Outcome of Surgical Approaches to Cervico-Thoracic Junction and Upper Dorsal Spine

A Systematic Review Submitted for Partial Fulfillment of the requirements of the degree of Master of Science in Neurosurgery

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Acknowledgment

I would like to begin by thanking GOD for his guidance and protection, may this blessing always guide us.

Moreover I would like to express my sincere and profound gratitude to Prof. Dr. Tarek Mohamed Lotfy Salem, Professor of Neurosurgery, Faculty of medicine, Ain Shams University, for his meticulous supervision, loyal encouragement and valuable advises throughout the work.

I wish to express deep appreciation to Assist. Prof. Dr. Ahmad Elsayed Desouky Elayouty, Assistant Professor of Neurosurgery, Faculty of medicine, Ain Shams University, for his continuous guidance, unique supervision and kind care.

I am also grateful to Dr. Ahmad Mohammed Abdelraheem El-sabaa, Lecturer of Neurosurgery, Faculty of medicine, Ain Shams University, for his kind effort, assistance he offered me throughout the performance of this work.

Dedications

To my beloved father and mother, to whom I will be grateful for rest of life for they unconditional and unlimited love and support.

To my beautiful sisters, who were my childhood companions and best friends.

To my dear wife and daughter, who are the delight of my life and holding the torch of light for my path.

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III. Background

Surgeons have always been concerned about approaching the cervicothoracic junction and following the upper thoracic vertebrae. Vital structures in the vicinity pose threats of iatrogenic complications[13]. A surgeon may encounter the trachea and esophagus with recurrent laryngeal nerves in-between, as well as the lungs, heart and surrounding mediastinum. Vascular structures to avoid would be the arch of aorta, common carotid artery and innominate vein, in addition to the thoracic duct and stellate ganglion[19].

A. Anatomy

1. Subaxial cervical spine

A vertebra (Figure 1) is composed of a vertebral body anteriorly, and a neural arch posteriorly which is composed of pedicles and laminae, and between them the vertebral foramen which is triangular in shape. In typical subaxial cervical vertebrae (and including the first thoracic vertebra) the body looks like a small square with a hook-shaped uncinate process on each side of the superior endplate; these articulate with the uncus surface of the inferior endplate of the vertebral body above, all of which compose the uncovertebral joint (Luschka's joint). At the union of both laminae extends the peculiar bifid spinous process. On the other hand, from the junction between the lamina and pedicle extends the transverse process on each side, which in the cervical spine has the particular property of having anterior and posterior bars harboring in between the foramen transversarium, which transport the vertebral artery (Figure 2). A surgical landmark is the anterior tubercle of transverse process of the 6th cervical vertebra (Chassaignac tubercle), which is bulky with a close relation to the carotid artery[9].

The junction between a lamina and a pedicle in the subaxial cervical spine has a marked bulge laterally between the superior and inferior articulate process to form another unique feature of the cervical spine which is the lateral mass. The superior articulate process has an ovoid flat surface which faces a superior posterior direction to articulate with the inferior articulate process of the vertebra above[9].

