Introduction

Spinal cord injury can be a devastating consequence of cervical spine injury from trauma or disease, the risk rises dramatically in the presence of head or facial injury, decreased level of consciousness or focal neurologic deficit. Patients with possible cervical spine injury may require urgent or emergent airway intervention for airway protection, hypoxia, hypoventilation, or hypotension which is a direct consequence of spinal cord injury or instead related to head or other bodily injury ***(Naola et al., 2014).***

Cervical spine injury is often occult, and secondary injury to the spinal cord must be avoided. Cervical vertebrae, being highly mobile for flexion, extension and rotation in vertebral column, are the most vulnerable ones for fracture, subluxation and dislocation. Atlantoaxial or atlantooccipital dislocation may even be fatal. Immobilization of the cervical spine must be instituted until a complete clinical and radiological evaluation has excluded injury ***(Murthy et al., 2005).***

Types of cervical spine injury include hyperflexion, hyperextension, compression, and clinically insignificant injuries ***(Etz et al., 2011).***

Airway management in patients with cervical spine injury is a difficult and challenging task. Attention to head positioning and stabilization during the initial evaluation and airway management is critical in the care of these patients in order to minimize the risk of secondary neurologic insult. Awareness that these patients are at risk for airway obstruction is critical. A systemic approach and development of an individualized airway plan is necessary for optimal management of patients with cervical spine injury ***(Daniel et al., 2013).***

Aim of the Work

The aim of this work is to focus on the anatomic and functional relationship between the airway, cervical column, and spinal cord and to provide safe and efficient care in cervical spine injured patients.

Anatomy of Cervical Spine

The portion of spine encompassing neck region forms cervical spine. Cervical spine is formed by first seven vertebra which are named as C1 to C7.

Anatomically, cervical spine starts where the top vertebra (C1) connects to the bottom of the skull. Normal cervical spine has a lordosis that means it is curved with convexity on anterior aspect. It ends when C7 joins the first thoracic vertebra ***(Arun, 2016).***

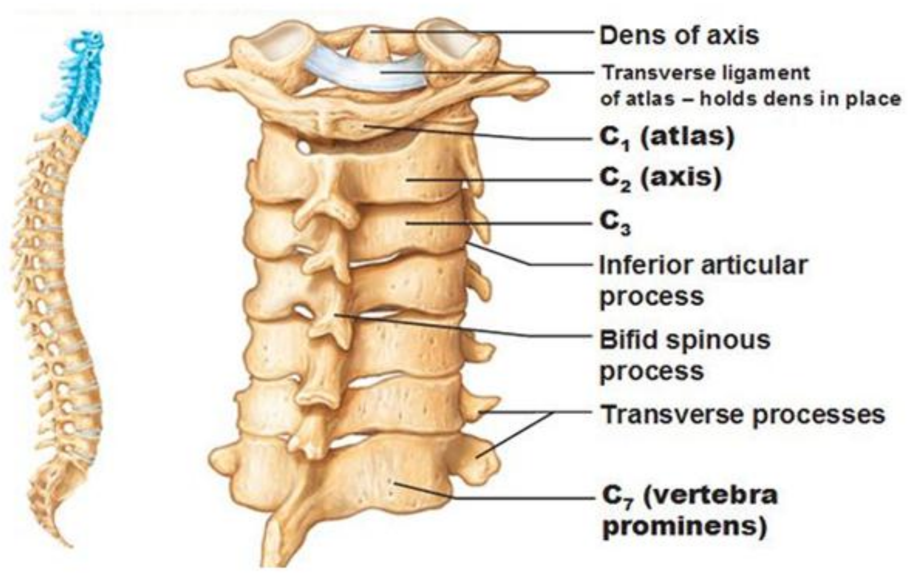


Figure (1): Anatomy of the Cervical spine ***(Arun, 2016).***

Upper cervical spine:

The upper cervical spine consists of the atlas (C1) and the axis (C2). These first 2 vertebrae are quite different from the rest of the cervical spine. The atlas articulates superiorly with the occiput (the atlanto-occipital joint) and inferiorly with the axis (the atlantoaxial joint). The atlantoaxial joint is responsible for 50% of all cervical rotation; the atlanto-occipital joint is responsible for 50% of flexion and extension ***(Tong et al., 2002).***

