Ain Shams University
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Anesthetic Management of Acute and Chronic Spinal Cord Injuries

Essay

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By

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Abstract

Dramatic improvement in the care of spinal cord injury patients have been achieved over the last few decades. The active management of urinary tract and respiratory complications has lead to decrease in mortality from respiratory and renal failure. The implications of increased survival are an increase in the prevalence of spinal cord injuries, an increase in the numbers of the patients presenting for elective surgery and over increasing number of spinal cord injured patients who develop further medical conditions as the result of normal aging.

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A spinal cord injury is a devastating condition of major public health importance.

Motor vehicle accidents are the main causes of spinal cord injuries account for about 40 to 50%of injuries. In descending order of frequency falls, sporting accidents (especially diving) and penetrating injuries of spinal column are responsible for almost all spinal cord injuries **(Banerjee, Fadale, 2004)**.

Most spinal cord injuries are produced by fractures, dislocations, or subluxations of the spinal vertebrae. Exceptions are gun and stab wounds that can damage the spinal cord by direct penetration, with laceration of nervous tissue, or by injury to blood vessels. In the case of a gunshot injury, the concussive effects of the bullet's impact on the vertebral column may result in a complete spinal cord lesion without actual penetration of the spinal canal **(Ronan Dardis *et al*, 2006)**.

Anatomically, the spinal cord is divided into the cervical, thoracic, lumbar, and sacral levels. At each of these levels originate spinal nerves that maintain various physiologic functions. The level of injury will dictate the loss of what physiologic functions. Owing to this, the higher the level of injury, the more catastrophic the impediments would be. These physiologic functions include not only the neuromuscular system but also cardiovascular, respiratory, metabolic and nutritional systems **(DiMarco, 2001)**.

Spinal injury usually occurs at the junction of a more mobile spinal section with a less mobile one of the spine. The cervical region and the thoracolumber junction (T11-L2) are the most commonly affected areas in spinal

injury, followed by the thoracic and lumber segments of the spine **(Ehod and Stephen, 2005)**.

Spinal cord injuries are initially evaluated through series of plain x-rays. After analysis of routine films a CT can be performed at areas of suspected bone injuries using 4 or 5 mm thick slices. In patients with neurological deficits or plain x-ray evident of canal compromise a high resolution CT, Myelogram or MRI can be used to evaluate the neural compression (MRI has the advantage of better visualization of the cord and ligaments injuries) .

The initial reduction of morbidity of spinal cord injuries is related to the better prehospital treatment, including stabilization, transport techniques and the management of the patient in a highly specialized trauma center **(Hadley and Browner 1992)**.

The chronic spinal cord injured patient poses an interesting and unique set of changes for the anesthetist. The anesthetist needs to have an understanding of the specific features of spinal cord injury as well as how other illnesses present in these patients in order to tailor appropriate anesthetic care **(Hambly, Martin, 1998)**.

Chronic spinal cord injured patients of whom there are an estimated 35-40000 in the United Kingdom With the changes in the long term management of such patients seen over the last 30 years life expectancy is improving, and therefore more patients will present with the need for surgery unrelated to their spinal cord injury **(Hambly, Martin, 1998)**.

Anatomical and Physiological Considerations

Anatomy of the Vertebral Column:

The Vertebral column is a midline structure extending from the base of the skull above to the pelvis below. It provides protection for the spinal cord and transfers weight through the pelvis, as well as having an extensive area for muscular attachment. It consists of bony vertebrae connected by intervertebral fibrocartilaginous discs **(McMinn, 2005)**.

There are seven cervical, twelve thoracic and five lumbar vertebrae, the sacrum comprises five and the coccyx four, fused segments **(Snell, 2004)**.

Curves of the Spine:

The adult spine presents four curvatures, those of the cervical and lumbar zones are convex forwards (lordosis), those of the thoracic and sacral regions are concave (kyphosis). The former are postural, the latter are produced by the actual configuration of the bones themselves. In the fetus, there is only a single concave forward curvature, the cervical compensatory curve develops, when the newborn infant holds up its head and the lumbar curve follows still later, when the child sits and then stands **(Young *et al*, 1997)**.

The Vertebrae

A typical vertebra has an anterior body and a posterior neural arch, the lumbar bodies are the largest, having to support proportionately more weight. The vertebral bodies are each separated by a tough fibrocartiligenous disc. The neural arch is connected to the vertebral body by two strong pedicles of bone. The pedicles each have articular facets

(superior and inferior), which articulate with similar facets of the adjacent vertebra as a synovial joint (facet joint). The neural arch is completed posteriorly by the two bony laminae joining to form a spinous process. A transverse process on each side projects laterally and provides additional surface area for muscular attachment. There are also two costal processes on each vertebral body, which are well developed in the thoracic area **(McMinn, 2005)**.

