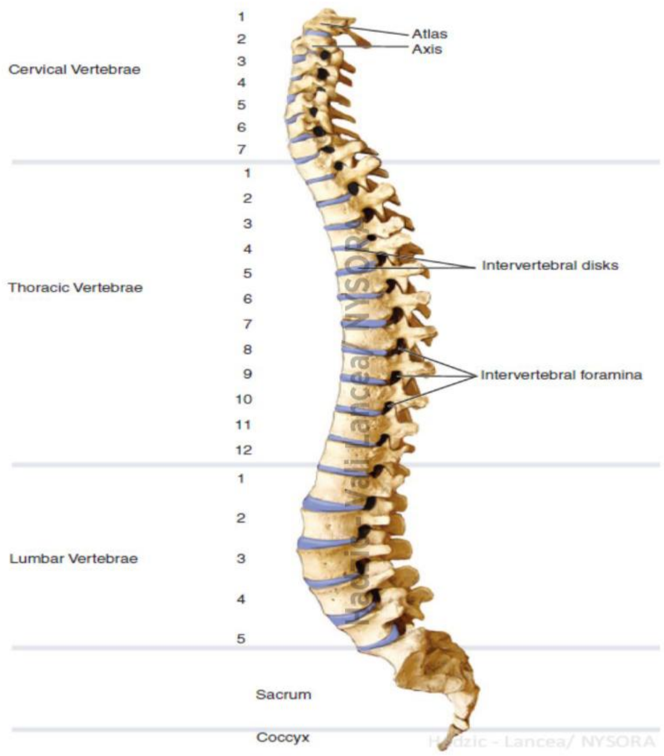

Figure (1): The vertebral column and the curvatures of the adult spine, lateral view.***(Hadzic ,2017)***

The vertebral column forms part of the axis of the human body, extending in the midline from the base of the skull to the pelvis. Its four primary functions are protection of the spinal cord, support of the head, provision of an attachment point for the upper extremities, and transmission of weight from the trunk to the lower extremities. The vertebral column serves as the landmark for a wide variety of RA techniques. It is important, therefore, that the anesthesiologist be able to develop a three-dimensional mental image of the structures developing the vertebral column. ***(Hadzic, 2017).***

The vertebral column consists of 33 vertebrae (7 cervical, 12 thoracic, 5 lumbar, 5 sacral, and 4 coccygeal segments). In the embryonic period, the spine curves into a C shape, forming two primary curvatures with their convex aspect directed posteriorly. These curvatures persist through adulthood as the thoracic and sacral curves. The cervical and lumbar lordoses are secondary curvatures that develop after birth as a result of extension of the head and lower limbs when standing erect. The secondary curvatures are convex anteriorly and augment the flexibility of the spine ***(Hadzic, 2017).***

Vertebrae

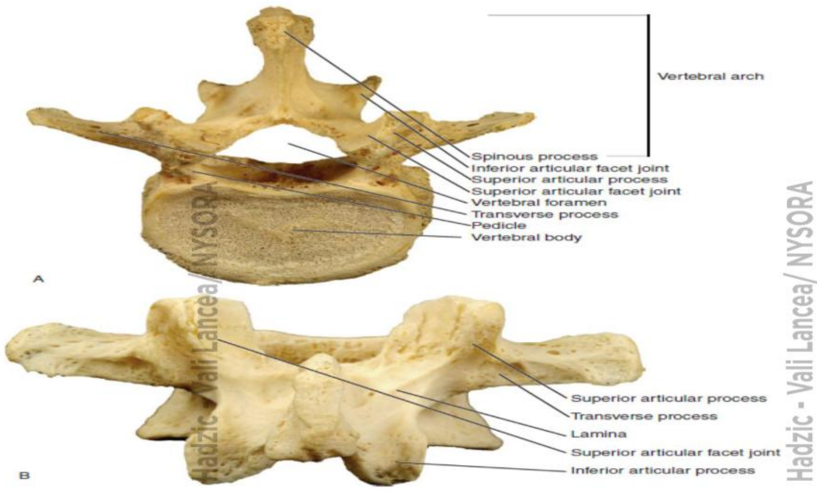

Figure (2): A typical vertebra. **A:** Superior view of the L5 vertebra. **B:** Posterior view of the L5 vertebra. ***(Hadzic ,2017)***

A typical vertebra consists of a vertebral arch posteriorly and a body anteriorly. This holds true for all vertebrae except C1. Two pedicles arise on the posterolateral aspect of each vertebra and fuse with the two laminae to encircle the vertebral foramen. These structures form the vertebral canal, which contains the spinal cord, spinal nerves, and epidural space. Fibrocartilaginous disks containing the nucleus pulposus, an avascular gelatinous body surrounded by the collagenous lamellae of the annular ligament, join the vertebral bodies. The transverse processes arise from the laminae and project laterally, whereas the spinous process projects posteriorly from the midline union of the laminae. The spinous process is frequently bifid at the cervical level and serves as an attachment for muscles and ligaments. ***(Hogan et al., 1991)***.