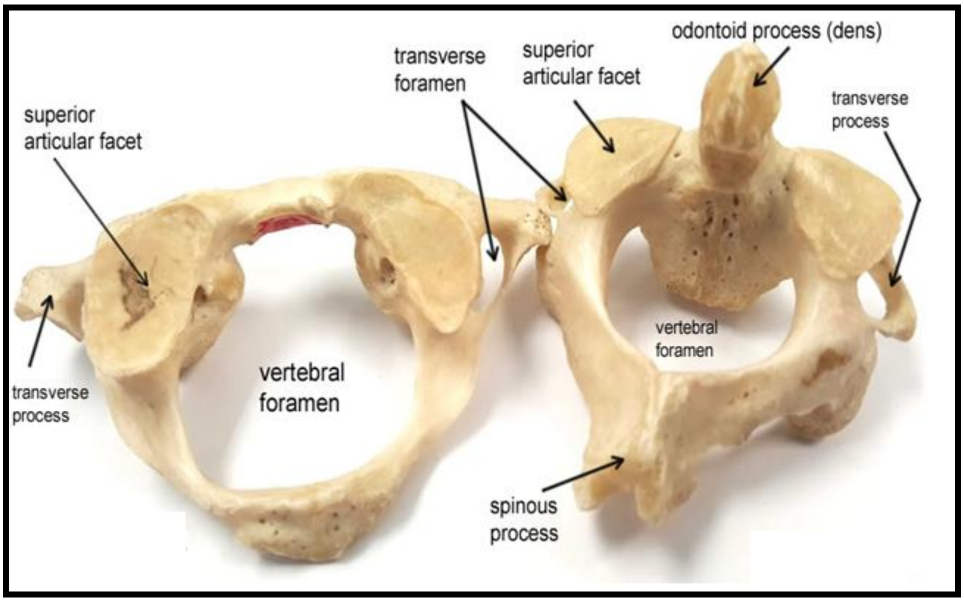


Figure (2): Anatomy of atlas and axis ***(Tong et al., 2002).***

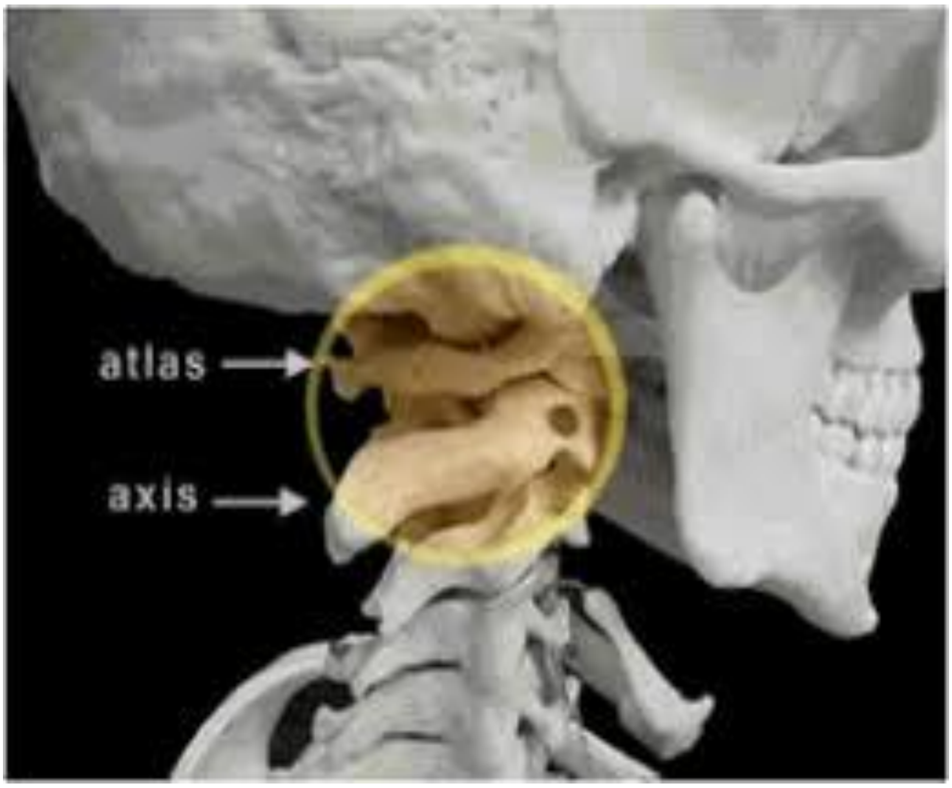
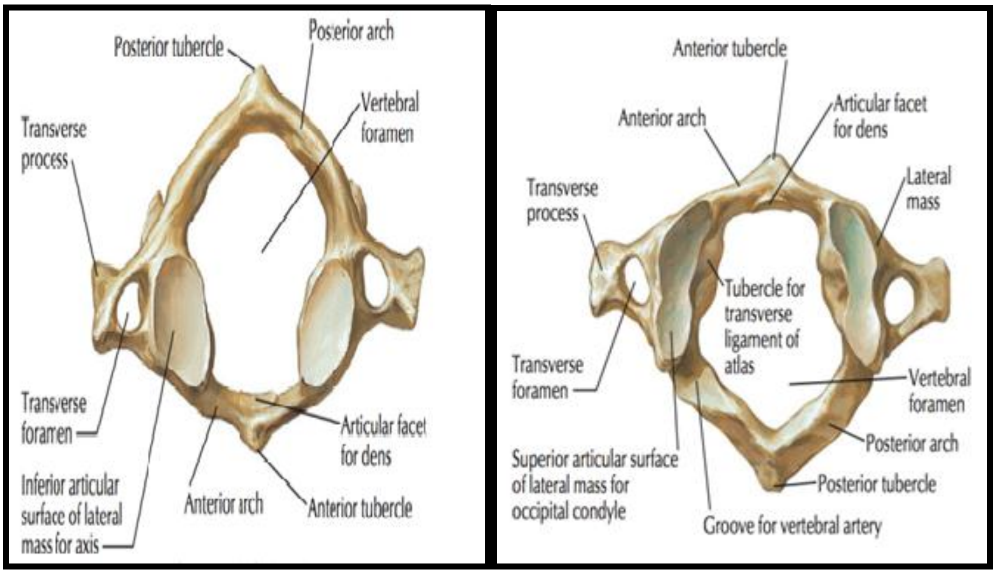


Figure (3): Atlas and axis ***(Tong et al., 2002).***

Atlas (C1):

The atlas is ring-shaped and does not have a body, unlike the rest of the vertebrae. Fused remnants of the atlas body have become part of C2 and are called the odontoid process, or dens. The odontoid process is held in tight proximity to the posterior aspect of the anterior arch of the atlas by the transverse ligament, which stabilizes the atlantoaxial joint. The apical, alar, and transverse ligaments, provide further stabilization and prevent posterior displacement of the dens in relation to the atlas by allowing spinal column rotation ***(Robert et al., 2013).***

The atlas is made up of a thick anterior arch, a thin posterior arch, 2 prominent lateral masses, and 2 transverse processes. The transverse foramen, through which the vertebral artery passes, is enclosed by the transverse process. On each lateral mass is a superior and inferior facet (zygapophyseal) joint. The superior articular facets are kidney-shaped, concave, and face upward and inward. These superior facets articulate with the occipital condyles, which face downward and outward. The relatively flat inferior articular facets face downward and inward to articulate with the superior facets of the axis. According to Steele's rule of thirds, at the level of the atlas, the odontoid process, the subarachnoid space, and spinal cord each occupy one third of the area of the spinal canal ***(Robert et al., 2013).***



Atlas: inferior view **Atlas: superior view**

Figure (4): Superior view and inferior view of Atlas ***(Robert et al., 2013).***

Axis (C2):

The axis has a large vertebral body, which contains the odontoid process (dens). The odontoid process articulates with the anterior arch of the atlas via its anterior articular facet and is held in place by the transverse ligament. The axis is composed of a vertebral body, heavy pedicles, laminae, and transverse processes, which serve as attachment points for muscles. The axis articulates with the atlas via its superior articular facets, which are convex and face upward and outward ***(Robert et al., 2013).***