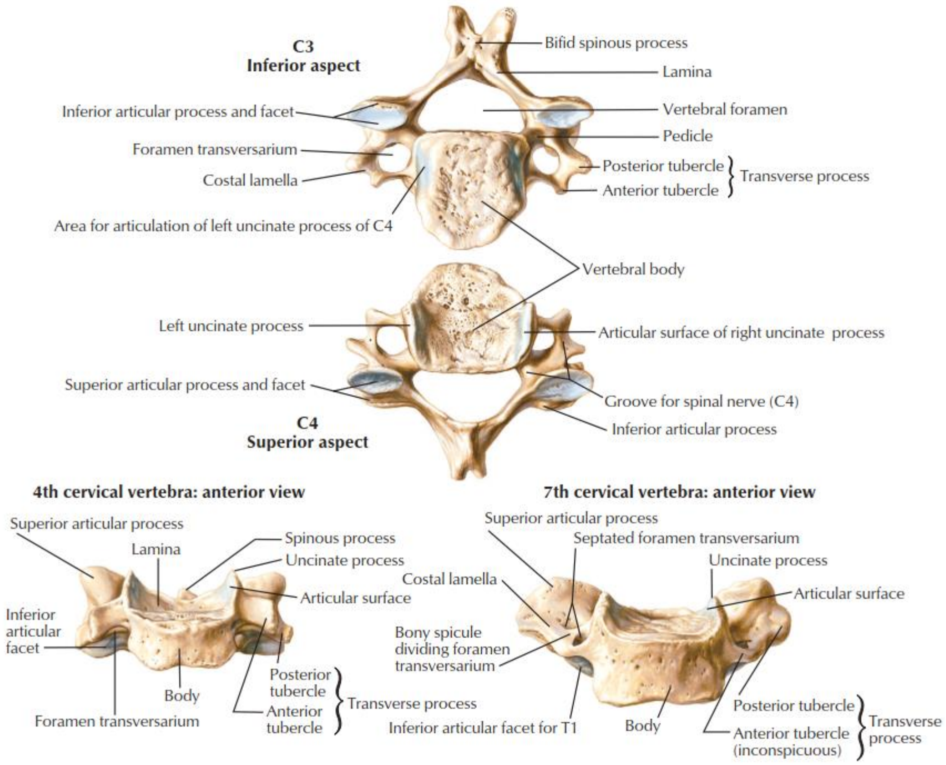


Figure 1: Figure showing anatomy of typical subaxial cervical vertebrae [27]

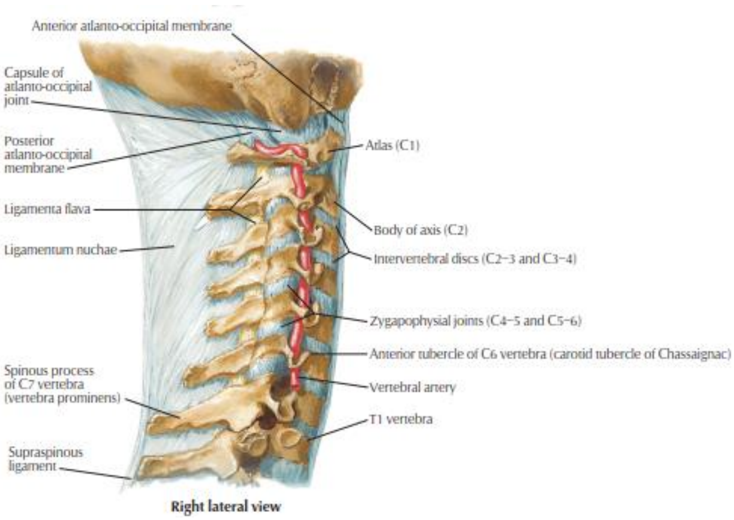


Figure 2: Figure showing vertebral artery passing through foramen transversarium of cervical vertebrae [27]

As the 7th cervical vertebra is in a transitional area between the cervical and thoracic spine, it has different properties than the rest of the subaxial spine. For instance, the spinous process is directed posterior and inferior, and is rather bulky than bifid as it serves as an attachment for ligamentum nuchae. Also, the foramen transversarium is usually devoid of a vertebral artery although it may contain a vertebral vein[9].

Articulations between two adjacent vertebrae (Figure 3) occur posteriorly between lateral masses in the form of facet joints, and anteriorly between bodies by the means of intervertebral discs and uncovertebral joints. An intervertebral disc is formed by a central gelatinous component (Nucleus Pulposus) and a peripheral fibrous part (Annulus Fibrosus). The uncovertebral joints allow extension and flexion movements while limiting the lateral flexion one[9].

Regarding ligaments connecting the cervical vertebrae (Figure 3) and allowing movement with strong stabilization maintained, the following are individualized ligaments[9]:

1. Anterior longitudinal ligament (ALL): a fibrous ligament which extends on the ventral surfaces of the vertebral bodies from the base of the skull to the sacrum. It resists hyperextension.
2. Posterior longitudinal ligament (PLL): it extends from the occiput to the sacrum. It is attached to the dorsal surfaces of the vertebral bodies. It usually has a close relationship with the dura.
3. Ligamentum flavum: Its etymology comes from the Latin flavus, which means yellow. Its color is due to a high content of elastic fibers. At each level there are two ligamenta flava; one at each lamina, maybe separated by a central fissure. They extend from half the ventral surface of the lamina of a vertebra above to the superior margin of the lamina of the vertebra below.
4. Interspinous ligaments: These connect every two consecutive spinous processes and extend anteriorly up to the ligamentum flavum
5. Ligamentum nuchae: This massive structure extends from the external occipital protuberance to the spinous process of the 7th cervical vertebra. Its fibers attach to the spinous processes of each cervical vertebra constituting a separation between the right and left paravertebral muscle compartments.