The interlaminar spaces in the thoracic spine are narrow and more challenging to access with a needle due to overlapping laminae. In contrast, the laminae of the five lumbar vertebrae do not overlap. The interlaminar space between adjacent lumbar vertebrae is rather large ***(Hogan et al., 1991)***.

In the lumbar spine, joint surfaces are curved, with a coronal orientation of the anterior portion and a sagittally oriented posterior portion. Thoracic facets are located anterior to the transverse processes, whereas cervical and lumbar facets are located posterior to their transverse processes. ***(Hogan et al., 1991)***.

Intervertebral Ligaments

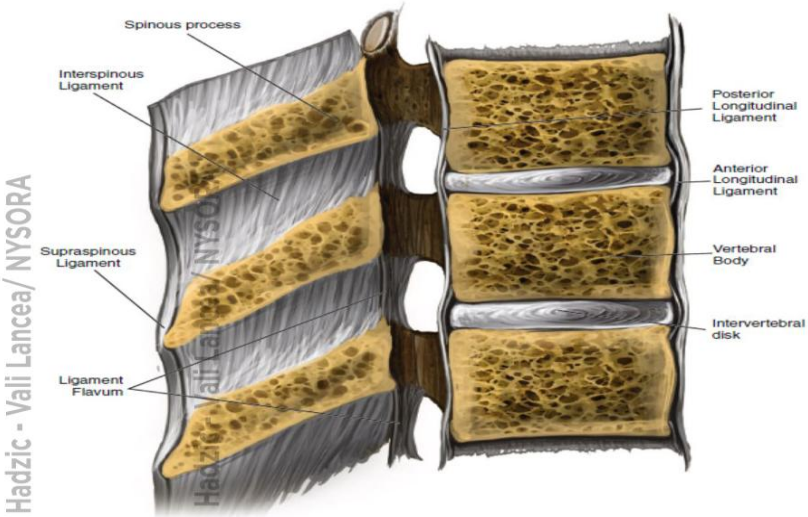

Figure (3): A cross-sectional view of the vertebral canal with the intervertebral ligaments, vertebral body, and spinous process. ***(Hadzic ,2017)***

The vertebral column is stabilized by a series of ligaments. The anterior and posterior longitudinal ligaments run along the anterior and posterior surfaces of the vertebral bodies, respectively, reinforcing the vertebral column. The supraspinous ligament, a heavy band that runs along the tips of the spinous processes, becomes thinner in the lumbar region. This ligament continues as the ligamentum nuchae above T7 and attaches to the occipital external protuberance at the base of the skull. ***(Hogan, 1998).***

The interspinous ligament is a narrow web of tissue that attaches between spinous processes; anteriorly it fuses with the ligamentum flavum and posteriorly with the supraspinous ligament. ***(Hogan, 1998)***.

The ligamentum flavum is a dense, homogenous structure, composed mostly of elastin which connects the lamina of adjacent vertebrae. The lateral edges of the ligamentum flavum surround facet joints anteriorly, reinforcing their joint capsule ***(Yoon et al., 2014).***

When a needle is advanced toward the epidural space, there is an easily perceptible *increase in resistance* when the ligamentum flavum is encountered. More importantly for the practice of neuraxial anesthesia, a perceptible, sudden *loss of resistance* is encountered when the tip of the needle passes through the ligamentum and enters the epidural space ***(Yoon et al., 2014).***

The ligamentum flavum consists of right and left halves that join at an angle of less than 90°. Importantly, this midline fusion may be absent to a variable degree depending on the vertebral level. These fusion gaps allow for veins to connect to vertebral venous plexuses. Of note, the fusion gaps are more prevalent at cervical and thoracic levels. Yoon et al reported that midline gaps between C3 and T2 occur in 87%–100% of individuals. The incidence of the midline gap decreases at lower vertebral levels, with T4–T5 the lowest (8%). In theory, a midline gap poses a risk of failure to recognize a loss of resistance at the cervical and high thoracic levels when using the midline approach, resulting in an inadvertent dural puncture ***(Yoon et al., 2014).***