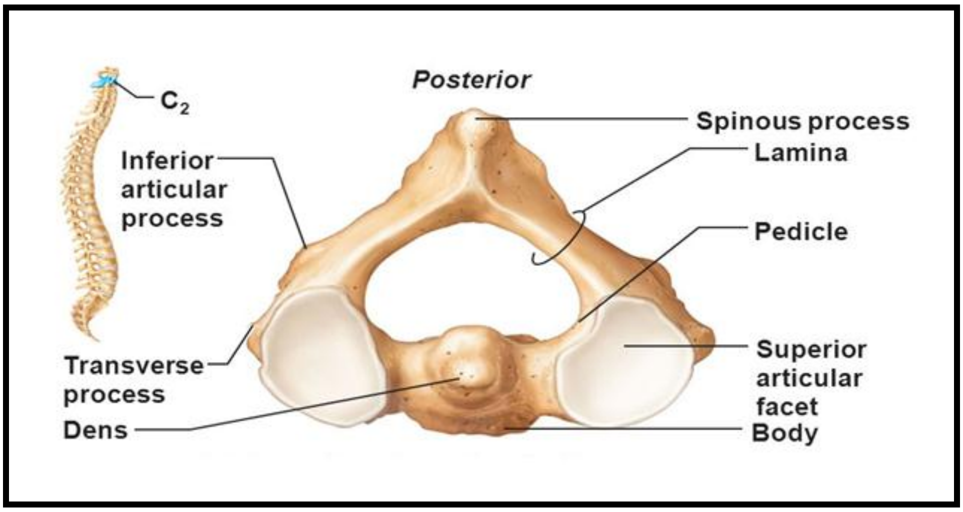


Figure (5): Superior view of Axis ***(Robert et al., 2013).***

Embryology:

The atlas is usually ossified from three centers, one appears in each lateral mass about the seventh week of fetal life, and extends backward; at birth, these portions of bone are separated from one another by a narrow interval filled with cartilage. Between the third and fourth years they unite either directly or through the medium of a separate center developed in the cartilage. At birth, the anterior arch consists of cartilage; in this a separate center appears about the end of the first year after birth, and joins the lateral masses from the sixth to the eighth year. The lines of union extend across the anterior portions of the superior articular facets. Occasionally there is no separate center, the anterior arch being formed by the forward extension and ultimate junction of the two lateral masses; sometimes this arch is ossified from two centers, one on either side of the middle line ***(Robert et al., 2013).***

C2 has a complex embryologic development. It is derived from 4 ossification centers: 1 for the body, 1 for the odontoid process, and 2 for the neural arches. The odontoid process fuses by the seventh gestational month. At birth, a vestigial cartilaginous disc space called the neurocentral synchondrosis separates the odontoid process from the body of C2. The synchondrosis (*a type of cartilaginous joint in which the cartilage is usually converted into bone before adult life)* is seen in virtually all children aged 3 years and is absent in those aged 6 years. The apical portion of the dens ossifies by age 3-5 years and fuses with the rest of the structure around age 12 years. This synchondrosis should not be confused with a fracture ***(Robert et al., 2013).***

Parts of the occiput, atlas, and axis are derived from the proatlas. The hypocentrum of the fourth sclerotome forms the anterior tubercle of the clivus. The centrum of the proatlas sclerotome becomes the apical cap of the dens and the apical ligaments. The neural arch components of the proatlas are divided into rostral and ventral components. The rostral component forms the anterior portion of the foramen magnum and the occipital condyles; the caudal component forms the superior part of the posterior arch of the atlas and the lateral atlantal masses. The alar and cruciate ligaments are formed from the lateral portions of the proatlas ***(Robert et al., 2013).***

Vasculature:

There is an extensive arterial anastomotic network around the dens, fed by the paired anterior and posterior ascending arteries arising from the vertebral arteries around the C3 level and the carotid arterial arcade from the base of the skull. The anterior and posterior ascending arteries reach the base of the dens via the accessory ligaments and run cephalad at the periphery to reach the tip of the process. The anastomotic arcade also receives tributaries from the ascending pharyngeal arteries that join the arcade after passing through the occipital condyle ***(Robert et al., 2013).***

Ligaments:

The craniocervical junction and the atlantoaxial joints are secured by the external and internal ligaments ***(Tubbs et al., 2004).***

The external ligaments consist of the atlanto-occipital complex, and anterior longitudinal ligaments.