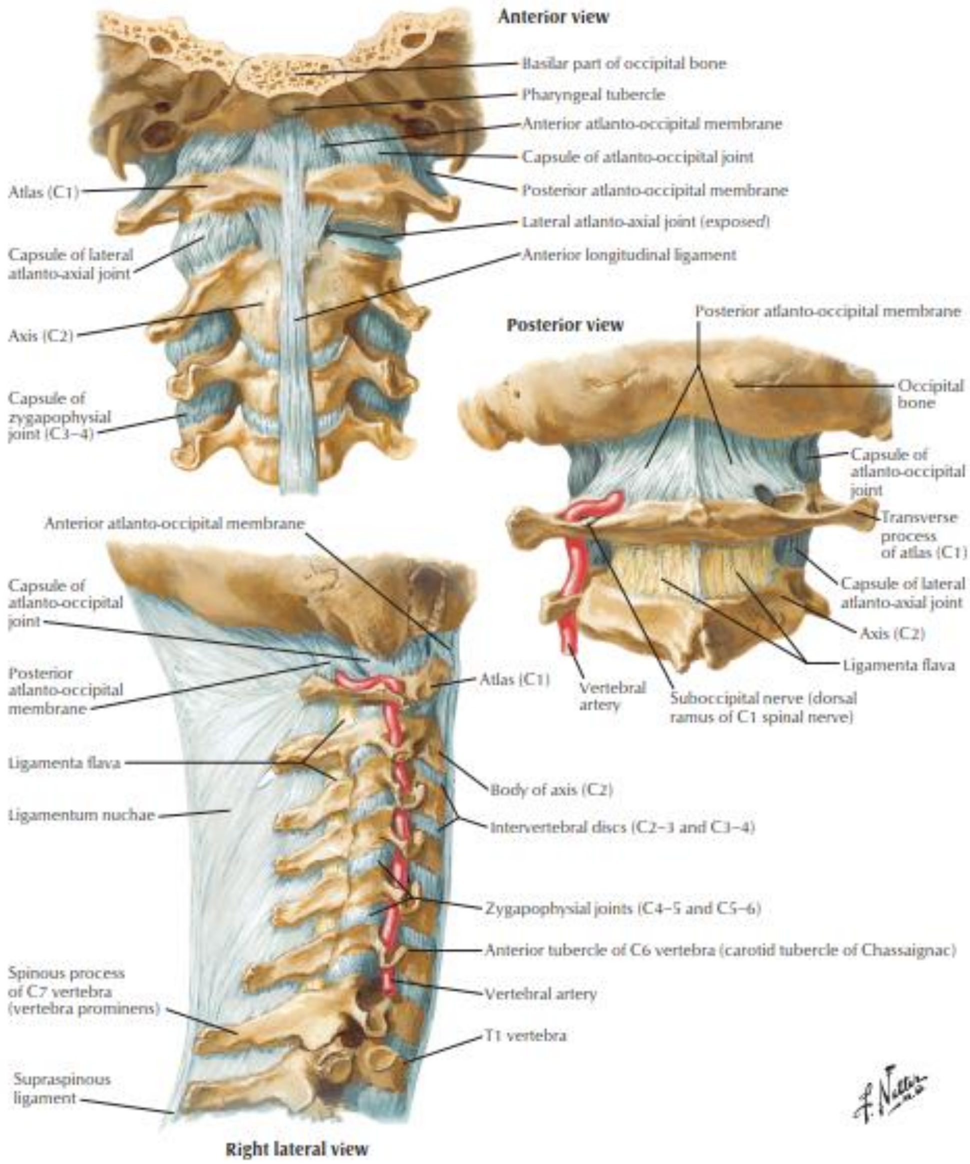


Figure 3: Figure showing joints and ligaments of subaxial cervical spine [27]