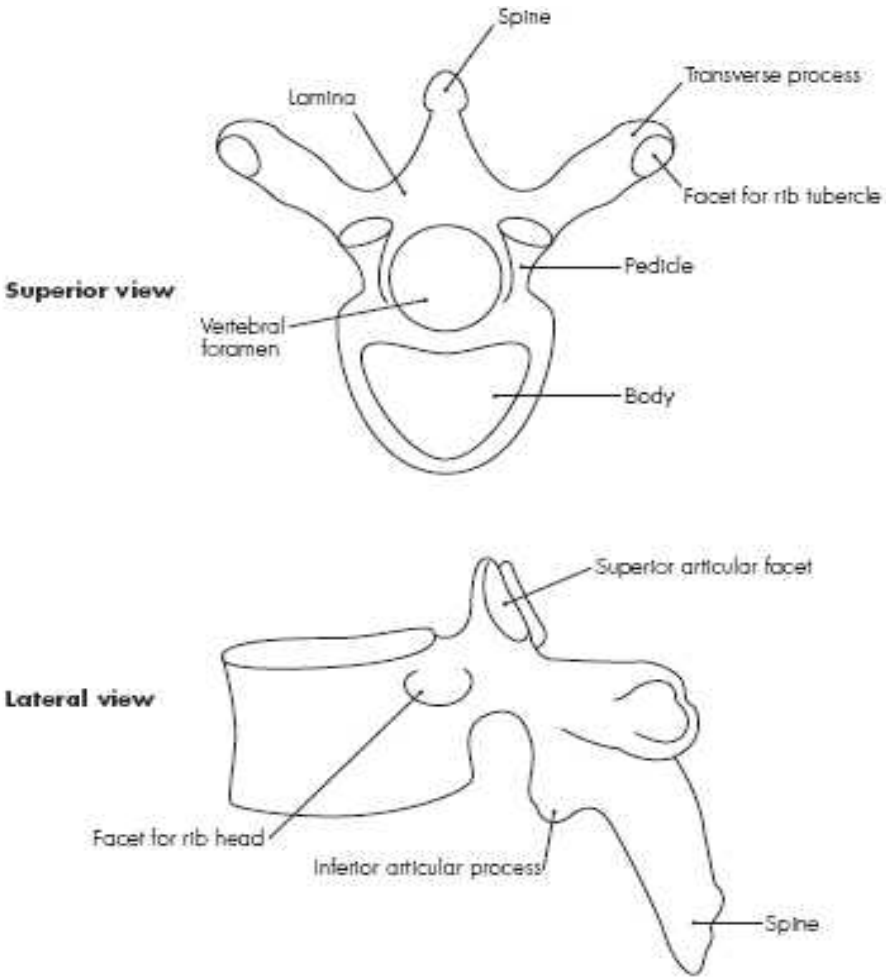

Fig 1: A typical vertebra (Wolfla, 2006).

The Cervical Vertebra

The typical cervical vertebrae are C3 – 6. Each of these has a small flattened body and a triangular, relatively large vertebral foramen. The pedicles project laterally as well as backwards, their superior and inferior notches are about equal. The superior and inferior articular facets are on an articular pillar between the pedicle and lamina, the superior facing upwards and backwards, and the inferior downwards and forwards. The transverse process is short and is pierced by the foramen transversarium, which transmits the vertebral vessels, it consists of an anterior and posterior root, each ending laterally in a tubercle and connected to each other lateral to the foramen transversarium by the costo-transverse bar. The anterior root and costo-transverse bar are homologous with a rib and like a rib, are attached to the side of the vertebral body **(Young *et al,* 1997)**.

The atypical cervical vertebrae are:

- Atlas (C1): It has no true body and essentially consists of a ring of bone, it supports the weight of the skull and articulates with the occipital condyles on its superior articular facets. The inferior facets articulate with the axis below. It also has a rounded facet on the anterior arch for articulation with the odontoid peg of the axis. The skull rocks backward and forward on the atlas.

- Axis (C2): It allows the head to rotate, it is also somewhat ring-like in shape. It has a projection of bone from the body the odontoid peg or dens, which is attached to the occipital bone by apical ligaments. The laminae are particularly strong and the transverse processes are short.

- Vertebra prominens (C7): It is the largest cervical vertebra. It has a particularly large spinous process and is transitional between the cervical and thoracic vertebrae.

Occasionally, a cervical rib may also be seen, extending from the transverse process **(Wolfla, 2006)**.