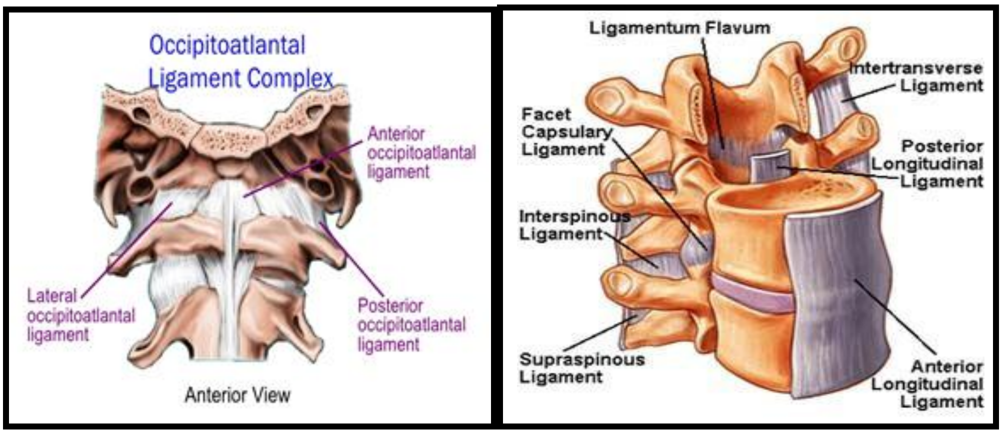


Figure (6): The external ligaments ***(Tubbs et al., 2004).***

The internal ligaments have 5 components:

- **The transverse ligament** holds the odontoid process in place against the posterior atlas, which prevents anterior subluxation of C1 on C2.

- **The accessory ligaments** arise posterior to and in conjunction with the transverse ligament and insert into the lateral aspect of the atlantoaxial joint. The 3 cm × 5 mm **accessory atlantoaxial ligament** not only connects the atlas to the axis but also continues cephalad to the occipital bone; functionally, it becomes maximally taut with 5-8° of head rotation, lax with cervical extension, and maximally taut with 5-10° of cervical flexion; it seems to participate in craniocervical stability**.**

- **The apical ligament** lies anterior to the lip of the foramen magnum and inserts into the apex of the odontoid process.

- **The paired alar ligaments** secure the apex of the odontoid to the anterior foramen magnum.

- **The tectorial membrane** is a continuation of the posterior longitudinal ligament to the anterior margin of the foramen magnum ***(Tubbs et al., 2004).***