The ligamentum flavum is thinnest in the cervical and upper thoracic regions and thickest in the lower thoracic and lumbar regions. As a result, resistance to needle advancement is easier to appreciate when a needle is introduced at a lower level (eg, lumbar). At the L2–L3 interspace, the ligamentum flavum is 3- to 5-mm thick. At this level, the distance from the ligamentum to the spinal meninges is 4–6 mm. Consequently, a midline insertion of an epidural needle at this level is least likely to result in an inadvertent meningeal puncture with epidural anesthesia-analgesia ***(Lirk et al., 2005)***.

The lateral wall of the vertebral canal has gaps between consecutive pedicles known as intervertebral foramina. Because the pedicles attach more cephalad of the middle of the vertebral body, the intervertebral foramina are centered opposite the lower half of the vertebral body, with the vertebral disk at the caudal end of the foramen. As a consequence, the borders of the intervertebral foramina are the pedicle at the cephalad and caudal ends, the vertebral body (cephalad) and the disk (caudally) on the anterior aspect, a portion of the next vertebral body most inferiorly, and posteriorly the lamina, facet joint, and ligamentum flavum ***(Yoon et al., 2014).***

Spinal Meninges

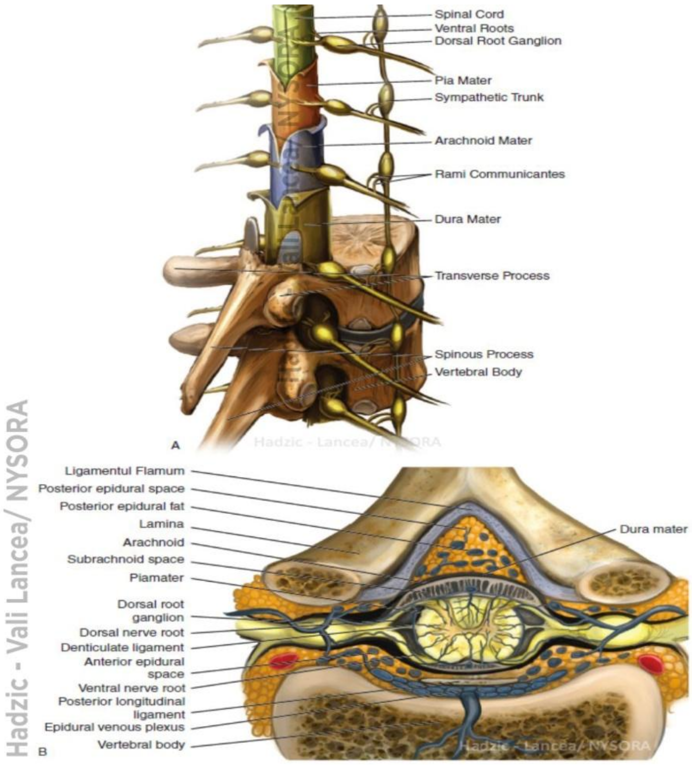

Figure (4): A. Sagittal view of the spinal cord with meningeal layers, dorsal root ganglia, spinal nerves, and sympathetic trunk. **B.** Crosssectional view of the spinal cord depicting the ligamentum flavum in respect to the posterior epidural space. Notice the close proximity of the posterior epidural space to the subarachnoid space. ***(Hadzic ,2017)***

The spinal cord is an extension of the medulla oblongata. It has three covering membranes: the dura, arachnoid, and pia maters. These membranes concentrically divide the vertebral canal into three distinct compartments: the epidural, subdural, and subarachnoid spaces. The epidural space contains fat, epidural veins, spinal nerve roots, and connective tissue the subdural space is a “potential” space between the dura and the arachnoid and contains a serous fluid ***(Neary, 2008).***

The subdural compartment is formed by flat neuroepithelial cells that have long interlacing branches. These cells are in close contact with the inner dural layers. This space can be expanded by shearing the neuroepithelial cell layer connections with the collagen fibers of the dura mater. This expansion of the subdural space can be caused mechanically by injecting air or a liquid such as contrast media or local anesthetics, which, by applying pressure in the space, separates the cell layers. The subarachnoid space is traversed by threads of connective tissue extending from the arachnoid mater to the pia mater. It contains the spinal cord, dorsal and ventral nerve roots, and cerebrospinal fluid (CSF). The subarachnoid space ends at the S2 vertebral level ***(Neary, 2008).***