2. Cervicothoracic junction

The cervicothoracic junction (Figure 4) is usually defined as a segment extending from C7 to T4-5 intervertebral discs. In front of it; lies the mediastinum behind the sternum with its contents. The left brachiocephalic vein, formed by the confluence of the left internal jugular and subclavian veins, lies immediately posterior to the upper sternum. The thymus gland is just anterior to this structure. Left and right brachiocephalic veins join to form the superior vena cava at the right first intercostal space. The superior vena cava joins the left atrium posterior to the third costal cartilage. The vagus and phrenic nerves are found anterior to the arch of the aorta. The recurrent laryngeal nerve stems from the vagus nerve between T1 and T3 on the left side and goes around the aorta to lie in the tracheoesophageal groove on its way up. The right recurrent laryngeal nerve however originates from the vagus nerve on a much higher level and encircles the right subclavian artery; it may also leave the carotid sheath at a further higher level and proceed anteriorly behind the thyroid to enter the tracheoesophageal groove. Thus, injury to the recurrent laryngeal nerve is more prevalent on the right side, especially at C5-T1 levels. However, preferring left versus right approach to avoid RLN injury is still controversial. Injury to RLN can cause mild dysphagia and dysphonia. The reported incidence of dysphagia for anterior approaches ranges from 28% to 57%, and the incidence of dysphonia is 2% to 30%. The phrenic nerve descends anterior to the pulmonary hilum to supply the diaphragm. In addition, the thoracic duct enters the superior mediastinum on the left side posterior to the arch of the aorta and then ascends between the left subclavian artery and the esophagus to drain into the junction of the left subclavian vein and the left internal jugular vein(11).

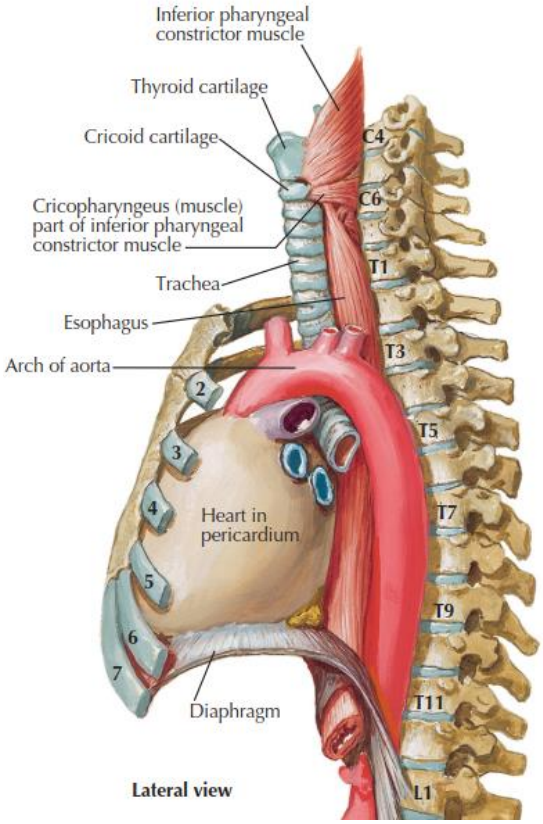


Figure 4: Figure showing CTJ and related structures. [27]