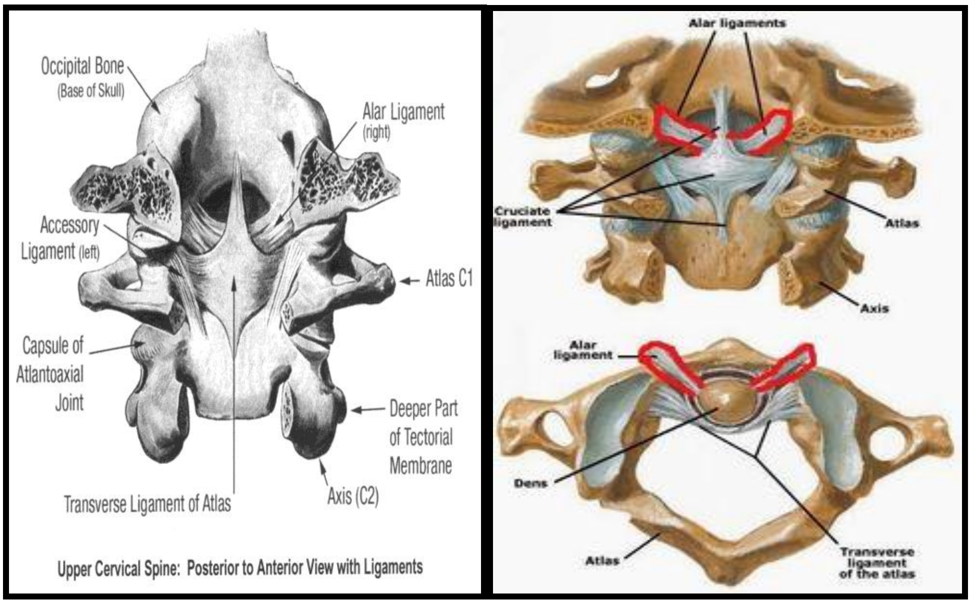


Figure (7): The internal ligaments ***(Tubbs et al., 2004).***

Neurovascular Structures:

The spinal cord at the craniocervical junction is located between the posterior halves of the lateral masses of the atlas and the pars interarticularis of the axis and fills not much more than 50% of the neural canal in the upper cervical spine.

The C-1 roots emerge from the spinal cord at a right angle and are located posterior to the occipital condyles superior to the lamina of the atlas.

The C-2 roots are larger than the C-1 roots and are located posterior and slightly caudal (towards foot) to the atlantoaxial joints ***(Arun, 2016).***

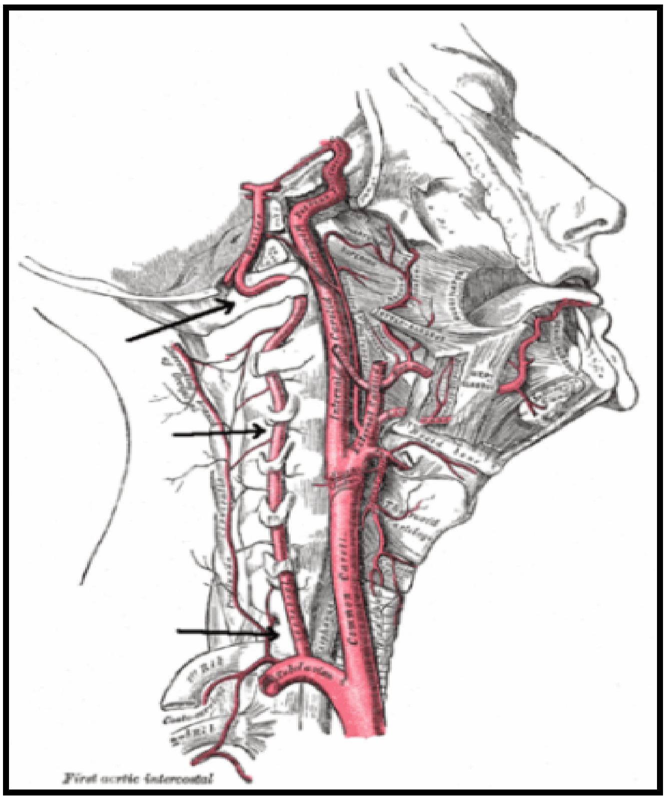


Figure (8): Neurovascular structures ***(Arun, 2016).***

The vertebral arteries emerge from the transverse foramina of the vertebral body of the axis in a cranial direction lateral to the pars interarticularis and the atlantoaxial joints. At the level of the atlas the vertebral arteries will enter the transverse foramen, course medially in a shallow bony groove located on the superior surface of the lateral third of the atlas lamina, and then head into the cerebellar fossa ***(Arun, 2016).***

Lower cervical spine:

The five cervical vertebrae that make up the lower cervical spine, C3-C7, are similar to each other but very different from C1 and C2. Each has a vertebral body that is concave on its superior surface and convex on its inferior surface. On the superior surfaces of the bodies are raised processes or hooks called uncinate processes, each of which articulates with a depressed area on the inferior lateral aspect of the superior vertebral body, called the echancrure or anvil ***(Robert et al., 2013).***