Spinal Cord

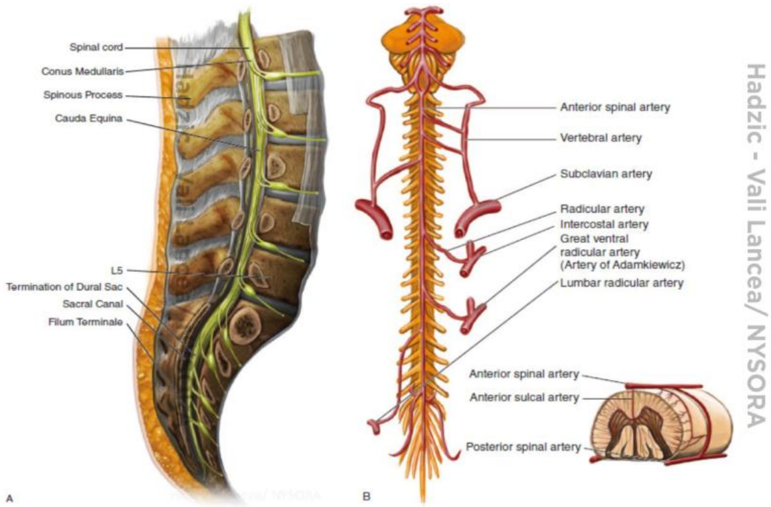

Figure (5): A. Sagittal view of the lumbar vertebrae. The spinal cord terminates at the L1-L2 interspace. **B.** Arterial supply to the anterior spinal cord. The Artery of Adamkiewicz emerges from T8-L1 vertebral segments. The small insert demonstrates the blood supply to the spinal cord (one anterior and two posterior arteries). ***(Hadzic ,2017)***

There are eight cervical neural segments. The eighth segmental nerve emerges between the seventh cervical and first thoracic vertebrae, whereas the remaining cervical nerves emerge above their same-numbered vertebrae. Thoracic, lumbar, and sacral nerves emerge from the vertebral column below the samenumbered bony segment· Anterior and posterior spinal nerve roots arise from rootlets along the spinal cord. The roots of the upper and lower extremity plexuses (brachial and lumbosacral) are significantly larger compared to other levels ***(MacDonald et al., 1999).***

The dural sac is continuous from the foramen magnum to the sacral region, where it spreads distally to cover the filum terminale ***(MacDonald et al., 1999).***

In children, the dural sac terminates lower, and in some adults, the sac termination can be as high as L5. The vertebral canal contains the dural sac, which adheres superiorly to the foramen magnum, to the posterior longitudinal ligament anteriorly, the ligamentum flavum and laminae posteriorly, and the pedicles laterally ***(MacDonald et al., 1999).***

The spinal cord tapers and ends as the conus medullaris at the level of the L1–L2 intervertebral disc. The filum terminale, a fibrous extension of the spinal cord, extends caudally to the coccyx. The cauda equina is a bundle of nerve roots in the subarachnoid space distal to the conus medullaris ***(MacDonald et al., 1999).***

The spinal cord receives blood primarily from one anterior and two posterior spinal arteries that derive from the vertebral arteries. Other major arteries that supplement blood supply to the spinal cord include the vertebral, ascending cervical, posterior intercostals lumbar, and lateral sacral arteries. The single anterior spinal artery and two posterior spinal arteries run longitudinally along the length of the cord and combine with segmental arteries in each region. The major segmental artery (Adamkiewicz) is the largest segmental artery and is found between the T8 and L1 vertebral segments. The Adamkiewicz artery is the major blood supplier to two-thirds of the spinal cord. Injury of this artery may result in *anterior spinal artery syndrome*, characterized by loss of urinary and fecal continence as well as impaired motor function of the legs. The radicular arteries are branches of the spinal arteries and run within the vertebral canal and supply the vertebral column. Radicular veins drain blood from the vertebral venous plexus and eventually drain into the major venous system: the superior and inferior vena cava and the azygos venous system of the thorax ***(Neary, 2008).***