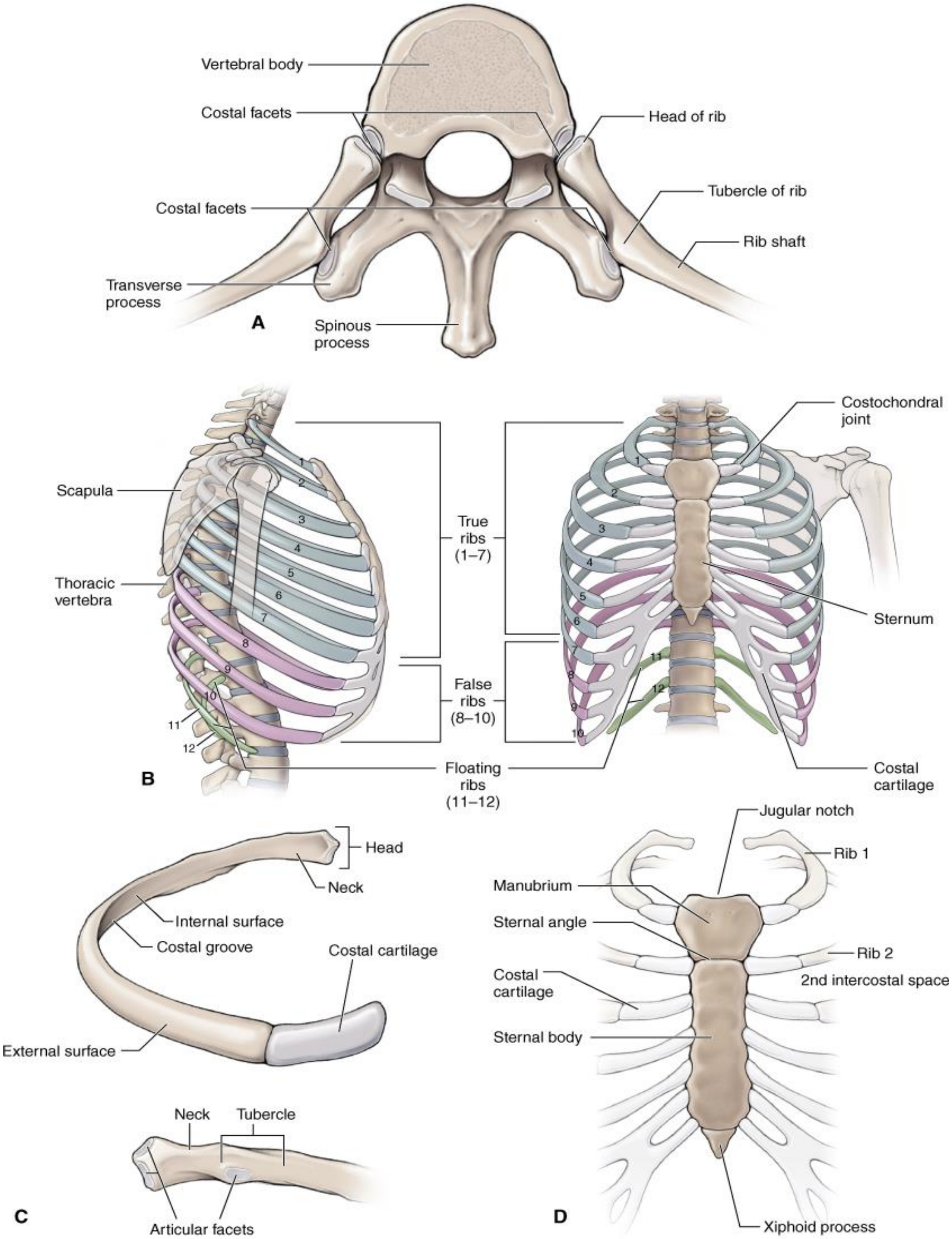
3. Thoracic spine

The thoracic spine (Figure 5) consists of twelve vertebrae. The vertebral bodies gradually increase in size from T1-T12. The first four thoracic vertebrae can mimic some cervical properties while the last four thoracic vertebrae have some lumbar features. For example the first thoracic vertebra has a superior vertebral notch, while the twelfth thoracic vertebra shows lateral direction of the inferior articular processes. Laminae are larger in the thoracic vertebrae than these of the cervical spine, and they usually overlap. On the other hand, the transverse processes increase in size going down through the thoracic spine. Also, the spinous processes of the thoracic vertebrae are variably arranged in horizontal, oblique, or overlapping vertical planes. So, horizontal spinous processes are found at T1-T2 and T11-T12, oblique spinous processes at T3-T4 and T9-10, while the rest of the thoracic vertebrae show overlapping vertical spinous processes[30].

Facet joints are mainly structured in a coronal plane, however they progress into a sagittal plane closing to the lumbar vertebrae. The spinal canal in the thoracic spine is smaller than both in cervical and lumbar regions[30].

Relationship of thoracic vertebrae to the ribs comes in two places on each side of a vertebra. A rib articulates with one costal facet which lies where the vertebral body and pedicle meet, and also articulates with another facet at transverse process. However, at levels T10-T12 there are no facets on transverse processes to articulate with relatively short ribs[30].

Stability of the thoracic spine is the greatest among all segments of the spine; this is due to the presence of an articulating thoracic cage. That is why the junctional areas between the thoracic, cervical and lumbar segments of the spine are liable to instability, due to the transition from a rigid immobile segment to a mobile less stable one. Hence, these junctional areas are usually susceptible to iatrogenic instability following surgical procedures[30].



Source: Dutton M: *Dutton's Orthopaedic Examination, Evaluation, and Intervention*, 3rd Edition: www.accessphysiotherapy.com

Figure 5: Figure showing anatomy of thoracic spine and rib cage. (A) Thoracic vertebra and attached ribs, (B) Rib cage, (C) Anatomy of a rib, (C) Anatomy of sternum.[6]