The spinous processes of C3-C6 are usually bifid, whereas the spinous process of C7 is usually non bifid and somewhat bulbous at its end**,** C7 enlarged spinous process is called vertebra prominence. It is the most prominent structure that can be palpated on passing fingers downwards from skull. Neural foramina of cervical spine allow exit of cervical spinal nerves which are eight in number and are named as C1 to C8. In between two adjacent vertebrae is interposed intervertebral disc. The longus colli muscles lie directly over and insert onto the anterolateral aspects of each cervical vertebra. The sympathetic plexus lies on top of the lateral muscle belly and may be injured aggressive dissection or retraction which can lead to Horner's syndrome. The prevertebral (deep) and alar (superficial) fascial layers separate the spine from the overlying esophagus ***(Arun, 2016).***

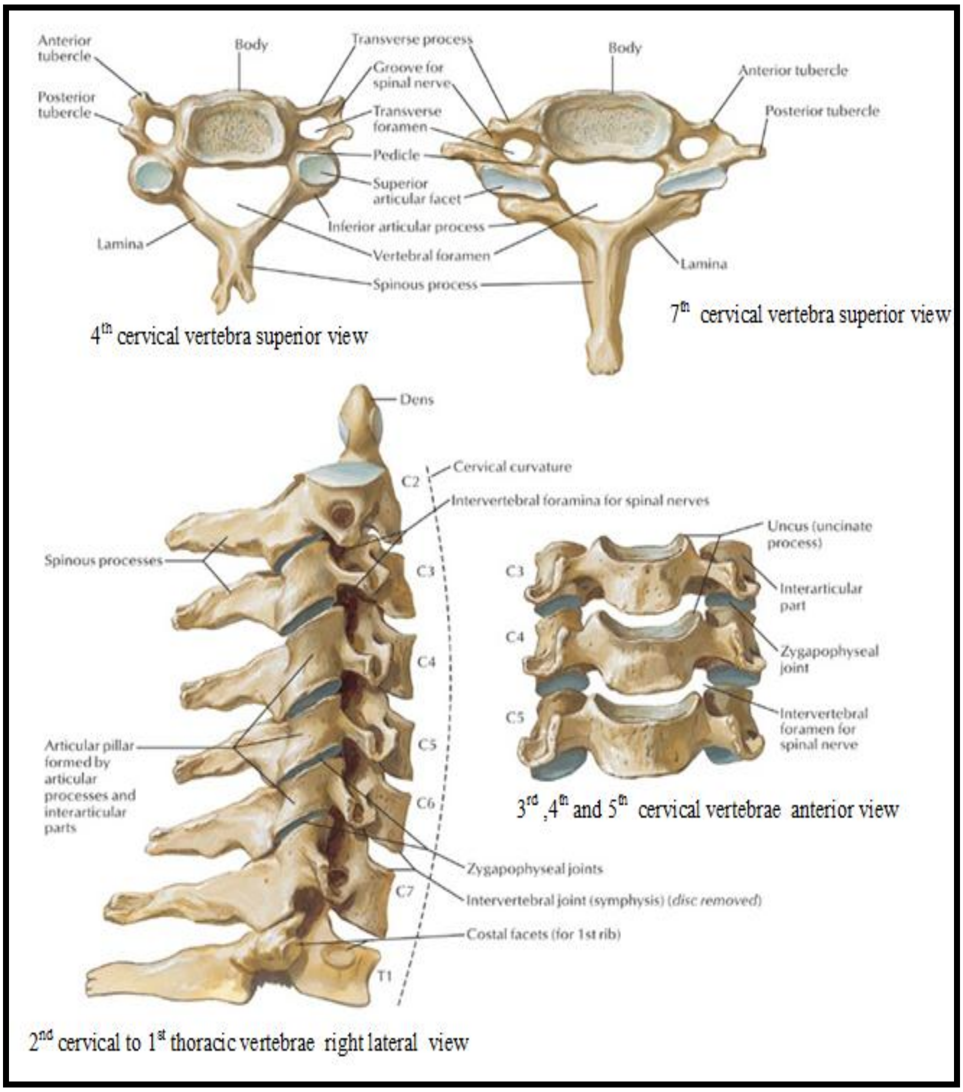


Figure (9): Normal anatomy of lower cervical spine ***(Robert et al., 2013).***