Anatomy of the gall bladder

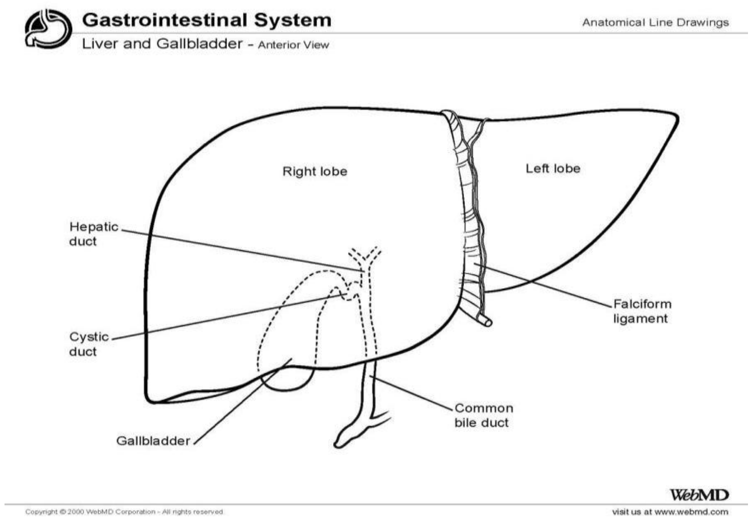

Figure (6): Liver and gallbladder, anterior view. ***(Agur et al., 2013)***

The gallbladder is a relatively small but surgically important organ of the body. Cholecystectomy (open or laparoscopic surgical removal of the gallbladder as a treatment for stones) is one of the most common surgical procedures performed the world over. ***(Agur et al., 2013).***

The gallbladder is a piriform (pear-shaped) organ that ocupy the undersurface of segments IVB and V of the liver. It has an inferior peritoneal surface and a superior hepatic surface that is closely applied to the gallbladder bed in the liver. The cystic plate is a condensation of fibro-areolar tissue that separates the gallbladder from the liver parenchyma. The cystic plate is well formed in the gallbladder body but gets thinner towards the gallbladder fundus. Small bile ducts may drain from liver parenchyma to the gallbladder through the cystic plate (ducts of Luschka). The part of the gallbladder projecting beyond the undersurface of the liver is called the fundus; fundus continues into the main body of the gallbladder, which lies in a fossa on the undersurface of the liver. The body of the gallbladder narrows into an infundibulum, which leads through the neck to the cystic duct ***(Agur et al., 2013).***

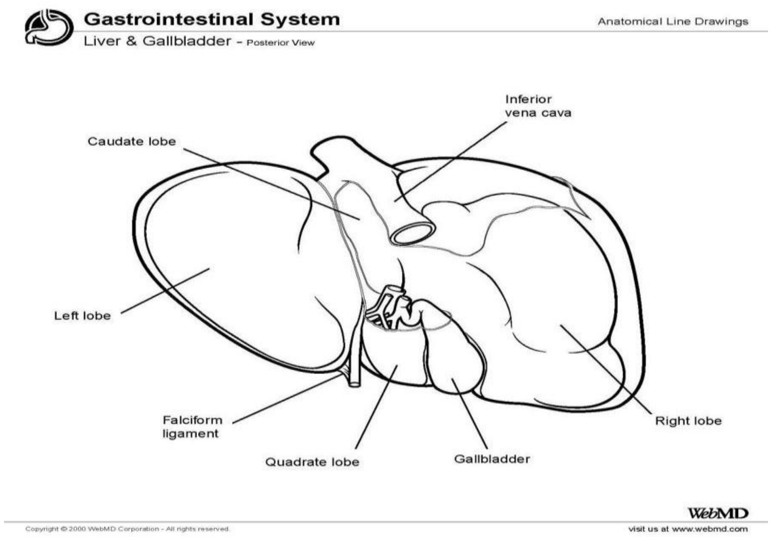

Figure (7): Liver and gallbladder, posterior view. ***(Agur et al., 2013)***

The cystic duct has spiral folds of mucosa called "valves" of Heister. An inferior sacculation (outpouching) of the gallbladder infundibulum or neck is sometimes present; this is called the Hartmann pouch. The Calot triangle is bounded by the cystic duct on the right, common hepatic duct (CHD) on the left, and undersurface of the liver above; the cystic artery and cystic lymph node of Lund lie in the Calot triangle. A peritoneal cholecystoduodenal fold connects the gallbladder neck to the first part of the duodenum ***(Agur et al., 2013).***