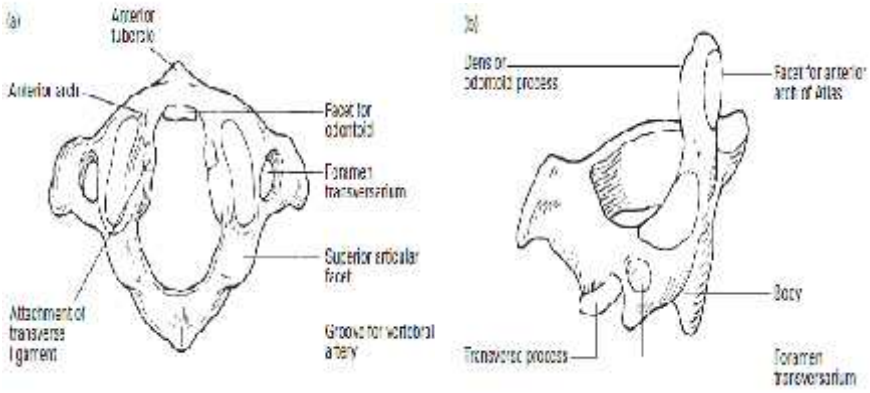

Fig 2: The atlas and axis vertebra (Wolfla, 2006).

The thoracic vertebrae

Thoracic vertebrae have articular facets on the vertebral bodies and transverse processes for articulation with the head and neck of the rib. The vertebral bodies are somewhat heart-shaped and have lateral half facets (superiorly and inferiorly) for the articulation of the head of the rib. The transverse processes are directed backwards, laterally and carry facets on the anterior aspect for articulation with the tubercle of the rib. The spinous processes are generally slender, long and are directed cauded. The atypical vertebrae are:

- T1 is similar to C7, with a broader and wider body. The upper costal facet is complete for articulation with the first rib and a transverse process facet placed more anteriorly. An articular shelf is also present, providing additional support to prevent backward displacement of C7 on T1.
- T9 and T10 may only show single costal articular facets.

- T11 and T12 are transitional between the thoracic and lumbar vertebrae (being stronger and having smaller transverse processes) **(Snell, 2004)**.

The Lumbar Vertebrae

Lumbar vertebrae are the largest vertebrae and lack foramina transversaria and costal facets. The bodies are large and kidney-shaped, the pedicles short and strong, and the transverse processes relatively small. The superior and inferior articular facets are vertically orientated. The body of L5 is wedge- shaped and is thicker posteriorly than anteriorly **(Snell, 2004)**.

The Sacrum

Sacrum is formed by the fusion of the five sacral vertebrae. It forms the central axis of the pelvic girdle, and articulates above with the fifth lumbar vertebra, on the sides with the innominate bone (at the sacroiliac joints), and below with the coccyx. It is concave anteriorly and roughly wedge-like in shape, and has four pairs of foramina for the exit of the ventral spinal nerves posteriorly **(Young *et al*, 1997)**.

The sacral canal is within the sacrum, with anterior and posterior margins created by the fused sacral vertebrae. It contains:

- Cauda equine.
- Filum terminale.
- Meninges (spinal).
- Coccygeal/sacral nerves.

- Epidural fat and veins.

The lower part of the sacrum shows that the fifth sacral laminae frequently fail to fuse. This is called the sacral hiatus. The hiatus is bounded above by the fused fourth sacral laminae, laterally by the deficient lamina margins of S5 (bearing the sacral cornua) and below by the posterior body of S5 **(Young *et al*, 1997)**.

The Coccyx

The coccyx is formed from the fusion of four small and rudimentary coccygeal vertebrae. The surfaces provide attachment for nearby pelvic and gluteal muscles **(Snell, 2004)**.

The vertebral ligaments

There is a complicated series of ligaments and joints that connect the various components of the vertebral column. These may be summarised as follows:

- Intervertebral discs – connect the vertebral bodies and make up 25% of the height of the spinal column. These consist of an outer annulus fibrosus and an inner nucleus pulposus. The superior and inferior surfaces of the vertebral bodies are also lined with hyaline cartilage, which allow adhesion to the intervertebral discs.

- Anterior longitudinal ligament – runs along the anterior surface of the vertebral bodies, from C2 to the sacrum. It adheres to the anterior surface of the vertebral bodies and the discs.

- Posterior longitudinal ligament – extends along the posterior aspect of the vertebral bodies and discs.

- Ligamenta flava – series of thick, elastic, vertical fibres that connect adjacent vertebral laminae.

- Interspinous ligaments – connect the shafts of the spinous processes.

- Supraspinous ligaments – tough fibrous column that connects the tips of the spinous processes.

- Ligamentum nuchae – superior extension of the supraspinous ligaments and extends from C7 to the occiput **(Wolfla, 2006)**.